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NUTRITIONAL STUDIES
OF MEN AND WOMEN AGED 50-75 YEARS

by

ELAINE C. TAYLOR (Née Blake)

T H E S I S

submitted for the degree of

DOCTOR OF PHILOSOPHY

Faculty of Science
University of Glasgow

VOLUME I
Text and References

April , 1989

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Statement of Personal Contribution to the Work Reported in the Thesis.

Professor John Durnin initiated this work by his interest in the effects of aging on energy requirements. Prior to joining his research unit I collaborated with him in a study of the comparative energy requirements of middle aged and young women.

After I joined his unit I took a major part in planning and carrying out the series of studies which became my special responsibility and are the subject of the thesis.

The planning decisions included those concerned with the selection of appropriate groups, the recruitment of subjects and technical staff, the implementation and the field of the chosen methods of measurement of food intake and energy expenditure, the maintenance and calibration of equipment and the choice of methods of data analysis.

Throughout the series I had responsibility for and personal detailed knowledge of all components of the field work. I also trained all new members of the team of investigators, who were usually dietitians, to ensure uniformity in collection of data.

I was a joint author under my maiden name. Blake, with Professor Durnin and others of six papers which reported the findings of some of the studies.

The new analysis and interpretation of the original raw data which is presented in this thesis was wholly planned and executed by me.

ACKNOWLEDGEMENTS

University of Glasgow

My very sincere thanks go to Professor J.V.G.A. Durnin for his positive response when I suggested writing the thesis after the passage of 20 years and for his encouragement in many trans-Atlantic telephone calls.

I would also like to thank Professor R.C. Garry for his kindness and support in my original application to be a doctoral candidate.

The expertise of many people was required to carry out the investigations reported and I acknowledge gratefully the contributions of my associates Dr. J. Brockway, Ms. Margaret Allan, Ms. Susan Blair, Ms. Anne Busby, Ms. Lena Couperwhite, Ms. Anne Drury, Ms. Margaret Friskey, Ms. Elizabeth Shaw, Ms. Jennifer Wheatcroft, Ms. Evelyn Wilson and Ms. Sylvia Yuill.

University of Washington, Seattle

I acknowledge with gratitude the understanding of Dr. Maureen M. Henderson, Professor of Epidemiology and Medicine at the University of Washington and Director of the Cancer Prevention Research Unit of the Fred Hutchison Cancer Research Center who has granted me a long leave of absence to complete the dissertation.

I am deeply indebted to Dr. Rick Connis for his invaluable guidance and practical assistance with statistical analysis and to Mylinh and Linh who were meticulous in tabulating statistical data.

Bonita Ferus of the Department of Family Medicine adopted this project some years ago and has carefully typed and documented the many versions of text and tables on the IBM Displaywriter. She has been patient, good humored and has never lost faith. Thank you, Bonnie, with all my heart.

To my husband, Tom, who has given me loving and persistent encouragement, to my children, Pauline and Helen, who have grown up to believe that when a mother talks about "work" it means book work and not housework, to many friends who have been neglected and to my parents, Helen and Roland Blake - thank you for your patience and your love.

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CHAPTER 1
SUMMARY

The principal aim of this thesis is the clarification of some relationships between occupation, energy expenditure, patterns of physical activity and energy and nutrient intake of groups of healthy, free-living men and women aged between 50 and 75 years. A subsidiary aim is to review the findings of the research in the light of current nutritional concepts, most importantly, the concepts developed in the FAO/WHO/UNU, (1985) Expert Consultation on Energy and Protein Requirements.

When the research began, national and international food and policy decisions concerning the nutritional requirements of the age group had to be based largely on intelligent guesswork. The Food and Agriculture Organization (FAO) Committee on Calorie Requirements (1957) stated that "present knowledge of the influence of aging on the quantity of food eaten and energy expenditure is deficient and further investigations are needed".

This thesis presents the results of studies of the total energy expenditure, physical activity and energy and nutrient intake of 13 groups of middle-aged and elderly Scottish men and women with particular reference to the effect of occupation and age on these variables. The findings are discussed in relation to those of comparable studies and to current nutritional concepts.

The Historical Review is divided into two parts. In Part 1 are traced some of the threads of scientific enquiry into the role of aging in the determination of the energy requirements of man from ancient times until the middle of the 20th century. The section on classical work on animal heat, respiration exchange apparatus, the development of calorie conversion factors, the development of indirect calorimetry, and early studies of dietary intake and energy expenditure cites authoritative contemporary reviews of the salient findings. The historical context in which the research was begun is then summarised. In Part 2 an account is given of some conceptual and methodological developments in relation to energy requirements, which have occurred since the completion of the studies.

Six research questions linking occupation and age to energy expenditure, patterns of activity and energy and nutrient intake arose from the review of the literature.

Four specific hypotheses were formulated to test these relationships, which were also addressed in six research questions. The specific hypotheses were:

A.1) There will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of mean age between 50 and 65 years between occupational groups of the same sex.

A.2) There will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of the same sex of mean age between 50 and 65 years and comparable groups of mean age of over 65.

B.1) There will be descriptive variations in the time and activity patterns and energy and activity patterns of groups of subjects of mean age between 50 and 65 years between occupational groups of the same sex.

B.2) There will be descriptive variations in the time and activity patterns and energy and activity patterns between groups of the same sex and of mean age between 50 and 65 years and comparable groups of mean age of over 65.

The methods were chosen to provide detailed reliable information on the food intake and energy expenditure of small groups of Scottish men and women whose occupational and non-occupational activities were representative of some of the normal patterns of work and leisure of their age group in the population. The groups to be studied were selected on the basis of age, sex, level of energy expenditure expected from description of occupation and whether or not they lived alone.

Total daily energy expenditure was assessed by the factorial method, which is also known as the activity diary and respirometer method. Total daily energy and nutrient intake was assessed by the weighed individual inventory method.

A full description of the methods of selection and recruitment of the subjects, of assessment of energy expenditure and energy and nutrient intake, together with a review of the limitations and errors of the methods are given in Chapter 5 (Methods).

Two sets of findings for individual subjects formed the data base which was used to examine the specific hypotheses and to address the research questions. These were obtained from the daily activity diaries of the majority of the subjects and the results of the analysis of the seven-day food intake records of all the subjects.

The primary variables used in the analysis were study number, subject number, age, height in centimetres, weight in kilograms, body mass index, mean daily protein intake in grams, mean daily fat intake in grams, mean daily carbohydrate intake in grams, mean daily calcium intake in milligrams, mean daily iron intake in milligrams, mean daily energy intake in kilocalories, mean daily energy expenditure in kilocalories and Basal Metabolic Rate calculated after Fleisch (1951) in kilocalories per minute.

It was found that there were significant differences for both men and women in energy expenditure, and for men, but not for women in energy and nutrient intake when comparisons were made between 1) occupational groups aged 50-65; and 2) comparable groups aged 50-65 and over 65. (Hypothesis A)

It was found that there were descriptive variations in time and activity and energy and activity patterns for men and women when comparisons were made between 1) occupational groups aged 50-65; and 2)comparable groups aged 50-65 and over 65. (Hypothesis B)

The research questions could not be answered fully by the formulation and testing of specific hypotheses. In the discussion they are further clarified by comparing the results with the findings of methodologically similar studies of groups of various ages, many of which have been published since the studies were completed.

The convention used in the FAO/WHO/UNU (1985) Expert Consultation on Energy and Protein Requirements ("UNU") of expressing energy requirements as multiples of BMR ("UNU"BMR) is applied to the results obtained for total energy expenditure ("UNU" TEE), to its component parts, namely, occupational and non-occupational activities and to energy intake ("UNU" TEI).

Discussion of the resultant values focuses on 1) individual and group BMRs and compares them with values obtained by the Fleisch (1951) method; 2) comparisons of group "UNU" TEE factors with one another and with other groups; 3) the differences between groups in "UNU" BMR based factors for the average energy cost of physical activity during occupational and non-occupational time and 4) comparison with "UNU" examples of similar work categories.

Comparisons are made with current commonly accepted standards for intake of energy and nutrients. Energy intake findings are also discussed in relation to the concept of levels of energy requirement based on normative judgements about desirable levels of activity and desirable body proportions made by the Consultation. The standard used for discussion of protein intake is the concept of a safe level of protein endorsed in the Consultation report.

The principal conclusions are as follows.

Occupation was a good predictor of energy expenditure in the majority of groups of men aged between 50 to 65 years and in younger and older groups. There was a difference of approximately 30 percent between those occupations involving hard labour and those which were comparatively sedentary. Occupation was not a good predictor of energy expenditure for the executive group of sedentary workers.

Occupation was not as good a predictor of total energy expenditure for groups of women aged 50-65 years or younger as it was for men. There was a difference of approximately 20 percent between groups who worked only in the home and those with employment in light industry.

Occupational energy expenditure was the principal reason for differences in TEE between groups of men aged 50-65 years and those aged under 50.

Very little difference in occupational expenditure was found between groups of women aged 50-65 years. The literature did not yield sufficient data to make this comparison between younger groups of women.

Changes in the patterns of activity of many women, in particular those occasioned by employment outside of the home, are likely to have maintained or increased the total energy expenditure of large groups of women in the 50-65 age group.

The energy cost of leisure time physical activity (LTPA) was comparatively high for all the groups of men by present day standards.

The differences in energy intake between the groups of men aged 50-65 years, reflected the differences in their expenditure better than those of the women or groups of men over 65. Occupation was a good index of energy intake for men but not for women.

There appears to be a middle years plateau of energy intake and energy expenditure which extends from about 40 to beyond 65 years for normally healthy, comparatively sedentary men. For men with more active occupations, it is likely that retirement reduces energy expenditure and intake to the level of the sedentary majority of the population. This plateau exists for women throughout adult life because the range of occupational energy demand is narrow. It may be perturbed slightly on retirement.

The lower energy intake of women does not fully explain their lower intake of calcium and iron compared to men. Women choose foods which have a lower nutrient density of calcium and iron.

A noticeable drop in the energy intake of sedentary men and women does not appear to take place until between 75 and 80 years. For men there is a drop at an earlier age under two circumstances. Firstly, on retirement from non-sedentary occupations and secondly, when moderately heavy occupations are continued beyond 65 years.

For men and women over 65 years who have had sedentary occupations retirement can produce a pattern of increased activity or sedentary behaviour may continue.

The adoption of 60 years as the age at which a different prediction equation for BMR is introduced has proved to be an obstacle in expressing energy requirements of occupational groups aged between 50 and 65 as a factor of BMR. The retirement age of 65 years is a more natural and useful dividing line. For reason of consistency between the sexes the same conclusion is drawn for women.

"UNU" BMR-based factors for energy cost of activity are a very useful way of comparing groups. The energy cost expressed as "UNU" BMR-based factors of the occupational physical activity of groups of men aged 50-65 did not differ from the under-50 age groups, although no under-50 age groups similar to the moderate work catergory groups were available for comparison. The energy cost of occupational physical activity of women in the 50-65 age group compared to under 50 groups, did not differ whether the cost was incurred by household and childcare acitivities or in a combination of outside work and household responsibilities. Underestimates of the energy requirements of women and men between 50-65 years may result if it is assumed that there is a decline in physical activity during those years.

In the 50-65 age group the normative energy requirements proposed for non-sedentary groups of men are 1.78 x BMR; for two sedentary groups, 1.55 x BMR and 1.41 x BMR; for a group of housewives and a group of bakery workers, 1.64 x BMR and for workers in a sewing machine factory, 1.56 x BMR.

In the over 65 age group the normative energy requirements proposed for a group of farmers is 1.78 x BMR; for a group of retired men, 1.66 x BMR and for a group of retired women, 1.64 x BMR.

A postscript suggests a research plan which is consistent with insights which have been gained into the extent of the error of the method of energy expenditure measurements and yet is a promising simple means of pursuing questions related to the energy requirements of middle aged and elderly men and women at the individual and population level.

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CHAPTER 2
INTRODUCTION

The aim of this thesis is the clarification of some relationships between occupation, energy expenditure, patterns of physical activity and energy and nutrient intake of groups of healthy free-living men and women aged between 50 and 75 years.

When the research was begun twenty-five years ago, it had been known for some time that older adults were becoming an increasingly large part of the population of many countries of the world. At that time, research on the processes and consequences of aging beyond the middle years was in its infancy and reliable scientific data was lacking on the effects of aging on the individual and the impact of an aging population on society.

In the area of nutritional requirements, national and international food and health policy decisions had to be based largely on intelligent guesswork. The Food and Agriculture Organization (FAO) Committee on Calorie Requirements (1957) stated that "present knowledge of the influence of aging on the quantity of food eaten and energy expenditure is deficient and further investigations are needed".

A small amount of information was available on the food intake of older men and women. With the exception of a study by Durnin, Blake and Brockway (1957) of 12 middle-aged housewives, there was no information on the 24-hour energy expenditure and daily patterns of physical activity of groups of men or women aged 50 and over in different occupations or who were retired from work.

This thesis presents the results of studies of the total energy expenditure, physical activity and energy and nutrient intake of 12 groups of middle-aged and elderly Scottish men and women with particular reference to the effect of occupation and age on these variables. The findings are discussed in relation to those of comparable studies and to current nutritional concepts.

Although some of the original material presented in the thesis has been published by J.V.G.A. Durnin, myself, and other members of the research team, the studies have never before been reported in detail.

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CHAPTER 3
HISTORICAL REVIEW

INTRODUCTION. This chapter is divided into two parts. In Part 1 are traced some of the threads of scientific enquiry into the role of aging in the determination of the energy requirements of man from ancient times until the middle of the 20th century. The section on classical work on animal heat, respiration exchange apparatus, the development of calorie conversion factors, the development of indirect calorimetry, and early studies of dietary intake and energy expenditure cites authoritative contemporary reviews of the salient findings. The historical context in which the research was begun is then summarised.

In Part 2 an account is given of some conceptual and methodological developments in relation to energy requirements, which have occurred since the completion of the studies. This has been a time of unprecedented growth in published studies of the causes and consequences of the aging process, of which the effect on energy and nutrient requirements in the middle years and beyond is a vital part.

The continuing importance of further study of the determinants of the energy requirements of man is illustrated by four questions asked by individual scientists and by an international body during this century.

> One principal which thus far has not received adequate recognition in dietary standards may perhaps be expressed by saying that the standards must vary not only with the conditions of activity and environment, but also with the nutritive plane at which the body is to be maintained. A man may live and work and maintain bodily equilibrium on either a higher or lower nitrogen level or energy level. One essential question is, what level is most advantageous? The answer to this must be sought not simply in metabolism experiments and dietary studies, but also in broader observations regarding bodily and mental efficiency and general health, strength and welfare.
>
> \- Quotation from Atwater and Benedict (1902) cited in the report of a Joint FAO/WHO Ad Hoc Expert Committee on Energy and Protein Requirements (1973).

How much should be eaten?. . . .many of the data for an adequate and complete solution are at present lacking.

- Cathcart (1931)

How much food does man require? We believe that the energy requirements of man and his balance of intake and expenditure are not known.

- Durnin, Edholm, Miller and Waterlow (1973)

[Energy and protein] requirements for what?. . .the aim should be to define requirements for health. . .almost every aspect of human health and function is potentially relevant.

- Report of a Joint FAO/WHO/UNU Expert Consultation on energy and protein requirements. (1985)

PART I: REVIEW OF LITERATURE BEFORE 1966

3.1 Early observations and speculations. Any inquiry dealing with a subject as fundamental to human life as nutritional requirements is bound to reveal that many of the concerns of the present were also those of the past. The role of diet and the manner in which man lived from day to day in maintaining health, curing disease and prolonging life have been the subject of speculation for centuries by observant and thoughtful people. McKenzie (1680-1761) made one of the many syntheses of these speculations in which appears the biological, social, psychological and ecological factors which are being examined today in the quest for a long and healthy life. In his publication "The History of Health and the Art of Preserving It" (1759), he noted a number of factors which predispose individuals to long life and health. Among these were: descent from at least one long-lived parent, a calm, contented and cheerful disposition, and good nourishment. He also advocated good air, good water, a frugal and simple diet and "the wise government of our appetites and passions". He summed up his advice as "a prudent choice and proper use of all the instruments of life and rules of health", and expressed his belief that "the practice of such rules as the experience of ages has established would make the life of man hold out free from the usual complaints of decrepitude longer than it does at present."

The appropriate composition of the diet has often been perceived as more efficacious than medicine, not only as an aid to long life but also in the treatment of disease. For example, Roger Bacon (1214-1294) and Francis Bacon (1561-1626) wrote similarly on the subject:

> But the use of these things and medicine is of no use, nor anything avails them that neglect the Doctrine of the Regiment of Life. . . Wherefore the physicians and wise men of old time were of opinion, that diet without physick sometimes did good but that physick without due order of diet never made a man one jot the better. --Roger Bacon

> Curing of Disease is affected by Temporary Medicines, but lengthening of life requireth observation of diets.
> --Francis Bacon

Cheyne (1725) emphasised the need to adjust the diet to individual needs depending on "age, sex, nature, strength, country and exercise". Possibly the first research plan for the study of the effects of normal aging on energy and nutrient requirements was drawn up by Francis Bacon who anticipated many of the concerns of current research including the aims of the research reported in this thesis.

> Inquire touching the length and shortness of life in men according to their Fare, Diet, Government of their Life, Exercises and the like. Inquire touching the signs and prognostics of long and short life; not those which betoken death at hand but those which are seen and may be observed even in health. Lastly, because it is behooveful to know the Character and Form of Old Age, which will then best be done if you make a Collection of all the Differences, both in the State and Functions of the Body betwixt Youth and Old Age that by them you may observe that it is that produceth such manifold Effects: let not this inquisition be omitted.

These quotations are taken from an excellent review of early writings on nutrition and longevity by Beeuwkes (1952) in which she noted that Bacon's appeal for a scientific study of aging and the aged was ignored for three centuries.

The scientific study of the relationships between aging, nutrition, health and longevity could not begin until the fundamental and ancient questions of how food is converted to body substance and how energy is released from nutrients and utilized by the body were addressed.

In a masterly and fascinating review of the evolution of concepts of nutrition and nutritional disease Guggenheim (1981) has documented the search for answers to these questions from Greco-Roman Antiquity to the present day. He identified a meeting of Priestly (1733-1804) and Laviosier (1745-1794) in 1774 as one of the most important events in the history of the modern science of nutrition. Priestly told Lavoisier of his preparation of "dephlogisticated air" (oxygen), which he believed was much better than common air for the purposes of respiration and combustion. Lavoisier subsequently turned his attention to the study and quantitative measurement of combustion, respiration and the generation of heat. In 1780 he and Laplace demonstrated for the first time that there was a relationship between the heat produced by an animal and the amount of carbon dioxide given out by it over the same period of time. He also measured the oxygen consumption of men and showed that it increased after food and exercise.

The work of Lavoisier and others was discussed by Webb (1984) in a review of the history of energy metabolism. Areas of perennial interest to scientists were delineated, the development of concepts was reviewed and the machines which have been used to quantify them were described. Webb traced the progress in understanding the release of energy from food for living and working using five categories of investigation. These are investigations which have been made of: the energy in the fuel; the rate of its oxidation; changes in body stores; internal work and rates of heat loss; and external work. He cited the respiration studies initiated by Lavoisier which were continued after his death and the fact that by 1886 Reynault and Reiset in Munich were able to measure with accuracy the respiratory exchanges of man in a large respiration chamber. A chamber devised by Pettenkofer and Voit, also in Munich, was in use at roughly the same time. Investigation of work and heat in addition to respiration was made possible by the construction by Rubner in 1894 of a calorimeter for dogs, and by Atwater and Rosa in the United States of one for men which also incorporated the respiration apparatus used by Pettenkofer and Voit. Approximately 500 experiments were completed with amazing accuracy. One of the most important results was the recognition that the law of conservation of energy held for life processes.

Understanding of protein, fat and carbohydrate in food as fuel sources arose through the work of Leibig (1803-1873), whose findings were refined and corrected by many subsequent investigators including Atwater. Atwater's studies of the heats of combustion of protein, fat and carbohydrate in the bomb calorimeter, together with analysis of the energy in urine and faeces when different types of foods were eaten, led to the derivation of "Atwater factors" for the energy available from these sources. Atwater and Benedict reported in 1903 that the energy of food taken less the energy of waste was matched by the loss of heat and external work, and that even small changes in fat stores were calculable from careful C-N-H balance (Webb, 1984). The importance of the work of Atwater, his colleagues and predecessors was emphasised again by Passmore and Eastwood (1986), who wrote "By 1906 Atwater had completed his work, and a chapter had been written in the textbooks of physiology which has needed no subsequent revision" (Davidson and Passmore, Human Nutrition and Dietetics, 1986).

New methods of studying changes in body stores of energy did not emerge until forty years after Atwater's work, but are now the subject of considerable research. The concept of internal work is at the frontier of investigation at the cellular level today. Over 40 years ago, in a letter to Nutrition Reviews in 1943, DuBois addressed "the neglected field of heat loss", which, at that time, had been crowded out by the growing interest in vitamins and minerals. He noted that the literature in nutrition paid little attention to the question of internal temperature and recommended that the study of nutrition should continue to include not only the study of heat production and elimination but also intermediary metabolism, tissue metabolism and "a great deal of biochemistry".

3.2 Energy expenditure and physical activity; development of methods of measurement for use in the field. 'Indirect calorimetry' has become the conventional term for the measurement of oxygen or of respiratory gas exchange, although some workers would prefer the term "calorimetry" to be reserved for the measurement of heat (Webb, 1984). Its use in measuring energy expenditure is based on the quantitative relationship between oxygen consumption and energy expenditure established by experiments in the Atwater-Rosa calorimeter. The term 'direct calorimetry' has been reserved for the measurement of heat, which remains much more complex technically than the measurement of oxygen consumption.

A good succinct account of the development of experimental methods for determining the energy expenditure of man from the end of the 18th century until the mid-20th century was given by Douglas (1956). Of particular relevance to the method of indirect calorimetry used in our studies was his description of a portable open-circuit apparatus designed by Edward Smith (1819-1874) in the mid 19th century, which he used to measure CO_2 production at rest and when walking. A more sophisticated portable dry gas meter which collected a sample of expired air for analysis and measured the volume of gas expired was developed and used by Zuntz, Loewy, Muller and Caspari (1906) in an extensive series of observations during rest and exercise. Douglas noted that "although this method fell into the background in subsequent years, it was resuscitated with trifling modification by Kofranyi and Michaelis (1940)." It was further improved by Muller and Franz (1952) and became the method of choice in the field for indirect calorimetry. Some reports of the rigorous tests which were made of this method of indirect calorimetry analysed possible sources of error and established methods of calibration of the respirometers and reliable gas analysis were those of Durnin and Brockway (1959), Durnin and Namyslowski (1958), Durnin and Edwards (1955), and Durnin and Mikulicic, (1956). The bag method developed by Douglas (1911), which also measures carbon dioxide, remained the simplest and most accurate for use in the laboratory. In its original form it was too cumbersome to use in the field, but with modifications its use in the field has been revived.

Smith, who designed the forerunner of the Kofranyi-Michaelis respirometer (K-M), planned the first systematic inquiry into metabolic and respiratory response of the human to muscular exercise. He estimated carbon dioxide output, heart rate, and respiratory volume at various levels of physical exercise in prisoners sentenced to hard labour (Guggenheim, 1981).

At the beginning of the 20th century, studies of rates of energy expenditure were made on many subjects during sleep and while performing many different types of activity. Interest in collecting such data appeared to decline from about 1910 until 1940. Renewed interest in energy expenditure measurements was shown during World War II by physiologists in Germany (Lehmann, Muller, and Spitzer, 1950) and facilitated by the introduction of the K-M respirometer. After the war, increasing mechanization of industry and consequent decline in energy expended at work, shorter working hours, and increased leisure time stimulated a reassessment of energy expenditure at work and in non-working time. Non-occupational activities had not been considered to contribute greatly to daily energy needs until these and other significant changes in the lifestyle of many people had occurred. Ownership of a car, higher wages, and the introduction of television altered ways in which energy was spent in leisure time just as mechanisation of heavy tasks and better working conditions changed expenditure at work. The distribution of time and energy in the seven to ten hours spent out of work but not asleep in bed was unknown. Thus, daily activity diaries began to assume importance.

Edholm, Fletcher, Widdowson, and McCance (1955) gave credit to Bedale (1922-23) for the first detailed study of energy expenditure made in addition to dietary intake. She measured the oxygen consumption of 100 school children during 25 different activities and the time they spent on the activities. This was, perhaps, the first recognition of the importance of patterns of activity. Orr and Leitch (1938) in their paper on the determination of calorie requirements laid down the form which much subsequent work on energy expenditure and estimated energy requirements of individuals would take:

> It does not seem unreasonable to suppose that, given estimates of energy expenditure by efficient performers doing different types of work on a time basis, with a time schedule of a day's activities, it will be possible to assess the total energy

expenditure for a day with such accuracy to be of some practical value.

They also stated that "the main parts of an energy balance sheet may be approximately assessed as 8 hours sleep, 8 hours work and 8 hours of the ordinary 'comings and goings' of life." On this basis, they drew up daily energy budgets for different hypothetical persons performing different tasks. These were shown to be in agreement with many previously done food intake studies on men and with the results from two studies of individual women in the United Kingdom and in the United States between 1933 and 1936.

This method of calculating total energy expenditure was further developed in an appendix to the 1957 FAO Report on calorie requirements (FAO: Committee on Calorie Requirements, 1957), and energy allowances were calculated for a reference man and woman.

Following the 1939-45 war, the type of studies previously suggested by Orr and Leitch were done in Britain. The results of four surveys in which the K-M respirometer was used were published between 1952 and 1955 (Passmore, Thomson, and Warnock, 1952; Garry, Passmore, Warnock, and Durnin, 1955; Widdowson, Edholm, and McCance, 1954; Edholm, Fletcher, Widdowson, and McCance, 1955). These measured the total daily energy expenditure and food intake for a week of students, coal face miners and colliery clerks, and military cadets.

A combination of indirect calorimetry and a complete record of daily activities, which became known as the factorial method, was used to estimate 24-hour energy expenditure. This method eliminated the practice of deducting estimated basal metabolic rate (BMR) and specific dynamic activity from all estimates of energy cost. The BMR was used as an estimate of energy expended at rest and asleep only. Records of time spent on activities were obtained under the categories of occupational, non-occupational and recreational time, and bed.

Bransby (1954) made a study of the food intake and energy expenditure of 152 male industrial workers (52 of whom were over 40 years of age). No measurements of individual energy expenditure were made in this study, but a full record was kept of work and leisure activities. Energy expended was estimated by using these records in conjunction with published measurements of the energy cost of activities made by indirect calorimetry using the K-M respirometer by Passmore, et al., (1952); and Garry, et al., (1955).

Studies using these methods were also made of the energy intake and expenditure of soldiers, especially of the U.S., British, Canadian, and Australian armies (Durnin, et al., 1957).

Passmore and Durnin in 1955 responded to the renewed interest in measuring energy expenditure by assembling many earlier measurements and publishing them in tables of estimated energy expenditure for a wide variety of activities for men and women. This was a major methodological advance comparable to the introduction of tables of food composition and a stimulus to research on energy expenditure. The authors gave precise instructions on the use of their tables and estimated the theoretical error involved as less than or equal to 10 percent. They hoped that the techniques of indirect calorimetry, which they described "together with a knowledgeable use of the tables in this review should make it practicable to carry out field surveys of energy expenditure on a much more extensive scale than has been possible up to the present". In their review they endorsed a definition of work divided into five levels of intensity which had been suggested for men by Christensen (1953), (Table 5.2). They published for the first time a similar definition for women (Table 5.3), and recommended that the BMR could be taken as a measure of metabolic rate when in bed asleep or awake. Durnin and Passmore (1967) expanded their original publication and included findings from the thesis study groups.

3.3 <u>Energy expenditure, energy requirements, and aging</u>. Much of the early work reported on energy expenditure after 50 years of age had been done on Basal Metabolic Rate and the factors affecting it. In 1899 Magnus-Levy and Falk cited by Matson and Hitchcock (1934), clearly indicated that advancing age was accompanied by a decrease in basal metabolism. By 1917 Aub and Dubois were able to publish a table for predicting the basal metabolism of normal men and women up to age 80. A decline of 2.5 percent was predicted for each decade from 30 years to

80 years. However, few studies had been made of men in the older groups and none of women. This was rectified in part by Benedict (1934), Benedict and Meyer (1932), and Matson and Hitchcock (1934). Although most of their subjects were over 75 years of age the studies confirmed that metabolic rate decreases slightly throughout adult life. The rate of decrease and the individual variation was and is uncertain. In 1952 Sherman estimated that studies had been made of the BMR of about 100 men and 75 women aged 60 years and over, but advised that more studies were needed at all ages between 60 and 100 years before satisfactory standards could be set up for this age range.

The lack of factual information on the effect of aging on total energy requirements was noted by Durnin in 1956. At that time, the Food and Agriculture Organization of the United Nations (FAO: Committee on Calorie Requirements, 1950) recommended a decrement of 7.5 percent of the requirement at age 25 for each 10 years beyond this age, while the figures suggested in the United States and in Britain were 5 percent and 3 percent respectively (Durnin, 1956). In this paper, Durnin anticipated much future research when he speculated that if the energy expended in a specific exercise were related simply to the weight of active tissue and expressed as "Cal/kg" of active tissue, the effect of age might be minimal. He also speculated that the increasing mechanisation of many occupations would lead eventually to reduced and more uniform energy expenditure during working time. Thus, if older workers had in the past moved from "heavy" occupations to lighter ones as they grew older, this would no longer be necessary and there would be little, if any, decrease in occupational energy expenditure.

The energy required for activities during non-occupational time was also unknown, but in the same paper Durnin proposed that differences in energy expenditure in leisure activities might be the greatest source of difference in total energy expenditure between groups of younger and older adults. He concluded that because the great majority of people lead very sedentary lives, the differences in energy expenditure even during non-occupational time from age 30 up to 50 or 60 might be very little, but that much more information was required on "how elderly people spend their daily lives and how energetic a life they may be capable of leading".

These questions and associated questions relating to possible changes in the food intake of older people prompted Durnin and his colleagues to begin the series of investigations reported in this thesis. The results of their first study of the energy expenditure and food intake of a group of older women was published in 1957. This study of twelve middle-aged housewives (aged 45-61) and their daughters (aged 16-27) who were shop assistants was designed to provide much needed data on the energy requirements of a younger and older group of women with similar occupations (Durnin, Blake and Brockway, 1957).

3.4 Studies of energy intake: dietary surveys. Dietary studies by Smith in 1862 of the effect of the cotton famine on levels of food intake in England were said by Guggenheim (1981) to be the first dietary surveys in public health nutrition. At about the same time, in 1881, a dietary survey was carried out by Voit and his colleagues in Munich when they recorded the food consumed by labourers and artisans in Germany. Atwater, who had been a pupil of Voit, began his measurements of the dietary intake of various groups of people in the Eastern United States about 1902. He devised one of the first "man value" scales for quantifying the energy intake of families. This was calculated by using a co-efficient of one (1.0) for a man. The energy intakes of other members of the family were calculated as a proportion of that of a man--for example, 0.83 for a woman and 0.20 for a child under one year. The many versions of these scales which were developed caused increasing confusion about the actual energy intake of individual men, women and children for almost thirty years (Cathcart and Murray, 1931).

In spite of a shift in interest from the quantity to the quality of the diet, which took place about 1906 with the discovery of "accessory food factors", later known as vitamins, there was a slow but steady growth in knowledge of total food intake through family studies. Widdowson (1936) listed nineteen studies from that of Paton, Dunlop and Inglis (1900), who estimated the dietary intake of the labouring classes in Edinburgh, to that of Boyd Orr (1936), who made a national study of food, health and income.

Continuing interest in the quantitative aspect of nutrition in this period was demonstrated by Cathcart (1931):

> It is the quantitative aspect which is of fundamental importance. Under the ordinary conditions of living for the majority of mankind in a country such as ours, it is highly improbable that taking the food as whole, it is so deficient qualitatively as to be hopelessly inadequate.

He was not convinced then that the question "How much should be eaten?" had been adequately answered. His concern with methods and the application of the findings of dietary surveys have not been discredited with time. He advised caution in the use of food intake data alone to judge degree of undernutrition and in the application of data from one country to another and he constantly emphasised the degree of accuracy which could be expected from his methods. In his opinion, the only reliable method of obtaining accurate dietary data was on small numbers of households and by "controlled visitations by a skilled investigator", a point of view which is held by responsible nutritionists today, but is often disregarded.

Orr and Leitch (1938) also emphasised the fundamental fact that "however important the requirements for specific nutrients may be, the energy requirement is primary and under ordinary conditions will be satisfied before and even at the expense of the other."

In a survey which Acheson (1986) characterised as one of the first applications of epidemiological methods to the study of nutrition in human populations Boyd Orr (1936) found that due to poverty, 50 percent of the population of the United Kingdom had food intakes which supplied less than the required standard of one or more nutrients. He concluded that the average diet of 10 percent of the population of the United Kingdom was inadequate, in all constituents, to maintain health . Social Security measures were designed to ensure that such a situation would not arise again.

One of the major methodological obstacles to dietary survey work was the lack of adequate and accurate tables of food composition. In Britain a first step in their compilation was taken in 1925 when Dr. R. A. McCance began to study the carbohydrate content of food used in the treatment of diabetes. Between 1925 and 1939, the results of analytical work on many foods were published and in 1939 the first edition of "The Composition of Foods" by McCance and Widdowson appeared (Medical Research Council Special Report Series, No. 297, HMSO, London). Subsequent expanded editions have been published in 1946, 1960 and 1974.

A standard method of recording the food intake of individuals was introduced by Widdowson (1936) and McCance and Widdowson (1936). In their "individual" method all items of food and drink were weighed, measured and recorded over a period of seven days. This became known as the weighed dietary inventory method. In 1939 Bigwood noted that it had come to be known as a kind of "gold standard" against which other methods should be compared. This view of the method is quoted today and should not be accepted uncritically. A variety of other methods of collecting dietary data were developed and tested during the 1940's and 1950's. All components of the "individual" method were varied: the number of days of study were reduced; household measures were used in place of weighing; retrospective records of food intake were made during periods of 24 hours to 7 days; self-administered records or questionnaires were substituted for regular contacts with a dietitian or other trained interviewer. The search for a faster, easier, less expensive yet accurate way of collecting dietary data is still in progress. In the United States the research dietary history (Burke, 1947) using household measures took firm root and the 24-hour recall method was widely used when information on groups was required (Young, Hagan, Tucker and Foster, 1952). Many workers have investigated the reliability and validity of each method. Becker, Indik and Beeuwkes published a comprehensive review of methodology in 1960.

3.4.1 Studies of individual energy and nutrient intake of older men and women up to 1957. The small group of selected studies which are briefly described in this and the next sub-section are compared to the thesis studies in the Discussion Section, Chapter 7. The findings for groups of women are listed in Tables 7.24 and 7.30 and for groups of men in Tables 7.19 and 7.28. The studies were selected because the methods of data collection were comparable to those of the thesis studies.

The lack of information on the food consumption of individuals of specific age, sex and occupational groups was recognised by Widdowson (1936) and Widdowson and McCance (1936), who published results of their studies of the food intake of 63 men and 63 women living in their own homes. Eleven of the women were aged between 50 and 62 years and ten of the men were aged between 51 and 89 years. The food of each individual was weighed and recorded for seven days. These authors were concerned by the lack of information on "what departures from the mean are compatible with average normal health". The principal findings of their studies are familiar to all who have since made similar investigations. A very wide variation in individual energy intake at all ages was found. Although there was a "definite but mathematically insignificant" decrease in energy intake with increasing age, the authors concluded that "the individual variation at each age was so great that no rules for the guidance of individuals as to their dietary requirements at different ages could possibly be formulated".

They found no significant correlation between energy intake and body weight. Their subjects derived a greater proportion of energy from fat (39 percent for men and 43 percent for women) than any previous study in Britain had shown. Also, a few subjects had very low energy intakes although they appeared to lead normally active lives, a finding which is of perennial interest. These studies were also noteworthy because little previous work had been done on the food intake of individual women (i.e., women who were not simultaneously taking part in a family record).

During the Second World War (1939-1945), studies of individual food intake in Britain temporarily ceased but information on the food intake at the family level continued to be regarded as of great importance. Its collection was recognized as a responsibility of government when the National Food Survey of Great Britain (NFS) was established in 1940, at the beginning of World War II, as a guide to wartime food policy.

Between 1942 and 1948 some very significant work on the food intake of older women was done in the United States. Very detailed weighed studies on small groups of women aged 48 to 77 were carried out in Iowa, Michigan and Missouri as part of a large-scale nutritional study (Ohlson, Roberts, Joseph and Nelson, 1948; Ohlson, Jackson, Boek, Cederquist, Brewer and Brown, 1950).

These studies reflected an interest in the study of the effects of aging, including the nutritional aspects, which had been growing during the decades of the 1920's and 1930's. During these years, there had been a noticeable increase in the proportion of the population aged 50 years and over in Europe and the United States. The age distribution of the population of Great Britain and Northern Ireland from 1871 to 1961 is given in Table 3.1.

Immediately after the war the committees on calorie requirements of the newly formed Food and Agricultural Organization of the United Nations and the World Health Organization (1950, 1957) found that there was too little information on the energy requirements of older people upon which to base dietary recommendations for the age group. This gave further impetus to the study of the nutrition requirements of middle aged, elderly and old men and women.

In one of the first nutrition studies of elderly people after the war, Pyke, Harrison, Holmes and Chamberlain (1947), studied 40 women and 24 men in London. Bransby and Osborne (1953) investigated 303 single and married men and women living at home in Sheffield. These were seven-day weighed studies of food intake and the subjects were all sixty years or over.

In 1948-49, San Mateo County, California was the site of "probably the largest cross-section study of the nutritional status of aging people made to that date" (Chope and Dray, 1951). A total of 577 men and women were studied and seven-day food records in household measures were obtained from them (Gillum and Morgan, 1955). It was shown that although the intake of energy and nutrients fell with increasing age, the decrease was insignificant when the results were expressed per kilogram of body weight. The least change in the energy intake of the survivors after a 14-year follow-up was that of the group who were between 75-79 years in 1955 (2160 kcal/d) and 89-93 in 1965 (1990 kcal/d) (Steincamp, Cohen and Walsh, 1965).

Jordan (1954) reported on the dietary habits of 76 women and 24 men aged 65 or older and living alone in New York. Lyons and Trulson (1955) reported the results of dietary histories taken from 69 women and 31 men over 65 years of age in Boston, but not necessarily living alone. Baines and Hollingsworth (1955) examined the National Food Survey records for elderly women living alone. They obtained data for 722 women aged 55 to over 80 and found much greater energy intakes than those reported by any other study. Their results prompted further investigation of that population group by Durnin, Blake, Brockway and Drury (1961), some findings from which are incorporated in this thesis.

The findings of Widdowson and McCance (1936) that there was great individual variation in intake of energy and that some subjects had an unexpectedly low energy intake were repeated in each study which has been reviewed. In addition there was evidence that in healthy, active elderly people, there was very little decrease in food intake until they were at least 70 (Bransby and Osborne, 1953; Gillum and Morgan, 1955). Cross-sectional studies which included the sick and the poor showed a much more pronounced decrease in energy intake beginning at an earlier age than those in which the subjects were healthy and affluent (Batchelder, 1957).

Ohlson, Roberts, Joseph and Nelson (1948) and Ohlson, et al., (1950) speculated that the role of nutrition in the health of the adult "may be in the delay of those cellular changes which are found in old age". They also noted that there was evidence that elderly people who had few complaints of ill-health and were within 10 percent of their ideal weight had a higher food intake than those who were overweight and suffered from vague ill health. These workers credited "purposeful activity" with stimulating energy intakes to a level above 1600 kcal/day, which they designated as the minimum energy intake at which there was a satisfactory amount and distribution of specific vitamins. This intake is still used as a useful guideline today. They re-emphasised the primacy of total energy intake as the determining factor in the ingestion of other nutrients.

In the United States increasing mention was made of overweight in the elderly. Lyons and Trulson (1955) found 48 percent of men and 56 percent of women aged 65 or over were 10 percent or more above their desirable weight.

3.4.2 Studies of individual energy and nutrient intake of older men and women concurrent with thesis studies. Three studies of the food intake of middle-aged and older men and women which were conducted at about the same time as the thesis studies were those of Exton-Smith Stanton, Newman and Ramsey (1965), of Morris, Marr, Heady, Mills and Pilkington (1963) in England, and of Fry, Fox and Linkwiler (1963) in the United States.

Ninety-nine male bank clerks aged 40-55 years were studied by Morris and his colleagues as part of an investigation of the aetiology of ischaemic heart disease. The group of 60 women which was studied by Exton-Smith and Stanton to determine whether there was a relationship between their energy and nutrient intake and their health was very much older. All but three were aged between 70 and 80 years and lived alone.

Active healthy women of 65 years of age and over were selected for study by Fry, Fox, Linkswiler (1963). Of the group of 32, 14 were aged between 64 and 74 years and the findings were compared to Recommended Dietary Allowances for the population of the United States.

3.5 Low intakes of energy and metabolic adaptation. This topic has been of continuing interest throughout the history of energy expenditure and energy intake measurements. It was noted in section 3.4.1 that there is evidence from a number of studies that some people are able to remain healthy and active on what appears to be an inadequate intake of energy.

During World War I, Benedict, Miles, Roth and Smith (1919) found that restriction of the energy intake of a group of young men to about two-thirds of their normal intake and maintenance of this diet for a prolonged period had few adverse effects on their health and work performance. After a weight loss of one-eighth of pre-experimental weight, the subjects required about two-thirds of pre-experimental intake to maintain the new weight. This was accounted for by a lowering of the basal metabolic rate during fairly long periods of food restriction. Sherman (1952), who described this study, noted that ample time for adjustment to the lower intake (3-10 weeks) had been given. Taylor and Keys (1950) described the degree of restriction of energy by Benedict's subjects as "mild". In their own study, the Minnesota Experiment on Semistarvation, the 32 male subjects, whose initial weight maintenance diet was 3,492 kcal/day, were provided with a diet of an average energy value of about 1,570 kcal/day for six months. The proportions of protein and fat were 14 percent and 15 percent respectively. The observed reduction in basal metabolism was attributed in part (65 percent) to shrinkage of the metabolising mass of tissue and in part (35 percent) to decrease in the intensity of metabolism. This adaptation and the finding that the heart also lost muscle mass are still of considerable interest today. The men in this experiment lost 24 percent of their body weight before weight maintenance was achieved, but unlike the young men in the 1919 experiment whose energy intake was approximately 2000 kcal/day, they did not remain in good health, and although they continued with an activity regime which had previously cost them about 3,500 kcal/day, their voluntary physical activity was reduced.

Hegsted (1952) described the changes which occur when intake of nutrients is decreased thus:

> Under the stimulus of loss, the efficiency of the body increases and eventually, balance is restored at the lower level

of intake. Conversely, when intake is increased the body utilises nutrients less efficiently.

3.6 Standards and recommendations for dietary requirements. Innumerable recommendations have been made concerning man's needs for energy and nutrients. Some have been based on observation of the amount of food consumed, some on measurements of energy expenditure by direct and indirect calorimetry and some on energy and nutrient balance studies. The standards reviewed in this section are limited as far as possible to those which were in use before and during the 1960's.

3.6.1 Energy requirements. The differences in energy requirements among occupations have been of great interest to physiologists. Voit Atwater, and Rubner assessed the daily energy requirements of a man doing moderate work at 3055, 3400 and 3093 kilocalories respectively (Sherman, 1952) and a figure of about 3000 kilocalories per day had become the standard recommendation for this level of work by 1950 (British Medical Association, 1950; National Research Council, 1953).

The requirements of women doing moderate work, as housework was classified, were, in the absence of individual studies, estimated as 80-90 percent of those of men, namely approximately 2500 kilocalories. Widdowson and McCance (1936) noted that, on the basis of kilocalories per kilogram of body weight, the requirements of women would then be almost exactly the same as those of men (43 kcal/kg). When they studied individual women, they found that even with few household aids, their mean intake was nearer to 2100 kilocalories per day.

Orr and Leitch (1938) recommended 2100 kcal/day for a housewife, 2000 kcal/day for a typist, and 2700 and 3200 kcal/day for a male clerk and a painter respectively. They considered these to be reasonable estimates and remarked that although it would be possible to live and work at much lower intakes, it might be at the expense of health and efficiency.

The Committee on Calorie Requirements of the Food and Agriculture Organization (FAO) 1957, recommendation for a reference woman aged 25 weighing 55 kg and engaged in ordinary housework was 2300 kcal/day and for a reference man aged 25 years weighing 65 kg, 3000 kcal/day.

An allowance for decrement in energy requirement with age was made in two reports of the Committee on Calorie Requirements of the Food and Agriculture Organization of the United Nations (1950 and 1957), but the committees had great difficulty in formulating their recommendations especially for women. There had been few good studies of the dietary intake of older individuals and practically none of 24-hour energy expenditure.

A review of the history of different standards of dietary requirements was made in a report of Joint Expert Committee on Energy and Protein Requirements (FAO/WHO 1973). It was pointed out that scales based solely on observations of actual food consumption may be in error because "what is" will not be "what should be". In spite of this, these observations have, in general, formed the main basis of energy scales because it has been assumed that the quantity of food eaten by healthy people living a normal life represents their requirements. This was the position taken when the thesis studies were undertaken to determine the energy requirements of some groups of elderly people in Scotland.

3.6.2 Protein requirements have been assessed at such diverse levels as 145 g/day by Voit in 1881, and 40 g/day by Chittenden in 1905. (Davidson and Passmore, 1986). Sherman (1933), The League of Nations Committee (1935), and the Food and Nutrition Board, NRC (1953) proposed 1 gram of protein per kilogram of body weight and this is still a useful and well-known standard. The Report of the FAO/WHO Committee on Energy and Protein Requirements (1973) traced the progress of estimates of protein needs, citing the extreme differences, such as those between Chittenden and Voit and the enormous amount of research on differences in protein quality for nutritional purposes beginning with the work of Thomas in 1909 to that of Rose on essential amino acids in the 1930's. In 1957 the concept of a reference protein of high nutritive value was arrived at by the FAO Committee on Protein

Requirements. In 1965 an estimate was made of the protein requirements of adults at 1.01 g/kg body weight. This was derived from complex calculations based on the three factors of obligatory N losses or N balances, protein quality based on biological values or chemical scores and a safety factor to allow for individual variations. This estimate differed little from that recommended by the League of Nations in 1935 which was 1g/kg body weight.

A relationship between the adequacy of energy intake and protein intake was noted by Cathcart in 1931 and by Munro in 1951. Cathcart acknowledged that in the earlier part of the century all the stress had been laid on the "calorie sufficiency of the diet". He endorsed the concept "Take care of the calories and the protein will take care of itself." Munro found that energy intake affects protein utilization and metabolism with the result that reduction in energy intake in adults results in a loss of body protein and in impaired utilization of proteins added to the diet. He advised that since part of the dietary protein is used to provide energy, the adequacy of energy intakes must be taken into account in determining protein requirements.

3.6.3 Composition of the diet. The contribution of protein, fat, and carbohydrate to the energy value of diets has fluctuated in the past as recommendations for protein intake increased or decreased. Today the recommended composition of the diet tends to vary with recommendations for fat intake. Voit in 1881 recommended a diet consisting of 15% protein, 65% carbohydrate and 20% fat as the correct proportions in a diet supplying 3055 kilocalories to a man working at manual labour for 8-10 hours a day. Playfair in Edinburgh proposed in 1865 that protein should contribute 15-20 percent and fat 13-18 percent to the energy value of the diet. These values were based on consumption data of different groups of workers (Guggenheim, 1981). The diets commonly consumed in Europe and the United States in more recent years and up to about 1970 have conformed to a pattern of approximately 12-15 percent protein, 40-45 percent fat, and 45-48 percent carbohydrate.
The 1950 report of the Committee on Nutrition of the British Medical Association (BMA) recommended that over 11 percent of total energy

value should be from protein and not less than 25 percent from fat rising to 35 percent with increasing energy expenditure. The importance of dietary fibre was underestimated until approximately 1969 (Eastwood and Passmore, 1983). There were no quantified recommendations on intake.

3.6.4 Calcium requirements. Reports of dietary studies in the U.K. and the U.S. throughout the 1940's and 1950's usually reported calcium intakes as being satisfactory in men and unsatisfactory in women. These conclusions were based firstly on comparisons with the level of intake recommended by Sherman in his textbook, Chemistry of Food and Nutrition (8th edition, 1952) and then on recommended allowances proposed by the British Medical Association (1950) and the National Research Council (1948) of 800 mg/day and 1000 mg/day respectively. A revision of the U.S. standards was made in 1953 to 700 mg/day. The requirement for calcium is open to debate. There is evidence that in many countries the intake is extremely low and yet no evidence of clinical deficiency exists. The presence in the gut of compounds which have been shown to impair calcium absorption, including phytate, fibre, cellulose and oxalate make the estimate of requirements uncertain. At the time of the thesis studies, these factors were the subject of controversy as they are today (McCance and Widdowson, 1942, Allen, 1982). The suggestion that calcium intake might be related to the development of osteoporosis was made by Nordin in 1960 and is still being debated (Nordin, 1985).

3.6.5 Iron requirements. The intake of iron reported in the early individual dietary studies has usually been said to be inadequate for women. Widdowson and McCance (1936) reported that the amount of iron in the food of their female subjects was probably inadequate for their physiological requirements. In 1950 the British and the American recommended allowance for non-pregnant, non- lactating adult women was 12 mg/day, the same as for adult men. Much of the work on iron absorption was yet to be done, but the British allowances remain the same to this day, even for post-menopausal women. They are based on the needs for replacement of tissue loss and an estimate of absorption as 10 percent of intake.

3.6.6 The use of dietary standards. Pett, in 1951, reviewed the evolution of dietary standards and concluded that the use intended for the standard had always influenced the choice of figures. He cited Smith in 1862 as the first scientist to advise certain levels of intake of carbon and nitrogen (equivalent to about 2800 kcal/day and 81 g/day of protein for men and about 2650 kcal/day and 77 g/day of protein for women) "to avert starvation diseases" among unemployed cotton workers. Four major purposes for dietary standards were defined by Pett: for use in calculating the nutrient requirements of a population; for use in establishing regulations under the food and drug act governing the contents of foods, dietary supplements or drugs and of allowable claims for them; for use in evaluating the dietary status of a group of people from the total and average quantities of foods eaten, or in providing foods for such a group; and for use in evaluating the dietary status of an individual from the foods eaten or from the foods purchased. He concluded that no one set of figures could be used properly for all these purposes. Recent work aimed at devising at least two levels of dietary standards is discussed by Passmore and Eastwood in Human Nutrition and Dietetics, 8th Edition, 1986.

3.7 Summary of the historical context of the studies reported in this thesis. In the late 1950's it was becoming increasingly clear that the number of people surviving into and beyond the 6th, 7th, and 8th decades of life had increased substantially since the beginning of the century, but very little was known of the processes and consequences of aging, particularly beyond the middle years.

One area of concern, nationally and internationally, was the lack of good information on the energy requirements of this growing segment of the population and of the possible differences in the patterns of activity of older compared to younger people, which might result in differences in their energy expenditure and energy intake.

A small amount of information was available on the food intake of older men and women, but there was none on the 24-hour energy expenditure and the daily patterns of activity of groups of men or women aged 50 and over in different occupations.

This information had been obtained in a study by Garry, et al., (1955) of miners and clerks aged between 20-46 years in Fife, Scotland. A number of questions were addressed about the relationships between energy expenditure in occupational and non-occupational time and between energy intake and expenditure. It was shown that there was a difference between the total daily energy expenditure of men who performed hard physical labour during their working hours and those whose work was mainly sedentary, that this difference was almost wholly due to the energy demands of occupational activities and that there was no difference between the expenditure of energy of the groups during non-occupational time. Also, the difference between energy intake from food of the two groups reflected the difference in their energy expenditure, the energy intake of each group reflected the energy expenditure of the group and the proportions of protein, fat and carbohydrate in the diet of each occupational group were very similar.

It was not known whether there would be similar findings if men and women in the age group 50 to 65 years were studied. Nor whether the speculation made by Durnin in 1956 that there might be very little change in total energy expenditure during adult life up to about 65 years would be substantiated.

Although there existed more information on the food intake than on the energy expenditure of older men and women, the nutrition of those individuals aged 60 and over who lived alone was of some concern. They were considered to be at higher risk of suffering from energy and nutrient deficiencies because of their socio-economic circumstances than people of the same age who lived with other family members.

Finally, methods were available for measuring food intake and energy expenditure which had been tested and refined in the laboratory and in the field and had been employed immediately prior to the thesis studies by Durnin, et al., (1957) in a survey of a group of middle-aged housewives and their adult daughters.

The studies which are reported in this thesis were undertaken from 1959 to 1965. They were among the first to investigate the total energy requirements of older men and women and they remain among the very few in which measurements have been made of the energy expenditure of healthy older people engaged in their usual occupations and living in their own homes.

PART 2. Review of Literature from 1966 to 1988.

3.8 Development and present status of concepts and methods

3.8.1 Introduction. The period since 1966 has been marked by many developments in the concepts and methods associated with the study of energy requirements and how they are affected by the aging process. Increased cooperation between epidemiologists and nutritionists to evaluate the contribution of diet to degenerative disease has necessitated critical examination of methods to assess their validity, accuracy and reliability as instruments for epidemiological research.

Two cooperative efforts relevant to the material of the thesis were the reports from the European Community on "The diet factor in epidemiological research" (1982) and "Surveillance of the dietary habits of the population with regard to cardiovascular disease" (1983). A third important report addressed "Human energy metabolism: physical activity and energy expenditure measurements in epidemiological research based upon direct and indirect calorimetry" (1984).

These three reports are authoritative reviews of methods used to obtain the type of data reported here. In addition to standardization of measurements of dietary intake, energy expenditure and indices of body size and composition, they emphasized that agreement is also necessary on study design, on definition of terms and on units used to express measurements and calculations. The recommendations of these reports are important because comparison and aggregation of the results of many studies are often hindered by the variety in purpose, study population and methods used. Durnin and Ferro-Luzzi (1982) suggested some basic standards for conducting and reporting studies on human energy intake and output.

3.8.2 Energy expenditure and physical activity; concepts and methods of measurement.

3.8.2.1 Energy expenditure. Durnin in 1978 made a critique of the practical problems involved in measuring energy expenditure by indirect calorimetry. He reviewed the variety of techniques which had been developed since the mid-1960's when the K-M respirometer had been the only portable device available. He did not consider that two techniques which appeared to be promising, the Integrated Motor Pneumotograph (IMP) or the assessment of energy expenditure from heart rate were sufficiently reliable. He assessed the instrumental error at anywhere from 2 percent to 20 percent depending on the circumstances of use. Although he concluded that, in the right hands, acceptable accuracy could be achieved by activity records and indirect calorimetry, he cited some of his own studies, which cast some doubt on the method. His studies of the energy cost of pregnancy in which careful energy expenditure measurements were carried out led him to conclude that such measurements "can be of little assistance in assessing energy balance under free living conditions" (Durnin, 1984a) and "cannot discriminate to levels of 420-630 kJ/day" (Durnin, 1987). He suggested that total energy intake coupled with data on changes in weight and body composition would provide satisfactory data on energy expenditure and energy balance if the energy intake studies were repeated at intervals and a regular record of weight made.

Acheson, Campbell, Edholm, Miller and Stock (1980 a,b,c,) published the results of a longitudinal survey of the energy intake, expenditure and balance of 12 men at an Antarctic base in which they compared methods of obtaining data. Their techniques included those used in the thesis studies. They used the factorial method to measure energy expenditure and weighed the food intake. They concluded that these methods, although not accurate enough to predict fat gain or loss, gave a reasonable estimate of food intake and energy expenditure. They discussed the possibility of combining long-term measurements of body fat and energy intake to provide an estimate of energy expenditure.

In a further paper on the subject from the report of a European Community Workshop on Human Energy Metabolism (1984b), Durnin analysed the sources of error in the method and outlined the type of information which use of the activity diary-respirometer combination could supply. If these suggestions on the use of long-term measurements of body weight and composition in combination with measurements of energy intake at specified intervals are acted upon, there may be a more rapid accumulation of data on energy expenditure. In the past twenty years little such data has been collected because of the difficulty and expense of field studies.

Brun, Webb, Rack and Blackwell (1984) attempted to validate the activity diary-respirometer method, by the use of direct calorimetry in a metabolic room over 24 hours as a reference technique. The diary-respirometer method underestimated the daily energy expenditure by an average of more than 300 kcal. Large intra and inter-variability was observed which limited the possibility of demonstrating a significant difference that could be attributed to technique alone. On the other hand, Prentice, Davies, Black et al., (1985) reported that when simultaneous studies of energy expenditure by this method and energy intake are made, energy expenditure estimates usually exceed energy intake estimates by a substantial margin.

The area of energy expenditure measurement in which enormous progress has been made is in the construction of human calorimeters. Webb (1984) reported that 25 machines had been built since World War II including the suit calorimeter, which he developed. A list of 10 direct calorimeters and 14 indirect-whole-body calorimeters was given by Van Es (1984). The use of the first of these post-Atwater machines was not reported until 1971. Some of the uses to which these new calorimeters are being put are in measurements of the energy cost of sleep, the energy cost of lifestyles which include various levels of physical activity and studies of dietary induced thermogenesis.

Perhaps most hopeful for field studies is the emergence of the doubly labelled water ($^{2}H_2{}^{18}O$) method of measuring CO_2 production over periods of a week or more (Lifson and McClintock, 1966). It has been criticised by Durnin (1984) as perhaps an expensive way of validating energy intake measurements. In this method, the subject receives an oral dose of stable isotopically labelled water ($^{2}H_2{}^{18}O$), CO_2 production is calculated and corrected for known isotopic fractionation effects and energy expenditure is calculated from the CO_2 production rate with standard indirect calorimetric calculations. The energy expenditure of 12 healthy free-living women aged 23 - 40 was studied by Prentice, Davies, Black, Ashford, Coward, Murgatroyd, Goldberg and Sawyer (1985). It was also measured by continuous whole-body calorimetry over a 36-hour period. This study was the first field measurement of total energy expenditure (TEE) with the doubly labelled water method and one of the first to present such data as absolute values and also as multiples of BMR.

Methods of conducting an energy expenditure study in which measurements of energy cost and an activity record are appropriate for the purpose of the study have altered little since the study of miners by Garry, et al., (1955). The K-M respirometer has been updated as the MISER and the Douglas bag has re-emerged for use in field studies. The importance of care and calibration of the instruments, sensitivity to the subjects who have to wear the apparatus and appreciation of sources of error and bias remains unchanged.

The division of energy expenditure into several compartments has become a useful convention. These compartments, namely resting metabolic rate (RMR), thermic effect of food (TEF) or dietary induced thermogenesis (DIT), thermic effect of exercise (TEE), and adaptive thermogenesis (AT) have been described by Horton (1983) in an overview of the assessment and regulation of energy balance in humans.

3.8.2.2 Physical activity, fitness, exercise and health. Interest in the relationship between physical activity, fitness, exercise and health has escalated rapidly during the last 20 years and has resulted in some confusion in terminology in reports of these relationships in the scientific literature and by the media. Caspersen, Powell and Christenson (1985) attempted to clarify some of the concepts involved by proposing definitions of the terms "physical fitness", "exercise" and "physical activity", which are often confused with one another and sometimes used interchangeably, as a basis for comparing studies of these concepts to health. Physical activity was defined by them as any bodily movement produced by skeletal muscles which results in energy expenditure; physical fitness was defined as a set of attributes that people have or achieve that relates to the ability to perform physical activity; exercise was defined as planned, structured and repetitive bodily movement done to improve or maintain one or more components of physical fitness. Exercise was further subdivided into skill-related fitness and health-related fitness and the latter into five fitness components including cardiorespiratory fitness and body composition. Each fitness component can then be measured with decreasing cost, precision and accuracy from measurements in the laboratory through epidemiological procedures to self-assessment. Each of these definitions as proposed does not imply achievement of a pre-determined level and allows for variation at least by age and sex.

The measurement of physical activity can be sub-divided in different ways. The divisions used in this thesis are the historical divisions into physical activity during sleep and during occupational and leisure time and into that which is of light, moderate or heavy intensity. Also used are new categories of physical activity which have gradually evolved and were specified in the FAO/WHO/UNU (1985) report as discretionary activities, optional household tasks, socially desirable activities and activities for physical fitness and the promotion of health.

Durnin (1985) also drew attention to the confusion which exists about "exercise" and its differing effects on the body in relation to muscular development, on efficiency of the cardiovascular system and on total levels of energy expenditure. He stressed that "exercise" or "physical activity" cannot be regarded physiologically or nutritionally in "some vague uniform fashion"; the effects produced by "exercise" on the body vary widely and will depend on the particular form of exercise, on its intensity and its duration.

Many methods of obtaining the physical activity pattern of individuals have been developed including questionnaires which are the method of choice of the epidemiologists.

One of the first questionnaires to incorporate the definition of physical activity and exercise in terms of type, duration, intensity and frequency was described by Montoye (1971). He used it to assess habitual physical activity in the Tecumseh Health Study. Morris, Chave and Adam (1973) used a detailed activity diary (often called the British Civil Servant questionnaire) to record leisure time activities on a weekday and a weekend day. Taylor, Jacobs, Schucker, Knudsen, Leon and DeBacker, (1978) developed the Minnesota Leisure Time Physical Activity Questionnaire. Sallis, Haskell, Wood, Fortmann, Rogers, Blair and Paffenbarger, (1985) described the questionnaire developed by them as one which is capable of characterizing the pattern of activity in a population, can provide an estimate of total calorie expenditure and specify the types of activity in different people, can be administered in a reasonable time period, has adequate reliabilities and is appropriate for evaluating changes in physical activity habits in a population. If it can be shown to fulfill these claims, it will indeed be an instrument with potential to increase knowledge of physical activity which may then be related to the incidence of chronic disease.

Washburn and Montoye (1986) reviewed nine of the most commonly used physical activity questionnaires using the criteria of validity, reliability, practicality and relationship to disease. None of the questionnaires satisfactorily met all the criteria, but some were better than others. The most satisfactory were: for information on the overall level of activity during occupation, the Tecumseh instrument; for leisure activity, the British Civil Servant questionnaire; for testing whether the physical activity reported exceeds the threshold required to increase cardiovascular fitness, the Five-City Project questionnaire (Sallis, et al., 1985).

Other methods of determining patterns of physical activity have included use of the socially acceptable monitoring instrument SAMI (Baker, Humphrey and Wolff, 1967) to record heart beats, the 7-day activity diary, the administration of one multiple choice question and the use of job title only. LaPorte, Cauley, Kinsey, Corbett, Robertson, Black-Sandler, Kuller and Falkel, (1982) gave a favourable evaluation to a motion sensor, the Large-Scale Integrated Activity Monitor (LSI).

3.8.3 Energy and nutrient intake; concepts and methods of measurement. The epidemiological approach to research in nutrition, particularly in relation to degenerative disease, has generated much discussion and re-evaluation of methods. Marr, in 1971, comprehensively reviewed methods of measuring food intake and their purpose. A more recent review by Block (1982) re-emphasised the necessity of validation and stressed that validation of any method must be viewed in the context of what inferences are to be drawn from the research done. If only the group means are of interest, the agreement between the two methods should be in group means, but if the inferences are to be directed towards agreement in individuals, then validations must be directed similarly. Many methods meet the first test but fail the second. Block, is one of many investigators in the last decade who has devised a food frequency questionnaire. She has developed and tested the questionnaire systematically.

Bingham (1982) examined the implications of individual variation in nutritional studies. She concluded that the effect of daily variation is such that seven-day weighing methods can no longer be considered a guaranteed method for the estimation of all items of diet. She reported development of the concept established by Marr (1971) of taking account of daily variation in individual nutrient intakes by the choice of the number of days necessary to obtain reproducible classification into tertiles of intake at a statistically significant level. This concept, together with considerations of whether group or individual results are required, variability in the subjects to be studied, e.g., men or women, and the level of accuracy desired, has produced some tentative guidelines, such as those of Beaton (1982).

His suggestions for the selection of methods to assess dietary intake based on the purposes of the planned study were adopted for the WHO project to monitor cardiovascular disease by Van Staveren and Burema (1983) thus: for a group average, a one-day intake from a large group with adequate representation of days of the week; for the proportion of a population "at risk", either replicate observations or a diet history; for individual nutrient intake for correlation or regression analyses, multi-replication of observations on each individual.

Ferro-Luzzi (1983) gave some practical guidelines on how to deal effectively with standardization of methods between laboratories and countries with regard to collection of dietary information and tables of food composition, especially the latter, which she considered to be potentially a source of serious error.

In a report on the diet factor in epidemiological research (EuroNut 1, 1982) Bingham and a number of other workers reviewed progress in identifying biological markers of food intake as independent measures of validity of dietary intake methods. Among those which are under investigation are 24-hour urine nitrogen, and 3 methyl histidine excretion for protein intake and adipose tissue biopsy for habitual fatty acid composition of the diet. The use of urinary data collected during a dietary survey period and, also when diet is not being assessed, as a means of determining whether or not diet records interfere with normal habits, would help to resolve a long-standing criticism of the seven-day weighed inventory method.

The method of conducting a seven-day weighed dietary survey has remained essentially unchanged since our studies, except for improvements in weighing and recording techniques such as digital scales and the possibility of tape recorded records. As with energy expenditure studies, the importance of care and attention to both subjects and instruments and the appreciation of sources of error and bias is unchanged.

3.8.4 Body size and composition; concepts and methods of measurement.

Measurements of body composition have grown in importance in the last twenty years, in particular, the assessment of body fat mass (FM) from skinfold thickness. Durnin and Womersley (1974) constructed tables based on measurements of 209 men and 272 women from which the fat content of the body as a ratio of body weight, corresponding to various values of the sum of four skin fold thicknesses in both men and women, divided into four age groups, can be found. These tables have been used extensively. Adequate skinfold thickness measurement techniques can be acquired with good, and not necessarily long, training (Durnin, 1984). Garrow (1982) reviewed many of the new methods for estimating body composition, and Mazess, Peppler and Gibbons (1984) reported their work on the use of dual-photon absorptiometry to determine skeletal mass as well as the lean and fat content of the entire body.

Durnin (1984) and Garrow (1982) have commented on the distinction between the terms "lean body mass" (LBM) and "fat free mass" (FFM), the latter being the more accurate term for what remains when "fat mass" (FM) is removed from body weight. FFM includes the physiologically active portion of adipose tissue but, except in very obese people, it is not very important to distinguish between LBM and FFM (Garrow, 1982).

Frame size derived from measurement of elbow breadth has been incorporated into new standards developed by Frisancho (1984) for the assessment of nutritional status of adults and elderly. The use of the standards is based on their inclusion of indicators of body fat tissue (skinfold thickness) and lean body tissue (bone free upper arm muscle area) specific for each sex, height and frame size category.

Body size, as described by height and weight, is particularly useful in defining obesity. A NIH Consensus Development Conference on the Health Implications of Obesity (1985) recommended that the height/weight ratio, Body Mass Index (BMI; weight in kg/height in m^2) be used more widely. This ratio was proposed by Keys, Fidanza, Karvonen, Kimura and Taylor (1972) as an index of relative body weight, firstly, to remove the dependency of weight on height, and secondly, as the relative weight index showing the highest correlation with independent measures of body fatness. Durnin (1983) cautioned that investigations by McKay, et al., (1981) on more than 5,000 men and 1,000 women make it obvious that no height and weight index can eliminate the possibility of considerable error if it is used to estimate fatness. Macdonald (1986) emphasised this latter point from data collected on 5,072 males aged 16-56 years and concluded that W/H^2 is of little value when assessing obesity in individuals. Simopoulos (1985) quoted Norgan and Ferro-Luzzi (1982) in stating that the BMI has a relatively high correlation with body fat (as estimated from body density) particularly when age is taken into account.

The Consensus Development Panel emphasised that BMI shows a direct and continuous relationship to morbidity and mortality in large populations. Two useful nomograms which relate BMI to the Metropolitan Life Insurance height/weight tables of 1959 and 1983 were published by Burton and Foster (1985). The regional distribution of body fat was cited as an important predictor of some health hazards of obesity. If these relationships become established, measurement of waist and hip circumference may join height and weight as standard anthropometric indices. White, Pereira and Garner, (1986) found that weight distribution (waist:hip ratio) to be a strong independent predictor of hypertension in both men and women, although its importance was secondary to that of body mass index. The study population consisted of a 10,724 subsample of men and women aged 20 to 69 years who took part in the Canada Fitness Survey (1983).

Definitions of overweight and obesity continue to be debated but the present medical consensus seems to be in favour of continuing to use the 1959 Metropolitan Life Insurance Company height-weight tables of desirable weight instead of the 1983 edition in which the upper levels of desirable weight were slightly increased. Both the panel and the Royal College of Physicians (1983) endorsed the concept of "desirable" or "acceptable" weight for height. No mention was made of thinking in terms of "dangerous weights" as advocated by Knapp in 1983. One of the recommendations of the panel was that there is need to develop an appropriate data base relating body weight by age, sex and possibly frame size to morbidity and mortality, which had been suggested by Garrow (1979). An average and range of desirable weights for height in adults together with the corresponding average and range of BMI is suggested in the <u>FAO/WHO/UNU</u> (1985) report.

3.8.5 <u>New emphases in defining and determining energy requirements</u>. The <u>FAO/WHO/UNU</u> Expert Consultation on Energy and Protein Requirements which met in 1983 (<u>FAO/WHO/UNU</u>, 1985) decided that, wherever possible, estimates of energy requirements should be based on estimates of expenditure, whether actual or desirable, rather than intake. It also decided that, because in the great majority of cases the largest component of energy expenditure is the BMR, there would be many advantages in calculating the various components of total energy expenditure as multiples of the BMR. The results of an extensive examination of the literature as the basis of obtaining reliable estimates of the BMR of people of different ages, sexes and geographical groups were published by Schofield, Schofield and James in 1985. The end product of this analysis of some 11,000 technically acceptable measurements on individuals considered to be healthy was the computation of linear equations for predicting BMR from body weight according to sex and age for use when it is not possible to use direct measurements.

When the BMR has been determined from the equations or from tabulations which are provided in the report, the total energy expenditure can be estimated by multiplying the BMR by a factor which covers the energy cost of increased muscle tone, physical activity, the thermic effect of food and, when relevant, the energy requirements for growth and lactation. The traditional classification of occupations into those which involve light, moderate and heavy physical activity was maintained, and multiples of the BMR applicable to each group have been calculated. These were based on the percentage of time spent in occupational activities and the energy cost of these activities. The gross energy expenditure on occupational work at light moderate and heavy levels of activity was estimated for young women as 1.7, 2.2, and 2.8; for young men as 1.7, 2.7 and 3.8. Non-occupational activities were systematically examined and heavily emphasised. These were usefully classified as discretionary activities, optional household tasks, socially desirable activities and activity for physical fitness and the promotion of health. An estimate of total energy requirements derived as multiples of BMR, was made by taking account of each component of energy expenditure and weighting them according to observed patterns of activity described in the literature. The total daily energy expenditure corresponding to light, moderate and heavy work was estimated as approximately 1.56, 1.64 and 1.82 for women and 1.55, 1.78 and 2.10 for men.

The use of the BMR as denominator largely corrects for inter-individual differences in lean body mass and permits cross-comparison of subjects without reference to height, weight, sex or age. The fractional portion of the value represents the energy cost of physical activity both obligatory and discretionary, and dietary and thermoregulatory thermogenesis. The fractional portion is dependent on total body weight when the energy cost of weight-bearing exercise represents a major part of it, as with athletes or manual workers, but in most cases will be relatively independent of body weight.

As defined and used in the FAO/WHO/UNU (1985) report, estimates of requirements relate to the maintenance of health in already healthy individuals. Health is understood to include patterns of activity that are judged to be consistent with satisfactory physiological and social function.

3.9 Current concepts of relationships between the aging process, energy expenditure, physical activity, food intake and obesity in individuals aged 50 to 75 years. The years 1966 - 1986 have seen a great increase in research on the relationships between the aging process, health and lifestyle factors of people of over 50 years of age. Publication of this research has been prolific. In the field of nutrition alone a textbook such as Handbook of Geriatric Nutrition (Hsu and Davis, 1981) reviews a sample of about 1500 relevant papers in 360 closely written pages.

Increasing emphasis during these years has been given to the uniqueness of the aging process in each individual based as it is on a multitude of inter-related variables. The variables include those of energy and nutrient intake, energy expenditure, patterns of activity and body size. Studies including the ones reported in this thesis have repeated the finding that men and women of all ages can maintain life and apparent health at very different levels of each of these individual variables. An important outcome of the wider recognition of this variation has been the approach taken to energy requirements in the FAO/WHO/UNU (1985) report, which relates these more closely to individuals than to populations and takes account of physiological factors including the effects of continual changes in rates of growth, body composition, physical activity and patterns of food intake.

One of the most persistent lines of research interest which is closely associated with individual differences in the aging process is that which seeks to discriminate between "normal" or physiological aging and pathological aging. Durnin (1983) described "normal" physiological degeneration as a relatively slow process which will still allow a way of life which includes active work or recreation into advanced age in contrast to those changes brought about by the disability arising from arthritic disease such as limited physical activity and perhaps obesity. Exton-Smith (1982) defined a further category, "pseudo-aging", in which changes in nutritional status which are age-associated may be incorrectly attributed to the effects of aging when they are due to changes in socioeconomic factors. A model (Figure 3.1) of the type of process which may occur was developed by Rao (1973).

At the other end of the spectrum of individual differences from those arising from socioeconomic factors lie those which are increasingly being found at the cellular level. A review by Hall in 1976 of progress in gerontological research concluded that the rapidly emerging application of cellular and molecular biology to aging was of great importance. A review linking this vast field of research to normal and pathological aging in the individual was made by Goldstein (1984). He summarised the cellular factors known to influence aging and health (Figure 3.2). Within this model, food intake, nutrition, exercise and energy expenditure can be viewed as environmental factors which influence the intrinsic processes of aging. He also endorsed the search for factors which can be manipulated to add "life to our years".

> Biological aging is a physiologic process, a normal epilogue of development that originates within DNA. Although it can be modulated by external environmental cues, aging is a universal process continuous with growth and development and the independent variable leading to cellular loss and decline of

> function. On the other hand, age-related diseases are dependent variables relying in part on the loss of cells and declining function but in other cases engendered by random genetic-metabolic alterations. It is evident that physiologic aging will proceed along an uneven front, occurring sooner in some cells and later in others within and between individuals. Age-dependent disorders, especially malignancy and atherosclerosis, show even further exaggeration of this "unevenness" and hence are not inevitable consequences of aging. Future studies should reveal the varied mechanisms of biologic aging within each cell type, the genetic basis of differences between individuals, and in turn, how environmental factors influence these intrinsic processes. Above all, such research should identify how rational medical intervention can lead to a more vigorous longevity and a better quality of life in the elderly.

A summary of some current views of the relationships between aging, body composition, physical activity and food intake was given in Proposals for Nutritional Guidelines for Health Education in Britain (1983). The proposal of a dietary scheme for the elderly described some changes which have been found in the aging individual which may affect energy and nutrient requirements.

> With aging, height, weight and lean tissue are reduced and body fat content may rise as a percentage of the total. Muscle power declines either because of atrophy or metabolic changes. Basal metabolic rates decline but only because lean tissue is lost. The causes of the decline in lean tissue are obscure but reduced physical activity is a major feature of middle and late years and may be the key factor leading to muscular atrophy. If reduced physical activity leads to a falling energy intake, unless more appropriate diets are chosen there will automatically be a higher risk of borderline nutritional deficiencies. The answer to these deficiencies may, therefore, depend on greater physical activity leading to a greater lean body mass and an increased total food intake. One of the principal objectives of nutrition education in the elderly may therefore be the maintenance of physical activity. The dietary scheme advocated in this document should then be as appropriate for the elderly as for the younger age groups.

The scientific basis for these changes and relationships in the age range of approximately 60 - 75 years was examined by Durnin (1983) in a review of nutrition in geriatric medicine and gerontology. In a discussion of the effects of body mass and body composition on energy expenditure he noted that cross-sectional data support the probability that fat mass increases with aging in both men and women, and that there is a fall in fat-free mass, which is probably a fall in muscle mass. There is also evidence that the density of skeleton seems to decrease, and that there is a decrease in size of Type II muscle fibres which leads to a diminished strength of contraction, and that there may be changes in mechanical efficiency of the limbs.

He reviewed some of the literature on exercise capacity and age and concluded that an improvement in the ability to exercise can certainly be accomplished in the elderly. Sidney and Shephard (1977) reported the results of a training program for older adults based on the premise that all functional changes are not due to aging, but some are due to disease and misuse. Introduction of a one-hour physical activity class four times per week increased the average daily energy expenditure by 150 - 200 kilocalories in the women. The added activity over a 12-month period was sufficient to augment aerobic power (three months of endurance training increased it by as much as 30 percent), to induce favourable changes in body composition, and to initiate changes in other areas of lifestyle including a diminished use of the car.

In examining the importance to health of activity, the authors quoted Hammond (1964), who found death rates to show a gradation with activity, particularly in those of over 65 years of age. Belloc and Breslow (1972) and Palmore (1970), showed that good health habits, including regular physical activity, conferred a health status equivalent to people 30 years younger. However, they cautioned that poor health may have influenced the decision not to take exercise in at least a proportion of the inactive. They concluded that a categorical answer to the question of health benefits must await larger longitudinal studies in which fitness and activity levels are correlated with objective measures of health experience.

Such a study was reported by Morris, Everitt, Pollard and Chave (1980), who concluded from the results of an 8½-year longitudinal follow-up of 17,944 middle-aged male British civil servants that vigorous exercise is a natural defence of the body with a protective effect on the aging heart against ischaemia and its consequences. They found that there was a weak association between high total physical activity on the Friday and Saturday on which the men completed a 5 minute by 5 minute retrospective record of how they had spent their time and subsequent incidence of coronary heart disease (CHD). There was a much stronger association between incidence of CHD and the report of vigorous exercise (VE) in leisure time in that the men who reported initially that they engaged in VE had an incidence of CHD in the next 8½ years of "somewhat less than half" that of their colleagues who recorded no VE. The activities classified as vigorous were defined as those likely to reach peaks of energy expenditure of 7.5 kcal/min. Although the authors pointed out that at that time no significant relationship had been found with other causes of death, they emphasised that CHD is the leading contributor to total mortality in middle age and as such shortens life span.

The relationship between amount of physical activity and length of life was quantified by Paffenbarger, Hyde, Wing and Hsieh (1986). In a study of 16,936 Harvard alumni aged 35 - 77 they found that exercise reported as walking, stair climbing and sports play related inversely to total mortality, primarily to death due to cardiovascular or respiratory disease. The physical activity index by which the relationships were quantified was based on estimates of energy expended derived from Passmore and Durnin (1955). Alumni aged 60 - 84 who reported the highest activity level (3500 kcal/week spent on exercise) had half the relative risk of death of those at the low end (<500 kcal/week). The amount of additional life attributable to adequate exercise as compared with sedentariness was from one to more than two years by the age of 80. The authors provided references from 1843 to the present to substantiate the belief that adequate physical exercise is necessary to preserve life and its desirable qualities into old age.

Pekkanen, Marte, Nissenen and Tuomilehto (1987) concluded that high physical activity may prevent premature death among middle aged men, but probably does not prolong maximum achievable lifespan. They examined the association of physical activity level with the risk of death in a cohort of 636 healthy Finnish men aged 45-64 years followed up for 20 years.

Many other workers have contributed to the acceptance of the old[1] adage "Use it or lose it" in relation to physical activity when it regained currency as the "Hypokinetic Theory" (DeVries, 1970, 1975). Bortz (1982) reviewed the biologic changes commonly attributed to aging from the perspective of disuse. He concluded that "there is no drug in current or prospective use that holds as much promise for sustained health as a lifetime program of physical exercise."

The amount of physical activity undertaken by people of 50 years and over, in common with younger people, is very variable and may or may not decline in the years between 50 and 75 depending on occupation, interests and health. The FAO/WHO/UNU (1985) report on energy and protein requirements noted that there are limited data describing the profiles of activities for different individuals. Some of the best data available were collected in the studies reported in this thesis, and they have been used extensively in comparisons of energy expenditure and physical activity patterns of men and women in different occupational groups. Even within occupational categories great variation in physical activity has been shown. Durnin (1983) used some of the data in this thesis to support his earlier contention (Durnin, 1956) that if a man or woman is still at work at age 60, 65 or 70 he or she will often expend as much energy during work as he did at 25 or 30 years, and especially in occupations demanding little physical effort, aging may have little influence up to about 75 years.

He expressed caution in the acceptance of the reduction of BMR with aging as a biological fact, although for most populations and for most individuals within these populations he estimated a reduction of BMR of about 10 percent between young adulthood and about 60 years,

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[1] "Speaking generally, all parts of the body which have a function, if used in moderation and exercised in labours to which each is accustomed, become thereby healthy and well developed and age slowly; but if unused and left idle, they become liable to disease, defective in growth and age quickly" Hippocrates (~ 460 - 360 B.C.).

and another 10 percent decline by 75 years. He proposed an alternative view in which the BMR will not necessarily become lower if elderly people have avoided the marked changes in body composition with reduced muscle mass and increased fat mass which usually occur as people become older, in which case there might be very little decline in BMR with age in many healthy, active people. Increased physical activity has been shown to slow down or reverse these changes in addition to improving cardiovascular and respiratory function (DeVries, 1970).

Durnin (1983) commented that the energy expenditure of the housewife starts to decrease at age 45 - 50 and falls proportionally more than that of a man up to 70 years or so. A study by Durnin, et al., (1957) showed that the energy expenditure of middle-aged women whose main occupation was in the home declined in relation to the expenditure of their adult daughters. At the time of the 1957 studies housewives were the greater proportion of the female population whereas today many women re-enter the workforce on a part-time or full-time basis between the ages of 35 and 45 years and do not necessarily retire at age 60. It is likely that their energy needs do not decline and may even increase to meet the demands of two occupations. Underestimates of the energy requirements of older women may result if it is assumed that there is a decline in activity in women aged 50 and over.

The large proportion of people in sedentary work and the trend towards a shorter working day have focused attention on physical activity during leisure time as the entity which may discriminate between individuals in terms of fitness. The type of physical activity chosen by an individual will determine whether it can be maintained through middle age to beyond retirement and thus maintain energy expenditure and energy intake. Walking, which can be done by young and old, has thus become deservedly popular and the findings of Paffenbarger et al., (1986) described in Section 3.9, have given further recent impetus to its promotion as a health-enhancing activity.

Durnin (1983) reviewed some of the literature on weight increase with advancing years and found some evidence that between 40 and 65-70 years the weight of men decreases whereas the weight of women frequently increases. He showed in an analysis of some of the thesis results that increasing fatness as opposed to increasing weight led to less physical activity (Durnin, 1967). An interesting study from Germany which he quoted showed that the energy expenditure of elderly women increased with body weight up to 80 kg whereas that of elderly men declined at weights over 70 kg. He suggested that this was yet another sign of the quite different meaning of moderate obesity in men where it is abnormal and in women where it is biologically normal.

Relationships between aging and obesity are only one aspect of research in the enormous field of obesity research which was comprehensively reviewed by Garrow (1978). The focus on the individual which has emerged in the field of aging was evident in his assessment that progress in the treatment of obesity would lie mostly in an increasing realisation that since the causes of obesity are so diverse, there can be no panacea. He recommended that an individual approach should be based on both metabolic and cognitive factors.

A summary of evidence that obesity has adverse effects on health in the middle-aged and elderly person was made by the National Institutes of Health Consensus Development Panel on the Health Implications of Obesity (1985). At or above a BMI of 27.8 in males and 27.3 in females, the prevalence of hypertension was found to be twice as high for the obese group as it is for the non-overweight group aged 45 through 74 years old. There was a similar prevalence for hypercholesteraemia. A negative association between obesity and longevity and a positive association between obesity and cancer of certain sites were also found. Other aspects of the Consensus Panel Report are discussed in Section 3.8.4.

Thompson, Jarvie, Lahey and Cureton (1982) reported on a very welcome change in emphasis in the prevention and treatment of obesity in a substantial review entitled "Exercise and Obesity: etiology, physiology and intervention". They noted that dietary manipulations have characterized past intervention strategies and that physical activity was examined in only 6 percent of all weight control studies reported up until 1979. In a society which is obsessed by weight and in which, until recently, reduction of energy intake appeared to be and was recommended as the best way to combat obesity, low energy intake has become a way of life.

Several workers have re-emphasised the fact that lowered energy intake results in reductions in basal metabolic rate (Garrow, 1978; Durnin, 1984) and thus counteracts the effects of dieting. Recommendations for a reduced energy intake have been made to middle-aged and elderly individuals on the basis of an assumed drop in physical activity without the inclusion of encouragement to maintain or increase physical activity. The result has been the proliferation of fad diets and low energy diets seriously lacking in nutrients.

Southgate and Durnin (1970), Garrow (1978), and James (1983) have each noted that it is the accumulation of small daily differences in energy intake and expenditure whether due to activity or to metabolic processes involved in digestion or utilization of nutrients which lead to obesity. It follows that achievement and maintenance of weight at a "healthy" or "desirable" level is also dependent in the long run on only a small increase in physical activity or a small decrease in energy intake of perhaps 100 - 200 kcal/day.

The process of growing fat, like the process of growing old, illustrates the importance of individual differences. Comfort in 1969 suggested that the concept of biological rather than chronological age would be useful in research. There has been a growing awareness both before and since then that many older people are functionally young and they have been variously described as the "young-old", "the frisky elderly", "the fortunate elite" and the "gerontocrats". There are as yet very few data showing trends in individuals in the physiological changes by which biological age is described such as rates of decline in various organ systems (McGandy, 1982).

3.10 Studies of energy expenditure and patterns of physical activity.

The purpose of this section is to identify the few studies of the energy expenditure of people in the 50 and over age group which have been made using methods similar to or identical to those of the thesis studies, and to indicate that there has been a growth in reports of studies of energy expenditure based on the physical activity questionnaires which were reviewed in 3.8.2.2.

A search of the literature reveals few studies of the energy expenditure of the over-50 age group using similar methods since the completion of the thesis studies. Salvosa, Payne and Wheeler (1971) used the SAMI heart-rate integrator to assess the energy expenditure of 52 women and six men, of whom only seven were under 75 years of age. The Douglas bag was used to measure oxygen consumption of some activities in a small number of subjects and some estimates were made of energy intake. They concluded that the SAMI was a potentially useful method of assessing energy expenditure and that their subjects had an adequate energy intake.

The long-term energy intake and expenditure of six obese women aged 30 - 58 were studied by Curtis and Bradfield (1971). They estimated energy expenditure for a month using the activity-diary respirometer method and dietary intake by the weighed individual inventory method for two weeks. The women were classified as obese. They were between 126 and 180 percent of standard weight for height and 39 to 50 percent of their body weight was fat. It was noted that energy expenditures were lower than expected for body weight, that little time was spent in moderate and strenuous activity and that the variation in energy intake was considerably more from day to day than was the case for energy expenditure.

Some estimates of total daily energy expenditure have been made in the last 20 years using activity data. In 1967 Grieve made a detailed study of the times spent in various activities by 45 housewives aged 21 - 41 with young children at home and from these estimated energy expenditure using figures taken from the studies of housewives made by Durnin, et al., (1957) and from Passmore and Durnin (1955). She also used the SAMI but concluded that it was not possible to make an accurate estimation of oxygen consumption from heart rate because the relationship between heart rate and oxygen consumption varied with different types of activity.

A new approach to the measurement of energy expenditure was set in motion in the early 1960's by interest in the epidemiology of cardiovascular disease and its relationship to physical activity. The questionnaires which were developed to examine this relationship have been reviewed by Washburn and Montoye (1986) and the development of a demand for detailed physical activity patterns to be quantified into levels of energy expenditure is clear.

In 1971 Montoye reported that few physical activity forms used in epidemiological research attempted to assess the energy requirements of both occupation and leisure and that none attempted to quantify the ratings of physical activity. For the Tecumseh Community Health Study he developed a system of metabolic cost of occupational and leisure tasks expressed as a ratio of work metabolism to basal metabolism. These costs were multiplied by the time spent in each activity derived from a questionnaire consisting of 36 occupational and 63 leisure time activities. The products were summed and divided to arrive at a weighted average daily work to basal metabolic ratio. Work to basal ratios during sleep of 1 and during quiet activities of 1.8 were assumed. The average energy expenditure calculated in this way was used for a number of studies.

Sidney and Shephard (1977) also used detailed activity diaries together with standard values for the energy cost of various tasks taken from the tables of Passmore and Durnin (1967) and from previous studies by the authors to calculate mean daily energy expenditure. Their subjects were 13 men and 21 women who volunteered for endurance training as part of their preparation for retirement. They were aged between 60 and 70 years. Their activity patterns were examined by diary, ECG tape recorder and the SAMI electro-chemical integrators. Both activity measurements and initial assessments of fitness indicated an inactive lifestyle on entry to the study. The method was used to demonstrate that participation by the subjects in a 1-hour physical activity class four times per week increased the average daily energy expenditure by 150 - 200 kilocalories. The added exercise also improved aerobic power and body composition over the year of observation.

An interviewer-administered questionnaire which has been used to evaluate energy expenditure in leisure time was developed by Taylor, et al., (1978). The ratio described by Montoye (1971) was used together with the duration of exercise in minutes for a year (D) to formulate an Activity Metabolic Index (AMI) such that AMI = work metabolic rate/BMR x D. Detailed information on the time spent on activities of light, moderate and heavy intensities defined by levels of AMI was obtained. The method was validated by a study of 175 men ranging from 36 to 59 years and the percentage of energy expended in leisure time activity at each level of AMI intensity calculated. The authors concluded that the Minnesota Leisure Time Activities (LTA) Questionnaire assessment of AMI score is closely associated with total kilocalories expended on LTA. They recommended that occupational physical activity and energy expenditure be quantified by means of the Tecumseh questionnaire.

LaPorte and seven other workers (1982) used the Paffenbarger Survey for Physical Activity to study 72 white post-menopausal women aged 45 to 74 years. They commented that little is known about physical activity in older women. Physical activity was converted into kilocalories of energy expenditure per week and was compared to measurements made using a motion sensor, the Large-Scale Integrated Activity Monitor (LSI). The LSI results and those of the Paffenbarger survey were related weakly but significantly, r 0.33. The results indicated that individuals who were most active during the day were also most active during the evening. This was also found in their study of 42 middle-aged men employed mainly as laborers in steel mills, in addition to the finding that work activity represented a very high proportion of the total daily activity.

Sallis, et al., (1985) reported the use of questionnaires in three separate assessments of the physical activity patterns of 1120 women and 1006 men between the ages of 20 and 74. They distinguished between "moderate activities", defined as requiring an energy expenditure in the range of 3 - 5 metabolic equivalents (METs) and vigorous activities requiring an expenditure at or above 6 METs where 1 MET is the energy expended while sitting at rest. Total energy expenditure over a seven-day period was estimated by a recall of physical activity and quantified using MET values. Some of their findings on the relationships between physical activity measures, age, occupation, energy expenditure and body mass index will be compared to the thesis findings in the Discussion section.

Physical activity data were also quantified by Paffenbarger, et al., (1986) to compute a physical activity index expressed in kilocalories per week. This scale was related to all-cause mortality and longevity of college alumni. No attempt was made to derive total energy expenditure.

Kornitzer (1984) listed and reviewed many of the studies in Europe and the United States in which energy expenditure in the form of physical activity has been and is being studied. His paper considered in detail the problems facing the epidemiologist who attempts to study energy expenditure in the form of physical activity.

3.11 Studies of energy and nutrient intake. The aim of the search of the literature for this section was to identify studies which were comparable to the thesis studies and which have provided some more recent information on the relationships between age, sex, occupation, energy and nutrient intake, and energy and nutrient requirements. Some results from a selected group of studies of middle-aged and elderly subjects have been extracted and are summarised in the Discussion section in Tables 7.20(a & b) and 7.25 (a & b) (energy intake) and Tables 7.29 and 7.31 (protein, fat, calcium and iron intake). These findings will be compared and contrasted with the thesis results and will be used in their interpretation in the Discussion section. The aims, purpose and therefore research design of each study differed, but each provided some estimates of the energy and nutrient intake of groups of subjects in the age groups of interest. The findings of some studies of subjects younger than 50 years are included for comparison.

The chief aims of the nutritional study of the elderly using epidemiological methods were stated by Exton-Smith in 1982 and all of the studies selected fall into one or more of the following categories defined by him:

1) to assess the nutritional status of the elderly population and to ascertain to what extent this differs from that of older adults;
2) to identify malnutrition and the factors involved in its causation;
3) to investigate the effect of aging on nutritional status and on nutritional requirements in old age;
4) to formulate recommendations for dietary allowances in old age;
5) to ascertain the range of "normal" biochemical and haematological values in old age with particular relevance to those related to nutrition;
6) to investigate the effects of nutrition on morbidity and mortality in the elderly and in particular to investigate the role of nutritional factors in the etiology of specific diseases, for example, osteoporosis and ischemic heart disease; and
7) to determine whether the health of the elderly can be improved by dietary modification.

The two latter aims were found by McGandy (1982) to be more often the focus of nutritional studies of middle-aged adults. By current definition many of our subjects were middle-aged (i.e., aged 50 - 65 years) and the only findings available for comparison are from chronic disease epidemiological investigations.

The research designs of the selected groups of studies were very varied. Some were longitudinal studies, some cross-sectional; in some the method of sample selection was random, in others a convenience sample was chosen. The selection was, therefore, made on the basis of the method of measuring dietary intake which was in most cases the collection of prospective dietary records for a minimum period of three days. The dietary history method was accepted in two studies because it was satisfactorily validated. One of these by Steen, Isaakson and Svanborg, (1977) reported that a comparison of the intake of protein from histories and from the results of an analysis of nitrogen in 24-hour urinary samples supported the conclusion that the history gave valid results and, in the other, Lonergan, Milne, Maule and Williamson, (1975) validated the history method against 2-day weighed records.

Differences in methodology make the interpretation and comparison of studies difficult. Longitudinal studies, of which there are few, are likely to provide the best means of detecting the effects of true age changes in nutritional status (Exton-Smith, 1982). Conclusions from three of these longitudinal studies, which are relevant to the thesis studies, are described here.

A study of 60 women aged over 70 who lived alone was made by Exton-Smith and Stanton in 1965. Sixteen of these women were followed up six and a half years later. From their first survey they found that with subjects of increasing age there was a decrease in the quantity of food eaten. In their second study Stanton and Exton-Smith (1970) demonstrated that what had previously appeared to be an age-related diminution in the quantity of the diet was in fact an age difference, defined as a difference between individuals of different ages related to factors other than age itself. The dietary intake changed little with age in those who remained in good health, but there was a marked drop in intake among those whose health had declined.

Twelve years later, in 1982, Exton-Smith reviewed the methodological problems of longitudinal studies. He concluded that (a) they represent the best means of detecting the effects of true age change in nutritional status; and (b) although there is an overall downward trend in the intake of energy and nutrients with advancing age, the rate of change with age may not be uniform throughout the age span. He quoted studies by Debry, Bleyer and Martin, (1977) which have shown that farm workers in the Lorraine region in France who maintain their active way of life to an advanced age also maintain their nutrient intake. In con- trast were results from urban residents reported by Elahi, Elahi, Andres, Tobin, Butler and Norris, (1983) from a longitudinal study of the nutritional intake of men from 1961 to 1975. The subjects were the 180 male participants in the Baltimore Longitudinal Study of Aging who were aged 35 - 74 years at the time of the first of three seven-day dietary diaries. The authors reported that aging had a negative effect on intake of energy, fat, saturated fatty acids and cholesterol. The longitudinal decrease in intake of energy is not readily apparent from the means (Table 7.20b) in this group of sedentary affluent men.

A longitudinal study of women (Garcia, Battese and Brewster, 1975) in which seven-day weighed food intakes were obtained at least twice between 1948 and 1969 found non-significant decreases in the intake of energy and carbohydrate with age and significant decreases in fat and saturated fatty acids. Steinkamp, Cohen and Walsh, (1965) obtained longitudinal data after fourteen years on the energy and nutrient intake of men and women originally studied cross-sectionally by Gillam and Morgan (1955). It appeared from these data that there was a difference in the rate of decline of energy intake between men and women. The intake of the men studied decreased on retirement at 65 years and remained fairly stable until about 80 years when it declined steeply. In those men who reached the age of 90, "the survival of the fittest" effect was shown by the apparent increase in energy intake of this old-old group compared to those in the eighth decade (Table 7.19, 7.20a), 7.20b). The energy intake of the women remained fairly stable between the ages of 55 and 75 and then appeared to decline gradually.

In Great Britain a number of cross-sectional epidemiological studies have been made which are useful for comparison with the older groups of thesis subjects. MacLeod, Judge and Caird, (1974) studied people between 65 and 74 and over 75 in North Glasgow and found a slight decline in energy intake after 75 years of between 5 and 7 percent. Lonergan et al., (1975) in Edinburgh, included subjects below retirement age in the younger age range of their study of men and women aged 62 - 74 and 75 and over. This may have contributed to the greater decrease (12 percent) in energy intake which they found between the two age groups for men. The reduction for women was 7 percent. In an extensive study of 879 men and women in England and Scotland (DHSS, 1972) aged between 65 - 74 and over 75 the energy intake of men and women decreased by 9 percent between the decades. A follow-up of the same groups (DHSS, 1979) showed the decline in energy intake after five years as approximately 5 percent for both men and women in the older and younger groups, i.e., less than 80 years and equal to or more than 80 years.

Bingham, McNeil and Cummings, (1981) studied a random sample of the population of a Cambridgeshire village. Their analysis used the age ranges 20 - 39, 40 - 59 and 60 - 79. There was no difference in energy intake between the two decades included in each of the two groups of older men nor between men in manual and non-manual occupations. The inclusion of men aged less than 65 years with those over 65 may have obscured a post-retirement decline in intake. Similarly the inclusion of women of 79 years and over with those of between 60 and 70 years may have obscured differences in the rate of decline in intake during the 20 year age span. The difference between the energy intake of the 40 - 59 age group compared to the 60 - 79 age group was 23 percent.

A Swedish study illustrated some of the conflicting evidence related to aging and energy intake. A comparison of representative random samples of middle-aged women aged 38 - 60 who participated in the population study "Women in Gothenburg 1968 - 1969" (Lenner, Bengtsson, Carlgren, Isaakson, Lundgren, Peterson and Tabblin, 1977) and 70-year-old women from the same area showed that the energy intake and body composition was of the same order of magnitude as far as it was possible to judge from cross-sectional studies (Steen, et al., 1977). The authors suggested that, in view of previous evidence of reduction of body cell mass with age, the similarity in body cell mass calculated from measurements of total body potassium might be the result of selective mortality between these ages. The energy intake figures indicated no change in physical activity between middle age and 70 years. In addition, the variations in intake of energy and nutrients did not differ between the groups.

The results of the comparison made between the findings of these two studies are noteworthy because cross-sectional studies in contrast to longitudinal studies usually demonstrate a reduction in intake of energy with increasing age.

The findings of a cross-sectional study by McGandy, Barrows, Spanias, Meredith, Stone and Norris, (1966) of men enrolled in the

Baltimore Longitudinal Study of Aging showed a 6 percent decline in energy intake between men in the age range 45 - 54 and 55 - 64 but no differences between those aged 55 - 64 and 65 - 74. After 75 intake dropped by 9 percent.

A study by Garry, Goodwin, Hunt, Hooper and Leonard, (1982) was designed to compare a dietary profile of a healthy elderly population with current Recommended Dietary Allowances. When the relationship between age and energy intake was examined it was found that a significant negative correlation existed for men but not for women. Further analysis based on age groups below 76 and 76 and over revealed a significant difference in intake for both sexes.

Dietary studies have also been made of small groups of elderly and old subjects to compare with indices of nutritional status. One example was that of Yearick, Wang and Pisias, (1980). In their study and one made by Grotkowski and Sims (1978), subjects were selected from a thirty-year age span. It is difficult to compare the findings of studies with such a range to those with a more restricted age span.

The fairly new and growing influence of behavioral science on the study of nutrition and the application of nutritional principles is exemplified by the work of Grotkowski and Sims which related the nutritional intake of elderly people to their knowledge of and attitude to nutrition.

Comparison of studies of the elderly and middle-aged made in the United Kingdom and the United States appear to show that energy intakes in the United States are consistently lower. There may be many variables which interact to produce this finding including the greater sedentariness of the U.S. population.

Workers in the United States have become concerned in recent years about the apparent decrease in energy intake in both males and females aged 19 to 54 years shown in the results of the 1977-1978 Nationwide Food Consumption Survey (NFCS) and the Health and Nutrition Examination Survey (HANES) II data (1976-1980) as compared to the 1965 NFCS data. These decreases appear to have occurred in spite of an increase in weight of males of 6 pounds and increase in females of 3 pounds accompanied by height increases of ½ - 1 inch in males and of ½ - 3/4 inch in females. The data which indicated that a decrease in intake had taken place was collected by 24-hour dietary recall (Mertz and Kelsay, 1984). A study by these authors and others (Kim, Kelsay, Judd, Marshall, Mertz and Prather, 1984) was designed to shed some light on the findings and on the role played by the method used in producing them. Data collected from 16 women and 13 men aged 20 - 53 years who recorded their dietary intake for one year indicated that diets freely consumed and capable of maintaining weight were about 300 kcal more than those reported by the NFCS. The energy intake of men was 2756 kcal/day and of women 1848 kcal/day (2434 kcal for 6 men between 35 and 53 year and 1803 kcal/day for 8 women between 35 and 53 years). These intakes are compared in the Discusson Section to the thesis results, which were also obtained from small groups of subjects. These findings were considered by the authors to be more representative of the habitual intake of the subjects than results which would have been obtained from a short-term study.

Many of the studies of energy intake also collected data on nutrient intake. Dietary intakes of protein and fat, their percentage contribution to total energy intake and intakes of calcium and iron have been summarised in Tables 7.28-7.31, and will be discussed in Section 7 in relation to the aims and findings of the thesis studies.

At the time of our studies not only was there little known about the energy needs of older people, but there was practically no information available on whether malnutrition was present in the population aged 65 and over. The research reviewed in this section has directly and indirectly addressed this question. In 1983 Durnin made a broadly based assessment of the key studies of nutrition in the elderly in the United Kingdom, the United States and Europe which have been made since approximately 1960. He concluded that although malnutrition appeared not to be a problem of wide importance it had been shown in several studies that the diets of the elderly were likely to be deficient in calcium, potassium, vitamin C and some of the vitamin B group.

Considerable and long overdue recognition is now being given to the snowball effect of increased physical activity, especially in older adults, leading to increased energy expenditure and ultimately resulting in increased energy intake with a corresponding improvement in the nutritional value of the diet (Ohlson, et al., 1950, Durnin, 1983, 1985).

3.12 Standards and recommendations for dietary requirements. The recommended dietary allowances or RDAs (the U.S. term) or the Recommended Daily Intakes or RDIs of Energy and Nutrients (the U.K. term) "are neither perfect nor complete; at best, they are an intelligent digest of available knowledge of human nutrient requirements on which the recommendations are based" (Mertz, 1980).

In Part 1 of this historical review (4.6) some of these standards for energy, protein, calcium and iron have been discussed and brief reference made to current understanding of human requirements. Internationally recognised standards for energy and protein requirements at this time are those produced in reports by FAO/WHO (1983) and by FAO/WHO/UNU (1985). New emphases in defining and determining energy requirements in the latter report have been discussed in 4.8.5. The results of the thesis studies will be considered in relation to these emphases in Section 7.

The conclusion of the report on protein requirements, which can be taken as the current consensus, was that there was no justification for making a distinction between adult men and women when recommending a safe intake of protein. The safe intake of good quality, highly digestible protein was set at 0.75 g/kg/day for both sexes. The same level was set for older adults and the elderly. Although it was thought likely that for older people this level might in general be higher in relation to lean body mass than for younger people, the committee regarded it as an accepted fact that protein utilization is less efficient in the elderly.

Many national standards for recommended intakes exist. The most recent standards for the United Kingdom have been produced by the Committee on Medical Aspects of Food Policy of the DHSS (1981) and those for the United States by the Food and Nutrition Board of the

National Academy of Sciences (1980), to which the results will be compared.

The United States practice of presenting recommended dietary intakes of energy and nutrients in separate tables has been commended by Davidson and Passmore (1986). This division makes it clear that the energy requirements of an individual are unique whereas, in general, the RDAs for protein, vitamins and minerals meet the requirements of the majority of the population.

A comprehensive review of the history, uses and limits of use and future of the U.S. RDAs was made in three papers by Harper (1985), Beaton (1985) and Kamin (1985). Harper ended his review of the origin of dietary standards by listing a few topics raised by Leitch (1942) which are of great current interest. These included; the concept of requirements to maintain "perfect health" which with its associated concepts of "minimum", "adequate", "optimal" and "ideal" recommendations is still at issue; the allowance to be made for individual variability which is not yet established for all nutrients; the hotly debated topic of the role of sugar and refined cereals in the diet; the most appropriate level of calcium intake, a matter which has caused much discussion and acrimony in the nutrition community (since Harper's review differences of opinion on calcium requirements have contributed to a delay in the publication of the 10th edition of the RDAs for the U.S.); protein requirements which have vacillated, as they did in the years before Leitch's review; and the appropriate level of iron intake which is still subject to debate. His conclusion was "The more things change, the more they stay the same".

The RDAs and the health of the elderly were addressed by Schneider, Vining, Hadley and Farnham, (1986) in a response to the National Research Council contention that lack of consensus on the interactions between nutrition and aging was one factor which led to cancellation of the 10th RDA report. Their extensive review of research findings and current, although not necessarily unanimous, opinions included a criticism of the practices of giving recommendations for groups labelled 51 and above or 65 and above and ignoring the enormous differences between groups at the upper and lower end of the scales. They recommended that known age-related alterations in absorption and metabolism of nutrients should be taken into account, that dietary allowances for older populations should be oriented towards the prevention of disease and that RDAs at all ages should take account of proven relationships between lifelong nutrition and age-dependent diseases such as the roles of calcium and vitamin D in preventing osteoporosis and osteomalacia. The debatable question was also raised of whether RDAs should be based on age-dependent changes in body composition and physiologic function or whether optimal body composition and levels of function can be defined for an age group and levels of nutrient intake recommended to achieve these. It was also noted that a decrease in energy intake with aging may predispose elderly people to deficiencies of specific nutrients such as zinc. One suggestion made by the authors was that the RDA of the adult might be individualized for each nutrient by using coefficients for variables such as age, disease and laboratory test results; another was that information on nutrient-nutrient and drug-nutrient interactions should be included in RDA documents. The importance of these latter factors was also emphasised by Munro (1985) in an examination of ways in which to improve dietary allowance research. This is further discussed in Section 3.13.2.

3.13 Composition of the diet.

> "...fatty meats, whole milk, butter, cream, eggs, sugar and sweets, highly salted foods and alcoholic beverages...Of course, I know that many people overeat and that excess consumption of one or more of the above foods predisposes to the development of serious diseases, but all of these foods are good for us when eaten in moderation and in appropriate circumstances...eat well and choose what we like from a wide variety of foods. The people of the United Kingdon have never before been so well fed or so healthy. The puritans who wish to alter the quality of foods that we have enjoyed for years and who advocate widespread dietary changes require more hard scientific evidence to support their claims." (Passmore, 1986).

> "A broader consensus base is needed to justify current efforts to place the American public on a variety of modified therapeutic diets in efforts to minimise the risk of chronic disease such as coronary

heart disease, cancer and osteoporosis. In my judgement, too much emphasis is given to diet-disease relationships; not enough attention is given to the achievement of genetic potential through good nutrition, exercise and positive health practices. Perhaps sometime we will agree that the common denominator of diet and health concerns is moderation, restraint and variety." (White, 1986).

"Both the science of nutrition and public health recommendations will be in jeopardy from loss of public confidence if clear lines of demarcation are not drawn between advice based on scientifically established evidence, deductions from indirect evidence and conjectures based on assumptions, no matter how logical they may seem". (Harper, 1988).

3.13.1 Concepts relating dietary components to nutrition, health, and disease. In the years since 1966 and particularly during the last decade, there has been an upsurge of interest in changing the proportions of protein, fat, and carbohydrate, which have been typical of Northern European and North American diets during the 20th century. It has been proposed that the fat intake should be reduced and the composition of the fat intake should be altered. It has also been suggested that the intake of dietary fibre should be increased.

These changes in fat intake have been advocated on epidemiological evidence, which is still disputed (Bingham, 1983) that fat intake, particularly the intake of saturated fat and cholesterol, plays a causal role in cardiovascular disease. Changes in fibre intake have been recommended because of reported associations between fibre intake and coronary heart disease (CHD) (Morris, et al., 1977) and between fibre intake and bowel disease, evidence for which was reviewed by Eastwood and Passmore (1983). It has also been suggested by the Committee on Diet, Nutrition and Cancer of the National Academy of Science (1982) that there is evidence that fat and fibre intakes may be related to various types of malignant disease.

In Britain, recommendations concerning dietary fat include those of the National Advisory Committee on Nutritional Education (NACNE) which suggested in 1983 that 30 percent of dietary energy should be derived from fat and that the contribution of saturated fatty acids to energy intake should be reduced to 10 percent. The Committee on Medical

Aspects of Food Policy (COMA) in 1984 suggested a total intake of 35 percent of energy intake.

The Dietary Goals for the United States (1977) prepared by the Senate Committee on Nutrition and Human Needs recommended an intake of 30 percent of dietary energy from fat and that this should consist of 10 percent saturated, 10 percent mono-unsaturated and 10 percent polyunsaturated fat (Truswell, 1977).

Recommendations have also been made by the NACNE that fibre intakes should on average be increased to 30 g/day from 20 g/day, that salt and sucrose intake should be reduced and that alcohol intake should decline to 4 percent of total energy intake.

The United States proposals, unlike those in Britain, recommended that the intake of dietary cholesterol should not exceed 300 mg/day.

The British Medical Association issued one of the more recent reports by official bodies in many countries on the topic of diet, nutrition and health (A report of the Board of Science and Education, BMA, 1986). The report reviewed the evidence suggesting that a diet high in fat, particularly saturated fat, salt and sugar and low in fibre, predisposes to obesity, dental caries, CHD, bowel disease and other medical conditions. It recommended the development of a national strategy for health promotion and disease prevention which would include improvement of the diet.

In Britain, as in other countries, the realisation of such a goal is hindered by genuine differences of opinion among scientists about the standard of evidence necessary before any dietary change can be recommended to the general public. Some current areas of debate include the degree of change necessary to reduce the morbidity and mortality of diet related diseases, the feasibility of change in habitual dietary patterns, the possible adverse side-effects of change and which populations should be encouraged to change.

A Lancet editorial (1986) examined some aspects of the role of the government in developing a food and health policy. The review of the history of some reports, which recommended dietary change, illustrated the conflict which exists over content and presentation of guidelines for the general public, even when there is a large measure of agreement on general principles.

Passmore (1986) and Stare (1986) are representative of nutritional scientists who oppose extreme change in patterns of dietary intake. They believe that a prudent diet should include a variety of foods from all major food groups including fats, meats and eggs in moderate quantities. Foods should be chosen within the framework of an energy intake and expenditure at which weight can be maintained at a reasonable level. Observation of variety and moderation in the diet is likely to ensure that most of the new demands for dietary modification will be met. These include variety in dietary sources of fats and oils including fish oils, in sources of vitamins A, C and β-carotene, in sources of selenium, calcium and iron, in sources of fibre and in sources of carbohydrate.

In 1977 Morris and his colleagues reviewed their data from a 1956-1966 study of diet and heart disease in 337 middle-aged men. The follow-up data led them to suggest that the pattern of healthy living associated with relatively little proneness to heart attack consisted of high energy intake, high energy expenditure, high intake of cereal fibre (and no cigarettes) while a pattern of low energy intake, physical inactivity, low intake of cereal fibre (and smoking) carried a relatively high risk of heart attack. The two statistically significant relationships with diet were with energy and fibre intake, but not with fat intake.

Despite cautious disclaimers by many nutritional scientists that there is very little evidence that diet is more than a minor risk factor in multifactorial diseases such as cardiovascular disease and cancer, it appears that many people are convinced that they should lower their fat, cholesterol, salt and sugar intake and increase their fruit, vegetable and fibre intake to avoid these diseases. The study of the motivations necessary to translate these beliefs into action is the realm of the behavioral scientist. In large scale clinical trials, which have a component involving long-term dietary change, nutritionists and dietitians now work closely with behavioral scientists.

Perhaps the considerable disagreement in the scientific community on the necessity for and extent and feasibility of change in the basic protein, fat and carbohydrate composition of the diet is the price to be paid for an increased public awareness of the elements of good nutrition in relation to good health and of the dangers to health of a sedentary existence.

Recent evidence of the gap between knowledge and implementation was given by Cairns-Smith, who was cited in a Lancet (1988) Conference Report. He indicated that, although many people in Scotland are well-informed about the effect of lifestyle on health, particularly in relation to CHD, few had changed dietary, exercise or health monitoring habits.

The identification of the place of nutrition among the multiple and interacting causes of chronic disease is a continuing challenge to nutritional scientists.

3.13.2 <u>Evolving understanding of the interaction of energy and nutrients and the interaction and bioavailability of nutrients</u>. Munro (1985) discussed some of the scientific bases on which RDAs are founded or may be founded in the future and identified some important areas for further exploration. These included bioavailability, nutrient interactions and drug-nutrient interactions. He noted, in relation to osteoporosis, that the role of protein intake in determining calcium loss was the subject of contradictory evidence. This subject was included in an extensive review of calcium nutrition and bone health in the elderly by Heaney, Gallagher, Johnston, Neer, Parfilt and Whedon, (1982) who concluded that protein and fibre taken in excess effectively increase calcium requirements by reducing retention of absorbed calcium or by increasing faecal excretion of calcium. The effect of fibre intake was discussed by Allen in 1982 in a review of calcium bioavailability and absorption and was stated by her (Allen 1986) as an increase of 100 mg in calcium requirement for every 18g of fibre consumed. She noted that the possible harmful effects on calcium absorption should be kept in mind when it was recommended that large amounts of fibre should be added to the diet.

Both Allen and Heaney suggested that the RDA for calcium for adults should be set at at least 1200 to 1500 mg/day. Heaney stated that the mean requirement ought to be thought of as a complex function of age, sex, absorption efficiency, intake of protein, fibre and probably other nutrients, oestrogen status and mechanical loading. This complex view of the requirements for one nutrient extends to requirements for all nutrients.

Munro (1985) illustrated this further in emphasising the role of ascorbic acid in promoting iron absorption and the role of level of energy intake on utilization of dietary protein.

A report on energy and protein requirements (FAO/WHO/UNU, 1985) concluded that the overall composition of the diet must be taken into account when assessing digestibility of protein. Variations may arise including those from differences in the nature of food protein, in the quantity of dietary fibre or in chemical reactions in the gut. Corrections of both energy and protein requirement were recommended to account for digestibility.

The importance of nutrient/nutrient interactions were emphasised by Munro and also by Mertz (1983) who, in a review of the new knowledge of trace elements, stated the following as a fundamental fact of nutritional science.

> "As part of a varied and well-balanced diet, the atom of our trace element is in equilibrium with other essential trace elements, vitamins, and micronutrients (not yet identified as essential) and all these in their entirety are in equilibrium with the macronutrients."
>
> He concluded that since no single food provides this "miraculous balance", variety in the diet is the way to obtain it and that the safety and adequacy of a diet increases with the number of its different food components.

3.14 Low intakes of energy and metabolic adaptation. The identification and quantification of adaptive changes by the body in response to changes in energy intake has continued since the Minnesota study of Keys, et al., (1950) which is described in Section 3.5.

Durnin, et al., (1973) noted that the results of careful studies in a number of countries suggested that some people, perhaps through some mechanism of adaptation are able to be healthy and active on energy intakes which, by current standards, would be regarded as inadequate.

In a review of studies of energy balance of man with particular reference to low intakes, he listed ten populations whose mean intakes of energy were "astonishingly low" (Durnin, 1979). He noted that an important change in attitude among scientists towards reports of low energy intakes had taken place during the 1970s. It was recognised that not all such reports were the result of errors in recording food intake. A study of ten Ethiopian men, which was conducted by Miller and Durnin, showed that two of the men appeared to have unusually low intakes of energy (1,500 kcal/day) and were able to maintain weight and normal activities even under careful supervision.

The energy intakes of pregnant and lactating women in New Guinea studied by Durnin appeared to be low compared to commonly accepted standards and some interesting recent work on energy sparing mechanisms has arisen from these observations and comparable ones in other countries.

In the report of one of these studies, Prentice (1984) reviewed factors which are considered to be of importance in studies of adaptation to long term low energy intake. Examination of comparative data relating to energy balance during pregnancy and lactation in affluent women from Cambridge UK and in poor rural women in Keneba, the Gambia showed that the women from Keneba achieved overall energy balance on intakes which during pregnancy and lactation ranged from means of 1,300-1,800 kcal/day. This was an energy deficit, compared to the Cambridge women of 29 percent during pregnancy and 27 percent during lactation. It was found that some Cambridge women appeared to maintain energy balance on a measured energy intake typical of a woman in Keneba, but these were considered to represent the extreme end of the normal distribution.

The most likely areas in which metabolic economies could be made by undernourished subjects were discussed by Prentice. These were reduced physical activity, reduction in active tissue mass, reduction in BMR, reduction in thermoregulatory non-shivering thermogenesis, reduction in diet-induced thermogenesis, reduction in energy cost of muscular activity and increased efficiency of absorption of dietary energy. He found that changes in their overall metabolic efficiency may have occurred but that they were not due to reduction in active tissue mass, nor to differences in eating patterns and, therefore, to differences in diet-induced thermogenesis nor to increased efficiency of absorption. The primary mechanisms by which he considered sufficient energy could be spared to account for the observed differences in intake between the two groups were reduction in themoregulatory non-shivering thermogenesis, possibly through prolactin mediation and fall in BMR per unit active tissue mass. Secondarily, there may have been differences in the absolute amount of physical activity and in the energy cost of muscular activity.

He concluded that many populations exist in genuine energy balance on surprisingly low energy intakes and that this finding is not the result of incorrect estimates of food intake, but of differences in metabolic efficiency.

In common with Orr and Leitch in 1938, who recognised that it was possible to live and work at much lower energy intake than they recommended, but that it might be "at the expense of health and efficiency", Prentice stated that "such dietary conditions are almost certainly incompatible with the optimum quality of life we wish to see achieved for such communities and must be regarded as minimum requirements".

In a report of some results from the Scottish centre of a multinational study on energy requirements in pregnancy and lactation, Durnin, McKillop, Grant and Fitzgerald, (1985) indicated that depression of the basal metabolic rate in the first half of pregnancy could produce considerable energy savings. There was little indication that physical activity altered significantly, except during the last few weeks of pregnancy.

In a further report on the same study, the authors (Durnin, Grant, McKillop and Fitzgerald, 1987) attributed a deficit of 193MJ (67,159 kcal) between the total energy cost of laying down fetal and maternal tissues and increased metabolism during pregnancy and the apparent increase in energy intake to "many small reductions in energy expenditure....which were not detectable by the methods used." Van Raaij, Vermaat-Miedema, Schonk, Peek and Hautvast, (1987) who studied pregnant Dutch women cited "adjustments to physical activity, an increase in work efficiency and an adaptation of the metabolic response to food" for the deficit found in their study.

The question of whether the energy intake of these two groups of pregnant women was indeed low, compared to their energy expenditure, remains open.

Major research on the subject of low intakes was reviewed in the FAO/WHO/UNU (1985) report on energy and protein requirements which summarised the problem as the definition of the range in total energy expenditure which can be achieved without any detectable disadvantage. This report and James (1985) considered some of the questions which exist in relation to variation in BMR. These are particularly striking between different racial groups. James speculated that there were a number of possible causes for the lower BMR values for Indian (Asian) as opposed to European or North American subjects. These were differences in diet and nutritional states; differences in body composition even at the same weight and height; climatic effects; genetically determined differences in the metabolic activity of tissues and some kind of adaptive mechanism that either decreases the amount of chemical work done in the body or enables it to be done more efficiently.

Blackwell, Brun, Webb and Rack, (1984) investigated the effect of possible racial differences in a comparison of the energy expenditure of eight Vietnamese and eight North Americans over 24 hours. No differences were found between the two groups in energy intake related to lean body mass or at moderate levels of activity in energy output per kilogram of fat free mass. The Asian subjects who appeared to be small eaters did not show a lower resting metabolic rate. The outstanding difference between the Asians and Caucasians was that the Asians seemed to increase their energy output significantly less when standing up from a lying position.

It has become increasingly common to study metabolic adaptation to low energy intakes in overweight and obese subjects. In one such study, a respiration chamber was used to measure energy expenditure, food, faeces and urine were analyzed and body density assessed by underwater weighing. The data collected from the six overweight female subjects suggested that a low energy intake over six weeks lowered the 24 hour energy expenditure more than could be accounted for by weight loss alone (de Boer, Van Es, Van Raaij and Hautvast, 1984). No normal weight women were used as controls as they were by Schutz and Jéquier (1986) who studied the energy expenditure of 20 obese women and 21 matched controls who spent 24 hours in a whole body calorimeter. The values obtained for total energy expenditure were 1.3-1.4 x BMR.

Prentice, Davies and Black, (1985) used the doubly-labelled water method (Section 3.8.2.1) to measure the average daily energy expenditure over 14-21 day periods in 12 healthy women following their normal activity pattern. The mean total energy expenditure was 1.38 ± 0.04, which was characterised by Prentice as an unexpectedly low level of energy expenditure, although only two of the 9 non-pregnant, non-lactating subjects expended less than 1,761 kcal/day.

Intermittent attempts at weight reduction have become part of the pattern of life of vast numbers of women and men in the western world over the last thirty years. The long term metabolic adaptations, which may occur under these "feast or famine" conditions were studied by Ghali and Durnin in 1977. The energy intake of the one female subject was varied considerably either above or below control level during a period of 20 months, while physical activity remained constant. During the undereating phases the BMR decreased and during the overeating phases, it increased again, but as the experiment continued, the BMR became reduced to progressively lower levels and at the end of 20 months, although the body weight had returned to its original control value, the BMR was 15 percent lower than initially (Durnin, 1984).

Reduction in BMR and reduction in physical activity remain the most credible sources of energy saving when dietary energy intake appears to be inadequate.

Two comments relevant to these issues were made in the FAO/WHO/UNU (1985) report on energy and protein requirements. One concerned the biological questions to be asked in setting energy requirements:

> "If estimates of energy requirements are to have wide validity, they must take account of the extent to which the body can adapt to different levels of intake by a change in either BMR or the efficiency of physical work. This is a major field for future research."

The second concerned the goals of future epidemiological and community studies:

> "It has been proposed that a cut-off point (an energy intake less than 1.2 x BMR) could be used to identify individuals where energy requirements are clearly not being met. It is a question for operational research whether a cut-off point of this kind is useful for planning purposes. If it is useful, then more work will be needed to identify the appropriate values of the cut off point for different groups of the population."

3.15 Summary of Part 2. The second part of the historical review covers the years from the completion of the thesis studies until 1988. It reviews:

1) studies which have used similar or identical methods in the study of men and women aged between 50 and 75 years;
2) changes in attitudes towards the methods in relation to their reliability and validity;
3) new developments and improvements in the original methods and alternative methods designed to obtain similar data;
4) new emphases given to body size and body composition measurements in relation to aging and morbidity and mortality from degenerative disease;

5) advances in knowledge of total energy expenditure and its components, basal metabolic rate and physical activity during occupational and leisure or discretionary time as a basis for estimating energy requirements of older adults;
6) advances in knowledge of dietary intake and utilization of energy and nutrients as a basis for estimating energy and nutrient requirements of older adults;
7) the content of some dietary guidelines and their dependence on current concepts of the relationships between dietary components, disease and health;
8) new ways of viewing and expressing energy requirements;
9) studies which focus on individuals and populations that appear to have inadequate levels of energy intake; and
10) advances in knowledge of the processes and consequences of aging beyond the middle years and particularly the interactions between nutrition, physical activity and aging.

CHAPTER 4
SPECIFIC AIMS

4.1 Research questions, specific hypotheses and specific aims.

The literature from which the general research questions arose was reviewed in the Historical Review, Part 1 and was summarised in Section 3.7. The review indicated that there was very little information available on the energy intake and energy expenditure of men and women of over 50 years of age and on the relationships between occupation, total energy expenditure, patterns of physical activity and energy and nutrient intake. There was also some concern about the nutritional adequacy of the diet of men and women aged over 65 years who lived alone.

Among the most important questions were:

1-a) Was there a difference between the total daily energy expenditure of groups of men aged 50-65 who performed hard physical labour during their work hours and those whose work was mainly sedentary? Did this differ from groups of men aged under 50 years?

1-b) Was there a difference in energy expenditure between groups of women who were housewives and those who also worked outside of the home? Did this differ from groups of women aged under 50 years?

2) Was any difference in total energy expenditure between groups almost wholly due to energy expended in occupational activities, the corollary being that there was little difference between groups in energy expended in non-occupational activities? Did this differ from groups aged under 50 years?

3) Did the energy intake of each occupational group reflect the energy expenditure of the group? Did this differ from groups aged under 50 years? Was the intake adequate by commonly accepted standards?

4) Were there differences between the occupational groups in intake of protein, fat, calcium and iron, which were not related to energy intake? Did the intakes meet commonly accepted standards of adequacy?

5) Was there a decrease in the energy expenditure and intake of groups aged over 65 compared to those aged 50-65 years?

6) Were the diets of individuals or groups of men and women who lived alone inadequate in protein, calcium or iron, compared to commonly accepted standards?

Four specific hypotheses were formulated to test the relationships between the variables addressed in the research questions.

Specific Hypotheses

A.1) There will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of mean age between 50 and 65 years between occupational groups of the same sex.

A.2) There will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of the same sex of mean age between 50 and 65 years and comparable groups of mean age of over 65.

B.1) There will be descriptive variations in the time and activity patterns and energy and activity patterns of groups of subjects of mean age between 50 and 65 years between occupational groups of the same sex.

B.2) There will be descriptive variations in the time and activity patterns and energy and activity patterns between groups of the same sex and of mean age between 50 and 65 years and comparable groups of mean age of over 65.

In order to assemble the data base necessary to examine these hypotheses, the following specific aims were chosen:

- to select and study independent groups of normally healthy, free-living men and women whose occupations and lifestyles represented some of the usual patterns of work and leisure of people aged 50 years and over in the Scottish population.

- to obtain a detailed, accurate record of daily activities from each individual for seven days.

- to obtain a detailed and accurate record of food intake from each individual for seven days.

- to measure the height and weight of each individual.

- to measure the energy cost to each individual of a selected group of occupational and non-occupational activities.

- to calculate, from records of time spent each day on activities and measurements of the energy cost of each activity, the mean and standard deviation for each individual and for each group of seven day energy expenditure.

- To calculate from seven day records of weighed food intake and of plate waste, the means and standard deviations for each individual and for each group of the intake of energy, protein, fat, carbohydrate, calcium and iron.

- to derive, from the primary set of measurements, a secondary set of variables relating energy intake to weight and to nutrient intake, energy expenditure to weight, and energy intake to energy expenditure.

- to use appropriate statistical techniques to quantify some relationships between age, occupation, energy intake and expenditure and intake of protein, calcium and iron.

- to describe differences between groups in the distribution of time and energy expended in their reported range of daily activities.

A subsidiary aim of this thesis is to review the findings of the research in the light of current nutritional concepts, most importantly, the concepts developed in the FAO/WHO/UNU, (1985) Expert Consultation on Energy and Protein Requirements.

4Aims/T5

Chapter 5
METHODS

5.1 Introduction. The aim of the research for which the following methods were used was to provide detailed reliable information on the food intake and energy expenditure of small groups of healthy, free-living Scottish men and women whose occupational and non-occupational activities were representative of some of the normal patterns of work and leisure of their age group in the population.

The groups to be studied were selected on the basis of age, sex, level of energy expenditure expected from description of occupation and whether or not they lived alone.

At the time they were made, the studies reported here were referred to as "studies of the elderly". The age group, 55-65 years, was then loosely defined as "elderly". In recent years, the term has been more consistently applied to the 65-75 year age group. Since the majority of our subjects were aged 50-65 years they have been described here as being in "late middle age".

Five groups of women comprising 78 individuals and eight groups of men comprising 93 individuals were recruited and studied for a period of five to seven days during the years 1959-1965.

The methods used to assess the total daily energy expenditure was the factorial method, which is also known as the activity diary and respirometer method. The method used to assess total daily energy and nutrient intake was the weighed individual inventory method.

A full description of the methods of selection and recruitment of the subjects, of assessment of energy expenditure and energy and nutrient intake, together with a review of the limitations and errors of the methods is given in this Chapter.

5.2 Composition of research team. The number and diversity of the tasks involved in planning and executing the studies and in analyzing and interpreting the findings required a large research team. The original members of the team were J.V.G.A. Durnin, physiologist and

Director of the unit, J.M. Brockway, physiologist, E.C. Taylor (née Blake), dietitian, and two laboratory technicians. In the text of the methods section, the first three members are referred to as J.V.D., J.M.B., and E.C.T. With the help of twelve student dietitians, this research team studied a group of housewives and their adult daughters [Durnin, Blake and Brockway, 1957(a) and (b)]. During the studies reported here three dietitians in addition to E.C.T. were employed. When they first joined the group, the dietitians were responsible for the food intake part of the survey only. As they gained skill and experience they also carried out the field work of the energy expenditure studies. Training of new members of the dietetic team took place fairly frequently. Quality control of data collection was ensured as far as possible by close supervision and training for at least one survey. All members of the research group had to be aware of, anticipate and have a plan to minimize the limitations and errors of the methods used. They required the ability to form good relationships with the subjects, to be non-judgemental and to be non-critical of unfamiliar lifestyles. They had to be capable of imparting knowledge and skills and of giving the subjects confidence in the value of the study and in their ability to do what was asked of them. They were also required to supervise the subjects closely and to gain an understanding of their way of life. This enabled them to detect possible errors and omissions in the records, to jog memories effectively about activities or food intake and deal with difficulties or misunderstandings. Good relationships, cooperation and communication between members of the survey team were also very important.

5.3 Selection of groups and recruitment of subjects. Five groups of women and eight groups of men were selected for study. The study group number and the criterion for selection and recruitment appear in Table 5.1. A statistical analysis identification number is also given. This identifies each group in the print-out of original data in Appendix I(a).

5.3.1 Women. Group 1 was selected primarily as part of an investigation of the food intake of elderly women who lived alone made by the Ministry of Agriculture, Fisheries and Food. National Food Survey records had shown that a suspiciously high intake of energy from food had been recorded for women over 55 years of age who lived alone and who took part in the National Food Survey (N.F.S.) in 1953 and 1954. The site of the study was Paisley, a large town about seven miles from Glasgow. Two groups of housewives were studied, one in March and the other in November 1958. These groups were the only ones randomly selected. The selection process was designed to make it comparable with that used by the National Food Survey. A random sample of women aged 60 to 69 was drawn by blocks from the registers of patients kept at the local Executive Council offices in Paisley of the National Health Service. The list of names taken by this means was then checked against the electoral roll in a preliminary attempt to eliminate women who did not appear to be living alone. In the March survey, a letter was then sent to the family doctors of the subjects selected. A short explanation was included of the purposes of the study and each doctor was asked to get in touch with the patient and establish whether she might be willing to take part in such an investigation. A letter was simultaneously sent out to each of the subjects describing the general reasons for the study. The family doctors returned the names of those patients who were provisionally willing to cooperate. These women were visited by J.V.D. and E.C.T., who explained exactly what the survey would involve. If consent was obtained, arrangements were made to begin the study.

In the November survey, the subjects were approached directly without the intervention of the family doctors who, it was thought, might introduce bias by influencing the subject in her decision. Letters were sent to thirty-eight subjects chosen in the same way as for the March survey and they were visited within a few days to explain the study and obtain their consent. Ten women were studied in March and seven in November, 1958.

The subjects in Group 2 had all volunteered to take part in studies of food intake and energy expenditure, which were being planned by J.V.D. They responded to an appeal for women aged fifty and over, which accompanied a newspaper article on the results of previous studies of middle-aged housewives and of women who lived alone. These volunteers were more representative of their age group than Group 1 who lived alone, in that the majority lived with families of varied size. The principal aims of the measurements made on this and subsequent groups was to examine the relationships between age, occupation and energy requirements of healthy women and men aged 50 years and over and to describe and compare the patterns of activity characterising the groups. All the women of Group 2 lived in the Glasgow area. Each potential subject was contacted by letter after her initial telephone call or letter to us. She was then visited at home to explain the study and to give her the opportunity to withdraw or consent. The women were studied in two groups, nine taking part in the study in February and the other twelve in September, 1959.

The women in Group 3 were employed by Singers, a sewing machine factory in Clydebank, near Glasgow. They were employed in assembling, packing and finishing sewing machines. They and Group 4 were selected to represent middle-aged and "elderly" (defined at that time as 55-65 years) women working in a variety of occupations in light industry. The majority of their occupational activities were expected to fall in the range of light activity (<3.5 kcal/min/55 kg woman) [Table 5.2, and Durnin & Passmore, 1967]. The details of the study were explained to potential subjects either at work or at home and their consent then sought. The survey was made in August, 1964.

The women in Group 4 were employed by Beatties and Bilsland Bakery in Glasgow. Their age was similar to that of the women in the Singer Factory. Recruitment was arranged through management, personnel and unions and a recruitment meeting was held. All potential subjects were later interviewed at work or at home. The group was studied in January, 1965.

The four older housewives comprising Group 5 were drawn from Group 2 volunteers, who were not used for that study. They took part in a study of investigator variability and its effect on the results of the individual weighed inventory method of assessing food intake (Durnin, J.V.G.A. and E.C. Blake, 1962). They have been included for comparison because they were an older group and their food intake over a period of eight days was very carefully monitored.

5.3.2 Men. The men of Groups 6 and 14 were working farmers from the Crieff area of Perthsire. Their farms included a large hill sheep farm and arable farms of 100 to 400 acres. The group was selected and studied during a busy season because many activities involved in farming were expected to require heavy physical effort in the range of 7.5-9.9 kcal/min/65 kg man and some in the very heavy range of 10.0-12.4 kcal/min/65kg man. [Table 5.3 and Christensen (1953)]. It was also expected that the total daily energy expenditure of the farmers would exceed that of other groups of men who had been previously studied (a description of these groups follows).

All the men were studied during and immediately after the harvest in 1965. Group 6 is made up of twenty-two farmers in the 50-65 age range and Group 14 of five farmers who were over 65 years of age.

Groups 7 and 8, steel workers and building workers, were selected because their occupations involved periods of hard physical labour during which their energy expenditure was expected to fall into the moderate-heavy work classification of 5.0-9.9 kcal/min/65kg man (Christensen, 1953 and Table 5.3). The steel workers were recruited by contacting a management representative of Stewarts and Lloyds, a steel and tube works in Mossend, Lanarkshire by letter, by telephone and personally. He agreed to cooperate in a study and through the Personnel Department gave us the names of a group of men aged fifty and over whose work fell into the requested category. A meeting was set up to explain the study in detail to the men, to management and to union officials. Those who volunteered were given more details and arrangements made to visit wives and other family members whose agreement and cooperation would be necessary. All the volunteers were first-hand melters. They were an elite group of men, each of whom was in charge of a blast-furnace and the crew which serviced it during an eight-hour shift.

The building workers were employed by Glasgow Corporation and worked on a large housing site in the city. The names of men who were eligible for the survey were obtained from the Corporation Personnel Department and a recruitment meeting was arranged at the worksite. Further explanation and home visits were arranged with the volunteers. Men of this group were plumbers, electricians, plasterers, joiners, a scaffolder and a "heavy squad" laborer. Nine steel workers were studied in March, 1959, and nine building workers in October, 1961.

The men in Groups 9 and 10 were employed by Singers sewing machine factory in making machine parts and by British Leyland's Albion Motor Works in Glasgow in making parts for and assembling motor lorries. They were selected because their work did not involve much physical labour and most of their activities were expected to be in the light to moderate activity category of 2.0-7.4 kcal/min/65 kg men, (Table 5.3). The initial contact was made with the permission of management and unions. Volunteers aged 50 years and over were solicited, one or several recruitment meetings set up and arrangements made to do home visiting. The occupations represented included fitters, turners, setters, machinists, drillers, wood workers, and painters. Twelve workers from Singers were studied in October, 1960 and twelve from Albion Motors in April, 1960.

Men in Groups 11 and 12 were employed by Glasgow Corporation Transport Department and Glasgow Corporation Building Department respectively. Men in executive positions and in clerical positions were selected because the majority of their occupational activities were expected to be in the sedentary to light category of activity of 2.0 - 4.9 kcal/min/65kg man), (Table 5.3). The procedure for contacting the men was the same as in the other groups. The executives were based in the main offices in the centre of Glasgow while the clerical workers had temporary offices at the same building site as Group 8.

Ten executives were studied in May, 1961. They were mainly heads of various departments. Nine clerical workers were studied in October, 1961. They were employed as time keepers and clerks.

Group 13, the retired men who lived alone were contacted through the Glasgow Branch of the Old People's Association. The study was explained at two meetings of local branches and men of 65 and over who lived alone were asked to volunteer. This older group was recruited to furnish us with some data on the energy requirements of retired men of over 65 years for comparison with our studies of employed middle-aged men. Men who lived alone were thought to be at risk of nutritional deficiency. Nine retired men were studied in March, 1961.

Five farmers over 65 years of age made up Group 15. They were studied at the same time and in the same area as the middle-aged farmers of Group 6.

5.3.3 Recruitment and compliance incentive. No payment or incentive was offered to the subjects. Each participant received a personal letter at the beginning of the study asking for his or her cooperation and a letter of thanks at the end. These were on University of Glasgow stationery and signed by Professor J.V.G.A. Durnin. They were often much prized and shown with pride to friends and neighbors because of the high esteem in which the University was held. Every effort was made to impress upon the subjects that they were part of a very important research project with implications far beyond Glasgow and that their cooperation was essential to its successful outcome. It was also made clear to them that they had the full support of the management, the union and their peers at work. The absolute confidentiality of the data obtained from them was also stressed. This was particularly important at the worksite where activity records might reveal unofficial "breaks" and at home where consumption of alcohol was a confidential matter.

One factor which limited the number of subjects who could be studied was the availability of transport. The field workers had only one van at their disposal. Travel by public transport was very time consuming.

5.4 Measurement of energy expenditure. The assessment of the total daily energy expenditure was made by the factorial method, which is also known as the activity diary and respirometer method. The subjects completed a daily activity diary and the metabolic costs of specific activities were measured by indirect calorimetry with the Max Planck or Kofranyi/Michaelis (K.M.) respirometer (Kofranyi and Michaelis, 1940, Muller and Franz, 1952). The number of minutes spent in each activity was then multiplied by the energy cost of that activity and the totals summed to give total daily energy expenditure.

5.4.1 Activity diary. Each subject recorded his or her activities during twenty-four hours of the day for five to seven days including the weekend. The records were made on daily diary cards which were similar to those described by Garry, et al., (1955) and had been used by the principal investigators including E.C.T. in a previous study (Durnin, et al., 1957). Each card was a minute by minute record of all activities during 24 hours. A symbol, for example "ST" for standing, was entered at the time each different activity was begun. The cards were easily folded in concertina fashion and fitted comfortably into a pocket or handbag. On the day before the activity record began each subject was given two diary cards and was carefully instructed in the use of the symbols. He or she was asked to fill in the card as each new activity was begun, to time the activities accurately and to make up symbols if necessary. All subjects were urged to have the diary with them at all times and to maintain their usual pattern of activity. The field staff made it as clear as possible that they would accommodate to the subjects' activities and visit at their convenience. The diaries were checked daily by the dietitian assigned to the subject or by J.V.D. or J.M.B. at work or at home. Errors and omissions were rectified and difficulties and misunderstandings resolved. The subjects were observed during their daily work and leisure activities to gain some knowledge of the normal pattern of these activities and their variability. Several measurements were made of each important activity to allow for this variability. Men in the sewing machine factory were observed for two days without their knowledge and the activity records obtained were compared to their own diary records. Members of the team were always present at the worksite to observe the type and duration of the activities of the subjects.

5.4.2 Measurements by indirect calorimetry. The energy expenditure of the individual subjects in their principal activities (sitting, standing, walking, activities at work and housework) and significant leisure pursuits was measured by indirect calorimetry using the K.M. respirometer. Two or three measurements were made of each activity at different times of the day or on different days. There was a "run-in" period of at least five minutes or as long as was necessary for the subject to become accustomed to the apparatus. Respiratory volume was then measured for about 10 minutes and aliquot samples of expired air collected. The work performed during the measurements was as nearly representative of normal (observed) performance as could be arranged. Care was taken to ensure that the subject was comfortable and not restricted in movement by the respirometer. For some sitting activities the "K.M." was set on a table beside the subject. If there was the possibility of the machine sliding up when the subject bent over, an extra strap was tied across the chest. Estimates of the energy expended in activities which could not be measured were made by J.V.D. based on the subject's weight, knowledge of the manner of their particular activity and of the other measurements of their energy output. The energy expenditure during sleep was taken to be equivalent to the basal metabolism estimated from Fleisch's (1951) tables as recommended by Passmore and Durnin (1955), and used in studies of young male students (Durnin and Brockway, 1959) and of middle-aged and young women (Durnin, et al., 1957).

5.4.3 Collection and analysis of samples of expired air. Samples of expired air obtained while the subjects were wearing the K.M.

respirometer were collected in butyl-rubber bladders and stored in canisters, which also contained expired air, to minimise diffusion of gases across the rubber. The bladders were then transported as quickly as possible (30 minutes to 2 hours depending on the number of measurements being made) to the laboratory. The oxygen present in the samples was measured by means of a Beckman E.2 paramagnetic oxygen analyzer. Carbon dioxide was measured by a Godart infra-red analyzer. From the results of these analyses, the energy cost of each activity was calculated using the formula developed by Weir (1949). This was based on his finding that with a 10 percent intake of protein the energy value of each litre of expired air was one-twentieth of the difference between the percentage oxygen concentrations of the inspired and expired air.

5.4.4 Maintenance and calibration of the instruments. Durnin and Brockway (1959) stated that it was not sufficiently realized that Max Planck (K.M.) respirometers could be used satisfactorily only if they were regularly serviced and calibrated. The methods used for calibration and maintenance have been described fully in their paper and were used in these studies. All new members of the team were instructed in the importance of there procedures. The main points of the maintenance schedule were that the pump and counter be regularly inspected and oiled, that moisture should be regularly drained from inside the bellows and that inspection for corrosion should be done after prolonged use. It was found that the calibration supplied by the makers was never accurate and an ingenious method of re-calibration was devised by Durnin and Brockway. This resulted in a calibration chart of correction factors to be used at volumes of flow ranging from 5-60 litres per minute for each respirometer. The Beckman and Godart analyzers were frequently checked using duplicate samples of a known gas mixture with the Haldane gas-analyzer as the standard. Gas analysis and calibration of the instruments was carried out principally by J.M.B. and two very experienced laboratory technicians.

5.4.5 Accepted limitations and rationale for use of the method. The objective of the method was to provide an assessment of the total energy expended during a 24-hour day by individual subjects over a period of several days during which energy intake was also being measured. Both measurements (i.e., energy intake and energy expenditure) were considered in making the decision on how many days would be required to obtain a good estimate of energy requirements, to find the degree of agreement between the two methods and to maximise subject compliance. Durnin (1957) had shown quite large differences (often 20-30% of the totals) between energy intake and energy expenditure of an individual on any one day. The results of both measurements could have been correct, but there was no way of finding "the truth". Edholm, et al., (1955) had found that the energy intake did not seem to be related to the energy expenditure of the previous day or that of two days previously. These findings indicated that for a subject who was assumed to be in energy balance, regulation of the balance did not take place within a period as short as three days. Durnin (1959) concluded that "over a period of a week or longer, it is likely that the normal healthy man living a steady routine life is in approximate calorie balance". For groups, errors in both measurements are likely to be random and it was reasonable to assume that taken together they would almost certainly provide a good estimate of the energy requirements of the group during the week of study. Although a measurement period of longer than seven days or a repeat study of the same group would have given more assurance that a measure of true energy needs was being obtained, a seven day study achieved the balance of desirability and feasibility necessary in such an intensive type of study.

Opportunity for error was present amongst subjects, observers (field staff), laboratory staff and in the instruments used. Several studies, which thoroughly tested all aspects of the techniques used, analyzed possible sources of error, established methods for calibration of the respirometers and ensured reliable gas analysis had been carried out (Durnin and Mikulicic, 1956; Durnin and Edwards, 1955; Durnin and Namyslowski, 1958 and Durnin and Brockway, 1959). Field studies using the techniques had been made on men (Garry, et al., 1955); and women (Durnin, et al., 1957). Sources of error had been identified and the method altered to minimize them. Types of subject error anticipated included failures in recording the duration of activities accurately, in defining activities and in behaving "normally" while energy expenditure was being measured.

There was also the possibility of unknown change in pattern of activity occasioned by the study. A critical concern of Durnin and Brockway (1959) was whether measurements of the energy cost of an activity made during short period of time were representative of the energy expended during many hours of the same activity. They conservatively estimated the actual error of the method to be at least 5 percent. This was considered to be acceptable for the purposes of the study. The validity of the method was uncertain because there was no method of known accuracy against which to standardize it. An estimate of the amount of difference which could be expected between measurements of energy intake and expenditure was made while the studies were in progress and using data from one of them and from previous studies. Data from seventy eight men and women were analyzed by Durnin and Brockway (1959). They found considerable discrepancy between the methods (r=.069 for all subjects combined). The authors concluded "It is a moot point at present which is the most accurate determination. The considerable size of the difference should be kept constantly in mind". Previous experience suggested that with careful instruction, supervision and checking, the activity diary was an accurate (valid) record of 24-hour activities. Similarly the accuracy of the measurements of the energy cost of each activity was achieved by meticulous attention to maintenance and calibration of the respirometers, skilled field staff to make the measurements and skilled laboratory staff to do the analysis. However, there was no certainty that accurate 24-hour records of activity for seven days of the year would predict activities during any other seven day period nor whether several short measurements of each activity were representative of the energy cost over the total duration of the activity during the week.

It was thought likely that subjects in the 50 years and over age groups would have a relatively ordered and predictable pattern of activity, thus increasing the reliability (repeatability) of the measurement. The method was judged to be a reasonable way of meeting the objective of the energy expenditure part of the study as long as the investigators gave constant attention to detail, appreciated the limitations of the method, and were alert to the areas in which error was likely to arise.

5.5 Measurement of food intake.

5.5.1 Weighed individual inventory method The food intake of all the subjects was measured by the weighed individual inventory method described and used by Widdowson (1936), Garry et al., (1955) and Durnin et al., (1957). In this method the food prepared or cooked by the subject is weighed immediately before consumption and plate waste is weighed and subtracted at the end of the meal. Energy and nutrient intake is calculated using tables of food composition.

On the day before the survey was due to begin a dietitian visited the subject at home. She explained to him or her or the relative who would be responsible for the food record how to use the balance to weigh foods and the method of entering weights in the log book. Each dietitian used a standard sheet of instructions to minimize error due to inconsistent or incomplete instruction. The logbook had eight detachable pages for recording the location and times of meals and the type and quantity of food eaten. The pages were printed in such a way that code numbers, which corresponded to individual items in the computerised tables of food analysis could be entered opposite each food. Subjects were asked to weigh each food separately, to describe composite dishes and to note the ingredients of recipes. Duplicate samples of foods eaten away from home were later bought and weighed by the dietitian. A small notebook was provided to record foods eaten outside of the home together with a sheet of simple instructions for reference. Canteen-bought meals were weighed by a dietitian. Some subjects took their spring balances with them when they went visiting. The balance, which was regularly calibrated, was a Salter spring balance weighing to 32 ounces in 1/8th ounce gradations. To avoid confusion, the accompanying gram scale was obliterated. The subjects also received two flat plastic plates to use as scale pans, three or four covered plastic containers for butter or margarine, sugar, jam and marmalade and two plastic measuring jugs, one of clear plastic for measuring and storing milk and one of opaque plastic for weighing fluids such as soup. The individual pots were first weighed with the lids on and then filled with butter, etc. Weights of the empty scale pan, pots, lids and jugs were recorded in the subjects' log books. The subjects were asked to weigh the pots each day at the same time, preferably last thing at night and refill them if necessary. Some subjects preferred to leave this task to the dietitian on her daily visit. It was stressed that the pots were for the exclusive use of the subject. Beer and other alcoholic drinks were recorded in pints or fluid ounces.

During the daily visit, the dietitian checked the food record for the previous 24 hours, enquired about plate wastage and obtained any further details of cooking methods and ingredients necessary to assign the food codes, which most closely corresponded to the foods consumed. Each dietitian coded the food records of "her" subjects.

It was continually impressed on the subjects that any change in their eating habits would adversely affect the whole study. Subjects were not asked to begin the food record and the activity record on the same day if they were responsible for both. When the food intake had been recorded for one day and the subject was comfortable with the technique, the activity diary was begun. Where a relative recorded the food intake, the activity record was begun on the same day.

5.5.2. Limitations and errors of the method and rationale for using it.

The objective of the method was to provide an assessment of the total intake of energy, protein, fat, carbohydrate, calcium and iron of individual subjects over a period of time during which an assessment of their total energy expenditure was also being made. The major objective of the studies was to determine the energy requirements of men and women of fifty years and over. It was accepted that the energy value of the food intake gave some measure of the actual energy requirement although Durnin and Brockway (1959) cautioned that "at the present time we are rather apt to ignore the errors inherent in dietary surveys and to accept uncritically the determination of energy intake as a standard of reference for determinations of energy expenditure." The simultaneous assessment of energy expenditure in the majority of our studies made it possible to test the degree of agreement between the measures, while bearing in mind the limitations of the energy expenditure measurements. Because an assessment of current food intake was required, the method of choice had to be one which would ensure that the subject would cooperate fully in providing accurate information. The precise weighing method, where aliquot samples of each food are analysed, was not feasible because of the demands placed on the subject by the energy expenditure part of the study. The best alternative was the individual weighed inventory method in which all the principal investigators had previous experience and which was considered the best available technique for field studies of small numbers. Interview methods, such as a 7-day recall of dietary intake or menu recording where foods are not weighed, were not considered. The choice of seven days as the study period has been discussed in the section in measurement of energy expenditure. The period had been used in several previous studies and had proved to be well-tolerated by the subjects. At the time when our studies were being planned and executed there already existed an extensive literature on comparisons of dietary survey methodology. Becker, Indik and Beeuwkes (1960) in their review "Dietary Intake Methodologies" cited 250 references which addressed the many limitations and errors of the method. Young and Trulson (1960) considered "the reliability or error variation in collecting and processing dietary data" and the validity of the measurement. They concluded that the primary problem was to evaluate how accurately any method of collecting information measures dietary intake when biases introduced by respondent error, observer error and instrument error are present to varying and unmeasurable degrees. They expressed the concern of many investigators that the data collected for a short period of time, no matter how accurately measured, may not be representative of the characteristic diet of an individual over a longer period of time. The error of the method was, and is, difficult to estimate but with cooperative subjects, experienced and aware dietitians, little alteration in normal eating habits induced by the study and careful use of the best food composition tables available, it was assumed to be not more than 5-10 percent. This level of error was considered acceptable in meeting the objectives of the energy intake part of the study.

5.6 Measurement of height and weight. Subjects were weighed and measured once during the course of the study using standard pressure scales. They were weighed in light indoor clothing without shoes using a portable metre stick. An average weight for indoor clothes (without shoes) of 2.2 kg for men and 1.5 kg for women was subtracted from the measured weights in calculating the Quetelet index or Body Mass Index (BMI) [weight without clothes and shoes/height: $W(kg)/H^2(M)$] (Keys, Fidanza, Karvonen, Kimura and Taylor, 1972; Bingham, McNeil and Cummings, 1981;).

Some anthropometric measurements were made on the farmers and female factory workers, but these have not been included in this analysis.

5.7 Analysis of data. Two sets of findings for individual subjects formed the data base which was used to examine the specific hypotheses and to address the research questions. These were obtained from the daily activity diaries of the majority of the subjects and the results of the analysis of the seven-day food intake records of all the subjects.

5.7.1 Daily activity diaries. These listed the minutes spent each day in each activity together with the measured or estimated energy expended per minute in each activity. Estimates of the energy cost of some activities made by the senior investigator were based on previous measurements and were usually scaled according to weight.

The energy cost of each activity per minute was multiplied by the number of minutes spent on it each day to give the total daily energy cost of each activity. The total energy expenditure each day was the sum of all the activities. The mean of the energy expenditure for each subject over the seven days of measurement was obtained. Some of these calculations had been made previously, but all were recalculated by the author to ensure complete consistency. The mean energy expenditure in kilocalories per day for each individual was used in the statistical analysis which is described later. The time in minutes and the energy in kilocalories spent per week by individuals in each activity were summed and a mean daily value obtained for each group.

These data were used to calculate the percentage of time and energy spent in each activity by each group per week. They were also regrouped into categories consistent with those used in the report of the FAO/WHO/UNU (1985) Expert Consultation on Energy and Protein Requirements and mean daily values of the time in minutes, energy in kilocalories and the percentages of daily time and energy calculated. These categories are further described in relation to the results in section 6.4. Histograms of the time and energy profiles of these categories together with those of individual activities were made using the Macintosh Chartpack program.

To address the subsidiary aim of the thesis, which is to review the findings in the light of current nutritional concepts, further analysis of the data was made based on concepts developed in the FAO/WHO/UNU Consultation report. These analyses appear in the Discussion section.

The prediction equations proposed by the Consultation, namely 11.6 W + 879 for individual men aged 30-60 and 13.5 W + 487 for men of over 60 years and 8.7 W + 829 for individual women aged 30-60 and 10.5 W + 596 for women of over 60 years, were used to obtain the BMR of each subject.

Factors for total energy expenditure were derived by dividing the mean daily energy expenditure of each individual by these BMR values. Means and standard deviations were calculated for each group. Factors using the BMR values calculated by the Fleisch (1951) method were also computed for comparison. The Basal Metabolic Rate of each subject calculated from the prediction equations, and the factors for total energy expenditure and total energy intake based on these form Appendix III.

Total energy expenditure factors using the BMR values calculated by the Fleisch (1951) method were also computed for comparison.

Factors for the energy cost of physical activity for groups during occupational and non-occupational time were derived from the ratio of the mean energy expended by the group to the mean BMR of the group during these periods of time.

Also calculated were the fractional portions of the total energy expenditure factor which were contributed by occupational and non-occupational physical activity.

5.7.2 Food intake records. Mean daily energy and nutrient intakes for individuals and groups were obtained from the food data using calculating machines and a series of programmes developed for the English Electric KDF 9 computer (Durnin and Wheatcroft, 1965). The food analysis programme was based on the third edition of the food composition tables of McCance and Widdowson (1960). Net energy values of 4, 9 and 3.75 were assigned to protein, fat and carbohydrate respectively. Calcium and iron were the only additional nutrients studied. Calculation of the vitamin content of the diet was not attempted as the methods were not specifically designed for such measurements. In the light of new data on the varied number of days necessary for valid information on various nutrients, especially vitamins, this was a wise decision (Historical Review, page 22).

These food tables incorporated the average nutrient content of cooked items of food and of dishes containing more than one ingredient such as pies, stews and puddings. Standard recipes for these items were included in the book of food tables. The subjects' own recipes were used where these differed from the food tables. Nutrient analyses of foods which were popular in the area, but did not appear in the tables, were obtained from the manufacturers and incorporated in the computer programme.

No reanalysis of this set of data was undertaken, since the original food records could not be found and it was used in the statistical analysis.

Earlier calculations which appear in papers published jointly by the author and other members of the research team were made with calculating machines and programmes developed for the DEUCE computer. The same edition of the food tables was used. At that time no software package for food data analysis existed. The preparation of programmes for DEUCE and the changeover to KDF9 was extremely time consuming (Taylor, 1970).

The results of the energy and protein intake analyses, in common with the physical activity data, were further analysed in the light of the concepts developed in the FAO/WHO/UNU Consultation report. Factors for total energy intake were derived by dividing the mean daily energy intake of each individual by the BMR values obtained from the prediction equations. Means and standard deviations were calculated for each group. Total energy intake factors using the BMR values calculated by the Fleisch (1951) method were also computed for comparison.

Group normative energy requirements were derived from BMR at desirable weight for each group multiplied by the mean group total energy expenditure factor at actual weight.

The safe level of protein intake defined as the average requirement plus two standard deviations was calculated for each group.

5.7.3 Statistical analysis. These analyses were made using the Control Data Corporation CYBER computer at the University of Washington, Seattle. The software used was the Statistical Package for the Social Sciences (SPSS) Version 9 (Vogelback Computing Center, Northwestern

University, 1984). Data was entered on a Macintosh Plus desk top computer and downloaded to the mainframe computer. For the purpose of statistical analysis, groups were distinguished by occupation, sex and age. The occupational groups were independently selected from the Scottish population. The selection process also allowed for automatic separation of the groups by sex and age.

In order to test the hypothesis that there were differences in energy expenditure, energy intake and intake of nutrients between the various groups, Mann-Whitney U tests were used. The Mann-Whitney U is a common non-parametric statistical test for differences in rank order between groups. Because, in general, the numbers of subjects in the groups tended to be small, assumptions regarding the shape of the distributions could not be made prior to data analysis. For example, outliers such as one or two very high or very low values could affect the outcome of analysis by influencing the mean values in a parametric test.

In order to control for confounding of the independent variables of occupation, sex, or age, comparisons were only made between groups when two of the three independent variables were held constant. For example, to compare energy requirements by age, male farmers aged 50-65 were compared to male farmers aged 65 and over.

For analyses that required a measure of the degree of association among variables, Pearson Product-Moment correlations were used. The Pearson r assesses intercorrelations using an interval scale of measurement, and was considered appropriate for the dependent variable data. For example, a Pearson r was used to assess the degree of association between measurements of energy intake and measurements of energy expenditure.

The primary variables used in the analysis were:

Study number, subject number, age, height in centimetres, weight in kilograms, body mass index, mean daily protein intake in grams, mean daily fat intake in grams, mean daily carbohydrate intake in grams, mean daily calcium intake in milligrams, mean daily iron intake in milligrams, mean daily energy intake in kilocalories, mean daily energy expenditure in kilocalories, and Basal Metabolic Rate calculated after Fleisch (1951) in kilocalories per minute.

The computer print-out of the primary variables for each subject forms Appendix I(a).

Derived variables computed from these were also used in the analysis. These were:

The ratio of energy expenditure to weight, the ratio of energy intake to weight, the average of energy expenditure plus energy intake, the ratio of energy expenditure to Fleisch BMR, energy intake minus energy expenditure, the ratio of protein intake to weight, the ratio of protein intake to energy intake per 1000 kilocalories, the ratio of calcium intake to energy intake per 1000 kilocalories, the ratio of iron intake to energy intake per 1000 kilocalories.

The computer print-out of the derived variables for each subject forms Appendix I(b).

CHAPTER 6
RESULTS

6.1 Subjects

6.1.1 Response rate. Random selection of subjects was attempted in only one group, housewives who lived alone. These subjects were selected in two groups, one in March and one in November, as described in 5.3.1. Of the first sample of 34 names drawn, 13 women were unsuitable, either because they were not in fact living alone or else because they intended to spend a large part of the week away from home. Eleven were unwilling to participate, so that 10 (almost 50 percent) cooperated. The positive response from the second sample was similar. When those who were not living alone (3) or were seldom in (7) or were seriously ill (4) were eliminated, the positive response was again about 50 percent, i.e., 13 out of 24. Six of these women were not studied by the weighed individual inventory method and their results have not been reported.

6.1.2 Compliance. The compliance of all groups with the study protocol was excellent. The only groups in which fewer than seven days of energy expenditure were recorded for some subjects were the housewives who lived alone, of whom three provided records for six days and three for five days, and the executives, of whom one had a heart attack on Day 6 of the study. Each abbreviated record included the weekend.

Activity diaries were kept meticulously in most cases and daily checking at work and at home ensured that few large errors were made. Three men who were unskilled labourers at a building site were poor subjects, but our practice of daily visiting by a dietitian made it possible to use their records. Daily visits of the investigators did not appear to disturb their routine in ways which would greatly affect energy expenditure.

Independent records of the activities of men in light industry were made by one of the investigators unknown to the subjects. While the duration of each short period of each activity was not always compatible with the independent record, the total time spent over the working period on each activity was not significantly different between the records of the subjects and of the observer. All subjects were able to accustom themselves to the K-M respirometer during various activities in spite of initial hesitation.

Record-keeping was most difficult for men and women who lived alone and for women. These groups, unlike men who lived with their wives, had to keep both food intake records and activity diaries. Little difficulty was found with the techniques of weighing and recording.

No subject apart from those previously mentioned was unable to complete the study. It was not possible to assess alterations in food purchases and food intake caused by the study.

6.1.3 Social class, health and living conditions. No attempt was made to select subjects by social class. The choice of occupations ensured a reasonable representation from classes 2 to 5, namely from unskilled worker to head of department within a city office (or the wives of men in such occupations). The majority were in Social Class 3.

A few pathological conditions were detected by questioning. Three elderly female subjects had arthritis, one mild Type II diabetes, and two minor heart conditions. All were willing and able to complete the survey.

Housing conditions varied considerably from one-room flats with outside toilets to five-room detached houses in good areas. Two- and three-room flats and houses, some owned and some rented from the local authority, were most common. Homes of farmers were also varied. The majority were well-kept and comfortable.

The main domestic aids were vacuum cleaners and electric irons. A few subjects had washing machines but these had hand-operated wringers. There were no dryers, dishwashers or automatic irons. Few households owned a refrigerator. Grass was cut by hand mowers in urban areas.

If there was a car in the household, it was not necessarily used routinely for shopping or going to work. Only the farmers drove regularly.

The number of additional people in the household also varied from none to a maximum of three, namely husband or wife and two teenage children.

Except for one woman in the "older women" group, all were the male and female heads of their households. No information on income was sought and none was offered.

Those subjects who were not employed received pensions, some from former employers, in addition to the old-age pension.

6.1.4.1 Occupational and non-occupational activities of men. Occupational activities. The criteria for selection of these groups based on the type of activities at work are given in Section 5.3. The two groups of farmers, those of 65 years and under and those of 66 and over, were all working farmers. Their farms included a large hill sheep farm and arable farms from 100 up to 400 acres. Two were primarily shepherds. They were studied immediately after harvest time and many of their activities required heavy physical effort. The least physically demanding tasks included tractor and combine harvester driving. Stacking bales of straw, forking sheaves, shovelling and loading were time-consuming activities at that time of year, as were various tasks associated with the potato harvest. Routine maintenance around the farm often involved heavy labour and such tasks included the repair of fences and stone dykes and digging. The care of sheep and cattle also involved heavy work and walking over fields and hillsides for long periods of time made a large contribution to total energy expenditure.

The nine steel workers were said to have one of the most physically energetic jobs in their steel works. They were first-hand melters, i.e., they were each in charge of a blast furnace which smelted the steel, and they ensured that the furnaces were kept in a good state of repair. This occupation involved occasional periods of very hard physical work shovelling large quantities of dolomite, in the form of gravel, into the furnaces, during which the men were exposed to high temperatures. The total period of this heavy labour, however, represented less than 1 hour per 8-hour shift, and during the investigation, because of a temporary recession in the steel industry, the men did only four shifts per week.

Two groups make up the light industry group of 24 men. The men working in the factory assembling motor lorries undertook a variety of jobs similar to those of many industries using the conveyor-belt system. The subjects were employed in the manufacture of gearboxes for the lorries and were skilled or semi-skilled mechanics of differing types. The work was mostly done standing up and did not involve much hard physical labour. Four were fitters and one a turner--these occupations were skilled--while the remainder--drillers, straighteners, a spray-painter and a setter--were unskilled.

The men who worked in the sewing machine factory did jobs of a character similar to those of the men in the factory producing motor vehicles. They were skilled or semi-skilled workers producing parts for the sewing machines or inspecting and servicing the machinery. They did little heavy physical work and most of the work during the shift was done standing at the bench, although one or two had jobs which permitted working in a sitting position. Four were fitters, two setters, one a die-sinker, and two machinists--these were all skilled occupations. The remainder were semi-skilled--a buffer and two machine operators. Some of the subjects in the two light-engineering factories had a full working day which allowed little time for rest pauses, but this was not always the case.

The fourth group of nonsedentary workers studied, the building workers, was employed by the Housing Department, and they worked at two sites on the outskirts of Glasgow. Six were skilled workers --foremen electricians and plumbers, a plasterer, and a scaffolding erector. Two men belonged to the "heavy" squad, a term which did not necessarily indicate the energy expenditure of the subjects, and one was a handyman.

The executive office workers were mainly the heads of various sections of Glasgow Corporation Transport Department.

The clerical office workers were employed by Glasgow Corporation Housing and Works Department. Two worked in the main office in the city and six worked on building sites as timekeepers and cost clerks.

The work of the retired men was a range of domestic responsibilities.

Non-occupational activities. None of the urban groups differed from the others in the form of their leisure activities. A few men had cars or motorcycles which they cleaned occasionally and repaired; most did a variety of work in the house, from fetching coal to painting and papering. Three men worked in public houses for two or three evenings weekly. Three played bowls, one did a little swimming, one cycled, two danced, and one played golf regularly on Sundays. Gardening was a pastime for seven men and may have been recorded by others if the surveys had been done at other times of the year. The most popular leisure time activity, however, was sitting, either reading or watching television or, in the case of the retired men, playing cards and singing at their club.

Since few men had cars, walking was an important part of transport to work or to social pursuits. Only one retired man went on long walks on a regular basis.

The leisure activities of a few of the younger farmers included active pursuits such as curling and country dancing. Most were similar to those of the other groups and included car washing, playing with children, going to church and to public houses, and a woodwork class. The older farmers did little apart from their farm work during the study period.

All the groups of men recorded some time given to housework. The steel workers reported most (66 minutes/day), perhaps because their working week was curtailed, but the average was about 15 minutes/day.

6.1.4.2 Occupational and non-occupational activities of women.

Occupational activities. Of the housewives who lived alone, ten were single women who had retired from their occupations, nine as workers at the local Paisley thread mills and one as a nurse. In addition to maintaining their homes, three women had part-time jobs as cleaners and, except for three who suffered from arthritis, had many activities including full social lives.

The housewives living with their families had more domestic responsibilities, and seven had paid employment outside of the home. Their jobs were diverse: one supervised the running of her small hotel, one was a seamstress who had her own small shop, one acted as a chemist's assistant for 3½ hours each evening, one worked full time in a lawyer's office, one spent about two hours weekly in her husband's gown shop, and another served for six hours a day in a canteen in British Railways. Of the four older women, one was 81, lived with her daughter and had few domestic responsibilities.

The 20 women who worked in the sewing machine factory were mainly engaged in sitting and standing activities. There were three clerkesses, two inspectresses, three finishers, three packers, eight assemblers, and a supervisor.

The 16 women who were employed by a bakery included seven whose jobs involved lifting and pushing loads and doing heavy cleaning and sweeping. The majority of occupations consisted of sitting and standing activities. Three women were clerkesses, three were machine workers, and 11 had various bakery tasks including working in the canteen.

Non-occupational activities. A wide variety of activities was undertaken by all the groups of women including golf, dancing, visits to the cinema, playing cards, amateur dramatics, visiting or being visited daily by family and friends, and looking after grandchildren. Some also bowled, gardened, and went to church. Two women painted their houses and one enjoyed rug-making. All the women shopped and some of this time may have been spent in recreational shopping but this was not distinguished in the records. Walking was associated with many social activities including playing with grandchildren.

6.1.5 Summary. In employment, activities, health, housing, social class and income, the subjects were typical of the majority of late-middle-aged and elderly people in Scotland in the 1960s.

Some women were full-time housewives, some had additional full-time or part-time paid employment. Some of the employed men had a second job. The retired men were solely responsible for their own households. Some men and women were single, some married and some widowed.

Most appeared to be fit and "active" in the sense of having many interests, although none engaged in regular exercise or sports.

Their food intake and activities did not appear to be unduly restricted by lack of money or by disability resulting from aging.

Their energy intake could be viewed as that of normally healthy people of their age group with typical patterns of activity.

6.2 Anthropometry

The data on age, height, weight and BMI for each group of men are presented in Table 6.1 and for women in Table 6.2. The differences in these variables between groups were measured by pairwise comparison of the groups by means of the Mann Whitney U test. A significance level of $p \leq 0.05$ has been used for all results. The results of these comparisons are summarised in Appendix I, Tables 1 - 13.

Comparison of all groups of men showed that the age of the light industry workers was significantly greater than that of all but one (executive office workers) of the other occupational groups. This is explained by the age range of the group (Table 6.1). It also showed that the age of the older farmers and retired men was significantly different from all the other groups.

In the groups of women, the housewives who lived alone were not significantly different in age from the older housewives but both these groups were significantly older than the other three groups.

Comparison of the groups of men on the basis of height showed that both groups of farmers, the executive office workers and the steel workers were significantly taller than the other groups. None of the groups of women was significantly different in height from any other and all groups were significantly smaller than all groups of men.

Comparisons of the differences in weight between the groups of men confirmed that the farmers and steelworkers were significantly heavier than all groups except the building workers. In both groups the range of weight was greater.

The mean weights of the groups of women were very similar but comparisons showed that the women who worked in the sewing machine factory were significantly heavier than the housewives with families.

The means of BMI for all groups of men (Table 6.1) showed that the executives had the lowest BMI (22.6 ± 3.2.) This was significantly lower than the old and younger farmers and the building workers. The building workers had the greatest BMI, and this was significantly greater than that of the clerical and light industry workers in addition to the executives. The range in BMI was greatest in the younger farmers and steel workers.

The means of BMI among all groups of women (Table 6.2) were not significantly different from each other. The sewing machine and bakery workers both had a wide range.

The standards of the 1959 and 1983 Metropolitan Life Insurance Company tables were used to compile two nomograms indicating body mass index at desirable weight and at 20 percent and 40 percent overweight levels for men and women (Burton and Foster, 1985). Using the 1959 criteria of a BMI of 26.4 at the 20 percent overweight level and 30.8 at the 40 percent overweight level, 24 men (25.3 percent) were between 20 and 40 percent overweight and 7 (7.4 percent) were more than 40 percent overweight. Use of the 1983 standards of 27.2 and 31.8 percent reduced the percentages between 20 and 40 percent overweight to 20 percent (19 men).

The corresponding 1959 standard for women of a BMI of 25.8 at the 20 percent overweight level and 30.1 at the 40 percent overweight level categorised 26 women (30.9 percent) as between 20 and 40 percent overweight and nine (10.7 percent) as over 40 percent overweight.

Use of the 1983 standards of 26.9 and 31.4 reduced the percentage between 20 and 40 percent overweight to 25 percent (21 women).

The ranges of desirable weight for height adopted in the report on energy and protein requirements (FAO/WHO/UNU, 1985) corresponded to a BMI of 20.1-25.0 with a desirable average of 22.0 for men and a BMI of 18.7-23.8 with a desirable average of 20.8 for women. The level of BMI designated as obese was 30.0 for men and 28.6 for women. Using these criteria 46 percent of the men and 40 percent of the women were in the desirable weight range, 35 percent of the men and 37 percent of the women were in the range between desirable and obese and 12 percent of the men and 21 percent of the women were obese. Seven of 98 men and 2 of 84 women fell below the desirable range.

6.3 Hypothesis A

The results of this dissertation will be presented in terms of the evidence for or against the specific hypotheses outlined in Chapter 4.

Hypothesis A(1) states that there will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of mean age between 50 and 65 years, between occupational groups of the same sex.

Hypothesis A(2) states that there will be systematic differences in energy expenditure and energy and nutrient intake of groups of subjects of the same sex of mean age between 50 and 65 years and comparable groups of mean age over 65.

These hypotheses were examined using the data on energy expenditure summarised in Tables 6.4, 6.6 and 6.12 for women and Tables 6.3, 6.5 and 6.11 for men. Data on energy intake appears in Tables 6.6, 6.8 and 6.13 for women and Tables 6.5, 6.7 and 6.14 for men. Nutrient intake values are presented in Tables 6.8 6.10 and 6.15 for women and 6.7, 6.9 and 6.16 for men. Ranges are given in these tables to show the great inter-individual variation which was found in all variables.

The differences in these variables were measured by comparing them in all pairs of these groups by means of the Mann Whitney U test.

The results of these comparisons are summarised in Appendix I, Tables 1 - 13.

6.3.1 Hypothesis A(1) Differences between occupational groups of the same sex and of mean age 50 to 65 years.

Men. The means of energy expenditure of six occupational groups of men given in Table 6.3 and the means, medians and ranges in Table 6.11 appear in descending order from farmers (3709 ± 487 kcal/day) and steel workers (3276 ± 504 kcal/day) to clerical workers (2287 ± 291 kcal/day). The three intermediate groups were building workers (3051 ± 418 kcal/day), light industry workers (2837 ± 410 kcal/day) and office executives (2824 ± 318 kcal/day). The energy expenditure of the farmers was significantly greater than all the other groups except steel workers, where the difference approached significance ($p = 0.055$). The mean energy expenditure of eight farmers exceeded 4000 kcal/day. There was no significant difference between steel workers, building workers and executives or between the latter two and men in light industry. The expenditure of the clerical workers was significantly lower than all the other groups.

Energy expenditure per kilogram body weight followed the same pattern (Table 6.5). The executives (42.0 ± 4.5 kcal/kg/day) and light industry workers (41.8 ± 6.2 kcal/kg/day) whose mean weight was 8 kg less than the steel workers (43.2 ± 4.9 kcal/kg/day) and building workers (40.5 ± 6.9 kcal/kg/day) did not differ significantly in this variable from them.

The energy intakes of farmers (3465 ± 481 kcal/day) and executives (2645 ± 438 kcal/day) were lower than their energy expenditures and those of light industry workers and clerical workers higher (2907 ± 337 and 2444 ± 313 kcal/day, respectively). Significant differences were found between farmers and light industry, clerical and executive workers. Clerical workers had a significantly lower intake than all other groups, except executives. The energy intake of one man was under 2000 kcal/day (1760 kcal/day). His BMI was below the desirable range of 20.1-25.0 and his energy expenditure was estimated at 2830 kcal/day. The means, medians and ranges of energy intake are shown in Table 6.14.

Energy intakes per kilogram body weight showed no significant difference between farmers, steel, building and light industry workers or between clerical workers and groups other than the farmers and light industry workers.

When the averages of energy intake and expenditure were calculated, the energy needs of the farmers were significantly greater and the clerical workers significantly less than the other groups. The mean daily energy expenditure was subtracted from the mean daily energy intake to give the variable named energy balance. Only the clerical workers and the light industry workers had positive energy balances but these were significantly different only from the farmers and executives, whose negative energy balances were -244 $\pm$ 461 kcal/day and -179 $\pm$ 355 kcal/day, respectively. Standard deviations for all groups were great.

Protein intake in general fell with decreasing energy intake. (Table 6.7) The intake of the farmers (111.3 ± 16.5 g/day) and steel workers (111.6 ± 15.8 g/day) was significantly higher than most of the other groups. Steel workers and clerical workers had the greater intake as a percentage of energy (14.1 percent and 13.7 percent)[Table 6.9]. The steel workers were traditionally considered to be heavy workers who required ample quantities of "good food" and their wives took pride in giving them large quantities of meat. For all the groups studied, approximately 60 percent of the protein eaten was of animal origin, mostly beef and milk, and the remaining 40 percent was obtained largely from bread, cakes, buns, and biscuits. Protein intake per kilogram body weight was greatest for steel workers and farmers (1.5 ± 0.40 g/kg/day) and least for executives (1.2 ± 0.2 g/kg/day). The differences between farmers and steel workers compared to all other groups were significant. In relation to energy intake, protein intake was greatest for steel workers and clerical workers (35 and 34 g/1000 kcal) and least for executives and light industry workers (31 g/1000 kcal). These differences were significant. Individual protein and fat intakes were closely associated with energy intake (r 0.82, r 0.88 respectively).

Mean daily fat intakes declined with decreased energy intake and that of the farmers was significantly different from all the other groups except the steel workers. Steel, building and light industry workers had similar intakes and the latter two were not significantly different from the two groups of office workers. The percentage of energy from fat was greatest in the diets of the sedentary clerical workers (42.4 percent) and least for the building workers (37.4 percent). Of the total fat intake, a little more than one-fifth was in the form of butter, one-fifth came from meat, one-fifth from cakes and biscuits, a little less than one-fifth from milk and cheese, and the remainder from soup, margarine, bread and other sources.

The percentage of energy supplied by carbohydrate was greatest in the diets of the executives, building and light industry workers and was significantly greater than that of the farmers and clerical workers.

The percentage of energy supplied by alcohol in the diets of the farmers (4 percent) was twice that of all groups except the steel workers (3.4 percent).

In general, the foods, which supplied the most energy were bread, buns, biscuits and cakes, which together contributed to 34 percent of the mean total intake. Dairy products supplied 22 percent, 13 percent being from milk, cheese and eggs and 9 percent from butter. Margarine accounted for only 2 percent. Meat products furnished 15 percent of the total energy, sugar 9 percent, puddings and breakfast cereals 4 percent, potatoes 3 percent, fish 2 percent and sweets and chocolates 2 percent. The remaining 7 percent came, in small quantities, from various other items.

Individual calcium and iron intakes were significantly ($p = 0.001$) related to energy intakes (r 0.66, r 0.74). There were no significant differences between groups in their calcium intakes per 1000 kilocalories, which were between 345 and 413 mg. For all groups, milk and cheese provided between 40 and 50 percent of the total calcium, and bread, buns, cakes and biscuits about 35 percent. Two of the men had intakes of 800 and 950 mg calcium daily in spite of eating no cheese at all and drinking only one quarter pint of milk daily.

Iron intakes per 1000 kilocalories were between 5.5 mg for light industry workers and 6.0 mg for executives. These differences were not significant.

Women. The means of energy expenditure of the three groups of women aged 50-65 shown in Table 6.4 and the means, medians and ranges in Table 6.12 The housewives expended 2257 ± 292 kcal/day, while the sewing machine and bakery workers expended 2319 ± 236 and 2511 ± 439 kcal/day, respectively. The differences were not significant. Two bakery workers had mean energy expenditures in excess of 3000 kcal/day and four between 2600 and 3000 kcal/day. Their energy expenditure per kilogram body weight (40.6 ± 6.5 kcal/kg/day) was significantly higher than that of the sewing machine workers (35.1 ± 7.3 kcal/kg/day), although the mean weight of the latter group was only 0.8 kg greater (Table 6.6). This value was not significantly different from the housewives with family, where mean weight was 1.5 kg less (37.8 ± 4.8 kcal/kg/day).

The energy intakes of all the groups were less than the energy expenditures, ranging from an apparent deficit of 196 kcal/day for the sewing workers (2126 ± 484 kcal/day) to 304 kcal/day and 319 kcal/day for the bakery workers (2208 ± 471 kcal/day) and housewives (1939 ± 390 kcal/day), respectively. The energy intake of the housewives was significantly lower than that of the bakery workers. There was no significant difference in energy intake per kilogram body weight between the groups or between the averages of intake and expenditure of the bakery workers and sewing workers. The means, medians and ranges appear in Table 6.13.

Eight of the women recorded mean daily energy intakes of between 1000 and 1600 kcal/day. In all cases energy expenditure was estimated at 2000 kcal/day or more. Five of these women had Body Mass Indices lower than 25.8 kg/m^2 and four were less than 150 cm in height. The energy intake of one woman was 802 kcal/day compared to her energy expenditure of 2492 kcal/day.

Individual protein, fat and carbohydrate intakes of all 74 women, 57 of whom were aged 50 - 65 years, were closely related to energy intakes (r 0.79, 0.89, 0.86). The ranges in individual intakes were large: 37.0 - 111.3 g protein/day, 54.5 - 155.9 g fat/day (Table 6.8).

Mean protein intake of the bakery workers (73.2 ± 20.0 g/day) was significantly higher than that of the housewives (61.6 ± 13.4 g/day). Bakery workers also had a greater percentage of energy intake supplied by protein (13.3%) (Table 6.10). In contrast to the male groups, the female groups obtained approximately 60 percent of their protein from vegetable sources, mainly from flour in cakes, biscuits, bread, rolls and cereal products. Beef was the meat most commonly eaten, although some pork, mainly bacon or cooked ham, and some stewed mutton or mutton chops were also consumed. Sausages and canned meats were taken occasionally by most subjects. Few of the subjects ate poultry. The mean consumption of eggs was four per week and they were usually boiled. Fresh milk was used regularly by most women. Fish was eaten regularly as were homemade soups.

Protein intakes per kilogram of body weight and per 1000 kilocalories were not significantly different between the groups and ranged from 1.0 ± 0.2 g/kg/day for the housewives to 1.2 ± 0.4 g/kg/day for the bakery workers (Table 6.15) and from 32 - 34 g per 1000 kilocalories.

The bakery workers had the greatest mean intake of fat (108.6 ± 32.6 g/day) but this was not significantly different from the other groups. They also obtained 44.3 percent of energy from fat. The three groups of women obtained over 40 percent of energy from fat. Very important contributors to the energy value of the diet and to the high percentage contribution of fat were cakes, biscuits, bread, rolls and cereal products, which supplied between 30 and 40 percent of the energy intake. Meat, the dairy group comprising milk, eggs and cheese and butter each contributed between 11 percent and 12 percent of the total energy intake.

Individual calcium and iron intakes were closely related to energy intake (r 0.66, 0.72). There were not significant differences between the groups in mean calcium intake or intake per 1000 kilocalories nor in mean iron intake or iron intake per 1000 kilocalories. The ranges of intake of both nutrients were great (351 - 1602 mg calcium/day, 4.2 - 17.8 mg iron/day) (Table 6.8). Mean calcium intake per 1000 kilocalories was in the range of 388 - 452 mg/1000kcal and mean iron intake in the range 5.1 - 6.0 mg/1000 kcal. A large proportion of the calcium intake was supplied by flour products, about 250 mg daily per person. Milk intake, which was on average between one-third and one-half of a pint per day supplied about 300 mg calcium. About 100 mg per day wereobtained from cheese.

6.3.2 Hypothesis A(2). Differences between groups of the same sex of mean age 50 - 65 years and comparable groups of mean age over 65.

Men. The mean daily energy expenditure of the group of retired men (2327 ± 406 kcal/day) was significantly lower than that of all groups of men except the clerical workers (2287 ± 291 kcal/day), while that of the older farmers (3011 ± 450 kcal/day) was significantly lower only than the younger farmers (3709 ± 487 kcal/day) and was significantly higher than that of the retired men (Tables 6.3 and 6.11). The difference between the mean daily energy expenditure of the younger and older farmers was approximately 19 percent. The group of building workers had a broad range of occupations and these were considered to be sufficiently representative of the previous occupations of the retired men for comparisons between the groups to be made. The difference between their mean daily energy expenditure and that of the retired men was approximately 23 percent. The range in energy expenditure was greater in the retired men than in the older farmers. Of the five retired men with the highest expenditure of energy, one 76-year-old former postman expended 3068 kcal/day while four other men in the group expended between 2500 and 2800 kcal/day. Three of the five farmers expended between 3144 and 3441 kcal/day.

In relation to other groups, mean energy expenditure per kilogram body weight followed the same pattern as energy expenditure. It was not significantly different between the two groups of older men, although the mean weight of the farmers was 78.6 kg compared to 70 kg of the retired men (Table 6.5). The findings were 38.1 ± 2.5 kcal/kg/day and 34.3 ± 4.2 kcal/kg/day, respectively.

The mean energy intake of both groups of older men was approximately 340 kcal/day less than their energy expenditure, a difference of 16.5 percent for the retired men and 12.9 percent for the older farmers. The mean intake of the retired men (2052 ± 355 kcal/day) was significantly less than that of all younger groups and of the older farmers. The energy intake of the older farmers (2667 ± 495 kcal/day) was not significantly different from four of the six groups of younger men, the exceptions being the younger farmers and the steel workers. The difference between the mean daily energy intake of the younger and older farmers was approximately 23 percent and between the building workers and the retired men approximately 33 percent.

Four retired men had mean daily energy intakes of between 1400 and 2000 kcal/day. Their body mass indices were 20.9, 20.7, which were in the desirable range of weight for height, and 27.4 and 30.3, which were above the desirable range. Two were small men of 146.7 cm and 156.2 cm. Energy expenditure exceeded intake in all cases, the largest difference being 1226 kcal/day.

The mean protein intake of the retired men (70.3 ± 9.7 g/day) was significantly lower than all younger groups but there was no difference between the mean intake of the farmers (95.4 ± 16.0 g/day) and all other groups.

Intake of protein per kilogram body weight was 1.2 ± 0.2 g/kg/day for the older farmers, 1.5 ± 0.3 g/kg/day for the middle-aged farmers, and 1.5 ± 0.2 g/kg/day for the steel workers. The differences between the older farmers and these two groups were significant. The intake of the retired men was 1.0 ± 0.1 g/kg/day and was significantly lower than all groups including the older farmers. The range of intake of both older groups was not as great as that of the younger groups (Table 6.16).

In relation to energy intake, both older groups had a significantly higher protein intake (35 and 36 g/1000 kcal) than the executives or men in light industry (31 g/1000 kcal), and the intake of the older farmers was significantly greater than that of the younger farmers. The contribution of protein to the energy value of the diet (Table 6.9) was similar for two groups of younger men (steel workers and clerical workers) and the two older groups (approximately 14 percent).

The fat intake of the retired men in parallel with energy intake was significantly lower than all groups, and it was also lower than all other groups as a percentage of energy intake. Similarly the fat intake of the older farmers was significantly lower than the groups with the greatest energy intake, i.e., the farmers and the steel workers, but not from the four groups whose energy intake was not significantly different from them.

The mean calcium intake of the retired men was 807 ± 213 mg/day, which was significantly lower than all groups except building and clerical workers, but in relation to energy intake there was no significant difference between the intake of 397 mg/1000 kcal of this group and that of the younger groups. The intake of the older farmers (461 mg/1000 kcal) was significantly higher than that of the building and light industry workers.

Mean intake of iron per 1000 kilocalories was not significantly different between the older and younger groups, and the lowest intakes were 8.9 mg/day recorded by one retired man and one clerical worker. The range of mean intakes per 1000 kcal for all groups was 5.7 - 6.1 mg/1000 kcal/day.

Women. Comparison of the results of energy and nutrient intake measurements of the group of four older women with those of the housewives who lived alone and were of mean age 66 ± 2.6 years revealed no significant differences between the groups. The small group is not used in the comparisons which follow. Comparison of older and younger groups of women are based on one group of older women, (the housewives who lived alone) of whom the majority were retired from work outside of the home.

The mean energy expenditure of the older housewives (1987 ± 248 kcal/day) was significantly lower than that of the three younger groups. It was approximately 13 percent lower than that of the younger housewives and of the sewing workers whose occupations were similar to those from which some of the older women had retired. The energy expenditure of nine of the older housewives was between 2000 and 2400 kcal/day. Energy expenditure per kilogram of the group of older women (33.5 ± 6.2 g/kg/day) was significantly lower than the younger housewives with family and the bakery workers but not lower than values for the sewing workers. The differences in weight between the groups were not significant.

The deficit in energy intake compared to energy expenditure was less in the older group, 58 ± 166 kcal/day compared to 196 or more in the younger groups, with a minimum standard deviation of ±343 kcal (Table 6.4). Mean energy intake was significantly lower in the older group (1917 ± 322 kcal/day) compared to the bakery workers only. The difference in mean daily energy intake between the sewing workers and the older housewives was approximately 10 percent.

Mean protein intake was not significantly different except in comparison to the bakery workers, and there was no difference in intake per kilogram between the groups (1.1 ± 0.3 g/kg/day for the older group) nor in intake per 1000 kcal (32 g). Protein intake as a percentage of energy intake (12.8%) was comparable to all groups except the bakery workers.

Mean fat intake was not significantly different between the older and younger housewives, but the older housewives had a significantly lower intake than the two groups of factory workers. The contribution of fat to the energy value of the diet was also lower in the older group (40.1%).

There was no significant difference between mean daily intake of calcium between the older and younger groups or of calcium in relation to energy intake (452 mg/1000 kcal/day). Some very low intakes were reported in the younger groups.

Mean iron intake and iron intake per 1000 kilocalories were not significantly different between the younger and older women (11.1 ± 2.9 mg/day, 5.7 mg/1000 kcal/day). One very low mean intake was recorded for an older woman (3.2 mg/day) and a younger woman (4.2 mg/day), but the remainder had intakes in excess of 8.0 mg/day.

Men and women. Both groups of older men were significantly older than the older housewives but their energy expenditure was significantly higher. The retired men were comparable in expenditure to the sewing workers and younger housewives, but the expenditure of the older farmers exceeded that of all groups of women.

In energy intake the retired men were not significantly different from older or younger groups of women but the intake of the older farmers was significantly greater.

The contribution of protein to the energy value of the diet rose slightly in the older groups of men but not in the group of older women.

The contribution of fat to the energy value of the diet of the men decreased in proportion to the drop in energy intake, while that of the group of older women showed a tendency to decline more than would be expected from the decrease in energy intake.

Associations between variables. The degree of association between measured, observed and calculated variables was found using Pearson Product-Moment correlations. When the results for all male groups including retired men and older farmers were combined (N = 98), there was a significant ($r \geq 0.33$, $p \leq 0.01$) association between energy expenditure and energy intake (r 0.73). When the results for all female groups were combined including the housewives who lived alone and the four older housewives (N = 74), there was a smaller but also significant association between energy expenditure and energy intake (r 0.49).

The association between weight and energy expenditure was of about the same magnitude for men (r 0.50) and women (r 0.49), but there was no significant association between the energy intake and weight of women and very little in men (r 0.26, P = 0.005).

There was a small but significant association between the BMI and energy expenditure of men (r 0.34) and women (r 0.42) and a small but significant negative association between energy expenditure and energy balance (r -0.44, r -0.36) for men and women respectively.

A small significant negative association was also found between the age and energy expenditure of men (r -0.34) compared to r -0.50 for women. There was no significant negative correlation between the age and energy intake of women in contrast to men (r 0.46).

For men, there were also similar small negative associations between age and intake of protein, fat and iron but not between age and calcium intake. For women, fat was the only nutrient which showed even a small significant negative association with age (r 0.37).

The intakes of all nutrients for men and women were significantly related to energy intake, namely energy intake and protein (r 0.82, r 0.79), energy intake and fat (r 0.88, r 0.89), energy intake and calcium (r 0.66, r 0.66), and energy intake and iron (r 0.74, r 0.72).

6.3.3 Summary of results of testing Hypotheses A(1) and A(2).

A(1) Differences between occupational groups of the same sex and of mean age 50 to 65 years. Men. Significant systematic differences were found between six different occupational groups in the age group 50 - 65 years. The energy expenditure of the farmers was significantly higher and the energy expenditure of the clerical workers was significantly lower than that of the other groups. These differences were maintained when energy expenditures per kilogram body weight were compared and therefore the differences were not due solely to the effect of weight. There were no significant differences between groups of building and light industry workers and executives. The energy expenditure of some men in this age group was in excess of 3500 kcal/day.

Intakes of energy followed the same pattern but only clerical workers and light industry workers appeared to be in positive energy balance over the week of study.

Individual protein, fat, calcium and iron intakes were closely associated with energy intake.

Although the age of the light industry workers was significantly greater than that of the building workers, shown by the means of 61 ± 3.9 and 54 ± 3.3 respectively and by the ranges 55-72 years and 55-57 years, there were no significant differences between these two similar occupational groups in energy expenditure or intake. The younger group, the building workers, were significantly heavier than the light industry workers.

Women. Few significant differences in the variables related to energy and nutrient intake were found between the three occupational groups of women of mean age between 50 and 65 years. The mean energy and protein intakes of the bakery workers were significantly higher than those of the housewives.

Although the mean energy expenditure of the group of bakery workers was 2510 ± 439 kcal/day it was not significantly different from the other groups, but in energy expenditure per kilogram body weight they and the housewives had significantly higher values than the sewing workers. The energy expenditure of some women in this age group was in excess of 3000 kcal/day.

A comparison was made between two groups of women whose occupations were similar but whose age was significantly different, i.e., sewing machine workers (55 ± 2.5 years, range 51-60) and housewives with family (59 ± 3.3 years, range 54-66 in which 11 women were 60 and over). No significant differences were found between the groups in energy intake or energy expenditure. The sewing workers were significantly heavier than the housewives.

A(2) Differences between groups of the same sex of mean age 50 to 65 years and comparable groups over 65 years. Men. A(2)Comparison by age of two groups of men of mean age of over 65 with six groups of younger men was confounded by the degree of difference between the two older groups. The energy expenditure, energy intake and nutrient intake of the retired men were significantly lower than those of the older farmers. Comparison of younger farmers with older farmers showed that the energy expenditure and energy, fat, calcium and iron intakes of the latter were significantly less. Compared to all other groups, except the clerical workers, whose energy expenditure and energy and nutrient intake were significantly less, few significant differences in the variables were found.

Comparison of the retired men with a group made up of a variety of building workers whose mixed occupations were assumed to represent those from which they had retired, showed that their energy expenditure and energy and nutrient intakes were significantly lower than those of the building workers. Their energy expenditure was not significantly different from the clerical workers but their energy, protein and fat intakes were significantly lower than those of the clerical workers.

Women. Comparison by age of one group of older women with three groups of younger women found the energy expenditure of the older women was significantly less than that of the younger groups. Energy and protein intake were significantly different from only one group and fat intake from two groups.

Men and women. Both groups of older men were significantly older than the older housewives but their energy expenditure was significantly higher. The retired men were comparable in expenditure to the sewing workers and younger housewives, but the expenditure of the older farmers exceeded that of all groups of women.

In energy intake the retired men were not significantly different from older or younger groups of women but the intake of the older farmers was significantly greater.

The contribution of protein to the energy value of the diet rose slightly in the older groups of men but not in the group of older women.

The contribution of fat to the energy value of the diet of the men decreased in proportion to the drop in energy intake, while that of the group of older women showed a tendency to decline more than would be expected from the decrease in energy intake.

6.3.4 Conclusions

The differences found in energy expenditure and energy and nutrient intake of groups of subjects of mean age between 50 and 65 years compared to one another by occupation and compared to older groups by age, sex and previous occupation were of such a degree that they cannot reasonably be ascribed to chance.

It may, therefore, be concluded that in general, occupation and age of the groups were related to the outcome variables.

6.3.4.1 Hypothesis A1. The hypothesis, that in groups of men and in groups of women aged 50-65 years there would be systematic differences between occupational groups in:

a) energy expenditure, was sustained for both men and women;
b) energy intake, was sustained for men but not for women;
c) nutrient intake, was sustained for men, but not for women.

6.3.4.2 Hypothesis A2. The hypothesis, that between groups of men and between groups of women aged 50-65 years and comparable groups aged over 65 years there would be systematic differences in:

a) energy expenditure, was sustained for men and for women;
b) energy intake, was sustained for men but not for women;
c) nutrient intake, was sustained for men but not for women.

6.3.4.3 Association between variables. There was a significant degree of association between energy intake and energy expenditure, and this was greater for men than for women. Comparably small but significant associations between energy expenditure and weight, BMI, and energy balance were found for both men and women. Age and energy expenditure were more highly negatively correlated for women than for men. There were significant negative associations between age and energy intake and intake of all nutrients except calcium for men, but only between age and fat intake for women. For both men and women the intakes of protein, fat, calcium and iron were significantly related to energy intake.

6.4 Hypothesis B

Hypothesis B(1) states that there will be descriptive variations in the time and activity patterns and the energy and activity patterns of groups of subjects of mean age between 50 and 65 years between occupational groups of the same sex.

Hypothesis B(2) states that there will be descriptive variations in the time and activity and energy and activity patterns between groups of the same sex and of mean age between 50 and 65 years and of comparable groups of age over 65.

These hypotheses were examined by classifying the findings on patterns of physical activity in two different ways.

6.4.1 Classification of patterns of physical activity.

Classification I. Time and energy patterns of groups are classified according to time and energy spent in bed and in "occupational", "non-occupational" and "relaxation" activities. "Non-occupational" plus "relaxation" activities are those undertaken in "leisure" as opposed to "occupational" time. In the terminology of the FAO/WHO/UNU Expert Consultation on Energy and Protein Requirements (1985) this is the "discretionary activities" category and includes "optional household tasks", "socially desirable activities" and "activity for physical fitness and the promotion of health". The term "relaxation" activities is used to facilitate comparison between two types of groups. One group consists of farmers, housewives, and retired men who had no clearly distinguishable "leisure" time or time during which all activities could be labelled "discretionary" and the other of groups where "occupational" and "leisure" time were defined. The findings for these two types of groups are summarised by this method in Tables 6.17 and 6.18 and Figures 6.1 to 6.6. The groups are labelled A and B. The five groups of subjects who make up Group B made their own working hours some extent. They are the two groups of housewives, the retired men, and the two groups of farmers.

For housewives and retired men, all sitting activities, all walking, personal and dressing, and active recreational activities such as dancing, bowling, gardening and playing with children make up the "relaxation" category. For the farmers, the "relaxation" category does not include walking because they seldom walked except in the course of farming activities. For all five groups, time and energy expended in all activities other than "relaxation" or "bed" are categorised for comparison with Group A as "occupational plus non-occupational" activities. This category is in effect "work" as opposed to "relaxation". The category of non-occupational "work" is made up of non-sitting household tasks and shopping. For women who work outside of the house and for some men, these tasks are not discretionary. Group A and Group B, therefore, do not have a comparable "discretionary" or "leisure" activities category, but have a comparable "relaxation" category.

<u>Classification II</u>. Time and energy patterns of groups are classified by time and energy expended in bed, on personal activities, in sitting activities, walking, shopping and in standing activities/" light activity", "moderate activity", "heavy activity" and "very heavy activity". Classification of activities into the latter three categories was made using the levels of energy cost published by Christensen (1953) and cited by Durnin and Passmore (1967) for a reference man weighing 65 kg and those of Durnin and Passmore (1967) for a reference woman of 55 kg. These authors used the terms "light", "moderate" and "heavy" to describe work which falls into the following ranges which are also given in Tables 5.2 and 5.3. "Light", "moderate", "heavy" and

"very heavy" levels of activity correspond to energy costs of 2.0 - 4.9, 5.0 - 7.4, 7.5 - 9.9 and 10.0 - 12.4 kcal/min respectively for men, and 1.5 - 3.4, 3.5 - 5.4, 5.5 - 7.4 and 7.5 - 9.5 kcal/min for women. Activities have been assigned to these categories by the actual energy cost to the individual of a specific activity. The findings are summarised by this method in Tables 6.19, 6.20, 6.21, and 6.22 and Figures 6.7-6.14.

The effect of applying an arbitrary adjustment for weight to the time spent by the group of farmers in activities in each category is shown in Table 6.25. The assumptions were made that activities with a measured energy cost of 5 kcal/min or more involved movement of the whole body mass and that therefore the energy costs of these activities would be directly proportional to the gross body weight (Durnin and Passmore, 1967). The energy costs of each activity of each farmer which fell into the moderate and above categories on the basis of measured cost was reduced by 7 percent for each increment of 5 kg in weight over 65 kilograms.

The result of the adjustment was to decrease by 57 min/day the mean time spent on activities with an energy cost of 5 kcal/min or over, and thus to reduce the mean percentage of time spent on them to 8 percent compared to 12 percent. The percentage of energy output spent on these activities was reduced from 29 percent to 13 percent.

Adjustments were not made for any other group because of the small percentage of time and energy contributed by comparable activities.

6.4.2 Hypothesis B(1) <u>Variations in time and energy patterns of physical activity of groups of men and groups of women mean age 50 - 65 years by occupation.</u>

6.4.2.1 <u>Contribution of "occupational" activities, "discretionary" activities and bed to time and energy patterns.</u>

<u>Men</u>. Three of the five groups of urban workers (Group A, Tables 6.17 and 6.18)--the building, light industry and clerical

workers-- spent comparable percentages of time in "occupational" activities (27, 26 and 27 percent respectively), in "relaxation" plus "non-occupational work" activities (39, 41 and 39 percent), and in bed (34, 33 and 34 percent) Overtime work was common in these groups. At least one third of the subjects worked overtime during the study week. The time and activity pattern of these groups differed only in percentage of time spent by the light industry workers in non-sitting household tasks and shopping ("non-occupational work" category), which was 10 percent compared to 5 percent and 6 percent of the other two groups. (Figures 6.1.a - 6.6.a)

The steel workers and executive workers had a fairly similar time and activity pattern during the week of study because the steel workers were working only four shifts per week. Percentage time spent in "occupational" activities was 19 percent and 20 percent, in "relaxation" plus "non-occupational work" ("discretionary" activities) was 44 percent and 48 percent, and in bed was 37 percent and 32 percent for steel workers and executives respectively. The main difference between the groups was the 5 percent greater time spent in bed by the steel workers. Occupational plus non-occupational work accounted for 29 to 36 percent of the time.

Farmers, who were classified as having a Group B occupation, spent comparable amounts of time in bed (33 percent) and slightly less in "relaxation" (31 percent) than the other groups of men except for light industry workers. The time they spent in "occupational" plus "non-occupational" activities (Figure 6.3.a) was identical to the latter group (36 percent) as was their "relaxation" time (31 percent) and time "in bed" (33 percent).

The energy and activity patterns of two groups, the building workers and light industry workers, were identical--41 percent, 42 percent and 17 percent of mean total daily energy expenditure in "occupational" activities, "discretionary" activities and bed respectively. They differed in the composition of "discretionary" activities, 6 percent of energy being spent in "optional household tasks" by the building workers compared to 14 percent by the light industry workers. The pattern of energy expenditure of the executives was very different from groups with similar total daily energy expenditure such as the light industry workers. Their percentage energy expenditure in "occupational" activities was 22 percent (compared to 41 percent) and their energy expenditure in "discretionary" activities 61 percent, of which 46 percent was the "relaxation" component. (Table 6.18 and Figures 6.1.b-6.6.b)

The steel workers also spent a high percentage of energy in "discretionary" activity (54 percent of which 39 percent was "relaxation") because they were underemployed. The farmers expended a very low percentage of energy in "relaxation" activities (19 percent), which reflected both their greater energy expenditure and the sedentary nature of their "relaxation" activities.

When energy expended in non-occupational work and relaxation was compared to occupational energy expenditure each group had a different pattern. The energy expended in non-occupational work by the executives was two-thirds of that spent in occupational activities (410 and 640 kcal/day respectively) and in relaxation activities was twice that of occupational activities. The corresponding figures for light industry and clerical workers were one-third in non-occupational work and two-thirds and one and one-third times the energy expenditure in occupational activities, respectively. The percentage of energy expended in bed varied according to total daily energy expenditure and was 14 percent for the farmers and 22 percent for the clerical workers.

Women. The two groups of women factory workers spent similar percentages of total time in "occupational" activities, 25 percent and 24 percent, in "discretionary" activities, 40 percent and 44 percent, and in bed 32 percent each. They spent identical percentages of time (14 percent) in "non-occupational work " (non-sitting household tasks and shopping). Similarly to three groups of men, overtime work was performed by at least one-third of the women.

The housewives with family spent 28 percent of time in "occupational" plus "non-occupational work" activities. This was 3 - 4 percent more than the "occupational" time of the factory workers. When these two fractions were summed for the factory workers, they amounted to 38 and 39 percent of time. Times spent on "relaxation" activities (37 percent) and in bed (35 percent) were greater than those of the factory workers (28 and 30%).

The energy and activity patterns of the sewing machine workers and bakery workers were also nearly identical. The percentages of energy expended on "occupational" activities were 32 percent and 33 percent, on "discretionary" activities 50 percent, and on bed 18 percent and 17 percent. The energy expended in non-occupational work was approximately two-thirds of that spent in occupational activities (490 compared to 740 kcal/day and 540 compared to 850 kcal/day, respectively. For these women the tasks making up non-occupational work could not be accurately described as optional household tasks because they were essential to the running of the household.

The energy pattern of the housewives compared to the other groups--bed (20 percent) and "relaxation" activities (34 percent)--reflected the greater time spent in these activities. Energy expended in "working" activities (i.e., "occupational plus non-occupational" category) was 46 percent of total daily energy expenditure.

The two groups of factory workers expended half the energy in relaxation that they did in occupational plus non-occupational work activities while the houswives spent three-quarters. The energy accounted for by relaxation in the groups of factory workers was 28 and 29 percent.

6.4.2.2 Contribution of specific activities and activities categorised by level of energy cost to time and energy patterns.

Men. The results discussed in this section are shown in Tables 6.19, 6.20 and 6.23 and Figures 6.7 to 6.11. The percentage of time spent in bed was similar for five of the six groups of men (33 - 34 percent), and the contribution of this activity to energy expenditure was lowest for the group with high energy expenditure (farmers) at 15 percent and greatest for the group with low energy expenditure (clerical workers) at 22 percent.

Sitting activities occupied 10½ hours or 44 percent of the day for clerical workers and contributed 43 percent of their energy expenditure. For light industry workers they occupied nearly 6 hours or 24 percent of the day and contributed 18 percent to their energy expenditure. The greater proportion of the sitting activities of the farmers and light industry workers was "relaxation" activities whereas all the other groups spent time in sitting at work. The time spent in sitting by the executives was 9.1 hours per day, by the building workers 8.1 hours per day and by the steel workers and farmers approximately 7 hours per day. Steel workers and building workers sat while waiting for supplies to arrive. The contribution of sitting to energy expenditure was lowest for the farmers (17 percent). Sitting was the activity on which the greatest proportion of the mean total daily energy expenditure of the building workers (27 percent), executives (32 percent) and clerical workers (43 percent) was spent. (Figure 6.7.a and 6.7.b)

Only the farmers spent more than 3 percent of time in activities classified as "moderate", "heavy" and "very heavy". The mean time spent by them per day was 12 percent or 2.9 hours, and this contributed 29 percent of their daily energy expenditure. Most of their activities at this level were occupational except for dancing done by two farmers.

The steel workers spent more time in "heavy" (13 minutes) than in "moderate" activity (9 minutes) because tending the furnaces by shovelling in slag and gravel was very arduous labour. The time spent on it per shift never exceeded 1 hour and it was possible for a shift to pass without the furnace being tapped. "Moderate" to "heavy" activity contributed 5 percent of the energy expenditure of the steel workers and was all occupational .

The building workers spent 41 min/day on "moderate" activity, which contributed 16 percent of energy expenditure. This was more than the steel workers. Most of the activities were occupational, but one man cycled and another painted his house at energy costs of more than 5 kcal/min.

The 19 min/day which the executives spent on "moderate" activity were all spent on non-occupational recreational activities such as golf and gardening, and contributed 5 percent of their energy expenditure.

The men in light industry spent a negligible amount of time in "moderate" activities either at work or in leisure time, but they spent a total of 8.6 hours in "light" activities (48 percent of their energy expenditure). (Figure 6.8.a) This exceeded the time spent by all other groups, which varied from 3.1 to 6.0 hours per day. This was the category into which most "recreational" activities and "optional household" activities including shopping fell. It was the single activity on which farmers, steel workers and light industry workers spent the greatest proportion of their total energy expenditure (25, 34 and 48 percent respectively).

Percentage of time (5 to 6 percent) spent on walking was similar for four groups--the farmers, steel, light industry and clerical workers --and was approximately 1.5 hours/day. The building workers and executives walked for a mean time of 2.2 and 2.1 hours per day respectively, which was 9 percent of the day and contributed 22 percent and 19 percent of their energy expenditure. (Figures 6.12.a and 6.12.b) The two groups differed in the distribution of the time spent in walking, the building workers walked mainly at work and the executives in "leisure" time (Table 6.23). The light industry workers did little walking at work and, with the exception of the building workers and the farmers, more walking was done in "leisure" than in working time.

Walking was not always an activity which fell into the "moderate" range of energy cost. For only two clerical workers and two executives was the cost of walking in excess of 5 kcal/min, but all steel workers and most farmers and building workers exceeded this level. The mean percentage contribution of walking to mean energy expenditure of the groups varied from 12 percent for the farmers to 22 percent for the building workers. The mean energy expended per day by each group in walking was approximately 370 kilocalories each by clerical and light industry workers, approximately 460 kilocalories each by farmers and steel workers, 520 kilocalories by executives and 670 kilocalories by building workers.

Women. The results discussed in this section are shown in Tables 6.21, 6.22 and 6.23 and Figures 6.7 to 6.11.

The percentage of time spent in bed was greatest for the housewives (37 percent) and the same for both groups of factory workers (32 percent), contributing 20, 18 and 17 percent to the mean energy expenditure of each group.

Sitting activities occupied 30 percent of the day for the sewing workers, 28 percent for the housewives and 26 percent for the bakery workers, or between 6.2 and 7.2 hours, contributing between 19 and 24 percent of mean daily energy expenditure. There was a difference in the site of the activity. The bakery workers spent a mean time of 50 minutes sitting at work and 5.2 hours sitting in "leisure" time, while the sewing workers sat for 2.9 hours at work and for 4.4 hours in "leisure" time. There was no group similar in occupation to male clerical workers, whose work consisted primarily of sitting activities.

The bakery workers spent three times as much time in "moderate" activity (energy cost, 3.5 - 5.4 kcal/min) as the other two groups. A mean time per day of 1.4 hours was spent in this activity compared to means of 23 minutes for the housewives and 24 minutes for the sewing workers. Twelve bakery workers recorded some "moderate" activity in non-working time and six of these also had "moderate" activity at work. One woman worked at the "moderate" level only in her occupation.

Few of the women spent more than 1 hour during the day in "moderate" activity. One exception was a woman who worked as a cleaner in the bakery. She averaged 7½ hours/day in "moderate" activity and 70 minutes in "heavy activity", her greatest expenditure on one day being 9 hours in "moderate" and over 2 hours in heavy activity. One very obese woman spent 5 hours/day and almost 9 hours on one day in "moderate" physical activity. These were women aged 45 to 50.

The occupations of the majority of sewing workers consisted of "light" activity and sitting, but two spent most of their working time in activities of "moderate" energy cost. Four sewing workers performed household tasks at the "moderate" level. Eight housewives also recorded housework at this level, and three had recreational activities --golf, dancing and gardening--which reached the "moderate" level of energy expenditure. One woman who had a part-time job in a canteen averaged 2½ hours per day in "moderate" activity. The contribution of "moderate" activity to energy expenditure was 14 percent for the bakery workers, 6 percent for the sewing workers, and 7 percent for the housewives.

All the groups of women spent over one hour a day in walking. The sewing workers spent 18 minutes of "occupational" time and 63 minutes of "leisure" time, while the bakery workers spent 25 minutes of "occupational" time and 41 minutes of "leisure" time in this activity. Total time spent in walking was 5 to 6 percent of the day and contributed 9 percent of the energy expenditure of the housewives and 11 percent of the energy expenditure of the two groups of factory workers (Table 6.23).

Walking for all except two of the bakery workers, six of the sewing workers and 12 of the housewives was a "moderate" activity.

The mean energy expended per day on walking was 206 kilocalories by the housewives, 260 kilocalories by the sewing workers, and 283 kilocalories by the bakery workers.

Standing activities and "light" activity made the greatest contribution of any activity towards the mean total daily energy expenditure of all the groups (37 percent for housewives, 33 percent for sewing workers, and 32 percent for bakery workers).

6.3.4 Hypothesis B(2) Variations in time and energy patterns of physical activity between comparable groups of mean age between 50 and 65 years and comparable groups of mean age of over 65.

6.4.3.1 Contribution of "occupational" activities, "discretionary" activities and bed to time and energy patterns. Men. The time and activity patterns of farmers in the two age groups were very similar. Both spent 31 percent of time in "relaxation" activities. Older farmers spent 3 percent more of their time in bed, 36 percent compared to 33 percent.

The time and activity pattern of the retired men was unlike any other group because of the very small percentage of time (13 percent) which they spent in "occupational" plus "non-occupational work" activities, i.e., "work" and thus the greater percentages of time spent in "relaxation" activities (48 percent) and in bed (39 percent).

The energy and activity patterns of the two groups of farmers differed considerably. The older farmers expended 49 percent of their total energy expenditure in the "occupational plus non-occupational work" category while the younger group expended 67 percent. The older men spent 13 percent more of their energy expenditure in "relaxation" activities than the younger men. The energy and activity pattern of the retired men did not resemble any other group since 60 percent of mean total daily energy was spent in "relaxation" activities.

Women. The older and younger groups of housewives spent the same percentage of time in "relaxation" activities, but the housewives who lived alone spent 5 percent more of their time in bed and thus 5 percent less time on domestic duties. Compared to the factory workers they spent 16 percent less time in "work" activities.

The energy patterns of the housewives differed in the percentage of energy spent on household activities by the younger women (43 percent) and the older women (34 percent). This difference of 9 percent was divided between the energy spent on "relaxation" activities, which was 41 percent for the housewives alone and 36 percent for those with families, and that spent in bed, which at 25 percent was a highest of all groups of men and women.

Men and Women. Time spent in bed by retired men was similar to that of the older housewives (40 percent) but the housewives spent almost twice as much time in "occupational" plus "non-occupational" tasks i.e., "work".

6.4.3.2 Contribution of specific activities and activities categorised by level of energy cost to time and energy patterns.

Men. The group of older farmers (mean age 73 years) spent a mean of 0.6 hours per day more in bed than younger farmers and 1.9 hours per day more in "light" activity. They spent 2 hours per day less in "moderate" activity and had no "heavy" or "very heavy" activities.

The time spent in walking was 15 min/day less than the younger farmers.

The mean daily energy expenditure of the older farmers was similar to that of the building workers, and the amount of time spent on "moderate" activity was identical to theirs.

"Light" activities provided the greatest percentage of energy expenditure for both groups of farmers, but this was 37 percent for the older farmers compared to 25 percent for the younger men.

No direct comparison of the retired men (mean age 72 years) with a group to which they belonged before retirement can be made. The group they most closely resembled in time and energy patterns of specific activities was the building workers. The time spent by both groups in sitting (8.1 and 8.3 hours per day) and in walking (2.2 and 2 hours per day) were similar. The retired men spent 1.5 hours per day more in bed, 1 hour per day less in "light activity", and a negligible amount of time in "moderate" activity in which the building workers spent 41 minutes per day. If these differences indicate changes in activity on retirement, they would be sufficient to decrease energy expenditure by the approximately 700 kilocalories or 23 percent which was the difference between the energy expenditure of the retired men and the group of building workers. The decrease in energy expenditure between the younger and older groups of farmers was 19 percent.

Women. The difference in mean age between the older group of housewives living alone (mean age 66 years) and the younger groups of women was not as great as that between the older and younger groups of men, but some differences in activity pattern were evident.

The time spent in bed by the older women was 1.3 hours per day more than the younger housewives and 2 hours per day more than both groups of factory workers. They spent about 30 minutes less per day in personal necessities. They did not spend any time in "moderate" activity while two of the younger groups spent about 40 minutes and one spent 86 minutes per day in this activity.

Less time in "light" activities and a little more time in sitting activities was spent by the older housewives than the other groups, but the time they spent in walking (66 min/day) was identical to that of two of the three younger groups.

The differences in activity patterns resulted in a difference of approximately 300 kcal/day or 13 percent between the energy expenditure of the older women compared to the younger housewives and to the sewing workers, a group whose occupation was similar to that from which some of the older women had retired.

Men and Women. Comparison of the retired men and the older housewives showed that the men spent 1 hour/day more in sitting 2 hours/day less in "light" activity and 1 hour/day more in walking. (Tables 6.19 and 6.21 and Figures 6.7.a, 6.8.a and 6.12.a)

6.4.4 Summary of descriptive variations of Hypothesis B.

B(1) Variations in time and energy patterns of occupational groups of mean age 50 to 65 years.

a) Male groups classified by "occupational" activities, "discretionary" activities and bed. Two patterns were found. Similar time and activity patterns of approximately 27 percent of total time spent in "occupational" activities, 40 percent spent in "discretionary" or "non-occupational work" plus "relaxation" activities and 33 percent spent in bed were discernible for three groups of men, the building, light industry and clerical workers. Steel workers and executives had a pattern of approximately 20 percent of time spent in "occupational" activities, between 39 and 44 percent in "discretionary" activities and between 32 and 37 percent in bed.

The farmers could not be compared to the other groups on the basis of "occupational" and "discretionary" activities, but when times spent on all activities apart from those defined as "relaxation" or bed were compared, farmers and light industry workers displayed a pattern in which 36 percent of time was spent on "occupational and non-occupational work" (all "occupational" for farmers) activities, 31 percent on "relaxation" activities and 33 percent in bed.

Differences in energy and activity patterns were most obvious in the percentages of energy expended in leisure time.

Identical energy and activity patterns were discernible for two groups, building and light industry workers, who had similar time patterns and similar total energy expenditure. These consisted of 41 percent of mean total energy expenditure spent in "occupational" activities, 42 percent spent in "discretionary" activities and 17 percent spent in bed.

One group, the executives, had a very low percentage of energy expended in "occupational" activities (22 percent) and a very high percentage expended in "relaxation" activities (46 percent), while the farmers expended a very low percentage of energy (19 percent) in "relaxation" activities.

The proportions of time and energy allocated to the two components of "discretionary" activity varied between groups, some groups spending nearly twice as much time and energy on non-sitting household tasks as others.

b) Male groups classified by specific activities. Occupation affected the amount of time and energy spent on the activities listed in Tables 6.19 and 6.20. Differences were also evident in the distribution of the activities between "occupational" and "leisure" time.

Patterns based on specific activities were largely determined by the amount of time spent in sitting, which varied from 24 percent for light industry workers to 44 percent for clerical workers. Sitting was the principal component of the energy and activity pattern of three groups, the executives, clerical and building workers while "light" activity was the principal component of the patterns of the steel and light industry workers and the farmers.

Sitting was a very dominant activity for clerical workers, contributing 43 percent of their energy expenditure in contrast to 18 percent of the energy expenditure of light industry workers. For the latter group and the farmers, sitting was mainly a "relaxation" activity.

The farmers were very different from the other groups in the amount of time (2.9 hours/day) spent in activities at or above the level of 5 kcal/min, on which 29 percent of their mean total daily energy was expended. Their energy and activity pattern differed substantially from all other groups because of the greater amount of energy expended in activities of "moderate" or greater energy cost, which contributed 29 percent of mean total daily energy expenditure.

The building workers and the steel workers both spent time at the "moderate" and above level of work, and this contributed 16 and 5 percent of energy expenditure respectively.

For these three groups, "moderate" activities were mainly "occupational" whereas for the executives they were all recreational and contributed 5 percent of energy expenditure.

The farmers and steel workers groups included individuals whose activities reached the "heavy" or "vigorous" activity level of 7.5 kcal/min.

Most recreational and optional household activities fell into the "light" activity classification.

No activities were done specifically for physical fitness and the promotion of health. The time spent on walking by all groups of men was between 1½ and 2 hours/day. Farmers did all their walking and building workers most of it during work, while the others groups and the executives in particular walked mainly in "leisure" time. In all groups 12 percent or more of energy expenditure was contributed by walking.

c) Female groups classified by "occupational" activities, "discretionary" activities and bed. The time and activity patterns and energy and activity patterns of the two groups of factory workers were almost identical and were distinctly different from those of the housewives in the same age group. The time patterns were, for the factory workers, 25 percent "occupational", between 40 and 44 percent "discretionary", of which about 29 percent was "relaxation" and 32 percent in bed, and for the housewives were 28 percent "occupational plus non-occupational work", 37 percent "relaxation" activities and 35 percent in bed.

The two energy patterns were 33 percent "occupational", 50 percent "discretionary", of which 29 percent was spent in "relaxation" activities and 17 percent in bed for factory workers, and 43 percent "occupational" plus "non-occupational work", 36 percent "relaxation" and 21 percent in bed for housewives.

d) Female groups classified by specific activities. Occupation had effects on the time and energy spent on the activities listed in Tables 6.21 and 6.22 although the range of occupations did not include women with sedentary occupations or with those requiring a very high level of physical activity from the majority of subjects in the group.

Housewives spent more time in bed than women with occupations outside of the home.

Sitting activities occupied between 26 and 30 percent of the day for each group, but the sewing workers spent three times as much time in sitting at work as the bakery workers.

The bakery workers were clearly distinguished from the other groups by the amount of time spent by them on "moderate" activity (approximately ½ hour compared to 1½ hours) and its contribution to energy expenditure, which at 14 percent was twice that of the other groups. Fewer of the sewing workers reported "moderate" activity, and the amount of "moderate" activity of the group was largely supplied by the energy expenditure of two women.

One housewife and two bakery workers also contributed disproportionate amounts of "moderate" activity to the totals of the groups. Great inter-individual variation was found in all groups.

Household tasks of "moderate" energy cost were undertaken by more bakery workers and housewives than sewing workers. The sewing workers therefore spent more time in sitting at work and less time in "moderate" activity at work and at home.

The greater proportion of walking done by the employed women took place in "leisure" time. It was a "moderate" activity for the majority of the bakery workers and the housewives and for six of the sewing workers.

The single group of activities which contributed the greatest percentage of mean daily energy expenditure was the "light" activity category in which were included most obligatory occupational tasks and recreational activities apart from walking.

B(2) Variations in time and energy patterns between age groups of mean age between 50 and 65 years and over 65 years.

a) Male and female groups classified by "occupational" activities, "discretionary" activities and bed. No differences were found in the time and activity patterns of older and younger farmers, but the pattern of the retired men was very different from that of all other groups of men and women.

There were also differences in the time patterns of older and younger housewives.

The energy and activity patterns of the groups of farmers differed substantially, particularly in the percentage of energy spent in "work" activities, and this difference was also found between the older and younger groups of housewives.

b) Male and female groups classified by specific activities. Variations in patterns of activity between groups of men of mean age 50 - 65 years and of over 65 were similar when farmers in the two age groups were compared and retired men were matched with a group of building workers. Both older groups spent more time in bed and less time in "moderate" activity than the comparable younger groups.

Their mean total daily energy expenditure was not lower than all younger groups; that of the older farmers (3010 kcal/day) exceeded the energy expenditure of three of the younger groups and that of the retired men (2327 kcal/day) exceeded the expenditure of the younger clerical workers.

The differing activities of comparable older and younger groups of men resulted in differences of approximately 700 kcal/day in the mean total daily energy expenditure. This represented a 19 percent difference in the energy expenditure of older compared to younger farmers and a 23 percent difference between retired men and building workers.

The variation in patterns of activity between older and younger groups of women were similar to those of the men, i.e., the older group spent more time in bed and less time in "moderate" activity. There was a difference of 300 kcal/day or approximately 13 percent between the energy expenditure of the older group of women compared to the comparable younger group.

6.4.5 Conclusions. It can be concluded from these comparisons that, in general, the occupation of the groups between 50 and 65 years was related to the amount of time and energy expended in daily activities and the occupation and age were related to these variables in groups over 65 years.

6.4.5.1 Hypothesis B1. The hypothesis, that in groups of men and in groups of women aged 50-65 years there would be descriptive variations between occupational groups in:

a) time and activity patterns, was sustained for men and women;
b) energy and activity patterns, was sustained for men and women.

6.4.5.2 Hypothesis B2. The hypothesis that between groups of men and between groups of women aged 50-65 years and comparable groups aged over 65 years, there would be descriptive variations in:

a) time and activity patterns, was sustained for men and women;

b) energy and activity patterns, was sustained for men and women.

6 R/T7

CHAPTER 7

DISCUSSION

7.1 Introduction. The research questions posed in Chapter 4 could not be answered fully by the formulation and testing of specific hypotheses. In this chapter they are further clarified by comparing the results with the findings of methodologically similar studies of groups of various ages, many of which have been published since the studies were completed.

The convention used in the FAO/WHO/UNU (1985) Expert Consultation on Energy and Protein Requirements ("UNU") of expressing energy requirements as multiples of BMR ("UNU"-BMR) is applied to the results obtained for total energy expenditure ("UNU" TEE), to its component parts, namely occupational and non-occupational activities and to energy intake ("UNU" TEI).

Discussion of the resultant values focuses on 1) individual and group BMRs and compares them with values obtained by the Fleisch (1951) method; 2) comparisons of group "UNU" TEE factors with one another and with other groups; 3) the differences between groups in "UNU" BMR based factors of the average energy cost of physical activity during occupational and non-occupational time and 4) comparison with "UNU" examples of similar work categories.

Comparisons are made with current commonly accepted standards for intake of energy and nutrients. Energy intake findings are also discussed in relation to the concept of levels of energy requirement based on normative judgements about desirable levels of activity and desirable body proportions made by the Consultation. The standard used for discussion of protein intake is the concept of a safe level of protein endorsed in the Consultation report.

Because of the unusual length of time which has elapsed between the field studies and this presentation of the results, critical reviews of the methodology have appeared in the literature. These have been discussed in Chapter 5 (Methods) and Chapter 3 (Historical Review, Part 2). It was concluded that the methods used for the measurement of energy expenditure and energy intake were appropriate and adequate for the principal aim of the thesis, i.e., the comparison of group results. No further discussion is included in this chapter.

Some of the results of these studies have been reported and discussed by Durnin, myself, and other members of the research team. Specific reference to the groups were made in the following papers. The retired women who lived alone were the subject of Durnin, Blake, Brockway, and Drury, (1961b) and Durnin and Blake (1962a); the housewives aged 50-65 of Durnin, Blake, Allen, Shaw and Blair (1961c); the four elderly women of Durnin and Blake (1962b); the elderly men were mentioned briefly in Durnin (1961); the elderly steel workers and the two groups of male light engineering workers of Durnin, Blake, Allen, Shaw, Wilson, Blair and Yuill (1961a) and the executives in Blake and Durnin (1963).

Some data from the other groups has appeared in several publications including Durnin (1964), Durnin (1966), Durnin and Passmore (1967), and Durnin (1983).

7.2 The 50-65 age group - Occupation, total energy expenditure and patterns of activity

7.2.1 Men - total energy expenditure. It was shown that occupational groups consisting of individuals aged between 50 and 65 years had significant differences between their mean total energy expenditure measured over seven days. Farmers were clearly differentiated from groups whose work was mainly sedentary and from groups whose occupations entailed some periods of moderate and heavy work. The latter groups were also distinguished from a group of sedentary clerical workers but not from one another or from a group of executives whose physical activity during leisure time made them comparable in total energy expenditure to groups whose occupational energy expenditure was greater.

A difference between the energy expenditure of two occupational groups made up of men of under 50 years, coal-face miners and colliery clerks, of 860 kcal/day (31%) was found by Garry, et al.,(1955). The miners carried out hard manual work and the clerks worked sitting or standing in offices. The difference between the mean total energy expenditures of the farmers and clerical workers in the thesis series of studies was 1400 kcal/day (62%). This sedentary group of clerical workers expended 500 kcal/day less than the colliery clerks, who were also classified in the same way. The group of executives was more comparable in energy expenditure to the colliery clerks. The difference between the energy expenditure of the farmers and the executives was 890 kcal/day (32%).

This occupational differential is illustrated in Table 7.1, in which the energy expenditure of sixteen groups of men studied by the same methods is shown. Three groups were of mean age less than 25 years, two groups were of mean age between 25 and 35 years, eight groups of mean age between 54 and 61 years and three groups of mean age between 70 and 80 years. The greatest percentage differences are found in comparing Scottish clerical workers to Swiss farmers (67%), [Durnin, Blake and Gzell, unpublished data], and to Scottish farmers (62%). Groups with occupations as sedentary as that of the clerical workers were not found in the other age ranges so the differences considered are between groups at the upper end of the range of sedentariness. In each age group there is a difference of 30 percent between those occupations in Scotland involving hard labour and those which were comparatively sedentary. Thus, the occupational difference in total energy expenditure found between groups of men of mean age between 25 and 35 years (miners and clerks) and of mean age less than 25 years [army cadets,(Edholm, et al., 1955) students, and laboratory technicians, (Durnin, unpublished data)] was maintained when men of mean age between 54 and 61 years were studied.

Sallis, et al., (1985) studied 1006 men aged between 20 and 74 years using a seven-day physical activity recall and estimated energy expenditure on the basis of 1 MET = 1 kcal/kg/hr. They found a difference of approximately 800 kcal/day between their manual group and their sedentary group which consisted of students. The reported daily energy expenditures of the manual workers, both skilled and unskilled, were significantly greater than those of all other occupational groups. Little difference was found between occupationally comparable groups of under 65 years of age.

Wheatcroft (unpublished manuscript) calculated the coefficient of variation of energy expenditure of a group of 179 adult men which included the series discussed in this thesis. She compared it to the coefficients of variation of each occupational group. That of the whole group was 21 percent, but in all but one occupational group, it was no greater than 15 percent. She concluded that the reduction demonstrated that occupation alone was a good predictor of total energy expenditure.

This was also true of groups when they were compared by the age ranges previously described. Coefficients of variation of energy expenditure in kilocalories per day in the range 11 - 14 percent were found for groups of students and technicians, and for groups of miners and clerks. The range 11 - 15 percent was also found in the groups aged 50-65 (Table 7.2). Thus, not only is occupational grouping as good an index of energy expenditure in groups aged between 50-65 as in younger age groups, but there is no greater variation between the mean energy expenditure of individuals in the various age groups who are in similar occupational groups.

The significant differences in weight found between the farmers, steel workers, and building workers who spent some time in moderate and heavy physical activity might be expected to increase the differential between their total energy expenditure and those of the other groups. It was shown that when mean energy expenditure per kilogram body weight was considered, there was still a significant difference between the farmers and all other groups and between the clerical workers and all other groups. The coefficients of variation compared to those of mean total energy expenditure in kilocalories per day increased from 13 percent to 20 percent for the farmers indicating the wide range in energy expended by individuals, from 14 percent to 17 percent for the building workers and decreased from 15 percent to 11 percent for the steel workers.

The difference between the groups was maintained when BMR-based factors for total energy expenditure (TEE) were compared. In order to compare the findings for TEE to the requirements for different occupational groups suggested in FAO/WHO/UNU (1985) they were calculated as factors of BMR. The BMR, which was employed in all the studies for estimation of individual energy expenditure when asleep and which was calculated from the surface area after Fleisch (1951), was used as denominator to obtain one set of BMR factors for TEE (Table 7.3).

The BMR, derived from the prediction equations 11.6W + 879 for individual men aged 30-60 and 13.5W + 487 for individual men of over 60 years, which were given in the FAO/WHO/UNU,(1985) report, was used to obtain a second set of BMR factors for TEE (Table 7.4). Durnin (1959) showed a high correlation between gross body weight and surface area and no significant difference between the correlation coefficient for energy expenditure and body weight and for energy expenditure and surface area.

The TEE expressed as the mean Fleisch-BMR factor for the farmers (2.31 x BMR) was still significantly greater than those of all other groups, except the steel workers, and that of the clerical workers was significantly less (1.56 x BMR). The rank order for TEE remained the same using the factor and kilocalories per day.

The variation within occupations using TEE factors was found to be different in some groups (Table 7.2). The coefficients of variation were increased for the farmers from 13 percent to 15 percent and decreased for the steel workers from 15 percent to 12 percent. These percentage changes were smaller than those found when TEE as kilocalories per day were compared to kilocalories per day per kilogram body weight, but were in the same direction. There was an insignificant effect on the figure for the building workers, unlike the 3 percent increase when weight was used as denominator and a decrease from 11 percent to 8 percent for the executives where the coefficient of variation was unchanged using the weight-based ratio.

The variation within occupations using TEE factors was found to be different in some groups (Table 7.2). The TEE expressed as the mean FAO/WHO/UNU-BMR factor ("UNU"-BMR) maintained the differentiation between farmers (2.13 x BMR) and other groups and clerical workers (1.41 x BMR) and other groups, but the rank order compared to kilocalories per day was changed. The TEE factor for the light industry workers and the executives exceeded that of the building workers (Table 7.4), although the difference between the groups was not significant. This resulted from the presence in these two groups of men aged more than 60 years and will be discussed shortly.

The considerable error possible in estimating total energy expenditure by the method used in these studies has been clearly demonstrated by Durnin, McKillop, Grant and Fitzgerald (1987) and was discussed in section 3.8.21 of the Historical Review. There is no reason to believe that the error introduced by the method would be greater for one occupational group than another and would alter the differences in total energy expenditure which have been demonstrated between the groups. Thus, the use of factors based on BMR derived from surface area and weight, does not alter the conclusion that in the age group 50-65 years there was a difference between the total daily energy expenditure of groups of men who performed hard physical labour during their working hours and those whose work was mainly sedentary. There was also no alteration in the difference between these two groups and four intermediate groups, which were more similar in their total energy expenditure than expected. The three levels of total energy expenditure distinguished by the "UNU" factors were those of the farmers (2.13 x BMR), the clerical workers (1.41 x BMR), and the intermediate group (1.74-1.92 x BMR). The three levels of TEE distinguished by the Fleisch factors were those of the farmers (2.31 x BMR), the clerical workers (1.56 x BMR), and the intermediate group (1.90-2.09 x BMR).

The importance given in the FAO/WHO/UNU, (1985) report to a critical approach in the use of the values was emphasized by the results obtained when individual figures for BMR based on the prediction equations were used to calculate both a BMR-based factor for TEE of each individual and from these to obtain a mean for each group. Two cautions particularly apply to the studies in question. The first was that an age range of 60 years onwards for calculation of BMR and energy requirements is too broad. The second was that values which change with age are continuous variables so that the uncritical use of artificial dividing lines, at which abrupt changes are supposed to occur, will introduce errors and inconsistencies.

In the course of obtaining the sets of Fleisch BMR-based TEE factors and "UNU"BMR-based TEE factors, the BMR for each individual and the mean BMR of each group were calculated and could be compared (Table 7.5). The mean of the "UNU"BMR for individuals in each group exceeded that of the mean of the Fleisch-BMR from within a range of 5 percent for the executives to 12 percent for the building workers. If the "UNU"-BMR was obtained for the group from the prediction equations or the tables supplied in the report using mean weight and age, the percentage difference was even greater ranging from 10 percent to 14 percent. In the light industry group, the mean "UNU"-BMR appeared to be 4.5 percent lower than the Fleisch-BMR. This resulted from the mean age of the group being 61 years. If it had been 60 years, the difference would have been in the same range as the other groups, namely 13 percent greater than the Fleish-BMR.

A comparison of two mean BMR values for each group obtained firstly from the prediction equations based on mean weight and mean age, and secondly from individual results, showed that where all individuals were in the same age group, the mean BMR was identical, but the more individuals who were over 60 years, the greater was the difference between the values. For example, in the light industry group with 11 of 24 men aged over 60 years, the discrepancy was approximately 140 kcal/day, while in the farmers group with 4 of 22 aged over 60 years, it was approximately 30 kcal/day. In the two groups in which the proportion of older men was high, there was a difference in mean TEE of 250 kcal/day between the four over 60 executives and the six 60 and under men (the older men had the greater

TEE), and of 80 kcal/day between the 11 older and 13 younger light industry workers (the younger men had the greater TEE). Using the age-appropriate equations to obtain "UNU"-BMR factors resulted in the older men in both groups having a factor of 2.0 x BMR, while that of the younger group was 1.7 x BMR.

The main importance of these comparisons with "UNU"-BMR factors to the discussion of the findings for TEE is an awareness of the possibility of this error . The groups involved, together with the building workers, make up the intermediate group between which there was no significant difference in TEE. If only the men aged 60 years and under are compared, the TEE factors of the three groups were identical (1.7 x BMR); if the older men were included, the TEE factors of the light industry workers and the executives exceeded those of the building workers. Any calculations of a TEE factor which include the lower figure for BMR of subjects aged over 60 elevate not only the factor for TEE, but also factors calculated for the energy cost of physical activity which will be discussed in the next section.

The commonly accepted decline in BMR of about 200 kcal/day from age 25 to 80 (Durnin & Passmore, 1967) is factored into the prediction equation for the over 60 age group. This results in a decrease of 268 kcal/day for a 65 kg. man predicted by the two different equations instead of a decrease of approximately 50 kcal/day, which would result if an estimated decrease of 1 percent per decade from 30-60 years were used. The use of these figures to produce a TEE factor makes it difficult to compare the mean TEE factors of groups, which consist of subjects above and below the dividing line. Such groups are otherwise fairly homogeneous in occupation and are normally considered to be in one age group with an upper limit of 65 years. For these male groups, the retirement age of 65 years, not 60 years, becomes the point at which major changes are likely to occur. In general, in both active and sedentary occupations, energy demands will differ little between men who are nearly 60 and men who are between 60 and 65.

Schofield, et al., (1985) in a review of the new equations, noted that "these age ranges were not chosen by inspecting the data, but they are in accordance with previous work and they approximate to commonly used clinical divisions of the human life span". In countries where the retirement age for men is 65 years, this division of the human life span in relation to BMR and energy expenditure is unhelpful. Use of the same equation is indicated up to 65 years. There is, however, a dearth of information on patterns of energy expenditure in the five years before and after retirement.

These comparisons show the type of error that can be introduced if mean age and mean weight are used to obtain group mean BMR since, as the report states, the values for BMR obtained from the equations are those of the individual or homogeneous class whose weight for age or weight for height is at the midpoint of the range.

The majority of the coefficients of variation from the mean BMR of the group, when the BMR was obtained for each individual, from the prediction equations, or by the Fleisch method, were between 5 percent and 9 percent (Table 7.5). The exceptions were the steel and light industry workers, where calculation by the "UNU" method resulted in coefficients of variation of 12 percent and 11 percent respectively (Table 7.5). These were between 3 and 4 percent greater than the Fleisch estimates.

The effect of using the higher estimate of BMR obtained from the "UNU" prediction equations to obtain a TEE factor for each individual was that the "UNU" TEE factors, except for men over 60 years, were lower than the Fleisch TEE factors.

This resulted in a mean "UNU" factor for TEE for all groups of men aged between 50 and 65 years (Table 7.4) which was lower than the mean Fleisch factors for TEE (Table 7.3). The difference was least in the groups which included men of over 60 years because, for the majority of these individuals, the "UNU"-BMR was lower than the Fleisch estimate. This increased the individual "UNU" TEE factor compared to the Fleisch TEE factor and raised the mean. This is in contrast to the situation for men of under 60 years of age, where the "UNU"-BMR was higher than that of the Fleisch estimate and the mean in comparison was lowered.

For the men who were over 60 years, the "UNU"-BMR was lower than the Fleisch estimates when the body mass index (BMI) was between 19 and 25. They were about the same between 26 and 30 and higher in only one subject, a farmer, whose BMI was 40.9 and weight 115.5 kilograms.

In only two individuals (one farmer and one light industry worker) were the TEE factors equal to or greater than 2 standard deviations from the mean of the TEE factors of their groups. This was found when the factors were obtained using both Fleisch and "UNU" estimates of BMR.

Use of the "UNU" BMR instead of the Fleisch value for the energy expenditure during sleep would increase the estimated mean TEE of each group between 25 and 75 kcal/day, an insignificant amount in view of the error associated with the method.

A summary of this section and that which follows appears in Section 7.23.

Men - patterns of activity. The factors which led to the differences in TEE found between the groups were variations in the amount of time spent at work and in its allocation to different activities, the variations in energy cost of these occupational activities, variations in the amount of non-occupational time and in its allocation to different activities and variation in the energy cost of these non-occupational activities.

It has been shown that the occupational energy demands of the groups which had non-sedentary work, that is, the light industry and building workers, were approximately 500 kcal/day in excess of those which had sedentary work, that is, the two groups of office workers. Also, although the steel workers were on short time, their occupational energy expenditure exceeded the sedentary groups by about 200 kcal/day. The farmers were not strictly comparable to the other groups, but when their occupational and discretionary work were combined, the energy cost was found to exceed that of the other non-sedentary groups by about 1000 kcal/day. The time spent at work was similar for building, light industry and clerical workers and exceeded that of steel workers and executives by approximately 2 hours/day (Table 7.6).

Garry, et al., (1955) found that the difference in occupational energy expenditure between miners and clerks who worked the same number of hours was 860 kcal/day over the same period of time. The time spent at work by the colliery clerks (29 percent) with an energy demand of 32 percent of TEE was similar to the pattern of the older clerical workers. The energy demand of the occupational work of the miners was 48 percent of TEE during 27 percent of the day and that of the farmers 67 percent of TEE during 36 percent of the day. There is no indication from a comparison of these groups that occupational energy expenditure was reduced with age at least in those groups where the work was defined as sedentary or as heavy.

The TEE of the miners was similar to that of the farmers, about 3700 kcal/day and that of the clerks 500 kcal/day greater than that of the clerical workers, of which 200 kcal/day was occupational energy. In Table 7.6 the groups studied are compared using factors for the energy cost of physical activity during occupational and non-occupational time expressed as multiples of the "UNU" BMR. These were derived from the ratio of the mean energy expended to mean "UNU" BMR during these periods of time. The relationships between the energy demands of the different occupations are clearly demonstrated. The average energy cost to the light industry workers (2.9 x BMR) exceeded that of building and steel workers (2.6 and 2.7 x BMR), respectively, and all three were comparable to the value of 2.7 x BMR for moderate work given in the FAO/WHO/UNU,(1985) report.

The energy cost of the executives' work (2.0 x BMR) was greater than that of the clerical workers (1.6 x BMR) and similar to that of the colliery clerks (1.9 x BMR) which was derived in the same way. The comparable FAO/WHO/UNU figure is 1.7 x BMR for light work. The occupational energy cost of farming and mining (Garry, et al., 1955) was about the same (4.0 and 3.9 x BMR), respectively, although the farmers' factor included all walking and may have included some discretionary activity. The comparable FAO/WHO/UNU figure is 3.8 x BMR for heavy work.

The comparisons, again, do not indicate any difference between the energy cost of the occupational physical activity of the younger miners and clerks and the older groups studied, although no groups similar to the moderate work category were available for this type of comparison.

Non-occupational energy demands, which were almost the same for the miners and colliery clerks, about 1400 kcal/day, varied from 1100 kcal/day for the clerical workers to about 1700 kcal/day for the steel workers and executives. The energy costs of non-occupational physical activity are shown in Table 7.6, expressed as multiples of "UNU"-BMR. These show that steel workers and executives incurred the greatest costs (2.3 x BMR). The same activities of the building and light industry workers (1.9 x BMR), were similar to the miners and clerks (2.0 x BMR). The cost to the clerical workers was 1.7 x BMR and to the farmers 1.3 x BMR. The energy cost of the physical activity of the executives was substantially greater cost during non-occupational than in occupational time. The factor for the farmers was probably artificially low since discretionary "work" and all walking were included in occupational energy costs because of their undifferentiated work day.

Occupational energy demands were mainly responsible for the differences in TEE between the moderate work groups and the clerical workers as they were in the comparison of the younger miners and colliery clerks, although the difference in TEE was 600 kcal/day compared to 1400 kcal/day between the latter groups.

For six groups, including the miners and colliery clerks, occupational energy expenditure was a good predictor of TEE. Occupational energy cost expressed as a multiple of "UNU"-BMR was also a good predictor. For the group of executives this was not so. They were chosen as a sedentary group and were found to spend 20 percent of the day in occupational activities, yet their TEE was not significantly different from the moderate work groups. They had more non-occupational time than any other group including the miners and clerks and the average energy cost of their physical activity during that time (2.3 x BMR)(Table 7.6) was higher than any group, except the steel workers. It has been shown that non-occupational energy demands of the steel workers also made an important contribution to their TEE. The contribution to TEE of non-occupational "work" of both steel workers and executives was shown to have been nearly two thirds of that of occupational physical activity. This exceeded those of the light industry and building workers, although the occupational energy expenditure of these two groups exceeded that of the steel workers by 300 kcal/day.

The usefulness of "UNU"-BMR factors (Table 7.6) for energy costs in comparisons of groups is illustrated by the following examples. Two factors contributed to the higher energy cost of the leisure time physical activity of the executives. One was shown to be non-occupational "work", that is, non-sitting household tasks. The executives spent 2.1 hours per day on this at an average intensity level of 3.0 x BMR, while the clerical workers spent 1.5 hours per day at 2.1 x BMR. In addition they spent 2.1 hours per day walking, most of it in leisure time, at an average energy cost of 3.8 x BMR, while the clerical workers spent 1.6 hours per day at 3.4 x BMR. Using this analysis, the energy cost of non-occupational work and occupational work was, surprisingly, the same for the steel workers. Both the building workers and light industry workers spent this time at lower levels of physical activity, but the physical activity of both the executives and clerical workers was greater than that in occupational time. For the executives, the occupational energy cost was 2.0 x BMR, whereas, non-occupational energy cost was 3.0 x BMR.

This method of presenting the data also makes it possible to make a better comparison of the farmers with the other groups based on the combination of energy cost during occupational and non-occupational time. The length of the working day of the farmers becomes comparable to that of the light industry workers and clerical workers (8.5, 8.7 and 8.0 hours, respectively), but is still an hour or more longer than that of the other groups. The intensity of the efforts involved during the working day is clearly seen in comparison to the other groups (4.0 x BMR compared to 2.8 and under x BMR). Also emphasized is the low energy cost of their physical activity in 7.5 hours of relaxation time (1.3 x BMR) compared to that of the other groups where the energy cost included walking.

In Tables 7.7 and 7.8 the contributions of occupational and leisure time physical activity to TEE are shown in two other ways for each group (Sections I and II of the table). These are compared to the figures for examples of light activity work, moderate activity work and heavy work given in the FAO/WHO/UNU, (1985) report for individuals aged 25 or 35 years (Section III). In Section I the fractional portions of the "UNU"-TEE factor contributed by occupational and non-occupational physical activity are shown. These were derived from the estimates of energy expended on these activities by each individual in the groups. They are also shown as percentages of the fractional portion. In Section II the recorded percentage contribution to TEE expressed as kilocalories per day are shown. In Section III the percentage of TEE calculated from the examples given in the report and the corresponding definition and TEE factor are shown.

The "UNU" example of light work was similar in both comparisons to the clerical workers although their TEE was lower (1.41 x BMR compared to 1.54 x BMR). Of the other two groups classified for comparison to the "UNU" example as "light activity" work, the executives and the colliery clerks, the latter were more comparable having spent 38 percent of the fractional portion in occupational work compared to 32 percent and 32 percent of TEE (kcal/day) compared to the "UNU" figure of 28 percent, but their TEE was greater (1.66 x BMR). The executives spent only 25 percent of the fractional portion of their TEE (1.81 x BMR) in occupational physical activity. The energy expenditure in leisure time of the steel workers, together with that of the executives exceeded their occupational energy expenditure both as the fractional portion of TEE and as percentage of observed TEE, and yet their TEE factor was more similar to "moderate activity work" than to "light activity work".

The groups classified for comparison as "moderate activity work", the building and light industry workers, were identical in the division of the fractional portion, but the occupational portion was 58 percent, compared to 63 percent of the "UNU" example. Additionally, the percentages of TEE devoted to occupation and leisure were about the same, whereas occupational energy expenditure exceeded that of leisure by 5 percent in the example.

The TEE factor of the miners, classified as a "heavy work" group, exceeded all the groups including the farmers but the percentage division of the fractional portion of TEE was more similar to that of the "UNU" example of moderate activity than to the example of "heavy work". In the example occupational time was 8 hours per day compared to the 6.5 hours per day averaged over 7 days spent by the miners. The fraction allocated to the occupational energy demands of the miners was 7 percent greater than that of the building and light industry groups (65 percent compared to 58 percent).

Expressed as a factor of BMR, the TEE of the miners was greater than that of the farmers, although the expenditures were 3700 kcal/day for the farmers and 3660 kcal/day for the miners. The mean weight of the miners was 65 kilograms and that of the farmers was 78 kilograms. The miners could not be compared to the farmers who were the "heavy work" group of the series, in terms of occupational and leisure activity, because of the nature of the working day of the latter. When the energy cost of the occupational and discretionary activity of the example of heavy work are combined, there is good agreement with the energy costs of the farmers. There is agreement in percentage of TEE spent in occupational activities (67 compared to 65 percent), in percentages spent on non-occupational, excluding "discretionary activity" (19 percent) and in the division of the fractional portion of TEE into occupational energy cost (91 percent compared to 89) and non-occupational energy cost (9 percent compared to 11 percent).

The range of the fractional portion of TEE for the five groups aged 50-65 comprising Group A was 0.41 to 0.92 x BMR. The range for occupational energy expenditure was 0.14 to 0.48 x BMR and for non-occupational energy expenditure 0.27 to 0.61 x BMR. The corresponding figures for the miners were 1.22, 0.76 and 0.43 x BMR and for the clerks 0.66, 0.25 and 0.41 x BMR. The activity pattern of the farmers (Table 7.8) was so different that they should be considered separately in any estimate of variability of aggregated groups.

The lack of information on activity patterns and their relationship to differences in individual and environmental circumstances was stressed in the FAO/WHO/UNU (1985) report. Berio and Perissé (1984) described the FAO programme of work on activity patterns and energy expenditure which has a long-term objective of defining a typology of actual activity patterns based on data from many more subjects than are presently available.

In the Historical Review sections 3.8.2.2 and 3.10, the development of the physical activity questionnaire for use in epidemiological research was discussed. Some of these questionnaires determine the level of physical activity in an absolute sense by calculating an average level of energy expenditure over a certain period of time, expressed in metabolic equivalents or kilocalories, while others provide a relative ranking of physical activities among subjects in the study population. They also vary in the emphasis placed on overall level of energy expenditure, energy cost of physical activities during work, and/or leisure, or physical activity that is likely to lead to an increase in cardiovascular fitness. The many questions remaining to be answered about these instruments were reviewed by Washburn and Montoye (1986). They also reviewed some of the more important studies using them and concluded that "given the variety of physical activity questionnaires with their inherent inaccuracies, it is somewhat remarkable that any relationship has been shown between physical activity scores and chronic disease or risk factors associated with disease."

Similarly, any agreement between data from detailed studies of a few individuals, such as those of the thesis and those of questionnaires is unexpected, but some comparisons can be made. For example, Haglund, (1984) using a single multiple-choice question, found that for men there was no correlation between physical activity during leisure time and at work in their cross sectional study of 7,986 individuals in the age range of 27 to 75 in a Swedish rural county.

Using some of the data from this series of studies together with some from groups of younger men, total number 178, Wheatcroft (unpublished manuscript), found that physical activity at work was related to TEE (r 0.68) whereas for physical activity at leisure and TEE, the relationship was r 0.09. The relationship between occupational and non-occupational physical activity was r -0.11. She concluded that physical activity at work was the more important determinant of TEE and that time spent in moderate activity was the most important index of TEE. A comparison of the two groups of sedentary workers showed that the difference in TEE was accounted for by energy expended in walking and moderate activities in leisure time.

A report by Sallis, et al., (1985) of the use of the Stanford physical activity assessment method on a population of 1,006 men found that occupation was related to the appearance in the activity pattern of moderate and vigorous activity (defined as 3.0-5.0 and 7.0 or greater METs respectively). Levels of these activities were highest where educational level was also high and the activities took place in leisure time. Level of education was also found to be positively related to a leisure time activity index for males by Baecke, Burema and Fritters (1982) and by Taylor, Coffey, Berra, et al.,(1984).

The data of Haglund, (1984) also showed differences between socio-economic groups regarding physical activity during leisure hours. That of civil servants, who can be compared to the executives, was higher than that of other workers. Their farmers were characterized by a high degree of physical activity at work and a low degree during leisure time. This is in agreement with our findings.

Metabolic constants based on BMR for individual activities were used in the FAO/WHO/UNU (1985) report. Sallis, et al., (1985) endorsed the use of such standard units as an important trend in allowing investigators to compare results of studies. Comparisons between groups of occupational and non-occupational energy costs is also simplified by the use of standard units such as the ratio of energy expended in these activities to BMR used in Table 7.6.

It has been possible to make some comparisons with the following two studies, in which data was obtained by the questionnaire method, because in both cases some findings have been expressed in kilocalories. In the case of the Harvard alumni study (Paffenbarger, et al., (1986) the energy expended in activities which are likely to lead to an increase in cardiovascular fitness was quantified.

Taylor, et al., (1978) studied the leisure time physical activity of 1,750 men aged 36-59 years who they regarded as relatively sedentary and homogeneous in on-the-job activity. They used the Minnesota LTA questionnaire which is very detailed and includes intensity codes for each activity. The mean energy cost of LTPA was 240 kcal/day. In contrast, in all the thesis groups, the energy cost of non-occupational work and non-occupational walking combined exceeded 240 kcal/day. It was least for the building and clerical workers (about 450 kcal/day) and greatest for the executives and steel workers (800 kcal/day and 900 kcal/day, respectively). In the latter groups some of the activities fell into the heavy intensity range of over 6 kcal/ minute, which contributed 42 percent of the 240 kcal/day spent by the Taylor, et al., (1978) group. These activities were defined as "moderate" that is the energy cost was 5.0-7.4 kcal/minute. They could be compared to the vigorous activities defined as likely to reach peaks of 7.5 kcal/minute by Morris, et al., (1980).

Paffenbarger, et al., (1986) found that for a group of 16,936 Harvard alumni, aged 35-74, energy expended in walking, stair-climbing and sports play, was inversely related to mortality. If the energy cost of these activities reached 500 kcal/week to 3500 kcal/week, there was a steady decline in death rates. For comparison with these figures, the actual number of kilocalories expended in walking per week by each group is shown in Table 7.9. The mean energy expended in walking in leisure time alone ranged from 1540 kcal/week for the clerical workers to 2653 kcal/week for the steel workers. When occupational walking was added, the energy cost of all walking ranged from 2569 kcal/week for the clerical workers to 4697 kcal/week for the building workers. However at the individual level where the effect on death rate occurs, large variations in the energy expended in each group were present. Of the 84 men in the six groups aged 50-65 years, 55 percent (46) expended between 1500 and 3500 kcal/week in walking, 21 percent (18) spent between 3500 and 5500 kcal/week, 7 percent (5) spent in excess of 5500 kcal/week, 14 percent spent between 500 and 1500 kcal/week and none spent less than 500 kcal/week.

Comparison with younger groups of students and technicians shows that the energy expended in walking and range of variation is more similar to that of the executives than to that of the clerical workers.

Moderate activity with an energy cost of between 5 and 7.4 kcal/-minute would be equivalent to the classification of sports by Paffenbarger, et al., (1986) as light (5 kcal/min) and mixed (7.5 kcal/minute) while heavy activity would correspond to vigorous sport (10 kcal/min). The latter two levels of energy cost might be expected to be associated with fitness in the individual. Because of the variation in moderate activity in each group addition of energy expended in moderate activity to walking was not meaningful for groups. Some individuals in each group, in addition to walking, expended energy at the moderate level of 5-7.5 kcal/minute (all 9 steel workers, 21 of 22 farmers, all 9 executives and 5 building workers). Only steel workers and farmers included work at the highest intensity in their activities.

It is generally agreed (Durnin and Passmore, 1967; Historical Review, Part 2,) that these activities, when they are of a certain duration and intensity, are associated with the maintenance of normal health, the prevention of degenerative diseases and perhaps with a small increase in life expectancy. Presentation of their energy cost in terms of total kilocalories spent per week at the requisite intensity level is an interesting new trend.

The physical activity of the majority of the men studied met or exceeded the Paffenbarger criteria. The group energy cost of walking expressed as a ratio to the "UNU"-BMR is given in Table 7.6 together with the group energy cost per minute, uncorrected for weight.

Walking fell into the category of moderate work (5-7.4 kcal/min.) for five of the groups. The "UNU"-BMR factors associated with these levels of activity were between 4.2 - 5.2 x BMR.

Interest in leisure time physical activity is based on the premise that differences in occupational energy expenditure are small. Although this was not found in the groups studied, which were selected precisely because they were expected to exhibit a wide range of occupational energy expenditure, the components of non-occupational physical activity are shown in Table 7.10 for comparison with the studies which focus on leisure-time physical activity. The breakdown also demonstrates that three of the groups, the steel workers, light industry workers, and the executives were more active, that is, expended about double the energy in non-sitting activities, than the building and clerical workers. Thus, very different patterns of leisure time physical activity were found in two groups of sedentary workers and in two groups in moderate to heavy occupations. The short working week of the steel workers made a similar comparison with them less convincing. The month of the survey may also have somewhat affected out-door leisure activities since the clerical and building workers were studied in October to November and the executives and twelve light industry workers in May and June.

Yasin, Alderson, Marr, et al., (1967) who used a system of daily activity scores to assess the physical activity of 117 male executive grade Civil Service officers aged 40-54 years found that even in such a comparatively homogenous group, there was a difference of 80 points per day within a range of 217 to 439 points per day between the means of the active third and the inactive third.

The similarity of the leisure time physical activity of the light industry workers to that of the executives agrees with the finding of Haglund, (1984) that skilled workers in common with more highly educated men included more physical activity in their leisure time.

7.2.2 <u>Women - total energy expenditure</u>. It was shown that in the three occupational groups consisting of individuals aged between 50 and 65 years there were no significant differences between their mean daily total energy expenditure (TEE) measured over seven days. The housewives with family who are also referred to in this section as "housewives- 6th decade", were not clearly differentiated from the factory workers, as might have been expected, either in TEE or in time and energy spent in work of moderate energy cost.

The narrow range of the differential between groups of women is illustrated in Table 7.11 which compares the energy expenditure of eleven groups studied, with the exception of two groups, by the same methods. Three groups had a mean age of less than 25 years, one group a mean age between 25 and 35 years, five groups a mean age between 51 and 59 years, and two groups a mean age between 65 and 66 years. The only age group in which there is a difference of more than about 150 kcal/day is that with the mean age between 51 and 59 years, where the TEE of twelve urban middle-aged housewives (Durnin, et al., 1957) differed by 890 kcal/day (42%) from that of eight rural Swiss women, who combined farming with housework and whose TEE was 2,980 kcal/day (Durnin, Blake, and Gsell, unpublished data). Between the Scottish groups in the same age range there was a difference of 420 kcal/day (20%). No groups equivalent to the male clerical workers whose work entailed long periods of sitting were found in any of the age groups for comparison. A greater variation might then have been found.

The TEE of the slightly older group of relatively sedentary Canadian women (2,000 kcal/day) studied by Sidney and Shephard (1977) differed little from that of the housewives. In this study a seven-day prospective record of activities was made by each individual and standard values from the literature were used to obtain energy costs and an estimate of TEE (Historical Review, Part 2). A group of younger (mean age 31 years) housewives with young children studied by Grieve (1967) using the same method had a TEE of 2,340 kcal/day, which was comparable to that of the sewing machine factory workers (2,320 kcal/day). The mean weight of the latter group exceeded that of the young housewives by approximately 5 kilograms. No methodologically similar studies of women in the younger age groups, whose occupations could be considered heavy, were found for comparison.

Sallis, et al., (1985) studied 1,120 women aged between 20 and 74 years using a seven-day physical activity recall and estimated TEE on the basis of 1MET = 1 kcal/kg/hr. They found no differences in TEE between one manual group and two sedentary groups which were labelled "managerial" and "student". The TEE of the 170 manual workers was 2,360 kcal/day and of the 402 managerial workers and 66 students was 2,330 kcal/day each, both of which figures were similar to over and under age 50 groups of students, housewives, and factory workers. A group of 368 homemakers had a TEE of 2,240 kcal/day and that of a group of 64 retired women was 2,130 kcal/day. Estimated kilocalories per day were relatively flat across the age range except for a small increase in the 50-64 age group.

Wheatcroft (unpublished data) calculated the co-efficient of variation of energy expenditure of a group of 103 adult women which included the series of studies presented in this thesis. She compared it to the co-efficients of variation of each of eight occupational groups. That of the whole group was 16 percent. Two of the eight groups had a higher variation than the whole group, in six it was reduced to between 8 and 15 percent. She concluded that for women occupation was not as good a predictor of TEE as it was for men.

This was also true of groups when they were compared by the age ranges previously described. The only younger groups for which the co-efficient of variation was available were a group of twelve saleswomen of mean age 21 years in which it was 13 percent and two groups of medical students studied by Happold (1945), in which the variation from the means of 2,350 and 2,410 kcal/day were 8 and 11 percent, respectively. The variations in the groups aged 50-65 years (Table 7.12) were 13 percent, 10 percent and 18 percent. No firm conclusion can be drawn that advancing age leads to a greater or lesser variation in TEE in groups in which TEE was similar.

A significant difference in weight found between the housewives, sixth decade, and sewing machine workers might be expected to increase the differential between them. When mean energy expenditure per kilogram body weight was considered, a significant difference was found although this was not so in a comparison of mean energy expenditure. The co-efficients of variation compared to those of mean total energy expenditure in kilocalories per day increased from 10 percent to 21 percent for the sewing machine workers This indicated that when an allowance was made for the effect of weight, there was a wider range in energy expended by individuals. The variation remained the same for the housewives and decreased by 1.5 percent in the bakery workers.

The lack of difference between the groups was also apparent when BMR-based factors for total energy expenditure (TEE) were compared. In order to compare the findings for TEE to the requirements for different occupational groups suggested in FAO/WHO/UNU (1985) they were calculated as factors of BMR. The BMR, which was employed in all the studies for estimation of individual energy expenditure when asleep and which was calculated from the surface area after Fleisch (1951), was used as denominator to obtain one set of BMR factors for TEE (Table 7.13).

The BMR, derived from the prediction equations 8.7W + 829 for individual women aged 30-60 and 10.5W + 596 for individual women aged greater than 60 years, which were given in the FAO/WHO/UNU, (1985) report, was used to obtain a second set of BMR factors for TEE (Table 7.14).

There was no significant difference between the groups when TEE was expressed as the mean Fleisch-BMR factor (Table 7.13). The rank order of the housewives and sewing machine workers was reversed when TEE was expressed as the BMR factor (1.80 and 1.73 x BMR, respectively), rather than as kcal/day (2,260 and 2,320 kcal/day respectively).

The variation within occupations using TEE factors was different in some groups. The co-efficients of variation were increased from 10 percent to 13 percent for sewing machine workers, decreased for the housewives with family from 13 percent to 11 percent and decreased for the bakery workers from 18 percent to 12 percent. These percentage changes were smaller for the two groups of factory workers than those found when TEE as kcal/day were compared to kcal/day/kg, but were in the same direction. Similarly for the housewives there was 2 percent change where little had been seen previously. There was greater variation in weight amongst the bakery workers (CV 22%) and sewing workers (CV 19%) than in the housewives (CV 16%).

The mean "UNU" - BMR factor for TEE (Table 17.14) was lower for each group than the Fleisch BMR factor and the rank order differed when compared to kilocalories per day. The TEE factor for the housewives with family (1.72 x BMR) exceeded that of the sewing workers (1.64 x BMR). This rank reversal using both "Fleisch" and "UNU" TEE factors resulted principally from the presence in the group of housewives of seven women aged more than 60 years, whose BMR was calculated from a different prediction equation than the women who were aged 60 years and under. Further discussion of this anomaly will follow.

The use of factors based on BMR derived either from surface area or from weight do not alter the conclusion that in the age group 50-65 years there was little difference between the TEE of groups of women, which were selected because it was expected that a difference would be found. The similarly calculated figure for young housewives with children was 1.8 x BMR, the same as bakery workers (1.81 x BMR). The BMR of the Canadian women could not be estimated from the data published.

The results of using individual figures for BMR based on the prediction equations given in the FAO/WHO/UNU, (1985) report to calculate a BMR based factor for TEE of each individual and using these to obtain means of the groups emphasized the importance of a critical approach to the use of the values as it did with the men. Two cautions made in the report and examined in the discussion of the results for the male groups were those noting that an age range of 60 years onwards for calculation of BMR and energy requirements is too broad and that the uncritical use of artificial dividing lines will introduce errors and inconsistencies.

The means of BMR obtained by two different methods are shown in Table 7.15. The mean of the "UNU" - BMR for individuals in each group exceeded that of the mean of the Fleisch-BMR by 5 percent in housewives with family and sewing workers and by 7 percent in the bakery workers. If the "UNU"- BMR was obtained for the group using mean weight and mean age from the prediction equations or the tables supplied in the report, the percentage differences were slightly greater for two groups (8%) and less for one (2%).

A comparison of two mean BMR values for each group obtained firstly from the prediction equations based on mean weight and mean age and secondly from individual results, showed that where all individuals were in the same age group, namely sewing and bakery workers, the mean of the individual BMR was 44 kcal/day more for the former and 9 kcal/day less for the latter. The effect on the TEE factor of the sewing workers was a value of 1.68 x BMR using the mean figure and 1.63 x BMR using the individual figure. In the housewives sixth-decade, in which the BMR of seven women was calculated by an equation which assumed a fall in BMR beyond age 60, the mean individual BMR was 35 kcal/day less than the BMR found using mean age and mean weight. The resulting TEE factor using the mean BMR of individual results of 1,315 kcal/day (Table 7.15) was 1.72 x BMR and using the mean age and mean weight was 1.67 x BMR. If the BMR of each woman was obtained from the same equation, the TEE factor became 1.66 x BMR, which was much closer to the figure for the sewing workers of 1.64 x BMR. The estimated BMR which best represents the actual BMR of the women will never be known. The TEE of the 7 over 60 group of housewives was 130 kcal/day less than that of the 60 and under group. Using the appropriate equations for BMR, the factor for each group was 1.7 x BMR.

These comparison show as they did in the male groups, that error can be introduced if mean age and mean weight are used to obtain group mean BMR. The values for BMR obtained from the equations are those of the individual or homogeneous class whose weight for age or weight for height is at the midpoint of the range.

The coefficients of variation from the mean BMR of the group, when the BMR was obtained for each individual, from the prediction equations, or by the Fleisch method, were between 7 percent and 12 percent (Table 7.15). The variation using the Fleisch method appeared to be slightly greater, but was at the most 3 percent.

The use of the higher estimate of BMR obtained from the "UNU" prediction equations to obtain a TEE factor for each individual resulted in lower factors, except for women over 60 years, compared to the Fleisch-factors.

This resulted in the mean of the "UNU" factor for TEE for all groups of women aged between 50 and 65 years (Table 7.14) being lower than the mean Fleisch factors for TEE (Table 7.13). The difference was least in the group which included women of over 60 years because, for six of the seven individuals, the "UNU" BMR was lower than the Fleisch estimate. This increased the individual "UNU" TEE factor compared to the Fleisch TEE factor and raised the mean. This is in contrast to the situation for women of under 60 years of age, where the "UNU" BMR was higher than that of the Fleisch estimate and the mean in comparison was lowered. The "UNU"- BMR was higher than the Fleisch - BMR in only one subject aged over 60 whose BMI was 30.35 and weight was 70.8 kilograms.

In three individuals (one housewife, one bakery worker, and one sewing machine worker) the TEE factors were equal to or greater than 2 standard deviations from the mean of the TEE factor of their groups. This was found when the factors were obtained using both Fleisch and "UNU" estimates of BMR.

Use of the "UNU"-BMR instead of the Fleisch value for the energy expenditure during sleep would increase the estimated mean TEE of each group between 13 and 22 kcal/day, an insignificant amount in view of the error associated with the method.

Women - patterns of activity. The influence of a variety of factors on the TEE of the groups was examined. Those which affected it were found to be variations in the amount of time spent at work and in its allocation to different activities, the variations in the amount of non-occupational time and in its allocation to different activities and variation in the energy cost of these occupational and non-occupational activities.

It has been shown that the occupational energy demands of the two groups of factory workers differed by 100 kcal/day but, unlike the men, there is no comparable sedentary group with whom to compare them, nor is there a group of younger industrial workers whose patterns of time and energy expenditure are similarly detailed.

In Table 7.6 the groups studied are compared using factors for energy cost derived in the same way as those for male groups. This method is also a useful way of comparing groups of women, some of whom are full time housewives and others who also work outside of the home.

For the sewing machine workers the average value for the energy cost of physical activity was 2.0 x BMR during 6.1 hours per day of occupational time whereas during 5.8 hours per day that of the bakery workers was 2.6 x BMR. The comparable figures from the FAO/WHO/UNU (1985) report are 2.2 x BMR for moderate work and 2.8 x BMR for heavy work.

Both groups also spent more than 3 hours per day in non-occupational work at an average energy cost of 2.7 x BMR and 3.0 x BMR, both higher than their occupational cost.

When these two categories were combined, the sewing workers spent 9.2 hours per day at an average cost of 2.3 x BMR and the bakery workers 9 hours per day at 2.7 x BMR. Using these values the groups could then be compared to the housewives of the same age who spent 6.7 hours per day at an average energy cost of 2.8 x BMR. Comparison was also possible with a group of 45 young housewives (Grieve, 1967) who spent 9.3 hours per day in household management and childcare at an average energy cost of 2.5 x BMR. Their hours of work were the same as both groups of factory workers while the energy cost of the work was lower than that of both bakery workers and housewives - 6th decade.

The comparison, although limited, does not indicate that there is a decrease in the energy cost of occupational physical activity with increasing age, whether the cost is incurred by household and childcare activities or in a combination of outside work and household responsibilities. The similar finding for TEE has already been discussed.

The average time spent by six employed Canadian women in their early sixties in occupational plus non-occupational work was 8.1 hours per day. These women spent one hour less in the two types of work than the factory workers and just over an hour longer than the housewives-6th decade. Underestimates of the energy requirements of older women (and men) may result if it is assumed that there is a decline in physical activity with increasing age.

The non-occupational energy demands of the two groups of factory workers were found to differ by 100 kcal/day. The energy costs of non-occupational physical activity are shown in Table 7.6 expressed as multiples of "UNU"-BMR. These show that the bakery workers incurred the greater cost (2.1 x BMR compared to 1.9 x BMR). The energy cost of non-occupational physical activity was greater than that of occupational physical activity for both groups due to the time and energy spent in the non-occupational work component. Comparison with the housewives was possible on the relaxation component, which included walking. The energy cost to all groups was similar (1.6 and 1.7 x BMR). One half of the 200 kcal/day difference between the TEE of bakery and sewing workers was accounted for by occupational energy demands. The remainder was due to the greater energy cost of the non-occupational work of the bakery workers. Since it was shown that there was no significant difference in TEE between the groups and since there is no age-comparable sedentary group with which to compare them, very little difference in occupational energy expenditure between groups of women has been found.

The similarity between the TEE of the housewives and sewing workers resulted from the greater energy cost to the housewives of their physical activity during occupational plus non-occupational work time (2.8 x BMR compared to 2.3 x BMR). However, it was shown that there was no significant difference in TEE between the groups. Occupational energy expenditure was not as good a predictor of TEE as it was for the men, although the rank order of energy spent in occupational plus non-occupational work time was the same as that of TEE. Occupational energy cost expressed as a multiple of "UNU"-BMR predicted the greater TEE of the bakery workers.

The average energy cost of physical activity during occupational plus non-occupational work time distinguished the bakery workers and housewives from the sewing workers (2.8 and 2.7 x BMR compared to 2.3 x BMR). It has already been shown that the sewing workers spent 200 kcal/day more than the housewives in these activities. This resulted from the greater number of hours devoted to these combined activities by the sewing workers (9.2 compared to 6.7 hours).

The importance of the contribution of non-occupational work to the TEE of the two groups of factory workers has been shown. It was only 10 percent less than that of occupational activities or two-thirds of the energy expended in them.

In Table 7.16 the contributions of occupational and leisure time physical activity to TEE are shown in two other ways for each group studied and for three other groups for which data was available (Sections I and II of the table). These are compared to the estimates of the energy requirements of two women with different patterns of activity given in the FAO/WHO/UNU, (1985) report.

In Section I the fractional portions of the "UNU"-TEE factor contributed by occupational and non-occupational physical activity, which were derived from the estimates of energy expended on these activities by each individual in the groups are shown. They are also shown as percentages of the fractional portion.

In Section II the recorded percentage contribution to TEE expressed as kilocalories per day and in Section III the percentage of TEE calculated from the examples given in the report and the corresponding definition and TEE factor are shown.

The percentage of the fractional portion of the TEE factor distinguished between the occupational demand of the bakery workers (46%) and the sewing workers (39%), which the percentage of kilocalories expended did not (32% and 33%). The percentage allocated to occupation by the young saleswomen (Durnin, et al., 1957) was 57 percent.

In the absence of a more useful example the figures which are compared to the factory workers are those of the energy requirement of a rural woman in a developing country.

The TEE factor of the example is 1.76 x BMR, which lies between the estimated average daily energy requirement given in the report of 1.64 x BMR for moderate work (sewing workers) and 1.82 x BMR (bakery workers) for heavy work. The contributions are very different because Group A and Group B patterns of activity are being compared. The TEE factor for the young saleswomen of 1.70 x BMR also lies between the two figures.

Comparison of the percentage of occupational energy expended by the groups (32 and 33%) with the percentage of the requirement (52%) showed an apparently large difference, but when the energy expended on non-occupational work was added to occupational energy expenditure, the percentages became more similar (53% for the sewing workers and 55% for the bakery workers).

The housewives - 6th decade did not have the same pattern of activity as the "UNU" example of a 25 year old housewife in an affluent society. There was a difference in the proportion of energy spent in occupational activities, which was 34 percent compared to the 25 percent of the example and in the percentage of the fractional portion (54% compared to 46%). The TEE factor of the housewives also exceeded that of the "UNU" example (1.72 x BMR compared to 1.52 x BMR). The housewives with young children studied by Grieve (1967) shown in Group B also most closely resembled the estimates given for the energy requirement of rural women. She defined their only noticeable leisure as their reported sitting time. Walking was included in "walking and shopping" and was, therefore, a homecare and childcare activity. For the older women, some walking was a leisure activity.

The TEE factor of middle-aged housewives (5th and 6th decade) studied by Durnin, et al., (1957) was almost identical to that of the "UNU" example of a housewife in an affluent society (1.50 compared to 1.52 x BMR). However, the proportion of the fractional portion allocated to occupation was 24 percent higher than the example and the recorded percentage of TEE contributed by occupation was 19 percent greater than in the example.

It may be speculated that active recreation such as jogging, running, and aerobic dance has replaced active home and childcare activities in the lives of many housewives in some affluent societies. These help to offset the lower energy demands brought about by the use of modern appliances and automobiles, but as yet have not halted the increase in weight of affluent populations, such as that of the United States (Mertz and Kelsay, 1984). MacNair (1986) commented on the striking fact that in seventeen countries the mortality rates for men from ischaemic heart disease had risen between 1950 and 1978, while those for women had fallen. He observed that "women's work has changed little in the past quarter century, since it is still most concerned with the physically exhausting business of running a home, while men have virtually ceased to indulge in physical work and are transported to and from what work they do".

In reporting a study of middle-aged housewives in 1957 (Durnin, et al., 1957) we noted that the time spent in activities which were of high energy cost was small and, therefore, the energy expended on these tasks did not have a great influence on TEE but that household activities are "mentally fatiguing".

An interview study by Oakley (1974) of 40 housewives aged 20-30 years in London found that job satisfaction with the housework portion of homemaking was low. She found that the average weekly hours of housework reported were 77. This exceeded the 65 hours found by Grieve (1967) for housewives in the same age range. The 6th decade (middle-aged) housewives spent 47 hours, but sitting household tasks were not included in the total.

It may well be true, as suggested by MacNair, that the total energy expenditure of women has altered little in the past 25 years. This may be due to changes in patterns of activity, not to lack of change in household tasks. Women of all ages have chosen or been forced, for financial reasons, to work outside of the home in addition to their domestic and childcare activities. This is likely to have increased their TEE or simply maintained it in spite of more gadgets for easing household tasks and greater use of personal transportation. This may have also prevented a decrease in total energy expenditure of women with increasing age.

The total energy expenditure of the factory workers did not differ from that of the young housewives with children. The activities on which energy was expended were very different. Caring for young children appears to be a very active occupation, but as with housework, periods of strenuous activity are usually of short duration and the pace of many activities is reduced to accommodate children. However, the working day is very long. The energy expenditure in this early phase of adult life is likely to be very similar to that of a women of 40, 50 or 60 years of age whose occupation is in an office, factory, shop or school, and who adds to the length of her working day by working in the home. The range of the fractional portion of TEE of the three groups of women comprising Group A was 0.64-0.81 x BMR. The range for occupational energy expenditure was 0.25 - 0.40 x BMR and for non-occupational energy expenditure 0.30 - 0.44 x BMR.

The lack of information on activity patterns is more acute for women than for men (FAO/WHO/UNU, 1985), in spite of the passage of thirty years since Durnin, et al., (1957) published a study of middle-aged housewives and their adult daughters. LaPorte, et al., (1982) also noted that "little is known about physical activity in older women."

Some studies using the questionnaire method were discussed in the previous section and some of these also included findings on women.

Haglund, (1984) using a single multiple choice questionnaire, found that for women, unlike men, greater physical activity at work corresponded to a higher degree of leisure time activity. He also found that 77 percent of women engaged in moderate physical activity in leisure hours.

Using some of the data from this series of studies together with some from groups of younger women, total number 95, Wheatcroft (unpublished data), found that the correlation between physical activity at work and TEE was r 0.43, whereas, for physical activity at leisure and TEE, the relationship was r-0.47. She concluded that, although the relationships were not of such a high order as those for men, the results were similar and that physical activity at work was the more important determinant of TEE. She also noted that there was less conclusive evidence than for men that time spent in moderate activity was the most important index of TEE.

A report by Sallis, et al., (1985) of the use of the Stanford physical activity assessment method on a population of 1,120 women found that occupation was related to the appearance in the activity pattern of moderate and vigorous activity (defined as 3.0-5.0 and 7.0 or greater METs respectively) but not to TEE. Levels of these activities were highest where educational level was also high and the activities took place in leisure time.

There have not, as yet, been studies on women which the collection of physical activity data on a very large group was as detailed as that of Paffenbarger, et al., (1986), who found that energy expended in walking, stair climbing and sports play was inversely related to mortality in men. The levels of energy expenditure on these activities between which a steady decline in death rates was seen were approximately 2 percent (500 kcal/week) to 17 percent (3500 kcal/week) of TEE, assuming an average TEE of 21,000 kcal/week (3000 kcal/day). If a similar effect were to be found in women, hypothetically equivalent figures would be approximately 300 kcal/week to 2300 kcal/week, assuming an average TEE of 14,000 kcal/week (2000 kcal/day).

For comparison with these hypothetical figures the actual number of kilocalories expended in walking per week by each group is shown in Table 7.17. The mean energy expended in walking in leisure time alone was in excess of 1100 kcal/week for all groups. The housewives-4th decade reported walking as an occupational activity. When occupational walking was added to leisure walking for the two groups of factory workers, they expended 1800 and 2000 kcal/week in the activity. There were, however, large variations in the energy expended by individuals in each group. It is at the individual level that the relationship of energy expended and death rate occurs. Of the 75 women for whom data on walking was available, one spent less than 300 kcal/week, 13 percent (10) expended between 300 and 900 kcal/week, 52 percent (39) expended between 900 and 2100 kcal/week, 31 percent (23) expended between 2100 and 3100 kcal/week and 2 spent between 3100 and 3700 kcal/week. In addition to walking, 13 bakery workers 8 sewing machine workers and 9 housewives expended energy in the moderate range. Similarly to the men the physical activity of most of the women met or exceeded the hypothetical criteria based on the findings of Paffenbarger, et al., (1986). In Table 7.6 the group energy cost of walking is expressed as a ratio to the BMR and also as energy cost per minute uncorrected for weight. The mean energy expenditure per minute in walking fell into the moderate work range (3.5 - 5.4 kcal/min.) for the bakery workers. The "UNU"-BMR factor associated with this level was 4.5 x BMR.

Comparison of Group A and Group B women suggested that having a job outside of the home, rather than age determined the energy expenditure in walking, probably because a walk to and from transport was necessary every working day. The energy expended in walking by the 6th and 7th decade housewives was 400 kcal/week greater than that of the 4th decade housewives with young children and of the 5th and 6th decade housewives whose children were older but still living at home.

In Table 7.18 the components of non-occupational physical activity are shown for comparison with studies which focus on leisure-time physical activity. In contrast to the male groups, there was little difference between the two groups of women.

7.2.3 <u>Summary - relationships between occupation, total energy expenditure and patterns of activity of men and women in the 50-65 age group</u>.

7.2.3.1 <u>Men</u>. The occupational difference in total energy expenditure found between groups of men of under 50 years was maintained when groups of men of between 50 and 65 years were studied. There was a difference of approximately 30 percent between those occupations involving hard labour and those which were largely sedentary. The difference in the 50-65 age group between the most sedentary (clerical workers) and the most active (Swiss farmers) was 67 percent.

<u>Women</u>. The narrow range of the occupational difference in total energy expenditure between groups of women aged 50-65 years was also found in groups of under 50 years. The range of 20 percent between Scottish groups was narrower than that of men but no group equivalent to the male clerical workers was found in any of the age groups for comparison. The difference in the 50-65 age group between the most sedentary (middle-aged housewives) and the most active (Swiss housewives/farmers) was 42 percent.

7.2.3.2 <u>Men</u>. Occupation was a good predictor of energy expenditure in groups of men aged between 50 to 65 years and in younger groups.

<u>Women</u>. Occupation was not as good a predictor of total energy expenditure for women aged 50-65 years as it was for men. There was some indication from limited data that this was also the case for women of under 50 years.

7.2.3.3 <u>Men</u>. There was no greater variation between mean energy expenditure of individual men in age groups under 50 years and between 50 and 65 years who were in similar occupational groups.

<u>Women</u>. There were fewer data for women upon which to base a judgement, but the trend appeared to be the same as that for men.

The following points arose from the examination of the findings in relation to the concepts developed in FAO/WHO/UNU, (1985) Expert Consultation on Energy and Protein Requirements:

7.2.3.4 Men. The use of calculated factors for total energy expenditure based on BMR derived from surface area or from weight did not alter the conclusion that there was the same range of difference in the 50-65 age group and the under 50 age group between groups of men who performed hard physical labour during their working hours and those whose work was mainly sedentary.

Women. The "UNU" TEE factors for groups of women did not alter the conclusion that in the age group 50-65 years there was little difference between the TEE of groups of women, which were selected as representative of sedentary, light, and moderate work.

7.2.3.5 Men. The total energy expenditure expressed as a factor of BMR derived from prediction equations (FAO/WHO/UNU, 1985) maintained the differentiation between the group of farmers and all other groups and between the group of clerical workers and all other groups.

Women. The "UNU" TEE factor differentiated the bakery workers more clearly from the sewing machine workers than did kilocalories per day.

7.2.3.6 Men. The results of using individual figures for BMR based on the prediction equations given in the FAO/WHO/UNU, (1985) report to calculate both a BMR based factor for TEE of each individual and using these to obtain the means given above for the groups served to emphasize the importance given in the report to a critical approach in the use of the values. The mean "UNU" TEE factor of groups, which include subjects where BMR has been calculated according to the over 60 prediction equation, was greater than that of groups for which the prediction equation of all members was that for the 30-60 age group.

The use of these figures to produce a TEE factor makes it difficult to compare the mean TEE factors of groups, which consist of subjects above and below the dividing line. Such groups are otherwise fairly homogeneous in occupation and are normally considered to be in one age group with an upper limit of 65 years. For these male groups, the retirement age of 65 years, not 60 years, becomes the point at which major changes in activity are likely to occur. In general, in both active and sedentary occupations, energy demands will differ little between men who are nearly 60 and men who are between 60 and 65. Because of the uncertainty about rate of decline of BMR and the probability that the decline is not more than about 100 kcal/day from young adulthood to 65 years, use of the same prediction equation is indicated for individuals who make up occupationally comparable groups of men up to 65 years.

Women. The same effect was seen for women when the over 60 prediction equation was used for seven housewives, thereby increasing the mean "UNU" TEE factor compared to the groups which did not include any subjects over 60 years. If women retire at a younger age than men the argument for delaying the use of a different equation may not be as strong. Consistency between the sexes is likely to be of more value for comparison of findings.

7.2.3.7 Men. The mean of the "UNU"BMR for individuals in each group exceeded that of the mean of the Fleisch-BMR by 5 percent for the executives to 12 percent for the building workers.

The effect of using the higher estimate of BMR obtained from the "UNU" prediction equations to obtain a TEE factor for each individual was that the "UNU" TEE factors, except for men over 60 years, were lower than the Fleisch TEE factors.

This resulted in a mean "UNU" factor for TEE for all groups of men aged between 50 and 65 years which was lower than the mean Fleisch factors for TEE.

Women. The mean "UNU" - BMR factor for TEE was lower for each group than the Fleisch BMR factor. The use of the higher estimate of BMR obtained from the "UNU" prediction equations to obtain a TEE factor for each individual resulted in lower factors, except for women over 60 years, compared to the Fleisch-factors.

This resulted in the mean of the "UNU" factor for TEE for all groups of women aged between 50 and 65 years being lower than the mean Fleisch factors for TEE.

7.2.3.8 Men and Women. The use of mean age and mean weight to obtain group mean BMR of groups in which some individuals are above and below 60 years is an erroneous use of the prediction equations and tables.

7.2.3 9 Men. Occupational energy expenditure of men was not reduced in the 50-65 age group compared to those under 50 in the groups where work was defined as sedentary or as heavy.

Women. Since it was shown that there was no significant difference in TEE between the groups and since there was no sedentary group with which to compare them, very little difference in occupational expenditure between groups of women aged 50-65 years has been found. The data were too limited to make this comparison with younger groups of women.

7.2.3.10 Men. The energy cost of occupational physical activity, expressed as "UNU" BMR-based factors, of the 50-65 age group of men did not differ from the under 50 age groups, although no under 50 groups similar to the moderate work category groups were available for comparison.

Women. Comparisons of these factors is a useful way comparing groups of women, some of whom are full time housewives and others who also work outside of the home.

The energy cost of occupational physical activity in the 50-65 age group compared to under 50 groups, did not differ whether the cost was incurred by household and childcare activities or in a combination of outside work and household responsibilities.

Underestimates of the energy requirements of women (and men) between 50-65 years may result if it is assumed that there is a decline in physical activity during those years.

7.2.3.11 Men. Occupational energy cost expressed as a "UNU" BMR factor was a good predictor of total energy expenditure.

Women. Occupational energy cost expressed as a multiple of "UNU"-BMR predicted the greater TEE of the bakery workers.

7.2.3.12 Men. Occupational energy demand was the principal reason for differences in TEE between the moderate work groups and the sedentary group of men aged 50-65 years as it was in under 50 age groups.

Women. The very small difference in occupational energy demand between two groups of female factory workers aged between 50 and 65 years was increased by the contribution of non-occupational work. No comparable younger groups were found.

7.2.3.13 Men. For five out of six groups of men, excluding the executives, occupational energy expenditure was a good predictor of TEE.

Women. Occupational energy expenditure alone was not as good a predictor of TEE for women as it was for the men, but the rank order of energy spent in occupational plus non-occupational work time was the same as that of TEE.

7.2.3.14 Men. Occupational energy expenditure was not a good predictor of TEE for the executive group of sedentary workers. This resulted from an average energy cost of physical activity during non-occupational time, which was greater than all groups except the steel workers.

Women. Similarly, non-occupational work made an important contribution to the TEE of the two groups of female factory workers. One half of the difference between them was accounted for by the non-occupational work of the bakery workers.

7.2.3.15 Men. Comparisons using a "UNU" BMR-based factor for energy costs highlighted differences and similarities between groups: a)The energy cost of non-occupational work and occupational work was the same for the steel workers; b) Both the building workers and light industry workers spent non-occupational time at lower levels of physical activity than occupational time, whereas the physical activity of both the executives and clerical workers was greater than that in occupational time; c) For the executives the occupational energy cost was 2.0

x BMR, whereas, non-occupational energy cost was 3.0 x BMR; d) This method of presenting the data makes it possible to make a better comparison of the farmers with the other groups based on the combination of energy cost during occupational and non-occupational time. At 4.0 x BMR it exceeded all other groups, the closest being the 2.8 x BMR of the light industry workers. The latter met the suggested figure for moderate work of 2.8 x BMR and the farmers exceeded the suggested figure of 3.8 x BMR for heavy work (FAO/WHO/UNU, 1985). The energy cost of relaxation activities was also shown to be lower than any other group, 1.3 x BMR.

Women. a) For the female factory workers, like the executives, the energy cost of non-occupational work exceeded that of occupational work; b) Comparison of the female factory workers and housewives was also facilitated. The average energy cost of occupational plus non-occupational work of the bakery workers and housewives was almost identical, 2.7 and 2.8 x BMR. This was greater than that of housewives under 50 years, 2.5 x BMR and was equivalent to the suggested figure of 2.8 x BMR for heavy work (FAO/WHO/UNU, 1985);

Men and Women. The energy cost of men and women can also be compared. Bakery workers, steel and building workers incurred the same costs (2.6 and 2.7 x BMR) in occupational activities as did sewing workers and executives (2.0 x BMR). When energy cost of occupational plus non-occupational work is compared the male and female groups form two clusters. One consists of steel workers, building workers, light industry workers, bakery workers and housewives, 6th decade with energy costs in the 2.6-2.8 x BMR range. The other consists of executives and sewing workers (2.3 x BMR). At the extreme ends of the range are found the farmers (4.0 x BMR) and the clerical workers (1.7 x BMR). This illustrates, again, the possible range for the energy expenditure of women, which was not covered in the groups studied. h) Groupings were different when energy costs of "relaxation" were compared. Most groups of men and women had an energy cost of between 1.6 and 1.8 x BMR. The extremes of the ranges were farmers (1.4 x BMR) and executives and steel workers (2.1 and 2.2 x BMR).

7.2.3.16. Men. Comparisons of the contributions of occupational and leisure time physical activity to TEE with the figures for examples of light activity work, moderate activity work and heavy work given in the FAO/WHO/UNU, (1985) report for individuals aged 25 or 35 years led to the following findings and conclusions: a) the TEE factors of all groups, except the clerical workers and farmers, exceeded those of the "UNU" examples of similar work categories; b) the "UNU" example of "light activity" work was similar in both comparisons to the clerical workers, although their TEE was lower (1.41 x BMR compared to 1.54 x BMR); c) the "UNU" example of "light activity" work was not in accord with the percentages of fractional portion allocated by the executives to occupational physical activity (25% compared to 32%) or to TEE (1.81 x BMR compared to 1.56 x BMR); d) the energy expended in leisure time by the steel workers and executives exceeded occupational energy expenditure both as a fractional portion of TEE and a percentage of observed TEE. The "UNU" TEE factor for both groups was nonetheless more similar to the "UNU" requirement factor for "moderate activity work" than to the factor for "light activity work"; e) the percentage of the fractional portion allocated to occupational activities by the building and light industry workers was 58 percent compared to 63 percent of the "UNU" example of "moderate activity" work; f) The percentage of the fractional portion allocated to occupation plus discretionary activities by the farmers, was very similar to the "UNU" example of "heavy activity" work (91% compared to 89%). For another group of heavy workers, used for comparison, a group of miners, the percentages were quite different from the "UNU" example (65% compared to 82%) and were more similar to the divisions of "moderate activity" work; g) The range of the fractional portion of TEE for the sixty-two men aged 50-65 comprising Group A was 0.41 - 0.92 x BMR. The range for occupational energy expenditure was 0.14 - 0.48 x BMR and for non-occupational energy expenditure 0.27 - 0.61 x BMR. The corresponding figures for 30 men from two groups under 50 years were a range of the fractional portion of 0.66-1.22 x BMR, of occupational energy expenditure of 0.25-0.76 x BMR and of non-occupational energy expenditure of 0.41-0.43 x BMR. The activity pattern of the farmers was so different that they should be considered separately in any estimate of variability of aggregated groups.

Women. For women, the comparisons were made with figures for examples of a rural woman in a developing country (RWDC), since no more comparable example was given, and a housewife in an affluent society (HAS): a) The TEE factors of groups compared to HAS exceeded those of the example, while of those compared to RWDC, one met, one exceeded, and one did not meet the TEE of the example; b) The "UNU" example of a housewife in an affluent society did not exhibit the same pattern in either comparison, i.e., of percentage of fractional portion or in percentage of requirement, as the three groups of 50-65 age group and younger housewives to which it was compared. It underestimated the percentages of fractional portion allocated to occupational activities and also the recorded percentage of TEE of each group. The TEE was in accord with only one group; c) When occupational and non-occupational work together were compared to the percentage of total energy requirement allocated to occupational work of the "UNU" example of a RWDC, the percentages surprisingly bore some resemblance to one another; d) A group of younger housewives most closely resembled the "UNU" estimate of a RWDC in percentages of the fractional portion, in percentage of TEE and in "UNU" TEE factor; e) Energy expended in leisure time exceeded that in occupational time in both comparisons for both groups of factory workers, but not for groups of housewives of varying groups.

The main focus of the following six points is leisure time physical activity.

7.2.3.17 Men. The findings of a higher degree of physical activity during leisure time by the executives agreed with findings by other groups of a positive relationship between level of education, higher socio-economic groups and leisure time activity.

Women. A similar finding for women factory workers was not associated with recreational activities but with household tasks and there was little difference in leisure time physical activity between the groups.

7.2.3.18 Men. A comparison with the energy cost of the leisure time physical activity of a large group of men in the United States led to the conclusion that, in contrast, in all the thesis groups, the energy cost of non-occupational work and non-occupational walking combined exceeded the 240 kcal/day, which was spent by the large group.

7.2.3.19 Men. Compared to the Paffenbarger, et al., (1986) criteria of the amount of energy spent in walking, stair-climbing and sports play, which appeared to have an inverse relationship to mortality, the physical activity of the majority of men studied was more than adequate to produce this effect.

Women. When hypothetical criteria based on those of men were compared to the findings for women, the physical activity of most of the women also met or exceeded the criteria.

7.2.3.20 Men. The "UNU"-BMR factors for gross energy expenditure in walking were between 4.2 and 5.2 x BMR for five of the groups. Their mean energy expenditure in walking fell into the category of moderate work (5-7.4 kcal/min).

Women. Walking fell into the moderate work range of 3.5-5.4 kcal/min for the group of bakery workers only and the "UNU" BMR factor associated with the level was 4.5 x BMR.

7.2.3.21 Men. Very different patterns of leisure time physical activity were found between two groups of male sedentary workers and between two groups in moderate to heavy occupations.

Women. The patterns of leisure-time physical activity of the women were similar for the two groups of factory workers and for the groups of housewives.

7.2.3.22 Men. The similarity of the leisure time physical activity of the light industry workers to that of the executives was in agreement with the finding of others that skilled workers in common with more highly educated men included more physical activity in their leisure time.

Women. Changes in patterns of activity of women, in particular those occasioned by employment outside of the home are likely to have maintained the energy expenditure of large numbers of women in the 50-65 age group at the same level as that of women in their twenties and thirties. Increased energy expenditure is quite possible.

7.3 The 50-65 age group: Occupation, energy intake and requirements.

7.3.1 Men - energy intake and requirements. It was shown that there were significant differences in energy intake between farmers and light industry workers, clerical workers and executives but not between the farmers and steel and building workers. The energy intake of the clerical workers was significantly lower than all groups, except the executives. Thus, there was not such a sharp distinction between the energy intake of the groups as there was in energy expenditure, but the differences in energy intake between the groups did reflect the differences in their energy expenditure.

The energy intake of the farmers (3460 kcal/d) was almost 250 kcal/day less than their expenditure. That of the group of miners (4040 kcal/day), to whom they have been compared in the energy expenditure section was 370 kcal/day in excess of energy expenditure. Similarly, the energy intake of the executives (2640 kcal/day) was 180 kcal/day less than their expenditure, while that of the colliery clerks (3040 kcal/day) was 240 kcal/day in excess of energy expenditure. Nevertheless, the difference between the hard labour group and the relatively sedentary group in each of the two age groups was large, (820 and 990 kcal/d) as it was when energy expenditures were compared (885 and 860 kcal/d). The difference in intake was 30 percent. A group of men aged 20-39 studied by Bingham, et al., (1981) had an intake similar to the clerical workers. The difference between them and a group of workers of the same age (Bransby, 1954) was 48 percent. This difference was also found in the 50-65 age group when sedentary workers were compared to Swiss farmers.

Many more methodologically comparable studies of energy intake are available than studies of energy expenditure. Some of these are listed in Table 7.19 (1936-1965) and Tables 7.20(a) and 7.20(b) (1966-1986).

The majority of these studies have been cited in the Historical Review to illustrate the extent of the work which has been done on the energy intake of older adult men. Although most studies are of groups aged between 50-65 and 65-80 years, the energy intake of some of the early middle-aged groups and of the younger groups used for comparison of energy expenditure are also shown. When taken together with the thesis findings, these indicate that occupation is a better predictor of energy intake than age.

The co-efficients of variation from the mean of energy intake (kilocalories per day) shown in Table 7.21 are similar to these of the younger miners (13%) clerks (14%) and technicians (17%). Increasing age does not seem to alter the degree of variation in energy intake between individuals.

When intake of energy was expressed in terms of weight, it was shown that the difference between the groups was reduced. It was still significant between the farmers and clerical workers. This effect was also found when mean energy intake was expressed as a mean "UNU" total energy intake (TEI) factor (Table 7.4). These factors ranged from 1.99 and 1.91 x BMR for the farmers and steel workers respectively to 1.52 x BMR for the clerical workers. The intermediate group factors were 1.76, 1.89 and 1.70 x BMR for building and light industry workers and executives respectively. The rank order of building workers and light industry workers was reversed as it was with energy expenditure due to the over-60/60-and-under years composition of the latter group. The co-efficients of variation of mean "UNU" TEI factors were greater for all groups, except the executives than those of kilocalories per day, but not as great as those of mean kilocalories per kilogram (Table 7.21).

The most striking finding when comparing the thesis studies to those selected and listed in Table 7.19 and 7.20, is the similarity of most of the findings for the age groups under 65 years to those of the clerical workers (2440 kcal/d). This level was exceeded only by groups whose occupations were definitely not sedentary, for example, where the occupations included some heavy labour or involved long hours of standing activities [light industry workers, bank clerks (Morris, et al., 1963)].

The difficulties of ascertaining the habitual intake of individuals are notorious and have been discussed in the Methods and Historical Review sections. Imperfect though the methods may be, some remarkably similar results have been found for groups. These are not indicative of any consistent difference in intake between occupationally comparable groups of 50-65 years and those which are younger. McGandy, et al., (1966) found a difference of about 100 kcal/day between a 45-54 year group and a 55-64 group, but no difference between 55-64 and 65-74 age groups. The thesis studies and others have found higher intakes than they did for sedentary workers in these under 65 age groups. Only the 20-39 year old group studied by Bingham, et al., (1981) reached the figure for clerical workers. In a study by Thomson et al., (1982) the intake of 40 year olds reached the level of the light industry workers. A 35-39 year old group studied by Elahi, et al., (1983) had an intake similar to the executives and it was found that those groups aged 40-44, 60-64 and 65-69 had the same mean intake of 2300 kcal/day, while four groups aged 45-49, 55-59, 75-79 and 80-84 had mean intakes of 2200 kcal/day. There is a slight indication, for example from Kim, et al., (1984) and Elahi, et al., (1983) that a drop in intake takes place between 35 and 40 years and then levels off.

In the Historical Review, Parts 1 and 2, it was noted that although there is an overall downward trend in intake of energy and nutrients with advancing age, the rate of decline may not be uniform throughout the age span. Evidence was cited that for sedentary groups beyond the age of 40 and up to somewhere between 75 to 80 years, very little decrease in energy intake has been shown. In parallel with energy expenditure there appears to be a middle-years plateau of energy intake. It tends to remain at about the 2300-2400 kcal/day level for normally healthy men. This level of intake of has been found in the majority of comparatively sedentary occupations in the studies cited.

This accords with the classical estimates such as those of Tigerstedt (1911), cited by Sherman (1952) of 2000-2400 kcal/day for a shoemaker and 2400 kcal/day for a weaver and of that of Orr and Leitch (1938) for a sedentary man who does not exercise. It is somewhat lower than the 2700 kcal/day recommended by them for a clerk. This latter figure is more in line with the category of "sedentary" worker who does not actually sit a great deal, e.g., the executives, the colliery clerks and the bank clerks.

In a general sense, it was true that the energy intake of each group reflected the energy expenditure because the high energy expenditure groups were the high energy intake groups and the low energy expenditure group was the low energy intake group. An association was also shown between the intake and expenditure of all male subjects (r 0.73). It is not known whether the estimated energy expenditure and intake during the week of study reflected the habitual level of each of these variables. It is likely that there was less change in the pattern of activity of the men, dominated as it was by their occupation, than in their food intake. This may have been adjusted, perhaps sub-consciously, by their wives to gain the investigator's approval.

The question of whether energy intake was, in fact, energy requirement is now addressed in the light of the FAO/WHO/UNU (1985) report on energy requirements which stated "In physiological terms, energy requirement may be defined as the level of intake required to match the levels of expenditure." This was qualified by "normative" judgements which were made about "levels of activity, growth rates, and body proportions that are deemed to be desirable."

A comparison has been made in the discussion of physical activity of the mean "UNU" TEE factors of each of the groups with factors suggested in the report for three levels of energy expenditure. It was found that the levels of activity were in the "desirable" range, i.e., the level considered to be adequate for good health, as discussed in the Historical Review Part 2. However, the body proportions of many of the subjects were not in the "desirable" range. It was shown that the BMI of 47 percent of the men exceeded 25.0, the upper point of the desirable weight range for men (FAO/WHO/UNU, 1985).

If the energy requirement of the fairly homogeneous occupational groups of the thesis includes the concept of the maintenance of health in already healthy individuals, and if it is accepted that there is a direct relationship between BMI and morbidity and mortality, then neither the energy expenditure nor the energy intake of the groups are acceptable as their energy requirements as defined in the report. The habitual energy expenditure may have been overestimated or the habitual energy intake underestimated. Acheson, et al., (1980) found the method underestimated the latter by 7 percent. They and others have stated that the methods are not accurate enough to predict fat gain or loss, which can be achieved by a very small imbalance of expenditure to intake over a period of time. The energy intake of 35 of the men aged 50-65 exceeded their energy expenditure, but this was not associated with BMIs over 25. The estimated energy requirements for the groups of men based on their desirable weight for height and their "UNU" occupational work classification are shown in Table 7.22. The normative requirements have been derived from BMR at desirable weight for each group multiplied by the mean group "UNU" TEE factor.

These normative energy requirements were less than the actual energy intake of farmers (12 kcal/day), of the steel workers (200 kcal/day), of the building workers (300 kcal/day), of the light industry workers (34 kcal/day), and the clerical workers (230 kcal/day). They were greater for the executives (289 kcal/day), the group whose BMI (22.6) was closest to the desirable average and whose actual and desirable weight showed the least discrepancy. Restoration of energy balance at a more desirable level of weight would be effected by these energy requirement estimates in all except the executive group and perhaps the farmers and light industry workers. Use of 2.1 x BMR for the average daily energy requirement of the farmers produced a figure of 3410 kcal/day, which differed little from actual energy intake (3470 kcal/day). However, energy intake for the week of the study appeared to be 240 kcal/day less than energy expenditure. It is doubtful whether the high level of energy expenditure necessitated by harvest time was maintained throughout the year and energy intake may have reflected a more usual level of expenditure. The moderate work level of 1.78 x BMR might then be a more appropriate requirement figure at desirable weight.

The actual intake of steel workers exceeded the estimated energy requirement at 2.1 x BMR. Therefore, 1.78 x BMR would be the appropriate normative level. This would also apply to the building and light industry workers.

The light work level of 1.55 x BMR would be appropriate for the executives, but not for the clerical workers where requirements at this level differed little from their energy intake and exceeded their expenditure. Energy requirement at the "UNU" TEE factor level of 1.4 x BMR was 2000 kcal/day less than energy intake.

The height, weight and BMI of individual subjects whose mean energy intake was less than 2000 kcal/day are given in Table 7.23. The energy intake is given in kilocalories per day and as a "UNU" energy intake factor. Only one man in the 50-65 age group fell into this low intake category. His intake was below the "UNU" cut-off point of 1.2 x BMR and his BMI of 19.0 suggested that his energy intake may have been inadequate, rather than the extreme end of a normal distribution.

The energy intakes of all groups exceeded the mean recommended intake of 2400 kcal/day (U.S. RDAs, 1980) and, in four groups, the upper limit of the range for men aged 51-75 years of 2800 kcal/day.

The summary of this and the following discussion appears in Section 7.3.3.

7.3.2 Women - energy intake and requirements. The only significant difference in intake shown between the three groups of women aged between 50 and 65 years was the lower intake of the housewives compared to the bakery workers (270 kcal/day). This was similar to the findings for energy expenditure (250 kcal/day).

Energy intakes found in studies which used similar methods are listed in Tables 7.24 (1936-1965) and Tables 7.25(a) and 7.25(b). The thesis findings can thus be seen in the context of preceding and succeeding surveys of the dietary intake of the age groups of interest.

The only women of all age groups whose intake exceeded 2200 kcal/day were the Swiss farmers/housewives and an apparently atypical group from the Framingham Heart Study, (Goor, Hoskins, Dennis, et al., 1985). Until after 75 years the lower mean level of intake appeared to be about 1800 kcal/day.

The co-efficients of variation from the mean of energy intake (kcal/day) shown in Table 7.26 were greater than those of men and of a group of young saleswomen (15%) but similar to a group of young students (20%). No firm conclusion can be drawn about change with increasing age in the degree of variation in intake between individuals.

It was shown that there was no significant difference in energy intake per kilogram body weight between the groups. This was also the case, when mean total energy intake (TEI) was expressed as a mean" UNU" TEI factor (Table 7.13). These factors were 1.55 x BMR for the housewives, 6th decade, 1.61 x BMR for the sewing machine workers and 1.72 x BMR for the bakery workers. The co-efficients of variation of mean "UNU" TEI factors were lower than those of kilocalories per day for all groups except the sewing workers. The greatest variation was exhibited by kilocalories/kilogram body weight.

It was shown that there was a much lower association between the energy intake and expenditure of all female subjects (r0.49) than of males (r 0.73) and that the intake was lower than expenditure in all groups.

The question of whether energy intake was the energy requirement is now examined as it was with the men in the light of the "normative" judgements made by the FAO/WHO/UNU (1985) Consultation.

It was suggested in the discussion of physical activity that the groups of women appeared to have levels of activity consistent with current recommendations for maintaining health i.e., in the desirable range. As with the men the body proportions of many of the subjects were not in the "desirable range. It was shown that the BMI of 58 percent of the women exceeded 23.9, the upper point of the desirable weight range.

Following the same argument put forward for the men, neither the energy expenditure nor the energy intake of the groups fulfilled the definition of energy requirements given in the report, since energy balance, if it had been achieved by individuals, was maintained at an undesirably high BMI. In Table 7.27 normative energy requirements are estimated using the mean group "UNU" TEE factor derived from "actual" energy expenditure and using the factors for various levels of work proposed in FAO/WHO/UNU (1985).

Normative requirements were derived from the previously calculated "UNU" TEE factor at actual weight and the BMR at desirable weight. These exceeded the "actual" energy intake of the housewives, 6th decade and the bakery workers which was, in each case, 300 kcal/day less than the energy expenditure. If energy balance had been achieved at the level of intake found, 1.64 x BMR would be an appropriate normative value for each group. Since the energy requirement of the sewing machine workers at 1.64 x BMR was only 35 kcal/day less than the "actual" intake, 1.56 x BMR would be a more appropriate normative requirement value for the group. Even if the energy intakes were underestimated the large number of overweight individuals in all such groups in affluent countries would justify setting the requirements at those levels. It is also possible that normative requirements might be even lower today due to the depressant effect on BMR of repeated episodes of low energy intakes (Historical Review, Part 2).

The height, weight and BMI of individual subjects whose mean energy intake was less than 1600 kcal/day are given in Table 7.23. Energy intake is shown as kilocalories per day and as the "UNU" energy intake factor. In the 50 to 65 age group, five housewives and four factory workers had intakes of less the 1600 kcal/day. For four of these housewives and all four factory workers the "UNU" TEI factor was below the "UNU" cut-off point of 1.2 x BMR. The BMI of these eight women was within or, for five women, exceeded desirable levels. There may have been errors in measurement of food intake, the intake may have not been habitual or the women may have been metabolically more efficient (Historical Review Section 3.14). The mean energy expenditure of each women was 2000 kcal/day or above.

The energy intake of the three groups of women exceeded the mean recommended intake of 1800 kcal/day (U.S. RDAs, 1980) and one group met the upper limit of the range (2200 kcal/day) for women aged 51-75 years.

7.3.3 Summary - relationships between occupation, energy intake and requirements of men and women in the 50-65 age group.

7.3.3.1 Men. The occupational difference in energy intake found between groups of men of under 50 years was also found in groups aged 50-65. It was the same as that for energy expenditures, 30 percent. The difference between the most sedentary and most active groups aged 50-65 was 60 percent and aged 20-39 was 48 percent. The differences in energy intake between the groups reflected the differences in their energy expenditure.

Women. The narrow range of difference of under 14 percent between groups of women who were at the high and low ends of the range of energy intake for Scottish women was half that of men. It was also lower than the difference between energy expenditure. The difference between the most sedentary group and the most active group (Swiss women) was 42 percent. Since no groups under 50 years with heavy occupations were found for comparison, it is not known whether a difference between them and sedentary workers is the same as in the 50-65 age group.

7.3.3.2 Men. Occupational grouping, not age, was a good predictor of energy intake in groups of men aged between 50 and 65 years and in younger groups.

Women. Neither occupational grouping nor age was a good index of the energy intake of women.

7.3.3.3 Men. There was no greater variation between mean energy intake of individual men in age groups under 50 years and between 50 and 65 years in similar occupational groups.

Women. The variation in intake between individual women aged 50-65 years was greater than that of men but from the limited data no firm conclusion can be drawn about differences or similarities to younger groups.

7.3.3.4 Men. There have been few studies of men of any age which report energy intakes as high as those of the thesis groups. Most reports are in the range of the clerical workers, 2440 kcal/day.

Women. From the many studies of the energy intake of women only the findings for the bakery workers and Swiss farmers exceeded 2200 kcal/day. 1800-2100 kcal/day was the range of the majority of studies.

7.3.3.5 Men. In parallel with energy expenditure there appears to be a middle years plateau of energy intake which extends from about 40 to beyond 65 years for normally healthy comparatively sedentary men. For men with more active occupations, it is likely that retirement reduces energy expenditure and intake to the level of the majority of the population. There was no reason to think that the energy expenditure of the men had changed since their thirties unless they had changed their occupational level of activity.

Women. This plateau exists for women throughout adult life. It may be disturbed slightly on retirement. There was no reason to think the energy expenditure of the women aged 50-65 had altered since their twenties. The range of occupational demand for women was small.

The following two points arose from the examination of the findings in relation to the concepts developed in FAO/WHO/UNU, (1985) Expert Consultation on Energy and Protein Requirements:

7.3.3.6 Men. Normative energy requirements which would result in the restoration of energy balance for each group of men at a more desirable weight, 1.78 x BMR for all groups, except the executives and clerical workers. These were 1.55 x BMR and 1.41 x BMR respectively.

Women. The normative requirements for the groups of women aged 50-65 were 1.64 x BMR for the housewives and bakery workers and 1.56 x BMR for the sewing workers.

7.3.3.7 Men and Women. The intake of one man and eight women were below 1.2 x BMR, but only the man appeared to have an inadequate intake based on the level of his BMI.

7.4 The 50-65 age group: Nutrient intakes and requirements of men and women. Intake of protein, fat, carbohydrate, calcium and iron found in some studies which used similar methods to the thesis studies are listed in Tables 7.28 and 30 (1936-1966) and Tables 7.29 and 7.31 (1966-1982). These are representative of studies of the age groups of interest, which preceded and succeeded those of the thesis. Some brief comparisons will be made.

In the Historical Review, Section 3.12, newer concepts governing standards and recommendations for dietary requirements have been discussed. The protein intakes found will be considered in relation to the concept of a safe level of intake for protein first defined by the Joint FAO/WHO Ad hoc Expert Committee on Energy and Protein Requirements (1971) and used in the FAO/WHO/UNU (1985) report.

Conflicting scientific opinions on the desirable proportion of fat in the diet and on implementing change in eating habits were discussed in the Historical Review. The analysis of the food intake did not include components of dietary fat so only a simple comparison of percentages of energy contributed as fat is made.

Similarly the conflicting opinions on desirable intakes of calcium and iron have been reviewed and the findings are simply compared to one well-known standard for an affluent population, that of the Food and Nutrition Board of the National Academy of Sciences (1980).

In the period covered by the studies which are listed, the emphasis of nutritional science in the developed countries has gradually changed from the alleviation of many of the diseases of poverty to combating the diseases of affluence in all age groups including children. At this distance in time, the nutrient intake findings of the thesis studies can be seen as a small contribution, based on more detailed dietary data than are usually obtained, to the pool of scientific knowledge concerning the nutrition of normally healthy middle-aged and elderly people.

7.4.1 Protein. It was shown that there were significant differences in protein intake between the two groups with the greatest energy intake and the others. This was also true for the findings of protein intake per kilogram, but as percentage of energy, the protein intakes of the steel workers and clerical workers were greatest. The higher intake of the steel workers appeared to be occupationally based. The protein intakes of men as percentage of energy intake agreed closely with the percentages found in the majority of studies listed, which included younger and older groups. The range including the thesis studies was from 11 to 14 percent for British studies and from 11 to 19 percent for American studies.

McGandy, et al., (1966) who studied prosperous, highly educated men in the United States found that protein provided 16 percent of their energy intake in every age group from 20 years upwards. There were no financial constraints on food selection for these subjects. There was a fall in total intake of protein in each decade from the third onwards as energy intake declined, similar to that seen in our groups of subjects whose intake declined with their activity at work.

The mean protein intake of the bakery workers, like their energy intake, was shown to be significantly higher than the housewives, but there was no significant difference in protein intake per kilogram. The differences as percentage of energy intake were small.

The proportion of protein in the British studies of women was in accord with our findings ranging from 12-15 percent. The range in the American studies was 13-16 percent.

In the FAO/WHO/UNU, (1985) report, the group physiological requirement or safe level was defined as the level which will meet or exceed the requirements of practically all individuals in the group, i.e., the average requirement + two standard deviations. For adults of both sexes the safe level of intake accepted by the Consultation was 0.75 g/kg/day in terms of proteins with the digestibility of milk or egg. The protein intakes of all but three men, each from a different group under 65 years exceeded 1g/kg/day. In no case was the intake less than 0.8 g/kg/day.

Many more women (28) than men (6) did not attain a daily intake of protein of 1 g/kg/day, (9 housewives with family, 10 sewing workers, 4 bakery workers). Of these, 5 did not attain 0.75 g/kg/day. Of these 5, 2 had energy intakes of less than 1600 kcal/day. It would appear that the protein intake of these 2 women was definitely inadequate and was probably inadequate for the other three. The average intake of 2 of the 3 groups, excluding the bakery workers, was 1 g/kg/day.

The mean intake of all the groups exceeded the USA Recommended Dietary Allowance (1980) of 56 g/day for men and 49 g/day for women of over 51 years, which is equivalent to 0.8 g/kg/day and of the DHSS recommendations for groups of people in the United Kingdom (1981).

7.4.2 Fat. It was found that the percentage of the energy intake derived from fat (37-39%) was about the same for all groups of men except the clerical workers (42%). This contribution was somewhat higher than the reported value of 35 percent for coal miners and 34 percent for colliery clerks (Garry, et al., 1955). Widdowson (1936) found the same percentage of fat (38%) in the diets of men aged 51-89. In the studies of men published before 1960, the percentages of energy found to be contributed by fat were under 40 percent. There is some evidence that the intake crept up for a few years after that and may be beginning to decline again. A small decline in fat intake with age may occur and this is consistent with the thesis findings for both men and women where small negative associations were found between age and fat intake. Fat as a percentage of intake does not appear to decline. The percentage of fat in the diet exceeded 40 percent in both the DHSS (1972), and the Macleod, et al., (1974) studies of men of 65 and over. In the study of older men in Edinburgh Lonergan found the fat contribution to be 38%, similar to our findings and those prior to 1965.

For women, the contribution of fat to energy intake has, on the whole, been higher than that of men both before and after 1965. This was also found in the thesis studies where in all 4 groups of women it met or exceeded the 40 percent level, which was found in only two groups of men. These figures were comparable to 41 percent of energy intake provided by fat in the diets of housewives and their daughters

(Durnin, 1957). Widdowson and McCance (1936) obtained the same results (41%) for eleven women aged 50-62 who were included in a larger study of 63 women aged 19-62 years. The figure for the whole group was 43 percent.

Fry, et al., (1963) reported that 50 percent of energy intake was contributed by fat and noted that the characteristic diet of women of the north central states of the U.S. contains more fat than that of women in California. Such an intake is questionable but was no doubt checked by the authors since they drew attention to it and noted "the current concern about the effect of both the quality and quantity of dietary fat on the development of atherosclerosis and heart disease." No appreciable drop in the fat component of the diet in Britain has been demonstrated by the studies cited, at least up until 1981 (Bingham, et al., 1981). In the U.S.A. Elahi, et al., (1983) reported fat intakes of 37-42 percent with a decline with age, while Kim, et al., (1984) gave a figure of 38 percent for all age and sex groups.

If the thesis studies are compared to one another, the percentage of fat in the diet was shown to increase from 40 percent in the group of women whose mean energy intake was 1900 kcal/day to 44 percent in one whose intake was 2200 kcal/day. This type of gradient was not shown for men nor was there any evidence of it in the limited number of comparable studies. The contributions of fat to the diets of Swiss men and women were only 30 percent and 36 percent respectively.

7.4.3 Calcium. Some of the continuing controversy over the safe level of calcium intake, especially for women, was discussed in the Historical Review, including the suggestion that the RDA for adults should be at least 1200 to 1500 mg/day. The intake of 31 men exceeded 1200 mg/day and, of these, 13 were farmers. The dietary intake of calcium recommended by the BMA in 1950 was 800 mg/day and this was the recommendation of the U.S. National Academy of Sciences in 1980. Only 10 men had intakes below this level. In the under 65 age groups, roughly 1 in 10 men had intakes between 500 and 800 mg/day and at this level, met the standard of 500 mg/day suggested by DHSS in 1969.

It has been commonly found that the intakes of men exceed any standards applied and the mean intakes of all the groups and the listed studies confirm this.

The mean intakes of the female groups met the standard of 800 mg/day but over half of the women in two groups had intakes between 500 and 800 mg/day. The exception was the bakery workers group and this was partially explained by their greater energy intake. The intakes of 6 were below 500 mg/day. Five women had mean intakes of over 1200 mg/day. Of the 29 women who had intakes of less than 800 mg/day, only nine were associated with energy intakes below 1600 kcal/day. Food choices made by women, in addition to energy intakes lower than men, are implicated in the difference between the sexes in calcium intake.

The mean intakes of the groups of women were similar to those found in the pre and post 1965 studies. Le Bovitt (1965) was one of many researchers who have found that calcium and ascorbic acid are the nutrients in shortest supply in the diets of women of all ages. Milk, fruit and green vegetables, which are important sources of calcium, were not prominent in the diet of the thesis subjects. Lack of these foods is still a feature of the Scottish diet (Report of the Scottish Coronary Heart Disease and the Scottish Heart Health Study, 1988).

The mean intakes found by Bingham, et al., (1981) in England and Lenner, et al., (1977) in Sweden for women in the 50-65 age group, exceeded those of the thesis groups by about 100 mg/day, although their mean energy intakes did not exceed them.

Groups of young women studied by Durnin and his colleagues (Durnin, et al., 1957, Durnin and Brockway, unpublished data) were found to have calcium intakes in the same range as those of the thesis studies.

If normative energy intakes are proposed for groups of women, attention should be paid to the effect on intake of calcium, which was shown to be significantly related to energy intake for women (r 0.66) and men (r 0.66). For both sexes it was between 350-450 g/1000 kcal/day.

7.4.4 Iron. The mean intakes of iron of all the male groups (13-20 mg/day) greatly exceeded the BMA (1950) standard of 12 mg/day, which was used at the time of the studies and also the lower standard of 10 mg/day, which is presently used (USA-RDAs, 1980). In the pre and post 1965 studies listed, mean iron intakes were all in excess of 11 mg/day. Only one thesis subject had an intake of less than 10 mg/day (9 mg) with an energy intake of 2100 kcal/day.

The mean intake of the three groups of women (11-13 mg/day), also were found to exceed the 10 mg/day standard. The intake of the two groups of factory workers exceeded the 12 mg/day standard. The findings of the studies given for comparison were consistent with ours. They showed that iron intake increased with energy intake and tended to decrease in the 75 and over age group, where energy intake levels also showed a decline. Only the Swedish group (Lenner, et al., 1977) had higher iron intakes although the level of energy intake was about the same as the thesis groups. Therefore, their choice of foods had a higher nutrient density of iron than those of the other groups cited.

One woman with an intake of less than 5 mg/day had an energy intake of 1100 kcal/day. In addition, the intake of 12 women did not meet the 10 mg standard. This applied to only one man.

A significant association was shown between iron and energy intake (r 0.72 for women, r 0.74 for men). The level of intake per 1000 kilocalories was also in the same range for both sexes at 5-6 mg/1000 kilocalories. This suggested that, at that time, the food choices of women at levels of energy intake below 2000 kcal/day led to intakes below the standard of 10 mg/day for about 25 percent of the female population. When energy intakes of men drop to this level, increase in the number of "low" intakes is to be expected.

Normative levels of energy intake would tend to reduce the iron intake unless foods with a nigher nutrient density of iron were included in the diet.

7.4.5 Summary - nutrient intakes and requirements of men and women in the 50-65 age group.

7.4.5.1 Men and Women. The occupational level of energy intake did not affect the proportion of protein in the diet of groups of men and women except for the steel workers. The protein intakes of men and women as percentages of energy intake agreed closely with the percentages found in the British studies listed, which included younger and older groups. The group intakes met or exceeded the safe level defined in the FAO/WHO/UNU, (1985) report and the U.S.A. (1980) Recommended Dietary Allowance for protein. The intake of five women in the age group 50-65 years did not reach the recommended safe level of 0.75 g/kg/day.

7.4.5.2 Men and Women. Fat intake for both men and women was closely related to energy intake, but the occupational level of energy intake did not affect the proportion of fat in the diet for most groups. One group of women, the bakery workers who had the greatest energy intake, also had the greatest percentage of protein and fat, while the group of men with the greatest percentage of protein and fat was the low intake group, the sedentary workers. The fat intake of both the men and women was consistent with other studies, which also showed that the contribution of fat to the energy intake of women was generally higher than that of men. In spite of public awareness that high fat intake may be associated with heart disease, no appreciable drop in the fat component of the diet in Britain has been demonstrated by the studies cited, at least up until 1981 (Bingham, et al., 1981).

7.4.5.3 Men and Women. Occupation did not affect calcium intake for either men or women, apart from its relationship to it through energy intake. The farmers did not have a higher intake per 1000 kilocalories than the other groups, although nearly half of the men with intakes over 1200 mg/day were farmers. The mean intakes of both the male and female groups attained the U.S.A. (1980) Recommended Allowance of 800 mg/day for calcium, but 1 in 10 men and over half of the women had intake of less than this level. The mean intakes of men and women were similar to those found in the pre and post 1965 studies and groups of the same age and younger. The same difference was shown between men and women. Food choices made by women, in addition to energy intakes lower than men, are implicated in the difference between the sexes in calcium intake. Safe levels of intake of calcium proposed as between 1200-1500 mg/day for women are unlikely to be reached by dietary means alone, especially at normative levels of energy intake.

7.4.5.4 Men and Women. Iron intake was closely related to energy intake for men and women and was not affected by occupation. The findings of the studies given for comparison were consistent with ours and the mean intakes of all groups exceeded the 10 mg/day standard (USA-RDAs, 1980). The intake of 12 women and only one man did not meet this standard. A higher energy intake and, thus, greater intake of iron-supplying foods led to the satisfactory intake for men. For women, dietary choices at their lower level of energy intake did not include foods which have a sufficiently high nutrient density of iron. The food choices made by the women studied at levels of energy intake below 2000 kcal/day would have led to intakes below the standard of 10 mg/day for about 25 percent of the population. Normative levels of energy intake would tend to reduce the iron intake unless foods with a higher nutrient density of iron were included in the diet.

7.5 The over 65 age groups. The primary focus of the studies of a group of men and a group of women of over 65 years who lived alone was the adequacy of their food intake. Two other very small groups were studied, a group of five farmers aged between 65 and 80 and a group of four housewives aged between 65 and 81 who recorded food intake only.

Although the numbers are not large, the two post retirement groups, one of men and one of women, have been compared to the pre-retirement groups to whom they bear most resemblance. The older still-working farmers have been compared to the farmers of 50-65 years.

7.5.1 Total energy expenditure and physical activity

Men - It was shown that the total energy expenditure of the retired men who lived alone was not significantly lower than that of the pre-retirement group of clerical workers. If their previous occupations had been sedentary, their energy expenditure might not have decreased on retirement. However, their previous occupations were considered to be more akin to the group of building workers and a significant difference was shown between these two groups. Similarly, the energy expenditure of the older farmers was shown to be significantly lower than that of the younger group of farmers. However, it was not lower than that of any of the other groups. In common with the 50-65 age group, a difference of 700 kcal/day was found between the sedentary and active group, i.e., retired men and farmers. The expenditure of the latter was comparable to a small group of Swiss farmers of the same age (Table 7.1). Thus, there was a difference of 23 percent between the energy expenditure of a non-sedentary pre-retirement group and a comparable retired group. Where age alone was the difference, in the case of the farmers, there was a 19 percent decrease. No other studies of energy expenditure for this age group were available.

The co-efficient of variation of energy expenditure in kilocalories per day for the group of retired men was greater than that of all other groups, but this disparity was reduced when it was expressed as a Fleisch or "UNU" TEE factor and as kilocalories per kilogram per day (Table 7.2).

Thus, there was the same scale of difference between the low and high end of the energy expenditure of groups of over 65 years as there was of groups 50-65 years; there was no greater or no less variation between individuals of over 65 years than under 65 years; and men over 65 years were capable of high levels of energy expenditure.

The "UNU" TEE factors for the older groups of men (1.66 x BMR, 1.95 x BMR) were closer than those of the younger groups to the Fleisch TEE factors (1.68 x BMR and 1.94 x BMR) [Table 7.3 and 7.4]. The nearly identical BMRs appear in Table 7.5.

The mean Fleisch TEE factor for the farmers was similar to that of the groups of moderate workers but the "UNU" factor exceeded all groups except the younger farmers.

The energy cost of occupational plus non-occupational work was 2.9 x BMR to the older farmers compared to 4.0 x BMR for the younger group. This reflected the finding that the older men spent 2 hours less per day in "moderate" activity and their routine included no "heavy" or "very heavy" activities. The energy cost of 2.9 x BMR exceeded the FAO/WHO/UNU (1985) report figure of 2.7 x BMR for moderate work. The older farmers were more active in "relaxation" time, 2.0 x BMR compared to 1.3 x BMR, and also walked a little more vigorously, 5.2 x BMR compared to 4.9 x BMR.

The same comparison of building workers and retired men showed, as expected, difference in the energy cost of work activities, 2.6 x BMR compared to 1.9 x BMR. It also showed that the relaxation activities of the older men had a greater energy cost, 2.1 x BMR, than those of the younger group (1.8 x BMR). Compared to the sedentary workers, the retired men were more active in both their very short (3.2 h/day) work time, (1.9 x BMR), and in their relaxation time (2.1 x BMR), exceeding the "UNU" standard of 1.7 x BMR for light work. The energy cost of their walking, 4.5 x BMR, was in the middle of the range for all the younger groups. It also exceeded the metabolic constant for walking at normal pace (3.2 x BMR) developed in the FAO/WHO/UNU, (1985) report.

The "UNU" TEE factors of both groups exceeded the TER factors given in the examples in Table 7.8 as did their observed percentage of TEE and percentage of the fractional portion spent in occupational activities.

A level of energy expenditure of 500-3500 kcal/week associated with decreased mortality was compared to findings for younger men in Table 7.9. The range of energy expended in walking by the farmers was 1737-3178 kcal/week. Three of the retired men spent between 3500 and 5000 kcal/week and 7 spent between 1500-3500 kcal/week. Walking fell into the category of moderate work (5-7.4 kcal/minute) only for the farmers.

Women. It was shown that the TEE of the retired women who lived alone was significantly lower than that of the housewives aged 50-65 years. It was similar to a group of slightly younger housewives studied by Durnin, et al (1957). No groups of older women who had an occupation as active as that of the older farmers were studied. If the retired women had previously been in occupations similar to the sewing machine factory workers, and they were indeed retired thread factory workers, the difference of 270 kcal/day (14%) between their energy expenditure might have been caused by retirement. However, it may never have been as great as the younger group because, living by themselves, they may have had fewer domestic responsibilities.

The co-efficients of variation of energy expenditure in kilocalories per day were the same in older and younger housewives, but that of the older women became greater when expressed as the two TEE factors. It is possible that two types of activity pattern were emerging in this age group - a pattern of increased activity after a sedentary occupation and a pattern of continuing sedentary behaviour into retirement. The average time spent by five retired Canadian women in their middle sixties in occupational plus non-occupational work was 5.4 hours per day, which was almost exactly the same (5.5 hrs/day) as that of the thesis group of retired women (housewives - 7th decade). Sidney and Shephard (1977), who studied this group of women, found it interesting that they spent 65 minutes more per day in active tasks than a group of women of the same age who were employed in sedentary occupations. It is likely that at least some women (and some men) may increase their TEE on retirement from sedentary employment. This variation in energy expenditure was greater for the retired women (CV 13%) than for the retired men (CV 10.8%), who were older than the women, and even less for the small group of old farmers (CV 7.7%) (Tables, 7.2 and 7.12).

Similarly to the men, the Fleisch and "UNU" BMRs were more alike in the older than in the younger housewives and, therefore, the resulting TEE factors were also more alike. (Tables 7.13, 14 and 15). The difference between the older and younger housewives was decreased when the TEE was expressed as the "UNU" TEE factor rather than the Fleisch TEE factor.

The energy cost of the work of the older housewives was lower than that of the younger group, 2.4 x BMR compared to 2.8 x BMR because they spent no time in moderate activity. At 5.5 hours the working hours of the older women were shorter than any group, except retired men (Table 7.6), but the energy cost exceeded the "UNU" standard for moderate work of 2.2 x BMR. The energy cost of their activity was slightly greater than that of the younger housewives in their relaxation time.

The energy cost of walking (3.7 x BMR) was a little above the figure of 3.4 x BMR presented in the FAO/WHO/UNU (1985) report as the metabolic constant for walking at normal pace.

The "UNU" TEE factor of 1.61 x BMR exceeded the TER factor of 1.52 x BMR given in the example in Table 7.16 as that of a housewife in an affluent society. Both the percentage of the fractional portion spent in occupational activity and the observed percentage of TEE were greater than those of the example.

Because of its brevity, this section is not summarised. Conclusions have been drawn within the section.

7.5.2 Energy intake and requirements.

Men. The mean intake of the farmers and of the retired men was shown to be significantly lower than the comparable groups of younger men. The drop in intake between the two groups of farmers was slightly greater than the drop in expenditure. It was 300 kcal/day greater than the drop in expenditure between the building workers and retired men because the intake of the retired men appeared to be 300 kcal/day less than their expenditure. Therefore, the intake of the retired men did not reflect their expenditure, nor did that of the farmers. In common with the younger farmers it was 300 kcal/day less than expenditure. The difference in intake between the non-sedentary group of farmers and the comparatively sedentary retired men was, however, as great as the difference in expenditure (700 kcal/day).

For the 50-65 age group it was shown that occupation was a better indicator of intake in healthy men than age. Although the numbers are small, these studies, together with those of four Swiss farmers (Durnin, et al., unpublished), indicates this holds true beyond 65 years. As discussed in the Historical Review, the conclusions of Exton-Smith (1982) and Debry, et al., (1977) lend support to this opinion, while those of Elahi, et al., (1983) appeared to contradict it.

Compared to the findings of the studies listed in Tables 7.19, 7.20(a) and 7.20(b) of sedentary men in the same age group, the retired men were at the lower end of the scale of intake. This ranged from 2000 kcal/day (Bransby, 1953) through approximately 2300 kcal/day (DHSS, 1972; Bingham, et al., 1981) to 2400 kcal/day (Elahi, et al., 1983; Lyons and Trulson, 1955). The intake of the farmers (2700 kcal/day) exceeded that of all the older groups.

The coefficient of variation of mean energy intake (Table 7.21) of the retired men was in the same range as the comparable younger group for kilocalories per day, but was not as great when intake was expressed as BMR factors. The variation in intake was not as great as in the younger group. The older farmers had about the same variation in intake as the younger group, but the numbers were really too small for comparison.

The difference between the older and younger groups was maintained when the "UNU" TEI factors were compared. The factor for the building workers was 1.76 x BMR and for the retired men was 1.43 x BMR and that of the younger farmers 1.99 x BMR and for older farmers 1.73 x BMR (Table 7.4).

The rate of decline of energy intake with age was discussed in the Historical Review and an apparent middle-aged plateau of energy intake was noted. There is evidence from the studies cited, that a noticeable drop in the energy intake of sedentary people does not take place until between 75 and 80 years. The thesis studies indicate that there is a drop at an earlier age under two circumstances. Firstly, on retirement from non-sedentary occupations and secondly, when moderately heavy occupations are continued beyond 65 years.

It was also noted that studies of random samples, especially in the over 65 age groups, tended to find lower intakes. People who maintain an active way of life also maintain their energy and nutrient intakes. There appear to be no studies which focus on the dietary intake of men who have retired from non-sedentary occupations. These men might be expected to reduce their total energy expenditure and, perhaps as a consequence, to adjust their energy intake slowly to a lower level. Gillum and Morgan (1955) recorded a drop of 300 kcal/day at age 65 and under 100 kcal/day at age 75-59. In the small mixed occupational groups studied by Bingham, et al., (1981) the mean energy intake was the same for the 40-59 age group as for the 60-79 group. Declines in intake of 12 percent, 9 percent, 7 percent and 0 percent were noted for some studies in the Historical Review.

The question of whether the actual intake could be considered to be the energy requirement has to be addressed for these two groups. Of the retired men, four had BMIs in the desirable range, four were overweight and one was obese, yet the energy expenditure of each man exceeded his energy intake. Two of the farmers were in the desirable range and three were overweight, yet in only one overweight subject, was intake in excess of expenditure. The normative energy requirements (Table 7.22) were nearly identical to the actual intake of the farmers, and greater than that of the retired men by 93 kcal/day. Restoration of energy balance at a more desirable mean level of weight would not be effected by the estimates for the farmers. An energy requirement at desirable weight of 1.78 x BMR would be more appropriate. In theory, the normative energy requirement would increase the weight of the retired men. Their recorded intake may, however, have been an underestimate of habitual intake or they may have been entering a period of lowered intake and consequent nutritional inadequacy. The normative level of 1.66 x BMR might then be most appropriate for the group.

Four of five men listed in Table 7.23 as having intakes under 2000 kcal/day were from the retired group. The intakes of two of these were below the "UNU" cut-off point of 1.2 x BMR (1.18 x BMR and 1.05 x BMR). The corresponding BMIs were 27.4 and 30.3. Both the intake and expenditure of the latter subject were low (1740 and 1750 kcal/day), but the expenditure of the former was 3070 kcal/day suggesting that an attempt at slimming was being made, or he was just too busy to eat on that particular week, or he wanted to please the dietitian.

Women. The mean energy intake of the over 65 years women was not shown to be significantly lower than that of the younger housewives in contrast to their energy expenditure. Also, compared to the younger groups, intake reflected expenditure more closely. It was, however, 200 kcal/day lower than that of a group studied by Durnin, et al., (1957).

The intake of comparatively sedentary groups of about the same age in the United Kingdom and the USA tended to be slightly lower, about 1800 kcal/day, except for that of Exton-Smith, et al., (1965). An even lower intake (1500 kcal/day) was found by Bingham, et al., in 1981. The intake of the retired women was very similar to that of the retired men.

The coefficients of variation of the energy intake differed principally when expressed as kilocalories per day (CV 20% and CV 17%). They were slightly reduced for the older and younger group when intake was expressed as the "UNU" TEI factor (Table 7.26). The "UNU" TEE factor for the housewives, 7th decade was 1.56 x BMR and for the younger women 1.47 x BMR.

The effect of aging on the energy intake of women was discussed in the Historical Review. It was noted that there appeared to be a difference between men and women. For men, there was a decline on retirement, unless they were sedentary, in which case, the plateau of intake would continue until 75-80 years. The intake of women tended to remain fairly stable until about 75 and then decline slowly.

The percentage decline in intake after 75 years for women has been variously reported to be 7 percent, 9 percent and 23 percent.

Garry, et al., (1982) found that a significant negative correlation between age and energy intake existed for men, but not for women. The correlation for the thesis subjects were r-0.46 for men and no negative correlation for women. The findings for men resulted in part from the surprisingly low intake of the retired men.

It was shown that eight of the seventeen housewives were in the desirable BMI range, one was below, and the remainder exceeded it. The normative level of energy requirement at desirable weight (Table 7.27) was less than actual intake by 120 kcal/day. Because the actual weight of the group diverged less than that of the other groups from the desirable weight, an energy requirement at the moderate level of 1.64 x BMR would be appropriate.

Two women had energy intakes below the "UNU"-suggested cut-off point of 1.2 x BMR. Only one of these had a BMI below the desirable range (17.63). Her intake level of 1120 kcal/day compared to an expenditure of 1580 kcal/day may well have been an habitually inadequate intake.

Because of its brevity, this section has not been summarised. Conslusions have been drawn within the section.

7.5.3 Nutrient intake and requirements.

Protein. In common with the 50-65 age groups, the protein intake declined as energy intake declined and that of the retired men was shown to be significantly lower than that of the building workers. As a percentage of energy intake it was not significantly different from the younger groups and it fell within the range of 11-14 percent found in all the studies cited.

Comparison of intake to the FAO/WHO/UNU (1985) report definition of a safe level of 0.75g/kg/day revealed that although the mean protein intake of the group was 70.3g/day or 1g/kg/day, the average requirement was 55.9 ± 7.6 g/day. The safe level was, therefore, 71.1 g/day, which was only slightly greater than actual intake. Three men had intakes between 0.8 and 1 g/kg/day.

The situation was similar with the group of housewives whose mean intake of 61.4 g/day did not quite achieve the safe level of 63.2 g/day. Three women did not obtain 0.75 g/kg/day, two whose energy intakes were 2030 kcal/day and 2110 kcal/day and one whose intake was 1120 kcal/day. The protein intake of the latter subject was almost certainly inadequate.

The mean intakes of the two groups exceeded the USA Recommended Dietary Allowance (1980) of 56 g/day for men and 49 g/day for women.

Fat. The fat intake of the retired men was shown to be lower than that of any other group in both total intake and percentage of energy intake. As a percentage, it was at the lower end of the range found in the studies cited and considerably less than the 42 percent found in the DHSS (1972) study and that of Macleod, et al., (1974). It was also much less than the contribution of fat to the energy intake of the retired women (40%).

The three U.K. studies of women over 65 years reported in 1972, 1974 and 1975 indicate that the proportion of energy intake from fat may have risen slightly since the thesis study of women in the same age group. In all three groups, the mean energy intake was 1800 kcal/day with 43, 44 and 45 percent contributed by fat. The thesis group intake was 1900 kcal/day of which 40 percent was contributed by fat.

Calcium. The intake of calcium/1000 kcal of both groups of older men was shown to exceed the younger comparable groups and the mean intake of the groups exceeded the standards of 800 and 500 mg/day previously discussed. Five of the retired men had intakes below 800 mg/day, three of which were associated with energy intakes of under 2000 kcal/day.

The mean calcium intake of the older housewives was found to exceed that of the younger group and was the same in relation to energy intake. Two thirds of the younger women and half of the older women had intakes between 500 and 800 mg/day. Only two of these low intakes were associated with energy intakes of less than 1600 kcal/day. It appeared from the thesis findings that a reduction in calcium intake occurred together with a reduction in energy intake in the older group of men. There was no other evidence of this from the studies reviewed. There was a slight indication that the mean calcium intake of groups of women of over 70 years declined.

Iron. The mean intakes of iron of both groups of older men were shown to be below those of the comparable groups, but were in excess of the 12 mg standard, while intake expressed as mg/1000 kilograms was very similar.

In the studies listed for comparison, only groups aged 75 and over had intakes as low as 10 and 11 mg/day. One retired man had an intake of 9 mg/day and an intake of 1700 kcal/day.

The intake of the housewives, which exceeded the 10 mg/day standard, was consistent with the listed studies. These indicated that iron intake also tended to decrease for women in the 75 and over age group. Three of the group of four older women had intakes under 10 mg/day as did four of the housewives. In one case it was under 5 mg/day. Thus, one man in 15 and seven women in 21 in the 65 and over age group did not meet the 10 mg/day standard. The percentages of both men and women with intakes below 10 mg increased from those in the 50 to 65 age group (23% to 33% for women; 1% to 6% for men).

Stanton and Exton-Smith (1970), noted that the low iron intakes of some of their 70 years and over female subjects were not associated with anaemia. The DHSS (1972) study showed that although the mean iron intake of 450 women aged 65 and over was 9 mg/day, the prevalence of anaemia was similar to that found in younger samples.

Because of its brevity this section is not summarised. Conclusions have been drawn within the section.

7.6 Composition of the diet. An excellent review of the changing patterns in British food habits since the Second World War was presented by Hollingsworth (1961). Her analysis was very relevant to our subjects whose food habits were greatly influenced by hard times from their youth during World War I, through the Depression of the 1930s, and the rationing of the war years. During the 1930's and 1940's they were between 20 and 35 years of age and most were bringing up families in frugal circumstances.

The national diet in 1960 was of greater nutritional value than before the war and the well-balanced diet enforced by rationing appeared to have had a lasting effect on the food intake of both men and food for other family members. This factor would be impossible to isolate since it is complicated by economic and psychosocial factors. Examples of these would include women's reluctance to cook and eat for themselves alone and men's lack of experience in the kitchen.

A study by Todhunter, House and Vander Zwagg (1974) of freeliving men and women of over 60 years found that those who lived alone and those who lived with others did not differ in dietary adequacy. Le Bovitt (1965) found that 52 percent of men living on their own had good diets and 35 percent had poor diets, compared to husband/wife couples (48 percent and 24 percent) and women on their own (46 percent and 24 percent). She also found that when the homemaker was over 75 years the quality of the diet declined.

In a review of food habits of the elderly, Beeuwkes (1960) drew at attention to food choice based on dental health which may, although by no means inevitably, lead to difficulties in masticating. The decline in the senses of taste and smell in advanced age was not applicable to our subjects, but many had false teeth. It may be that the reduction in food intake and weight in people over 75 years who are not otherwise disabled, is due to lack of interest in food brought about by sensory changes.

Jordan (1954) found that medical and social factors were given more frequently than economic reasons for changes in eating habits. This was found also in the DHSS (1972) study where no evidence was found that the abnormal values in various biochemical and other tests were more prevalent in those who spent less than in those who spent more on food. "The quality of the diet depends on judicious and informed buying and perhaps an interest in food" (Cathcart, 1931).

Garry, et al., (1955) found that the miners studied by them obtained the additional energy needed for their harder physical work by eating more of every type of food in the diet. Fifteen years later it was stated in the DHSS (1972) report that "the foods that old people eat are much the same as those eaten by other people . . . . when allowance is made for the lower energy expenditure". Thus, people with low and high energy expenditures appear to alter quantities of individual foods, but not established food patterns.

The speculation made by Hollingsworth (1961) that "the pattern of food habits of the whole population will in the long term approach more closely that of the richest group which now have a much greater consumption of liquid milk, cheese, meat, fish, green and other vegetables and fruit" has been borne out. Baines in 1979 remarked that the whole pattern had shifted "up-market" in regard to consumption of greater amounts of protein and fat. Hollingsworth also felt that "nutritional considerations are more likely to play their part through the actions of food manufacturers and perhaps the Government than through deliberate changes made by consumers in their eating habits".

Recommendations by various official bodies in the U.K. and U.S.A. on dietary fat intake, in particular, were discussed in the Historical Review. It is generally accepted that a high intake of fat is one of the risk factors for CHD. The intakes of the thesis groups were high, especially the intake of women, and studies of 63 young women aged between 17 and 23, which were made at about the same time by the same team of investigators, found that their intake of fat also contributed about 41 percent of energy intake. In contrast the intake of a group of 20 young men was 36 percent.

At a conference of the Scottish Coronary Heart Disease and Scottish Heart Health Study, it was noted that in 1985 Scotland had the second highest mortality rate from CHD for men aged 40-69, has had the highest female mortality for most of the past twenty years, and that regional variation in mortality appears to show an east-to-west gradient. It is interesting that studies done in Edinburgh and Glasgow of groups of men and women of over 65 years show differences in fat intake. The percentages of total energy contributed by fat in the Edinburgh studies of Lonergan, et al., (1975) was 38 percent for men and 42 percent for women, whereas in the Glasgow studies of Macleod, et al., (1974) it was 42 percent for the men and 45 percent for the women.

In 1910 in Britain, fat provided 32 percent and carbohydrates 57 percent of energy intake (Greaves and Hollingsworth, 1966). In 1962 the figures were 41 percent and 47 percent. The factors responsible for such a change could not have been predicted in 1910. What combination of factors will have to be present to return the composition of the diet to the "desirable" levels of the early part of the century and perhaps contribute to a lower level of CHD.? When they advocated the better British diet in 1979, Passmore, Hollingsworth and Robertson recognized that the acceptance and implementation of changes, especially those which attempt to reverse trends in consumption, may take a long time.

The fall in the death rates of men from CHD in Canada and the United States between 1958 and 1976 has been partially attributed to changes in dietary patterns. Since death rates of women have fallen in almost all countries studied, albeit very slowly in Scotland, it may be that the constant attempts by women to lose weight have significantly reduced their overall fat intake. In the two North American countries, it is at least possible that men are more likely to try to lose weight also, in addition to attempts at control of cholesterol intake and that their fat intake has been similarly affected.

T9

CHAPTER 8
CONCLUSIONS

8.1 Introduction. The conclusions of the research are presented in three categories:

a) in terms of specific hypotheses;

b) in terms of research questions. These questions could not be answered fully in the form of specific hypotheses. They are addressed by integrating the results of testing the hypotheses with relevant findings from the literature and by applying, where appropriate, some of the concepts suggested by the FAO/WHO/UNU, (1985) Expert Consultation on Energy and Protein Requirements;

c) as the results and conclusions of a review of the data in relation to some of the concepts developed by the Consultation.

8.2 Hypothesis A.

8.2.1 Hypothesis A1. The hypothesis, that in groups of men and in groups of women aged 50-65 years there would be systematic differences between occupational groups in:

a) energy expenditure, was sustained for both men and women;

b) energy intake, was sustained for men but not for women;

c) nutrient intake, was sustained for men, but not for women.

8.2.2 Hypothesis A2. The hypothesis, that between groups of men and between groups of women aged 50 to 65 years and comparable groups aged over 65 years there would be systematic differences in:

a) energy expenditure, was sustained for men and for women;

b) energy intake, was sustained for men but not for women;

c) nutrient intake, was sustained for men but not for women.

8.3 Hypothesis B.

8.3.1 Hypothesis B1. The hypothesis that in groups of men and in groups of women aged 50-65 years there would be descriptive variations between occupational groups in:

a) time and activity patterns, was sustained for men and women;

b) energy and activity patterns, was sustained for men and women.

8.3.2 Hypothesis B2. The hypothesis that between groups of men and between groups of women aged 50-65 years and comparable groups aged over 65 years, there would be descriptive variations in:

a) time and activity patterns, was sustained for men and women;

b) energy and activity patterns, was sustained for men and women.

8.4 Research questions.

8.4.1 Question 1-a. Was there a difference between the total daily energy expenditure of groups of men aged 50-65 who performed hard physical labour during their work hours and those whose work was mainly sedentary? Did this differ from groups of men aged under 50 years?

Conclusions. For groups of men aged 50-65 years, there was a difference of approximately 30 percent between those occupations involving hard labour and those which were comparatively sedentary. This difference was found between groups of less than 50 years whose total energy expenditure was in the same range. A range of 67 percent can be found between very sedentary and very active groups of men aged 50-65 years. Occupational grouping was as good a predictor of energy expenditure in groups of men aged between 50 to 65 years as in younger groups. There was no greater variation between mean energy expenditure of individual men in age groups under 50 years and between 50 and 65 years who were in similar occupational groups. Use of "UNU" TEE factors did not alter the conclusion for groups of men that there was the same occupational range of difference in the 50-65 age group and the under 50 age group and maintained the differentiation between the groups of men.

8.4.2 Question 1-b. Was there a difference in energy expenditure between groups of women who were housewives and those who also worked outside of the home? Did this differ from groups of women aged under 50 years?

Conclusions. For groups of women aged 50-65 years, there was a difference of approximately 20 percent between groups who worked only in the home and those with employment in light industry. This difference was found between similar groups of less than 50 years whose total energy expenditure was in the same range. A range of 42 percent can be found between fairly sedentary and very active groups indicating that a greater range is possible. Occupational grouping was not as good a predictor of total energy expenditure for groups of women aged 50-65 years as it was for men. There was some indication from limited data that this was also the case for groups of women of under 50 years. There were fewer data on individual variation in energy expenditure for women than for men, but the trend appeared to be the same. Use of the "UNU" TEE factors confirmed that for groups of women there was little difference in TEE but it differentiated the TEE of two groups of factory workers more clearly than kilocalories per day.

8.4.3 Question 2. Was any difference between groups in total energy expenditure almost wholly due to energy expended in occupational activities, the corollary being that there was little difference between groups in energy expended in non-occupational activities? Did this differ from groups aged under 50 years?

Conclusions.

a) Occupational energy expenditure was the principal reason for differences in TEE between the moderate work groups and the sedentary group of men aged 50-65 years as it was in under 50 age groups. The very small difference in occupational expenditure between two groups of female factory workers aged between 50 and 65 years was increased by the contribution of non-occupational work .

b) Occupational energy expenditure of men was not reduced in the 50-65 age group compared to those under 50 in the groups where work was defined as sedentary or as heavy. Since it was shown that there was no significant difference in TEE between groups of women and since there was no sedentary group with which to compare them, very little difference in occupational expenditure between groups of women aged 50-65 years has been found. The literature did not yield sufficient data to make this comparison between younger groups of women.

c) For five out of six groups of men, occupational energy expenditure was a good predictor of TEE. Occupational energy expenditure alone was not as good a predictor of TEE for women as it was for the men, but the rank order of energy spent in occupational plus non-occupational work time was the same as that of TEE.

d) Occupational energy expenditure was not a good predictor of TEE for the executive group of sedentary workers. This resulted from an average energy cost, expressed as a "UNU" BMR based factor of physical activity during non-occupational time, which was greater than all groups, except the steel workers. Similarly, non-occupational work made an important contribution to the TEE of the two groups of female factory workers. One half of the difference between them was accounted for by the non-occupational work of the bakery workers.

e) Very different patterns of leisure time physical activity were found between two groups of male sedentary workers and between two groups in moderate to heavy occupations. The patterns of leisure time physical activity of the women were similar for the two groups of factory workers and for the groups of housewives.

f) Changes in patterns of activity of women, in particular those occasioned by employment outside of the home, are likely to have maintained or increased the total energy expenditure of large groups of women in the 50-65 age group.

g) The finding of a higher degree of physical activity during leisure time by the executives agreed with findings by other groups of a positive relationship between level of education, higher socio-economic groups and leisure time activity, including recreational activity. The similarity of the leisure time physical activity of the light industry workers to that of the executives was in agreement with the finding of others that skilled workers, in common with more highly educated men, include more physical activity in their leisure time. The energy cost of leisure time physical activity (LTPA) was comparatively high for all the groups of men by present day standards. The energy cost of non-occupational work and non-occupational walking combined exceeded 240 kcal/day. Compared to criteria shown by Paffenbarger, et al., (1986) to have an inverse relationship to mortality, the physical activity of the majority of men studied was more than adequate to produce such an effect.

It is speculated from comparisons with similar but hypothetical criteria based on those of men that the physical activity of most of the women may also have been sufficient to produce such an effect.

At the group level, both the farmers and retired men in the over 65 age group exceeded the same energy expenditure criteria, but the mean intensity of activity for the retired men did not, nor did that of the retired women.

8.4.4 Question 3. Did the energy intake of each occupational group reflect the energy expenditure of the group? Did this differ from groups aged under 50 years? Was the intake adequate by commonly accepted standards?

Conclusions.

a) The differences in energy intake between the groups of men aged 50-65 years reflected the differences in their expenditure, but in half the groups the difference between TEE and intake exceeded 150 kcal/day. The difference in energy intake between those occupations involving hard labour and those which were comparatively sedentary was the same as that for energy expenditure, 30 percent. The expenditure of the groups was greater by 7 percent than intake. This difference was also found between groups of under 50 years. A range of 60 percent was found between the most sedentary and most active groups aged 50-65 and of 48 percent between groups aged 20-39. Occupation was a good index of energy intake in groups of men aged between 50 and 65 years and under 50 years. There was no greater variation between mean energy intake of individual men in age groups under 50 years and between 50 and 65 years in similar occupational groups.

b) The differences in energy intake between groups of women aged 50-65 years did not reflect the differences in the energy expenditure to the same extent as those of men. In all the groups TEE exceeded intake by 200 kcal/day or more. There was a narrower range of difference between the intake of groups who worked only in the home and those with employment in light industry (14% and under) than there was in energy expenditure (20%). The expenditure of the groups exceeded the intake by about 15 percent. This narrow range of difference also occurred in groups of under 50 years. In the absence of data from very sedentary groups under 65 years, the possible range of intake cannot be stated with certainty, but will exceed 42 percent which was found between a comparatively sedentary group and a very active one. Occupation was not a good index of the energy intake of women. The variation in intake between individual women aged 50-65 was greater than that of men but from the limited data no firm conclusions can be drawn about differences or similarities to younger groups.

c) The energy intakes of the groups of men and women aged 50-65 years exceeded the means of the recommended allowances (U.S. RDAs, 1980) for ages 51 to 75. The finding that the BMIs of 47 percent of the men and 58 percent of the women exceeded the desirable range prompted the use of the concept of normative energy requirements proposed by the FAO/WHO/UNU, Consultation (1985). The normative energy requirements proposed for all except the sedentary groups of men are 1.78 x BMR, for the two sedentary groups 1.55 x BMR and

1.41 x BMR, for a group of housewives and a group of bakery workers 1.64 x BMR and for sewing workers 1.56 x BMR.

d) The intakes of one man and eight women were below 1.2 x BMR, but using BMI as the criterion, only the man appeared to have an habitually inadequate intake.

e) there have been few studies of men of any age which report energy intakes as high as those of all except the very sedentary group. From the many studies of the energy intake of women only the findings for the bakery workers and a group of Swiss housewives/ farmers exceeded 2200 kcal/day. There appears to be a middle years plateau of energy intake and energy expenditure which extends from about 40 to beyond 65 years for normally healthy, comparatively sedentary men. For men with more active occupations, it is likely that retirement reduces energy expenditure and intake to the level of the sedentary majority of the population. This plateau exists for women throughout adult life because the range of occupational demand is narrow. It may be perturbed slightly on retirement.

The intake of the farmers of over 65 years exceeded that of all older groups found in the literature, while that of the retired men was at the low end of the range. The intake of comparatively sedentary groups of women aged over 65 in the United Kingdom and the USA tended to be slightly lower than that of the retired women.

8.4.5 Question 4. Were there differences between the occupational groups in intake of protein, fat, calcium and iron, which were not related to energy intake? Did the intakes meet commonly accepted standards of adequacy?

Conclusions.

a) The differing levels of energy intake between occupations did not affect the proportion of protein in the diet of groups of men and women except for the steel workers. The protein intakes of men and women as percentages of energy intake agreed closely with the percentages found in British studies including those of younger and older groups. The group intakes met or exceeded the safe level defined in the FAO/WHO/UNU, (1985) report and the USA (1980) Recommended Dietary Allowance for protein. The intake of five women in the age group 50-65 years did not reach the recommended safe level of 0.75 g/kg/day.

b) Fat intake for both men and women was closely related to energy intake. The occupational level of energy intake did not affect the proportion of fat in the diet. The percentages of fat in the diets of all groups of men and women were in excess of the "prudent" level of 35 percent.

c) Occupation did not differentially affect calcium intake for either men or women. The mean intakes of both the male and female groups attained the USA (1980) Recommended Allowance of 800 mg/day for calcium, but 1 in 10 men and over half of the women had intakes below this level. Food choices made by women, in addition to energy intakes which are lower than those of men, are implicated in the difference between the sexes in calcium intake. Safe levels of intake of calcium proposed as between 1200-1500 mg/day for women are unlikely to be reached by dietary means alone, especially at normative levels of energy intake.

d) Iron intake was closely related to energy intake for men and women and was not affected by occupation. The findings of comparable studies were consistent with ours and the mean intakes of all groups exceeded the 10 mg/day standard (USA-RDAs, 1980). The intake of 12 women and one man did not meet this standard. A higher energy intake and, thus, greater intake of iron-supplying foods led to the more satisfactory intake for men. For women, dietary choices at their lower level of energy intake did not include foods which have a sufficiently high nutrient density of iron. The food choices of about 25 percent of women whose levels of energy intake were at or below 2000 kcal/day led to intakes below the standard of 10 mg/day. Normative levels of energy intake would tend to reduce the iron intake unless foods with a higher nutrient density of iron were included in the diet.

8.4.6 Question 5. Was there a decrease in the energy expenditure and energy intake of groups aged over 65 compared to those aged 50-65 years?

Conclusions.

a) There was the same difference in energy expenditure (30%) between a comparatively sedentary and a very active group of men of over 65 years as there was between similar groups of 50-65 years, but at a level of TEE about 22 percent lower than that of the younger groups. There was no greater or no less variation between individuals of over 65 years than under 65 years. Men over 65 years were shown to be capable of high levels of energy expenditure. There was a difference of 23 percent between the energy expenditure of a non-sedentary pre-retirement group of men and a comparable retired group. Where occupation remained the same and age alone was the variable, the difference was 19 percent.

b) The difference between groups of pre- and post-retirement women was 14 percent. There was some indication of two types of activity pattern in women over 65, a pattern of increased activity after a sedentary occupation and a pattern of continuing sedentary behavior into retirement.

c) The intake of the retired men did not reflect their expenditure, nor did that of the farmers. In common with the younger farmers it was 300 kcal/day less than expenditure.

The difference of 700 kcal/day in intake between the non-sedentary group of farmers and the comparatively sedentary retired men was, however, as great as the difference in expenditure (34 percent) and reflected the difference in their energy expenditure.

For the 50-65 age group and the under 50 age group, occupation was a better indicator of intake in men than age. Although the numbers are small, these studies, together with those of four Swiss farmers indicate that this holds true beyond 65 years.

d) The intake of retired women more closely reflected their energy expenditure than did that of the men or of the women of 50-65 years.

e) The variation in intake in the group of retired men was not as great as in the younger group, while that in the groups of women was the same.

f) A noticeable drop in the energy intake of sedentary men and women does not appear to take place until between 75 and 80 years. The thesis studies indicate that for men there is a drop at an earlier age under two circumstances. Firstly, on retirement from non-sedentary occupations and secondly, when moderately heavy occupations are continued beyond 65 years.

g) The energy intakes of the group of farmers exceeded the US RDA (1980) of 2400 kcal/day, but that of the retired men did not reach it. The intake of the retired women exceeded the standard of 1800 kcal/day. The normative energy requirement proposed for the farmers is 1.78 x BMR, for the retired men 1.66 x BMR and for the retired women, 1.64 x BMR.

h) The intakes of two men and two women who lived alone were below the "UNU" suggested cut-off-point of 1.2 x BMR. Only one of the women whose BMI was below the desirable range appeared to have an habitual inadequate intake.

8.4.7 Question. Were the diets of individuals or groups of men and women who lived alone inadequate in protein, calcium, or iron compared to commonly accepted standards?

Conclusions.

a) Protein intake as a percentage of energy intake of men and women was not significantly different from the younger groups and it fell within the range of 11-14 percent found in all comparable studies. The mean intakes of the two groups exceeded the USA Recommended Dietary Allowances (1980) of 56 g/day for men and 49 g/day for women.

In neither group was the safe level, defined by the FAO/WHO/UNU (1985) Consultation as the average requirement, based on 0.75 g/kg/day, plus two standard deviations, achieved. The differences were small (intake 70.39 g/day for men compared to a safe level of 71.1

g/day; intake for women 61.4 g/day compared to a safe level of 63.2 g/day) but indicated the possibility of inadequate intake, even at energy intake levels of 2000 kcal/day. The protein intake of one woman, which was below 0.75 g/kg/day, with an energy intake of 1120 kcal/day was almost certainly inadequate.

b) The mean calcium intakes of the groups of men and women exceeded those of younger groups, but half of each group had intakes of less than the standard of 800 mg/day.

c) One man in 15 and seven women in 21 in the 65 and over age group did not meet the 10 mg/day standard for iron intake. The percentages of both men and women with intakes below 10 mg increased from those in the 50 to 65 age group (23 % to 33% for women; 1% to 6% for men). It is not known whether these low levels were associated with anaemia. The food choices of older men and women should, to be prudent, include foods with a higher nutrient density of iron.

8.5 Results and conclusions of a review of the research data in relation to some of the concepts developed by the FAO/WHO/UNU (1985) Expert Consultation on Energy and Protein Requirements.

8.5.1 Use of 30-60 and over 60 years prediction equations for mixed age groups. The occupational groups of men and women consisted of subjects aged from 50 to 60 and from 61 to 65 years. The prediction equations differ for each of these two age groups. Use of the over 60 years prediction equation for an individual results in a BMR lower than that of an individual of similar weight for whom the 30-60 years equation is used. Total energy expenditure expressed as a factor of the lower BMR appears to be greater than that of a similar individual whose weight and TEE is the same but is 60 years or less.

Groups which included a greater number of individuals over 60 years thus appeared to have a greater "UNU" TEE factor than those with fewer or none. Use of the same prediction equation for BMR is indicated for individuals who make up occupationally comparable groups of men up to 65 years. For reasons of consistency between the sexes the same conclusion is drawn for women.

8.5.2 Comparison of "UNU" and Fleisch estimates of BMR. The "UNU" BMRs of individuals 60 years and under and of occupational groups exceeded the BMRs calculated after Fleisch (1954), which were used as estimates of energy expenditure during sleep. The amount by which use of the "UNU" BMR for sleep would increase the mean TEE of each group is insignificant (about 20 kcal/day or less). The lower Fleisch-BMR resulted in TEE factors greater than the "UNU" TEE factors.

8.5.3 Energy cost factors.

a)"UNU" BMR based factors for energy cost were very useful for comparing groups. "UNU" BMR-based factors for energy costs of activities highlighted differences and similarities between groups of the same sex, of different sex and between groups with defined and undefined occupational time.

The energy cost of the occupational physical activity, expressed as "UNU" BMR-based factors of the 50-65 age group of men did not differ from the under-50 age groups, although no under-50 age groups similar to the moderate work category groups were available for comparison. The energy cost of occupational physical activity of women in the 50-65 age group compared to under-50 groups, did not differ whether the cost was incurred by household and childcare activities or in a combination of outside work and household responsibilities. Underestimates of the energy requirements of women and men between 50-65 years may result if it is assumed that there is a decline in physical activity during those years.

Occupational energy cost expressed as a "UNU" BMR factor was a good predictor of total energy expenditure in male groups. Occupational energy cost expressed as a multiple of "UNU"-BMR predicted the greater TEE of the female bakery workers.

The energy cost factors are another way of highlighting the finding that the contribution of the energy cost of non-occupational activities to TEE was greater for the executives than for the other groups. For the executives, the occupational energy cost was 2.0 x BMR, whereas, non-occupational energy cost was 3.0 x BMR. For the female factory workers, like the executives, the energy cost of non-occupational work exceeded that of occupational work, i.e., comparatively sedentary groups were more active in non-occupational time than occupationally active groups.

b) Use of the energy cost factors give a measure of the intensity at which the various groups worked:

The average energy cost of occupational plus non-occupational work of the bakery workers and housewives was almost identical, 2.7 and 2.8 x BMR. This was greater than that of housewives under 50 years, (2.5 x BMR) and was equivalent to the "UNU" suggested figure of 2.8 x BMR for heavy work. Bakery workers, steel and building workers incurred the same costs (2.6 and 2.7 x BMR) in occupational activities as did sewing workers and executives (2.0 x BMR). When energy cost of occupational plus non-occupational work is compared the male and female groups form two clusters. One consists of steel workers, building workers, light industry workers, bakery workers and housewives, 6th decade with energy costs in the 2.6-2.8 x BMR range. The other consists of executives and sewing workers (2.3 x BMR). At the extreme ends of the range are found the farmers (4.0 x BMR) and the clerical workers (1.7 x BMR). This illustrates the possible range for the energy expenditure of women, which was not covered in the groups studied.

Groupings were different when energy costs of "relaxation" were compared. Most groups of men and women had an energy cost of between 1.6 and 1.8 x BMR. The extremes of the ranges were farmers (1.4 x BMR) and executives and steel workers (2.1 and 2.2 x BMR). The "UNU"-BMR factors for gross energy expenditure in walking were between 4.2 and 5.2 x BMR for five of the groups of men for whom mean energy expenditure in walking fell into the category of moderate work (5-7.4 kcal/min).

Walking fell into the moderate work range of 3.5-5.4 kcal/min for the group of female bakery workers only and the "UNU" BMR factor associated with the level was 4.5 x BMR.

8.5.4 Comparison with examples of similar work categories.

a) The TEE factors of all male groups, except the clerical workers and farmers, exceeded those of the "UNU" examples of similar work categories. The fractions allocated to occupational and leisure activities varied markedly in some of the groups from the examples of male groups. In general, the occupational fractions of the groups exceeded the examples.

b) The examples given for women were not as comparable to the thesis groups as those of the men. The only apparently comparable example, that of a housewife in an affluent society was not similar in TEE nor in percentage of fractional portion nor in percentage of energy requirement allocated to occupational and leisure activities.

8.5.5 The over 65 age group.

8.5.5.1 Prediction of BMR and effect on total energy expenditure. For both men and women the Fleisch BMRs and the "UNU" BMRs were practically identical, in contrast to those of the 50-65 age group. The "UNU" TEE factors for the older groups of men and women, thus, were closer than those of the younger groups to the Fleisch TEE factors

8.5.5.2 Energy cost factors. The energy cost of occupational plus non-occupational work was 2.9 x BMR to the older farmers compared to 4.0 x BMR for the younger group. The energy cost of 2.9 x BMR exceeded the FAO/WHO/UNU (1985) report figure of 2.7 x BMR for moderate work. The older farmers were more active in "relaxation" time, 2.0 x BMR compared to 1.3 x BMR.

The same comparison of pre-retirement and retired men showed, as expected, a difference in the energy cost of work activities, 2.6 x BMR compared to 1.9 x BMR. It also showed that the relaxation activities of the older men had a greater energy cost, 2.1 x BMR, which exceeded the "UNU" standard for light work of 1.7 x BMR, than those of the younger group (1.8 x BMR). The energy cost of walking for the retired men exceeded the metabolic constant for walking at normal pace (3.2 x BMR) developed in the FAO/WHO/UNU, (1985) report.

8.5.5.3 Comparison with examples of similar work categories. The TEE factors of the two male and one female group exceeded those of the "UNU" examples of energy requirement and the percentages allocated to work and leisure were different.

CHAPTER 9
POSTSCRIPT

The studies which are reported in this thesis were undertaken from 1959 to 1965. They were among the first to investigate the total energy requirements of older men and women and they remain among the very few in which measurements have been made of the energy expenditure of healthy older people engaged in their usual occupations and living in their own homes.

Many major research challenges remain in seeking to understand the relationships between aging, nutritional requirements, patterns of activity, energy expenditure, health and disease.

I would pursue four areas in which questions have been raised by discussion of the research findings. These concern: a) the discrepancy, particularly in women, between measurements of energy intake and expenditure; b) the changes which occur in energy requirements at different stages of life due to either alterations in patterns of food intake or of physical activity; c) the differences in patterns of activity between men and women; and d) the importance of episodic weight loss on long term dietary fat intake.

The finding that there is a large individual variation in energy intake measurements compared to energy expenditure measurements, especially in women, is not unique to these studies and is still unexplained. It appears from many published studies that there is an unknown percentage of women whose energy intake barely exceeds or does not reach the level of estimated BMR and yet who lead physically active lives. On the suggested energy requirement of 1.2 x BMR (FAO/WHO/UNU, 1985) these women would gain weight. This does not appear to occur to the same degree in studies of men. Speculative explanations range from the degree of error introduced by the method to the degree of metabolic efficiency of the individual. Are women more metabolically efficient than men, either inherently or by adaptation? Are there any reasons why they should be? For example, is the metabolism of some women permanently altered by pregnancy?

There is very little information available on changes in energy requirements which occur during the lifetime of individuals whether in the form of profiles of energy intake or profiles of energy expenditure. Stages in life relevant to the research are retirement for both men and women and the post-child-rearing years for women. Other events which might produce change are marriage, increased family size, change of occupation, acquisition or loss of a car, change of home, illness and death of a spouse.

Men and women differ in their pattern of physical activity throughout life. Is it possible that life is lengthened for men who follow the predominant female life-long pattern of extended periods of light activity?

The noticeable decline in CHD in the U.S.A. and Canada noted in the Discussion has been partially attributed to a decrease in total fat intake and to alterations in the composition of the dietary fat. There are few profiles of the fat intake of individuals from longitudinal studies. Large numbers of men and women who constantly seek to lose weight by lowering their energy intake many times during life usually do so by reducing their carbohydrate and fat intake. Their total fat intake is thus lowered perhaps over a period of years. Could this reduction in fat intake contribute to a decreased risk of CHD, compared to non-dieters? If intermittent decreases in fat intake led to intermittent weight loss the changes in plasma lipids and lipoproteins brought about by the weight loss, not the alterations in fat intake, might be the factors leading to decreased risk. (Wood, Stefanik, Dreon, et al. 1988)

Because the task of collecting, analyzing and interpreting the vast quantity of data relevant to these topics is immensely complex, I would favour the approach advocated by the Ad Hoc Expert Committee on Energy and Protein Requirements (FAO/WHO, 1973) i.e., the systematic collection and interpretation of simple data on a large scale at population level. Much data is collected at this level but it is seldom individual longitudinal data.

Much useful information on these topics could be obtained by the collection of measurements of weight and height at regular intervals over the adult life of large random samples of the population, e.g., parallel studies of cohorts starting at each decade after 30 years. Baseline estimates of energy intake by a simple method would be necessary and could be repeated as called for by the study design. Such a study could:

a) identify individuals at all levels of energy intake who appear to be in energy balance. It could indicate whether more women than men maintain energy balance at levels considered to be low and which factors (e.g., pregnancy, dieting) reduce the level at which balance is achieved.

b) provide profiles of energy requirements by recording profiles of change in weight. The biological questions posed by FAO/WHO/UNU, (1985) of the variability of requirements in the same individual at different points in time and of energy expenditure over relatively long periods of time would thus be addressed. Appropriate questions to subjects in the research protocol could identify whether gain or loss of weight were associated with changes in patterns of food intake or physical activity together with the reasons for such changes, some of which were cited previously. It should also be possible to distinguish people who are active all their lives from those who are sedentary all their lives, and to identify with more certainty the reasons for the definite decrease in energy requirements shown by cross-sectional studies to occur somewhere between 75 and 80 years.

Some clarification might be expected of the length of time necessary for decreased energy expenditure or increased energy intake to be reflected in increased weight or for energy balance to be restored. Because a study is itself an intervention, it would be prudent to have a control group as part of the design with contact restricted to perhaps 5 yearly intervals.

The usefulness of such a study in questions of the relationship between weight, energy and fat intake and CHD is somewhat more speculative, but a decrease in weight due to lowered energy intake will usually imply a reduced fat intake even although fat as a percentage of the total energy intake remains the same. History of illness and cause of death might reveal associations.

One of many methodological questions to be addressed would concern the estimation of dietary intake. Since habitual energy intake would be the prime focus, methods of obtaining it could be tested and validated with the object of finding a simple and inexpensive method.

One way of obtaining consistency in measurement and regular calibration of instruments would be by fitting a van with the necessary measuring instruments and taking it to the subjects at home or at their place of work.

The current emphasis on individual energy requirements and the continuing and accelerating interest in finding relationships between energy intake and expenditure, patterns of food intake and physical activity, health, disease, longevity and death underline the fundamental importance of the studies which have been presented and discussed.

T10

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NUTRITIONAL STUDIES
OF MEN AND WOMEN AGED 50-75 YEARS

by

ELAINE C. TAYLOR (Nee Blake)

T H E S I S

submitted for the degree of

DOCTOR OF PHILOSOPHY

Faculty of Science
University of Glasgow

VOLUME II
Tables, Figures, Individual Data

April , 1989

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Table 3.1: Age distribution of population of Great Britain and Northern Ireland, 1871-1961

Age Groups	Percentage Total Population			
	1871	1901	1931	1961
0 to 9 years	25.3	22.2	16.2	15.3
10 to 19 years	20.4	20.3	16.8	15.0
20 to 29 years	16.6	18.3	17.0	12.5
30 to 39 years	12.6	13.9	14.5	13.3
40 to 49 years	10.0	10.5	12.9	13.5
50 to 59 years	7.4	7.3	11.0	13.2
60 to 69 years	4.8	4.7	7.3	9.6
70 and over	2.9	2.8	4.3	7.5

TAYLOR

Table 5.1 Occupation, age, sex, type of sample, special characteristics and occupational activity level of 15 groups of men and women

Group no.	Occupation	No.	Age	Sex	Sample	Occupational activity level and special characteristics	Statistical analysis identification no.
1.	Housewives	17	60-69	F	Random	Lived alone/Sedentary-light	12
2.	Housewives	21	54-66	F	Volunteer	Lived with family Sedentary-light	22
3.	Factory workers-sewing machine	20	51-60	F	Volunteer	Light-moderate	32
4.	Factory workers-bakery	16	50-60	F	Volunteer	Light-moderate	42
5.	Older housewives	4	65-81	F	Volunteer	Subjects of a methodology study* (no expenditure studies)	62
6.	Farmers	22	44-62	M	Volunteer	Moderate-very heavy	11
7.	Steel workers	9	55-63	M	Volunteer	Moderate-heavy	21
8.	Building workers	9	55-66	M	Volunteer	Moderate-heavy	31
9. +	Sewing-machine assembly workers	12	55-66	M	Volunteer	Light-moderate	41
10. +	Motor assembly workers	12	57-72	M	Volunteer	Light-moderate	51
11.	Office workers-executive	10	55-62	M	Volunteer	Sedentary-light	61
12.	Office workers-clerical	10	51-60	M	Volunteer	Sedentary-light	71
13.	Retired men	9	64-77	M	Volunteer	Lived alone/Sedentary-light	81
14.	Farmers >65 years	5	68-80	M	Volunteer	Sedentary-light Moderate-very heavy	91
15. +	Light industry	24	55-72	M	Volunteer	Light-moderate groups	01

+ Composite of Groups 9 & 10

*Durnin, J.V.G. and E.C. Blake. An experiment in dietary survey methodology. Proc. Nutr. Soc. 21: X1, 1962.

T5.1/T4

Table 5.2 Categories of physical activity:
energy expended (kcal/min) by reference man

Activity	Kcal/min/65 kg man
Light	2.0 - 4.9
Moderate	5.0 - 7.4
Heavy	7.5 - 9.9
Very heavy	10.0 - 12.4
Unduly heavy	12.5 -

Table 5.3: Categories of physical activity:
energy (kcal/min) expended by reference woman

Activity woman	Kcal/min/55 kg
Light	1.5 - 3.4
Moderate	3.5 - 5.4
Heavy	5.5 - 7.4
Very heavy	7.5 - 9.4

5.2T/T2

Table 6.1: Mean values, standard deviations, and ranges for age, height, body weight, and body mass index (BMI) of eight groups of men

Group	Number	Age yr SD (range)	Weight(W) kg SD (range)	Height(H) cm SD (range)	BMI (W/H^2) kg/M^2 SD (range)
Farmers	22	56 ± 5.2 (44 - 62)	78.4 ± 14.4 (61.8 - 115.5)	171.1 ± 6.4 (160.0 - 182.5)	26.0 ± 4.9 (19.1 - 40.9)
Steel workers	9	58 ± 2.6 (55 - 63)	76.3 ± 12.5 (61.4 - 100.9)	168.0 ± 5.3 (163.0 - 176.5)	26.1 ± 4.7 (20.9 - 36.1)
Building workers	9	54 ± 3.3 (50 - 57)	76.0 ± 8.1 (63.2 - 84.1)	164.0 ± 3.5 (160.0 - 170.0)	27.5 ± 3.4 (22.5 - 32.2)
Light industry workers	24	61 ± 3.9 (55 - 72)	68.5 ± 9.9 (52.4 - 87.7)	163.7 ± 5.7 (153.5 - 176.9)	24.6 ± 3.4 (19.1 - 32.2)
Office workers, executive	10	59 ± 2.8 (55 - 62)	67.8 ± 10.0 (56.4 - 79.5)	170.5 ± 5.3 (164.0 - 177.5)	22.6 ± 3.2 (18.6 - 27.7)
Office workers, clerical	10	57 ± 3.6 (51 - 60)	66.6 ± 8.0 (57.3 - 80.9)	163.9 ± 3.5 (160.7 - 171.6)	24.0 ± 2.7 (19.9 - 28.9)
Retired, living alone	9	73 ± 5.6 (64 - 77)	70.0 ± 10.1 (53.2 - 83.6)	163.5 ± 8.2 (147.5 - 173.7)	25.4 ± 3.5 (20.6 - 30.3)
Farmers over 65 years	5	72 ± 4.5 (68 - 80)	78.6 ± 7.2 (70.9 - 87.3)	172.2 ± 9.4 (159.6 - 185.2)	25.8 ± 2.1 (23.4 - 27.5)

T7/SECT6.1T/p1

Table 6.2: Mean values, standard deviations, and ranges for age, height, body weight and body mass index (BMI) of five groups of women

Group	Number	Age yr SD (range)	Weight(W) kg SD (range)	Height(H) cm SD (range)	BMI (W/H^2) kg/M^2 SD (range)
Housewives, living with family	21	59 ± 3.7 (54 - 66)	60.4 ± 9.6 (46.7 - 78.0)	155.3 ± 6.4 (142.0 - 168.8)	24.5 ± 4.1 (17.2 - 34.7)
Factory workers, sewing machine	20	55 ± 2.5 (51 - 60)	62.7 ± 12.1 (43.3 - 87.8)	157.8 ± 7.9 (148.0 - 176.5)	26.6 ± 3.6 (21.2 - 37.0)
Factory workers, bakery	16	54 ± 3.9 (50 - 60)	61.9 ± 13.3 (44.5 - 89.4)	156.0 ± 9.4 (141.2 - 157.5)	25.8 ± 5.7 (19.6 - 42.0)
Housewives, living alone	17	66 ± 2.6 (60 - 69)	60.7 ± 11.8 (41.4 - 80.0)	154.3 ± 7.2 (134.0 - 162.5)	24.7 ± 4.1 (17.6 - 30.7)
Older women	4	71 ± 6.9 (65 - 81)	53.7 ± 3.9 (51.4 - 59.4)	148.5 ± 7.7 (142.0 - 157.0)	23.7 ± 1.4 (21.8 - 24.8)

T7/SECT6.1T

Table 6.3: Mean values, standard deviations, and ranges for daily energy intake, daily energy expenditure, the difference between energy intake and expenditure and the average of energy intake and expenditure of eight groups of men.

Group	Number	Intake kcal SD (range)	Expenditure kcal SD (range)	+Intake minus expenditure kcal SD (range)	#Average of intake and expenditure kcal SD (range)
Farmers	22	3465 ± 481 (2194 - 4224)	3709 ± 487 (2973 - 4672)	-244 ± 461 (-927 - 625)	3587 ± 425 (2649 - 4441)
Steel workers	9	3226 ± 342 (2733 - 3804)	3276 ± 504 (2598 - 3958)	-49 ± 576 (-948 - 768)	3250 ± 320 (2668 - 3667)
Building workers	9	3076 ± 563 (2329 - 4026)	3051 ± 418 (2440 - 3730)	-25 ± 587 (-989 - 1209)	3064 ± 399 (2544 - 3818)
Light industry workers	24	2907 ± 337 (2204 - 3656)	2837 ± 410 (2185 - 3714)	70 ± 297 (-599 - 463)	2872 ± 346 (2194 - 3555)
Office workers executive	10	2645 ± 438 (1757 - 3218)	2824 ± 318 (2340 - 3272)	-179 ± 355 (-1071 - 221)	2734 ± 339 (2229 - 3245)
Office workers - clerical	10	2444 ± 313 (2090 - 3112)	2287 ± 291 (1826 - 2910)	168 ± 338 (-332 - 821)	2360 ± 250 (2094 - 2743)
Retired, living alone	9	2052 ± 355 (1470 - 2547)	2327 ± 406 (1754 - 3068)	-338 ± 356 (-1227 - -12)	2221 ± 337 (1612 - 2665)
Farmers over 65 years	5	2667 ± 495 (2230 - 3436)	3011 ± 450 (2448 - 3441)	-344 ± 568 (-1211 - 292)	2839 ± 378 (2367 - 3290)

+ Variable name : Energy balance
# Variable name : Energy needs

T7/T6.3/p1

Table 6.4: Mean values, standard deviations and ranges for daily energy intake, daily energy expenditure, the difference between energy intake and expenditure, and the average of energy intake and expenditure of five groups of women

Group	Number	Intake kcal SD (range)	Expenditure kcal SD (range)	+Intake minus expenditure kcal SD (range)	#Average of intake and expenditure kcal SD (range)
Housewives, living with family	21	1939 ± 390 (1243 - 2886)	2257 ± 292 (1795 - 2926)	-319 ± 343 (-1119 - 358)	2098 ± 299 (1672 - 2849)
Factory workers, sewing machine	20	2126 ± 484 (1737 - 2829)	2319 ± 236 (2018 - 2981)	-196 ± 518 (-1690 - 953)	2223 ± 279 (1646 - 2984)
Factory workers, bakery	16	2208 ± 471 (1448 - 3144)	2511 ± 439 (1982 - 3393)	-304 ± 452 (-971 - 833)	2358 ± 392 (1826 - 3100)
Housewives, living alone	17	1917 ± 322 (1115 - 2320)	1987 ± 248 (1492 - 2409)	-58 ± 166 (-466 - 126)	1940 ± 282 (1348 - 2324)
Older women	4	1720 ± 263 (1477 - 2086)	-	-	-

+ Variable name: Energy balance
# Variable name: Energy needs

T7/Sec6Tc/p1

Table 6.5: Intake and expenditure of energy of eight groups of men expressed per kilogram of body weight, means and standard deviations

Group	Intake kcal/kg SD	Expenditure kcal/kg SD	Mean weight kg
Farmers	45.8 ± 10.8	48.5 ± 9.8	78.4
Steel workers	43.0 ± 6.0	43.2 ± 4.9	76.3
Building workers	41.1 ± 9.8	40.5 ± 6.9	76.0
Light industry workers	42.9 ± 5.2	41.8 ± 6.2	68.5
Office workers, executive	39.2 ± 5.5	42.0 ± 4.5	67.8
Office workers, clerical	37.3 ± 7.4	34.3 ± 4.7	66.6
Retired, living alone	29.5 ± 4.7	34.3 ± 4.2	70.0
Farmers over 65 years	34.1 ± 6.3	38.1 ± 2.5	78.6

T4/T6./p2

Table 6.6: Intake and expenditure of energy of four groups of women expressed per kilogram of body weight, means and standard deviations

Group	Intake kcal/kg SD	Expenditure kcal/kg SD	Mean weight kg
Housewives, with family	32.6 ± 7.2	37.8 ± 4.8	60.4
Factory workers, sewing machine	32.6 ± 11.1	35.1 ± 7.2	62.7
Factory workers, bakery	36.1 ± 9.6	40.6 ± 6.5	61.9
Housewives, living alone	32.4 ± 6.4	33.5 ± 6.2	60.7

T4/T6./p1

Table 6.7: Mean daily intake of protein, fat, carbohydrate, calcium, iron and energy by eight groups of men

Group (range)	Protein g SD (range)	Fat g SD (range)	Carbohydrate g SD (range)	Calcium mg SD (range)	Iron mg SD (range)	Energy Intake kcal SD (range)
Farmers	111.3 ± 16.5 (92.0 - 142.0)	158.7 ± 28.3 (106.0 - 202.2)	425.2 ± 62.1 (333.0 - 539.5)	1437 ± 441 (750 - 2272)	20.1 ± 3.8 (13.9 - 28.4)	3465 ± 481 (2194 - 4224)
Steel workers	111.6 ± 15.8 (85.5 - 139.2)	140.0 ± 24.0 (103.6 - 183.6)	372.6 ± 66.7 (291.6 - 477.5)	1238 ± 304 (770 - 1,480)	19.1 ± 3.7 (12.0 - 23.3)	3226 ± 342 (2805 - 3963)
Building workers	97.4 ± 17.1 (70.6 - 127.2)	126.6 ± 24.7 (93.1 - 166.1)	371 ± 105.0 (297.4 - 591.0)	1057 ± 292 (862 - 1,721)	18.3 ± 4.2 (13.3 - 27.6)	3076 ± 563 (2265 - 4014)
Light industry workers	89.6 ± 11.2 (70.6 - 109.2)	125.6 ± 23.7 (75.5 - 174.6)	365.0 ± 55.0 (274.8 - 517.8)	1110 ± 292 (672 - 1673)	16.0 ± 2.3 (11.0 - 19.7)	2907 ± 337 (2119 - 3685)
Office workers, executive	81.6 ± 13.8 (61.4 - 103.9)	114.0 ± 18.1 (81.8 - 140.0)	331.9 ± 60.3 (206.6 - 405.5)	1046 ± 260 (552 - 1461)	15.7 ± 2.6 (11.5 - 19.8)	2645 ± 438 (1809 - 3325)
Office workers, clerical	83.4 ± 13.1 (59.4 - 103.1)	115.1 ± 13.6 (95.8 - 135.6)	275.6 ± 50.5 (206.9 - 392.2)	950 ± 247 (450 - 1257)	14.4 ± 3.2 (8.9 - 18.6)	2444 ± 313 (2001 - 3173)
Retired, living alone	70.3 ± 9.7 (55.5 - 84.3)	83.5 ± 16.6 (61.7 - 111.8)	268.6 ± 65.3 (169.8 - 329.0)	807 ± 213 (551 - 1077)	13.0 ± 3.4 (8.9 - 19.2)	2052 ± 355 (1406 - 2606)
Farmers over 65 years	95.4 ± 16.0 (80.0 - 121.0)	113.8 ± 26.5 (81.0 - 155.0)	332.0 ± 91.1 (217.0 - 414.0)	1262 ± 502 (786 - 2094)	16.2 ± 2.8 (13.4 - 19.3)	2667 ± 495 (2230 - 3436)

T4/T6.5(a)/p2

Table 6.8: Mean daily intake of protein, fat, carbohydrate, calcium, iron and energy by five groups of women

Group	Protein g SD (range)	Fat g SD (range)	Carbohydrate g SD (range)	Calcium mg SD (range)	Iron mg SD (range)	Energy kcal SD (range)
Housewives, living with family	61.6 ± 13.4 (40.9 - 85.6)	90.5 ± 17.9 (60.5 - 131.0)	231.7 ± 58.6 (149.1 - 336.8)	776 ± 223 (427 - 1265)	11.4 ± 2.8 (7.4 - 17.8)	1939 ± 390 (1245 - 2886)
Factory workers, sewing machine	66.5 ± 14.3 (52.5 - 111.3)	102.9 ± 21.2 (88.6 - 113.1)	246.7 ± 73.5 (119.8 - 271.4)	836 ± 300 (372 - 1524)	12.2 ± 3.0 (4.2 - 17.4)	2126 ± 484 (1737 - 2829)
Factory workers, bakery	73.2 ± 20.0 (37.0 - 108.3)	108.6 ± 32.6 (59.2 - 155.9)	248.6 ± 60.0 (179.1 - 366.5)	869 ± 311 (351 - 1602)	13.4 ± 3.7 (7.1 - 17.4)	2208 ± 471 (1486 - 3144)
Housewives, living alone	61.4 ± 12.7 (29.8 - 84.7)	85.5 ± 14.5 (52.4 - 105.8)	232.8 ± 48.1 (139.5 - 313.1)	853 ± 198 (612 - 1223)	11.1 ± 2.9 (3.2 - 15.4)	1917 ± 322 (1107 - 2283)
Older women	59.0 ± 9.6 (44.6 - 68.8)	80.8 ± 8.8 (78.4 - 93.8)	190.0 ± 46 (138.9 - 237.7)	703 ± 189 (563 - 981)	8.8 ± 1.8 (6.4 - 10.9)	1720 ± 263 (1477 - 2085)

S6T/T7/p6

Table 6.9: Contribution of protein, fat, carbohydrate, and alcohol to the total energy value of the diets of eight groups of men

Group	Protein % energy intake	Fat % energy intake	Carbohydrate % energy intake	Alcohol % energy intake
Farmers	12.0	40.0	44.0	4.0
Steel workers	14.1	39.2	43.3	3.4
Building workers	12.7	37.4	47.9	2.0
Light industry workers	12.3	39.9	46.2	1.6
Office workers, executive	12.4	38.9	47.0	1.7
Office workers, clerical	13.7	42.4	42.0	1.9
Retired, living alone	13.6	36.6	49.4	0.4
Farmers, over 65 years	14.0	38.0	47.0	1.0

T4/T6.5(a)/p1

Table 6.10: Contribution of protein, fat, and carbohydrate to the total energy value of the diets of five groups of women

Group	Protein % energy intake	Fat % energy intake	Carbohydrate % energy intake
Housewives, living with family	12.7	42.0	45.3
Factory workers, sewing machine	12.5	43.6	43.9
Factory workers, bakery	13.3	44.3	42.4
Housewives, living alone	12.8	40.1	47.1
Older women	13.7	43.8	42.5

T4/T6.5(a)/p4

Table 6.11: Mean daily energy expenditure of eight groups of men

Group	Energy expenditure (kcal/day)			
	Mean	Minimum	Maximum	Median
Farmers	3710	2970	4670	3650
Steel workers	3280	2600	3960	3290
Building workers	3050	2440	3730	3008
Light industry workers	2840	2190	3710	2820
Office workers, executive	2820	2340	3270	2880
Office workers, clerical	2290	1830	2910	2290
Retired, living alone	2330	1750	3068	2370
Farmers, over 65 yrs.	3010	2450	3440	3140

T3/6.4T/p1

Table 6.12: Mean daily energy expenditure of four groups of women

Group	Energy expenditure (kcal/day)			
	Mean	Minimum	Maximum	Median
Housewives, living with family	2260	1800	2930	2180
Factory workers, sewing machine	2320	2020	2980	2320
Factory workers, bakery	2510	1980	3390	2400
Housewives, living alone	1990	1490	2410	2000

T3/6.4T/p2

Table 6.13: Mean daily energy intake of five groups of women

Group	Energy intake (kcal/day)			
	Mean	Minimum	Maximum	Median
Housewives, living with family	1940	1320	2780	1950
Factory workers, sewing machine	2130	801	2990	2150
Factory workers, bakery	2210	1450	3140	2260
Housewives, living alone	1920	1120	2320	2010
Older women	1720	1480	2090	1660

T7/S6.2T/p2

Table 6.14: Mean daily energy intake of eight groups of men

Group	Energy intake (kcal/day) Mean	Minimum	Maximum	Median
Farmers	3470	2190	4220	3460
Steel workers	3230	2730	3804	3200
Building workers	3080	2330	4030	2900
Light industry workers	2910	2204	3660	2920
Office workers, executive	2650	1760	3218	2680
Office workers, clerical	2440	2090	3112	2350
Retired, living alone	2050	1470	2550	2017
Farmers 65 years	2670	2230	3440	2540

T7/S6.2T/p1

Table 6.15: Mean daily intake of protein per kilogram body weight by five groups of women

Group	Protein g/kg SD (range)
Housewives, living with family	1.0 ± 0.2 (0.6 - 1.3)
Factory workers, sewing machine	1.0 ± 0.3 (0.5 - 1.7)
Factory workers, bakery	1.2 ± 0.4 (0.6 - 2.1)
Housewives, living alone	1.1 ± 0.3 (0.6 - 1.6)
Older women	1.1 ± 0.2 (0.9 - 1.3)

T7/T6.6f

Table 6.16: Mean daily intake of protein per kilogram body weight by eight groups of men

Group	Protein g/kg SD (range)
Farmers	1.5 ± 0.3 (0.7 - 2.0)
Steel workers	1.5 ± 0.2 (1.2 - 1.9)
Building workers	1.3 ± 0.3 (0.8 - 1.8)
Light industry workers	1.3 ± 0.2 (0.9 - 1.6)
Office workers, executive	1.2 ± 0.1 (1.0 - 1.5)
Office workers, clerical	1.3 ± 0.2 (0.9 - 1.7)
Retired, living alone	1.0 ± 0.1 (0.8 - 1.2)
Farmers 65 years	1.2 ± 0.2 (1.0 - 1.5)

T7/T6.6g

Table 6.17 Expenditure of time in bed and in occupational, non-occupational, and relaxation activities by eight groups of men and four groups of women

	Occupational activities		[a]Non-occupational "work"		Occ. activities plus non-occ. "work"		[b]Relaxation		[a+b]Relaxation plus non-occup "work"		Bed	
	min/d	%24h	min/d	%24h	min/d	%24h	min/d	%24h	min/d	%24h	min/d	%24h
Group A												
Men												
Steel workers	274	19	153	10	427	29	485	34	638	44	528	37
Building workers	391	27	69	5	460	32	493	34	562	39	487	34
[c]Light industry workers	374	26	146	10	520	36	450	31	596	41	470	33
Office workers-executive	294	20	123	9	417	29	562	39	685	48	461	32
Office workers-clerical	383	27	91	6	474	33	469	33	560	39	497	34
Women												
Sewing machine workers	367	25	183	14	550	39	398	28	621	43	452	32
Bakery workers	350	24	191	14	541	38	435	30	626	44	464	32
Group B[d]												
Men												
Farmers	-	-	-	-	511	36	450	31	-	-	479	33
Farmers >65 years	-	-	-	-	482	33	442	31	-	-	516	36
Retired men	-	-	-	-	190	13	682	48	-	-	568	39
Women												
Housewives, living with family	-	-	-	-	399	28	532	37	-	-	509	35
Housewives, living alone	-	-	-	-	328	23	531	37	-	-	581	40

a. Non-sitting household tasks, shopping.
b. Sitting and walking in non occupational time, personal and dressing and active recreational activities (gardening, dancing, bowling).
c. Sewing machine and motor assembly workers have been combined.
d. In Group B the distinction between occupational and non-occupational time and activities was not clear.
e. No walking is included in farmers' leisure time.
a+b. Activities include "optional household tasks", "socially desirable activities", and the equivalent of "activity for physical fitness and the promotion of health", i.e., "discretionary activities" (FAO/WHO/UNU, 1985) or "leisure-time activities" (FAO/WHO, 1973).

T6.23p2/T6

Table 6.18: Contribution of bed and occupational, non-occupational, and relaxation activities to total daily energy expenditure of eight groups of men and four groups of women

	Occupational activities		[a]Non-occupational "work"		Occup plus non-occup" work"		[b]Relaxation		[a+b]Relaxation plus non-occup "work"		Bed	
	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE
Group A												
Men												
Steel workers	885	27	494	15	1379	42	1275	39	1769	54	622	19
Building workers	1251	41	187	6	1438	47	1094	36	1281	42	519	17
[c]Light industry workers	1163	41	387	14	1550	55	805	28	1192	42	482	17
Office workers - executive	640	22	411	15	1051	37	1294	46	1705	61	479	17
Office workers - clerical	683	30	213	9	896	39	887	39	1100	48	504	22
Women												
Sewing machine workers	742	32	490	21	1232	53	663	29	1153	50	424	18
Bakery workers	849	33	544	22	1393	55	698	28	1242	50	420	17
[d]Group B												
Men												
Farmers	-	-	-	-	2465	67	[e]725	19	-	-	541	14
Farmers >65 years	-	-	-	-	1475	49	[e]978	32	-	-	557	19
Retired men	-	-	-	-	366	16	1406	60	-	-	555	24
Women												
Housewives, living with family	-	-	-	-	1029	46	785	34	-	-	443	20
Housewives, living alone	-	-	-	-	683	34	819	41	-	-	485	25

a. Non-sitting household tasks, shopping.
b. Sitting and walking in non-occupational time, personal and dressing, and active recreational activities (gardening, dancing, bowling).
c. Sewing machine and motor assembly workers have been combined.
d. In Group B the distinction between occupational and non-occupational activities and time was not clear.
e. No walking is included in farmers' leisure time.
a+b. Activities include "optional household tasks", "socially desirable activities" and the equivalent of "activity for physical fitness and the promotion of health", i.e., "discretionary activity" (FAO/WHO/UNU, 1985) or "leisure-time activities" (FAO/WHO, 1973).

T3/6.5T/p9

Table 6.19 Expenditure of time (minutes/day and percentage of 24 hours) in various activities by eight groups of men

Activity	Farmers		Steel workers		Building workers		Light industry		Office workers - executive		Office workers - clerical		Retired men		Farmers >65 years	
	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h	min/d (hrs)	%24 h
In bed	479 (8.0)	33	528 (8.8)	37	487 (8.1)	34	470 (7.8)	33	461 (7.7)	32	497 (8.3)	34	568 (9.5)	39	516 (8.6)	36
Personal dressing	31	2	53	4	43	3	31	2	51	4	37	3	58	4	21	1
Sitting activities	412 (6.9)	28	402 (6.7)	28	487 (8.1)	34	346 (5.8)	24	546 (9.1)	38	630 (10.5)	44	498 (8.3)	35	421 (7.0)	29
*Standing and "light activity"	265 (4.4)	18	359 (6.0)	25	249 (4.2)	17	517 (8.6)	36	232 (3.9)	16	183 (3.1)	13	190 (3.2)	13	375 (6.3)	26
**"Moderate activity"	155	11	9	<1	41	3	4	<1	19	1	-	-	-	-	41	3
***"Heavy activity"	12	1	13	1	-	-	-	-	-	-	-	-	-	-	-	-
****"Very heavy activity"	6	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walking	80	6	76	5	133	9	72	5	124	9	93	6	119	8	65	5
Shopping	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Total	1440	100	1440	100	1440	100	1440	100	1440	100	1440	100	1440	100	1440	100

*Energy cost <5 kcal/min.

**Energy cost between 5 and 7.4 kcal/min.

***Energy cost between 7.5 and 9.9 kcal/min.

+Shopping included in "light activity" (occupational).

T3/6.10T/p1

Table 6.20 Expenditure of energy (kilocalories per day and percentage of daily expenditure) in various activities by eight groups of men

Activity	Farmers		Steel workers		Building workers		Light industry		Office workers - executive		Office workers - clerical		Retired men		Farmers >65 years	
	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE
In bed	541	15	622	19	519	17	482	17	479	17	504	22	555	24	557	19
Personal, dressing	81	2	165	5	96	3	62	4	120	4	80	3	140	6	55	2
Sitting activities	618	17	753	23	824	27	511	18	916	32	964	43	698	30	553	18
*Standing activities and "light activity"	933	25	1107	34	453	15	1392	48	640	23	372	16	362	16	1108	37
**"Moderate activity"	909	24	62	2	488	16	23	1	145	5	-	-	12	<1	367	12
***"Heavy activity"	95	3	108	3	-	-	-	-	-	-	-	-	-	-	-	-
****"Very heavy activity"	70	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walking	462	12	459	14	671	22	369	13	524	19	367	16	537	23	370	12
Shopping	+	+	-	-	-	-	-	-	-	-	-	-	23	1	+	+
TOTAL	3709	100	3276	100	3051	100	2837	100	2824	100	2287	100	2327	100	3010	100

*Expenditure less than 5 kcal/min.

**Expenditure between 5 and 7.4 kcal/min.

***Expenditure between 7.5 and 9.9 kcal/min.

****Expenditure 10 kcal/min. and above.
+Shopping included in "light activity" and as a component of occupational energy expenditure.

T3/6.5T6.11/p1

Table 6.21 Expenditure of time (minutes/day and % of 24 hours) in various activities by four groups of women

Activity	Housewives w/family min/d (hrs)	Housewives w/family % 24 h	Factory workers sewing machine min/d (hrs)	Factory workers sewing machine % 24 h	Factory workers bakery min/d (hrs)	Factory workers bakery % 24 h	Housewives alone min/d (hrs)	Housewives alone % 24 h
In bed	509 (8.4)	35	452 (7.5)	32	464 (7.7)	32	581 (9.7)	40
Personal, dressing	55	4	70	5	61	4	29	2
Sitting activities	405 (6.6)	28	434 (7.2)	30	373 (6.2)	26	436 (7.3)	30
*Standing activities and "light activity"	339 (5.7)	23	350 (5.8)	24	373 (6.2)	26	305 (5.1)	21
**"Moderate activity"	40	3	35	2	86	6	-	-
Walking	66	5	81	6	66	5	66	5
Shopping	26	2	18	1	17	1	23	2
TOTAL	1440	100	1440	100	1440	100	1440	100

*Energy cost <3.5 kcal/min.

**Energy cost 3.5 - 5.4 kcal/min.

T3/6.5Tables/p6

Table 6.22: Expenditure of energy (kilocalories/day and percentage of daily expenditure) in various activities by four groups of women

	Housewives w/family		Factory workers sewing machine		Factory workers bakery		Housewives alone	
Activity	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE	kcal/d	%dly EE
In bed	443	20	424	18	420	17	485	25
Personal, dressing	103	4	140	6	122	5	85	4
Sitting activities	457	20	560	24	477	19	529	27
*Standing activities and "light activity"	842	37	767	33	808	32	621	31
**"Moderate activity"	148	7	128	6	356	14	-	-
Walking	206	9	260	11	283	11	205	10
Shopping	60	3	41	2	45	2	62	3
TOTAL	2259	100	2319	100	2511	100	1987	100

*Expenditure less than 3.5 kcal/min.

**Expenditure between 3.5 and 5.4 kcal/min.

T3/6.5T/p7

Table 6.23 Percentage contribution of walking to total daily energy expenditure and daily expenditure of time during occupational and non occupational time

	Time and energy expended in walking											
	Occupational				Non-occupational/ Leisure				Total			
	Min/d	% 24h	kcal/d	%dly EE	Min/d	% 24h	kcal/d	%dly EE	min/d	% 24h	kcal/d	%dly EE
Group A												
Men												
Steel workers	20	1.4	80	2.4	56	3.9	379	11.6	76	5.3	459	14
Building workers	90	6.3	416	13.6	43	2.9	255	8.4	133	9.2	671	22
Light industry workers	7	0.5	61	2.2	65	4.2	308	11.4	72	4.7	369	13
Office workers, executive	43	2.9	178	6.3	81	5.7	346	12.3	124	8.6	524	19
Office workers, clerical	37	2.6	147	6.4	56	3.9	220	9.6	93	6.5	367	16
Women												
Sewing machine workers	17	1.2	63	2.7	63	4.4	197	8.5	81	5.6	260	11
Bakery workers	25	1.7	109	4.3	47	2.8	174	6.9	66	4.5	283	11
Group B												
Men												
Farmers	80	6.0	462	12.0	-	-	-	-	80	5.6	462	12
Farmers over 65 years	72	5.3	370	12.0	-	-	-	-	65	4.5	370	12
Retired men	-	-	-	-	119	8.0	537	23.0	119	8.3	537	23
Women												
Housewives, living alone		-	-	-	66	10.0	205	10.0	66	5	205	10
Housewives, living with family		-	-	-	66	5.0	206	10.0	66	5	206	9

T6/T6.23/p1

Table 6.24: Energy cost to steel workers of "fettling" and walking by weight and body mass index (BMI)

Subject no.	Weight kg	BMI kg/M^2	Fettling kcal/min	Walking kcal/min
1	61.2	20.90	7.6	5.2
5	65.4	22.94	6.5	6.3
8	67.5	24.68	7.4	5.3
2	69.4	23.39	7.0	6.1
3	74.8	26.22	9.8	6.9
9	76.3	23.79	7.6	6.9
4	81.5	25.81	8.6	5.4
7	90.4	31.07	8.9	7.0
6	100.6	36.14	8.0	8.9

T4/T6./p3

Table 6.25: Time spent on "light", moderate", "heavy", and "very heavy" activity at measured energy cost and at energy cost adjusted for weight for 22 farmers

Activity	Time spent on activities: At measured energy cost min/day	%24 h	At energy cost adjusted for weight min/day	%24 h
In bed	479	33	479	33
Personal, dressing	31	2	31	2
Sitting activities	412	28	412	28
Standing activities and "light activity" (<5 kcal/min)	265	18	322	23
"Moderate activity" (5-7.4 kcal/min)	155	11	110	8
"Heavy activity" (7.5-9.9 kcal/min)	12	1	2	-
"Very heavy activity" (10 kcal/min and above)	6	<1	4	-
Walking	80	6	80	6
TOTAL	1440	100	1440	100

T6/T6.25/p1

Table 7.1: Daily rates of energy expenditure by men with various occupations

Occupation	Energy expenditure (kcal/day) Mean	Minimum	Maximum
c Office workers, clerical	2,290	1,830	2,910
d Elderly retired	2,330	1,750	3,070
b Colliery clerks	2,800	2,330	3,290
c Office workers, executive	2,820	2,340	3.270
a Laboratory technicians	2,840	2,240	3,820
c Light industry workers	2,840	2,180	3,710
d Elderly Swiss farmers	2,910	2,210	4,150
a University students	2,930	2,270	4,410
c Building workers	3,000	2,440	3,730
d Elderly farmers	3,010	2,450	3,440
c Steel workers	3,280	2,600	3,960
a Army cadets	3,420	2,990	4,100
b Coal miners	3,660	2,970	4,560
c Forestry workers	3,670	2,860	4,600
c Farmers	3,710	2.970	4,670
c Swiss farmers	3,840	3,280	5,010

a Mean age less than 25 years (3 groups)
b Mean age between 25 and 35 years (2 groups)
c Mean age between 54 and 61 years (8 groups)
d Mean age between 70 and 80 years (3 groups)

7.1/T4

Table 7.2: Co-efficients of variation from the means of energy expenditure of eight groups of men expressed as a) mean kilocalories per day, b) mean of TEE factor computed from BMR (Fleisch, 1951), c) mean of TEE factor computed from BMR (FAO/WHO/UNU, 1985) and d) mean kilocalories per kilogram body weight.

Group	Coefficients of Variation(%)			
	Mean kcal/d	Mean Fleisch TEE factor	Mean "UNU" TEE factor	Mean kcal/ kilogram/d
Farmers	13.1	15.2	13.1	20.2
Steel workers	15.4	11.5	11.5	11.3
Building workers	13.7	13.3	13.2	17.0
Light industry workers	14.5	13.5	13.7	14.8
Office workers, executive	11.3	8.4	11.1	10.7
Office workers, clerical	12.7	12.2	17.0	13.7
Retired, living alone	17.4	10.7	10.8	12.2
Farmers over 65 years	14.9	8.2	7.7	6.6

T7.2/T4

Table 7.3 Mean values, standard deviations and ranges of energy intake and energy expenditure of eight groups of men expressed as multiples of Basal Metabolic Rate (Fleisch, 1951)

Group	Energy Intake			Energy Expenditure		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Farmers	2.16 (1.32-2.81)	0.36	16.6	2.31 (1.71-3.12)	0.35	15.2
Steel workers	2.06 (1.79-2.38)	0.19	9.2	2.09 (1.79-2.48)	0.24	11.5
Building workers	1.97 (1.37-2.56)	0.37	18.8	1.95 (1.68-2.45)	0.26	13.3
Light industry workers	1.94 (1.60-2.32)	0.25	12.9	1.92 (2.56-2.63)	0.26	13.5
Office workers, executive	1.77 (1.31-2.05)	0.22	12.4	1.90 (1.68-2.11)	0.16	8.4
Office workers, clerical	1.68 (1.37-2.18)	0.22	13.1	1.56 (1.32-2.00)	0.19	12.2
Retired, living alone	1.44 (1.11-1.73)	0.19	13.2	1.68 (1.32-1.96)	0.18	10.7
Farmers over 65 years	1.73 (1.35-2.27)	0.30	17.3	1.94 (1.74-2.08)	0.16	8.2

T7.3/T4

Table 7.4 Mean values, standard deviations and ranges of energy intake and energy expenditure of eight groups of men, expressed as multiples of Basal Metabolic Rate (FAO/WHO/UNU, 1985)*

Group	Energy Intake			Energy Expenditure		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Farmers	1.99	0.30	15.0	2.13	0.28	13.1
	(1.33-2.53)			(1.70-2.81)		
Steel workers	1.91	0.25	13.1	1.92	0.22	11.5
	(1.56-2.50)			1.56-2.25)		
Building workers	1.76	0.34	19.3	1.74	0.23	13.2
	(1.49-2.36)			(1.44-2.25)		
Light industry workers	1.89	0.25	13.2	1.83	0.25	13.7
	(1.42-2.31)			(1.40-2.33)		
Office workers, executive	1.70	0.27	15.9	1.81	0.20	11.0
	(1.16-2.06)			(1.49-2.10)		
Office workers, clerical	1.52	0.24	15.8	1.41	0.24	17.0
	(1.20-1.98)			(1.18-1.47)		
Retired, living alone	1.43	0.20	14.0	1.66	0.18	10.8
	(1.05 - 1.78)			(1.26-1.96)		
Farmers over 65 years	1.73	0.28	16.2	1.95	0.15	7.7
	(1.34 - 2.19)			(1.73 - 2.11)		

*Basal Metabolic Rate prediction equations:
1) 11.6 W + 879 for men aged 30-60 years
2) 13.5 W + 487 for men aged over 60 years

T7.4/T4

Table 7.5: Mean Basal Metabolic Rates of eight groups of men using a) Fleisch (1951) calculation and b) FAO/WHO/UNU (1985) prediction equations.

	B.M.R. (kilocalories/day)					
	"Fleisch"			"FAO/WHO/UNU"		
Group	Mean	SD	CV%	Mean	SD	CV %
Farmers	1613	137	8.5	1750	145	8.3
Steel workers	1567	121	7.7	1706	205	12.0
Building workers	1568	78	5.0	1761	89	5.1
Light industry	1482	121	8.2	1555	170	10.9
Office workers, executive	1490	108	7.2	1566	100	6.4
Office workers, clerical	1459	75	5.1	1626	115	7.4
Retired, living alone	1417	120	8.5	1432	128	8.9
Farmers over 65 years	1549	124	8.0	1548	88	5.6

T7.5/T4

Table 7.6: Average values for groups of men and women of the "UNU"- BMR based energy cost of physical activity in occupational, and non-occupational time.

Group A	Occupational activities		[a]Non-occupational "work"		Occup plus non-occup" work"		[b]Relaxation		[a+b]Relaxation plus non-occup "work"		Walking		
	E/Cost x BMR	Hrs/day	E/Cost x BMR	Hrs/day	E/Cost x BMR	Hrs/day	E/Cost x BMR	Hrs/day	E/Cost X BMR	Hrs/day	E/Cost x BMR	Hrs/day	E/Cost per min
Men													
Steel workers	2.7	4.6	2.7	2.6	2.7	7.1	2.2	8.1	2.3	10.6	5.0	1.3	6.1
Building workers	2.6	6.5	2.1	1.2	2.6	7.7	1.8	8.2	1.9	9.4	4.2	2.2	5.0
Light industry workers	2.9	6.2	2.5	2.4	2.8	8.7	1.7	7.5	1.9	9.9	4.7	1.2	5.1
Office workers - executive	2.0	4.9	3.0	2.1	2.3	7.0	2.1	9.4	2.3	11.4	3.8	2.1	4.2
Office workers - clerical	1.6	6.4	2.1	1.5	1.7	8.0	1.7	7.8	1.7	9.3	3.4	1.6	3.9
Women													
Sewing machine workers	2.0	6.1	2.7	3.1	2.3	9.2	1.7	6.6	1.9	10.4	3.1	1.4	3.2
Bakery workers	2.6	5.8	3.0	3.2	2.7	9.0	1.7	7.3	2.1	10.4	4.5	1.1	4.3
[c]Group B													
Men													
Farmers	-	-	-	-	4.0	8.5	[d]1.3	7.5	-	-	4.9	1.3	5.8
Farmers >65 years	-	-	-	-	2.9	8.0	[d]2.0	7.3	-	-	5.2	1.1	5.7
Retired men	-	-	-	-	1.9	3.2	2.1	11.4	-	-	4.5	2.0	4.5
Women													
Housewives, 6th decade	-	-	-	-	2.8	6.7	1.6	8.9	-	-	3.4	1.1	3.1
Housewives, 7th decade	-	-	-	-	2.4	5.5	1.8	8.9	-	-	3.7	1.1	3.1

a. Non-sitting household tasks, shopping.
b. Sitting and walking in non-occupational time, personal and dressing, and active recreational activities (gardening, dancing, bowling).
c. In Group B the distinction between occupational and non-occupational activities and time was not clear.
d. No walking is included in farmers' leisure time.
a+b. Activities include "optional household tasks", "socially desirable activities" and the equivalent of "activity for physical fitness and the promotion of health", i.e., "discretionary activity" (FAO/WHO/UNU, 1985) or "leisure-time activities" (FAO/WHO, 1973).

T4/T7.6

Table 7.7 Men - Contribution of occupational (O) and leisure-time (L) activities to total energy expenditure (TEE) of Group A men expressed I as factors of mean BMR (FAO/WHO/UNU-"UNU") of groups and from "UNU" examples for individuals, II as recorded mean percentage contribution to TEE, and III as percentage contribution to total energy requirement (TER) of "UNU" examples of work categories.

		Occupational and leisure-time activities				
		I Contribution to fractional portion of BMR factor		II Recorded % of TEE	III Examples of "UNU work category estimates	
Group A		Group	"UNU"Example	Group	% of TER	TER*
Steel workers	O	0.33(36%)	0.50(63%)	27	44	"MA"
	L	0.59(64%)	0.28(37%)	54	37	work
	TEE	1.92(100%)	1.78(100%)	-	-	1.78xBMR
Building workers	O	0.43(58%)	0.50(63%)	41	44	"MA"
	L	0.31(42%)	0.28(37%)	42	37	work
	TEE	1.74(100%)	1.78(100%)	-	-	1.78xBMR
Light industry workers	O	0.48(58%)	0.50(63%)	41	44	"MA"
	L	0.35(42%)	0.28(37%)	42	37	work
	TEE	1.83(100%)	1.78(100%)	-	-	1.78xBMR
Office workers, executive	O	0.20(25%)	0.17(32%)	22	28	"LA"
	L	0.61(75%)	0.37(68%)	61	51	work
	TEE	1.81(100%)	1.54(100%)	-	-	1.54xBMR
Office workers, clerical	O	0.14(34%)	0.17(32%)	30	28	"LA"
	L	0.27(66%)	0.37(68%)	48	51	work
	TEE	1.41(100%)	1.54(100%)	-	-	1.54xBMR
Colliery clerks	O	0.25(38%)	0.17(32%)	32	28	"LA"
	L	0.41(62%)	0.37(68%)	50	51	work
	TEE	1.66(100%)	1.54(100%)	-	-	1.54xBMR
Miners	O	0.79(65%)	0.93(82%)	48	59	"H"
	L	0.43(35%)	0.21(18%)	39	25	work
	TEE	2.22(100%)	2.14(100%)	-	-	2.14xBMR

*"MA"=moderate activity", "LA"=light activity, "H"=heavy

T4

Table 7.8 Men - Contribution of occupational (O) and leisure-time (L) activities to total energy expenditure (TEE) of Group B men expressed I as factors of mean BMR (FAO/WHO/UNU-"UNU") of groups and from "UNU" examples for individuals, II as recorded mean percentage contribution to TEE, and III as percentage contribution to total energy requirement (TER) of "UNU" examples of work categories.

		Occupational and leisure-time activities				
		I Contribution to fractional portion of BMR factor		II Recorded % of TEE	III Examples of "UNU work category estimates	
Group B		Group	"UNU"Example	Group	% of TER	TER*
a.Farmers	O	1.03(91%)	1.01(89%)	67	65	"H"
	L	0.10(9%)	0.13(11%)	19	19	work
	TEE	2.13(100%)	2.14(100%)	-	-	2.14xBMR
a.Farmers	O	0.63(66%)	0.50(63%)	49	44	"MA"
over 65	L	0.32(34%)	0.28(37%)	32	23	work
years	TEE	1.95(100%)	1.78(100%)	-	-	1.78xBMR
b.Retired	O	0.14(21%)	0.07(14%)	16	7	"Retired
men over	L	0.52(79%)	0.44(86%)	60	71	elderly
65 years	TEE	1.66(100%)	1.51(100%)	-	-	men 1.51xBMR

*"MA"=moderate activity, "H"=heavy

a. O=occupational and non-occupational tasks which were largely indistinguishable, including walking
   R=all other activities/relaxation(R=relaxation)

b. O=household tasks
   R=all other activities including walking

T4

Table 7.9: Energy expended in walking during occupational and non-occupational time and in moderate activity for men

	Walking							Moderate Activity	
	Occupational		Non-occupational		Total			Total	
Group A	kcal/d	kcal/wk	kcal/d	kcal/wk	kcal/d	kcal/wk	CV%	kcal/wk	CV%
Steel workers	80	560	379	2653	459	3213	55	434	72
Building workers	416	2912	255	1785	671	4697	52	3416	129
Light industry	61	427	308	2156	369	2583	35	161	118
Office workers, executive	178	1246	346	2422	524	3668	33	1015	103
Office workers, clerical	147	1029	220	1540	367	2569	43	-	-
Students	-	-	-	-	517	3618	43	354	-
Technicians	-	-	-	-	454	3181	27	85	94
Group B									
Farmers	462	3234	-	-	462	3234	66	6363	49
Farmers over 65 years	370	2590	-	-	370	2590	16	2569	101
Retired men	-	-	537	-	537	3759	49	84	141

T7.9/T4

Table 7.10: Mean energy expended in non-occupational physical activity for men.

Group	Non-occupational physical activity Work kcal/d	Walking kcal/d	Recreation kcal/d	Total kcal/d
Steel workers	494	379	38	911
Building workers	187	255	100	542
Light industry	387	308	97	792
Office workers executive	411	346	185	942
Office workers clerical	213	220	36	469

T7.10/T4

Table 7.11: Daily rates of energy expenditure by women with various occupations

Occupation	Energy expenditure (kcal/day) Mean	Minimum	Maximum
d Housewives, 7th decade	1,990	1,490	2,410
d Elderly sedentary workers, Canadian	2,000	-	-
c Housewives (1)	2,090	1,760	2,320
a Laboratory technicians	2,130	1,340	2,540
a Saleswomen	2,250	1,820	2,850
c Housewives (2)	2,260	1,800	2,930
a University students	2,290	2,090	2,500
c Factory workers	2,320	1,970	2,980
b Housewives with young children	2,340	-	-
c Bakery workers	2,510	1,980	3,390
c Swiss housewives/farmers	2,980	2,200	3,860

a Mean age less than 25 years (3 groups)
b Mean age between 25 and 35 years (1 group)
c Mean age between 51 and 59 years (5 groups)
d Mean age between 65 and 66 years (2 groups)

7.11/T4

Table 7.12: Co-efficients of variation from the means of energy expenditure of groups of women expressed as a) mean kilocalories per day, b) mean of TEE factor computed from BMR (Fleisch, 1954), c) mean of TEE factor computed from BMR (FAO/WHO/UNU, 1985) and d) mean kilocalories per kilogram body weight.

	Coefficients of Variation(%)			
Group	Mean kcal/d	Mean Fleisch TEE factor	Mean "UNU" TEE factor	Mean kcal/ kilogram/d
Housewives, 6th decade	12.9	10.6	9.3	12.7
Sewing machine workers	10.2	12.7	10.4	20.5
Bakery workers	17.5	12.3	13.3	16.0
Housewives, 7th decade	12.5	12.8	13.0	18.5

T7.12/T4

Table 7.13 Mean values, standard deviations and ranges of energy intake and energy expenditure of four groups of women expressed as multiples of Basal Metabolic Rate (Fleisch, 1951)

Group	Energy Intake			Energy Expenditure		
	Mean	S.D.	C.V.(%)	Mean	S.D.	C.V.(%)
Housewives, 6th decade	1.55 (1.02-1.99)	0.28	18.1	1.80 (1.45-2.21)	0.19	10.6
Factory workers, sewing machine	1.61 (0.50-2.55)	0.44	27.3	1.73 (1.51-2.49)	0.22	12.7
Factory workers, bakery	1.72 (1.23-2.63)	0.37	21.5	1.95 (1.70-2.56)	0.24	12.3
Housewives, 7th decade	1.59 (1.03-1.92)	0.26	16.4	1.64 (1.26-2.10)	0.21	12.8

T7.13/T4

Table 7.14 Mean values, standard deviations and ranges of energy intake and energy expenditure of four groups of women, expressed as multiples of Basal Metabolic Rate (FAO/WHO/UNU, 1985)*

Group	Energy Intake			Energy Expenditure		
	Mean	S.D.	C.V.	Mean	S.D.	C.V.
Housewives, 6th decade	1.47 (1.00-2.00)	0.27	18.4	1.72 (1.42-2.10)	0.16	9.3
Factory workers, sewing machine	1.51 (0.51-2.22)	0.36	23.8	1.64 (1.48-2.14)	0.17	10.4
Factory workers, bakery	1.60 (1.19-2.39)	0.34	21.0	1.81 (1.08-2.39)	0.24	13.3
Housewives, 7th decade	1.56 (1.05-2.00)	0.25	16.0	1.61 (1.20-2.11)	0.21	13.0

*Basal Metabolic Rate prediction equations:
1) 8.7 W + 829 for women aged 30-60 years
2) 10.5 W + 59b for women aged over 60 years

T7.13/T4

Table 7.15: Mean Basal Metabolic Rates of four groups of women using
a) Fleisch (1951) calculation and
b) FAO/WHO/UNU (1985) prediction equations.

	B.M.R. (kilocalories/day)					
	"Fleisch"			"FAO/WHO/UNU"		
Group	Mean	SD	CV%	Mean	SD	CV %
Housewives, 6th decade	1,242	95	7.6	1,314	94	7.2
Factory workers, sewing machine	1,352	141	10.4	1,421	103	7.2
Factory workers, bakery	1,287	129	10.0	1,377	113	8.2
Housewives, 7th decade	1,211	142	11.7	1,233	121	9.8

T7.15/T4

Table 7.16 Women - Contribution of occupational (O) and leisure-time (L) activities to total energy expenditure (TEE) of Group A and Group B women expressed I as factors of mean BMR (FAO/WHO/UNU-"UNU") of groups and from "UNU" examples for individuals, II as recorded mean percentage contribution to TEE, and III as percentage contribution to total energy requirement (TER) of "UNU" examples of work categories.

		Occupational and leisure-time activities				
		I Contribution to fractional portion of "UNU" BMR factor		II Recorded % of TEE	III Examples of "UNU"work category estimates	
Group A		Group	"UNU"Example	Group	% of TER	TER*
Sewing machine workers	O	0.25(39%)	0.58(76%)	32	52	"RWDC"
	L	0.39(61%)	0.18(24%)	50	29	1.76xBMR
	TEE	1.64(100%)	1.76(100%)	-	-	
Bakery workers	O	0.37(46%)	0.58(76%)	33	52	"RWDC"
	L	0.44(54%)	0.18(24%)	50	29	1.76xBMR
	TEE	1.81(100%)	1.76(100%)	-	-	
Saleswomen 3rd decade	O	0.40(57%)	N/A	38	N/A	N/A
	L	0.30(43%)	N/A	40	N/A	N/A
	TEE	1.70(100%)	N/A	-	-	
Group B**						
Housewives 4th decade (Grieve)	O	0.58(77%)	0.58(76%)	56	52	"RWDC"
	L	0.17(23%)	0.18(24%)	25	29	1.76xBMR
	TEE	1.75(100%)	1.76(100%)	-	-	
Housewives 5th&6th decade	O	0.35(70%)	0.24(46%)	43	24	"HAS"
	L	0.15(30%)	0.28(54%)	34	54	1.52xBMR
	TEE	1.50(100%)	1.52(100%)	-	-	
Housewives 6th decade	O	0.49(68%)	0.24(46%)	43	24	"HAS"
	R	0.23(32%)	0.28(54%)	36	54	1.52xBMR
	TEE	1.72(100%)	1.52(100%)		-	
Housewives 7th decade	O	0.33(54%)	0.24(46%)	34	24	"HAS"
	R	0.28(46%)	0.28(54%)	41	54	1.52xBMR
	TEE	1.61(100%)	1.52(100%)		-	-

*"RWDC"=rural woman in developing country, "HAS"=housewife in an affluent society

**O=household tasks
R=all other activities including walking

N/A=data not available

T4

Table 7.17: Energy expended in walking during occupational and non-occupational time and in moderate activity for women.

	Walking						
	Occupational		Non-occupational		Total		
Group A	kcal/d	kcal/wk	kcal/d	kcal/wk	kcal/d	kcal/wk	CV%
Sewing machine workers	63	441	197	1379	260	1820	36
Bakery workers	109	763	174	1218	283	1981	36
Saleswomen (3rd decade)	N/A*	N/A	N/A	N/A	310	2170	N/A
Group B							
Housewives 4th decade	146	1022	-	-	146	1022	N/A
Housewives 5th & 6th decade	-	-	160	1120	160	1120	64
Housewives 6th decade	-	-	206	1442	206	1442	37
Housewives 7th decade	-	-	205	1435	205	1435	58

*N/A = data not available

T7.17/T4

Table 7.18: Mean energy expended in non-occupational physical activity for women.

Group	Non-occupational physical activity: Work kcal/d	Walking kcal/d	Recreation kcal/d	Total kcal/d
Factory workers, sewing machine	490	197	9	696
Factory workers, bakery	544	174	6	724

T7.18/T4

Table 7.19 Selected studies of mean daily intake of energy of men (1936 - 1965)

Source	Subjects No.	Subjects Age	Energy intake Kcal/day
Widdowson (1936) U.K.	7	51-60	2770
Pyke et al., (1947) U.K.	12	60-85	2130
Garry et al., (1955) U.K.	10	20-46	3040
	19	20-45	4030
Bransby and Osborne (1953) U.K.	23	60-69	2130
	58	70-74	2150
	44	75+	2000
Bransby (1954) U.K.	44	20-29	3600
	40	30-39	3510
	52	40+	3430
Edholm et al., (1955) U.K.	12	18-20	3430
Gillum and Morgan (1955) U.S.	73	55-64	2560
	71	65-74	2250
	16	75-79	2160
Lyons and Trulson (1955) U.S.	31	65-83	2460
Durnin et al., (unpublished) Switzerland	8	49-65	3918
Durnin et al., (unpublished) Switzerland	4	76-80	2900
Bramwell (1961) U.K.	26	34-49	2790
Morris, et al., (1963) U.K.	99	40-55	2850
Steinkamp et al., (1965) U.S.*	37	69-78	2170
	24	79-88	1700
	5	89-93	1990

*Fourteen year follow-up of age groups in Gillum and Morgan (1955)

T7.2-3-4/T4

Table 7.20(a) Selected studies of mean daily energy intake of men (1966 - 1986)

Source	Subjects No.	Age	Energy intake kcal/day)
McGandy et al. (1966) U.S.	52	45-54	2450
	50	55-64	2330
	50	65-74	2300
	37	75+	2100
Passmore and Durnin (1967) U.K.	17	51-69	3550
Wheatcroft (1969) U.K.	9	20-29	3040
Wheatcroft (1969) U.K.	20	24-35	3120
Buskirk et al. (1971) U.S.	20	48	2600
DHSS (1972) U.K.	231	65-74	2340
	194	75+	2100
Macleod et al. (1974) U.K.	45	65-74	2390
	32	75+	2210
Lonergan et al. (1975) U.K.	158	62-74	2490
	54	75-90	2180
Brown et al. (1977) U.S.	9	72-90	2170
Greger and Sciscoe U.S. (1977)	18	52-89	1720
Steen et al. (1977) Sweden +	174	70	2344*
Grotkowski and Sims U.S. (1978)	10	72	1800
DHSS (1979) U.K.	111	<80	2217
	58	≥80	2024
Vir and Love (1979) U.K.	10	65-89	2550
Yearick (1980) U.S.	25	66-96	2180
Singman et al. (1980) U.S. (L)	681	50-59	2420
Acheson et al. (1980)	12	21-29	3210
Bingham et al. (1981) U.K.	13	20-39	2440
	12	40-59	2350
	7	60-79	2360

*Not including alcohol
+Diet history method

T5/T7.Ab/p3

Table 7.20(b): Selected studies of mean daily energy intake of men (1965 - 1986)

Source	Subjects No.	Subjects Age	Energy intake kcal/day)
Garry et al. (1982) U.S.	125	60-80	2170
Thompson et al. (1982) (U.K.)	97	40	2895
Elahi et al. (1983) U.S. (L)*	18	35-39	2604
	18	40-44	2338
	18	45-49	2152
	40	50-54	2370
	40	55-59	2168
	40	60-64	2303
	18	65-69	2258
	18	70-74	2037
	18	75-79	2084
	14	70-74	2404
	14	75-79	2239
	14	80-84	2163
Kim et al. (1984) (U.S.)	7	≤35	3030
	6	>35	2430
Baseline Data From Four Intervention Studies			
National Diet-Heart Study 1963-1964	1196	45-54	2565
Framingham Heart Study 1960-1964	373	45-54	2666
	491	55-64	2563
Lipid Research Clinics Program 1972-1975	355	35-39	2844
	370	40-44	2730
	302	45-49	2612
	317	50-54	2492
	257	55-59	2368
Multiple Risk Factor Intervention Trial 1973-1975	12,847	35-57	2488

*Longitudinal data on four groups

T5/T7.Ab/p4

Table 7.21: Co-efficients of variation from the means of energy intake of eight groups of men expressed as a) mean kilocalories per day, b) mean of TEI factor computed from BMR (Fleisch, 1951), c) mean of TEI factor computed from BMR (FAO/WHO/UNU, 1985) and d) mean kilocalories per kilogram body weight.

	Coefficients of Variation(%)			
Group	Mean kcal/d	Mean Fleisch TEI factor	Mean "UNU" TEI factor	Mean kcal/ kilogram/d
Farmers	13.9	16.6	15.0	23.6
Steel workers	10.6	9.2	13.1	14.0
Building workers	18.3	18.8	19.3	23.8
Light industry workers	11.6	12.9	13.2	12.1
Office workers-executive	16.6	12.4	15.9	14.0
Office workers-clerical	12.8	13.1	15.8	19.8
Retired, living alone	17.3	13.2	14.0	15.9
Farmers over 65 years	18.6	17.3	16.2	18.5

T4/T7.21

Table 7.22: Normative*** energy requirements of eight groups of men.

Group	BMI (W/H^2)	Actual weight kg.	Desirable weight kg.	Energy requirement at desirable weight at "UNU" Work Levels 1.55	1.78	2.1	at TEE factor (level)**	Energy intake kcal/d	Energy expend kcal/d
Farmers	26.0	78.4	64.0	N/A*	2885	3405	3453*** (2.13)	3465	3709
Steel workers	26.1	76.3	61.7	N/A*	2837	3350	3062*** (1.92)	3226	3276
Building workers	27.5	76.0	59.6	N/A*	2795	3297	2732*** (1.74)	3076	3051
Light industry	24.6	68.5	59.6	N/A*	2795	3297	2873*** (1.83)	2907	2837
Office workers executives	22.6	67.8	64.0	2513	2885	N/A*	2934*** (1.81)	2645	2824
Office workers clerical	24.0	66.6	59.6	2434	N/A*	N/A*	2214*** (1.41)	2444	2287
Retired	25.4	70.0	59.6	2002	2300	N/A*	2145*** (1.66)	2052	2327
Farmers over 65 years	25.8	78.6	65.0	N/A*	2430	2867	2662*** (1.95)	2667	3011

* N/A - Not applicable.
** "UNU" TEE factor derived from mean TEE and BMR at actual weight.
*** Normative requirements i.e., energy requirements calculated from BMR at desirable weight and mean TEE derived from findings of the study (BMR x TEE factor).

Table 7.23: Details of individual subjects whose mean energy intake was under 1600 kcal/day for women and under 2000 kcal/day for men. Comparison with energy intakes expressed as factors of Basal Metabolic Rate (FAO/WHO/UNU, 1985)

Subject	Energy Intake kcal/d.	Energy Intake BMR factor	Height cm	Weight kg	B.M.I kg/M^2
Men:					
Executive	1758	1.16	167.0	55.3	19.0
Retired	1719	1.43	156.2	53.2	20.9
Retired	1842	1.18	168.3	79.8	27.4
Retired	1470	1.05	146.7	67.3	30.3
Retired	1961	1.52	166.4	59.4	20.7
Women:					
Retired	1484	1.15	148.5	66.3	29.4
Retired	1115	1.05	151.0	41.7	17.6
Retired	1552	1.66	134.0	41.4	22.2
Housewife	1438	1.09	144.8	54.8	25.4
Housewife	1319	1.00	154.5	54.0	22.0
Housewife	1595	1.14	149.9	63.5	27.6
Housewife	1469	1.32	156.0	49.5	19.7
Housewife	1327	0.98	151.1	70.8	30.4
Worker	802	0.51	165.0	86.2	31.1
Worker	1556	1.11	162.0	63.9	23.8
Worker	1448	1.19	148.0	44.5	19.6
Worker	1486	1.08	146.5	62.5	28.4

T7.23/T4

Table 7.24 Selected studies of mean daily energy intake of women (1936 - 1965)

Source	Subjects No.	Subjects Age	Energy Intake (kcals/day)
Widdowson and McCance (1936) U.K.	24	25-39	2170
	4	40-50	2070
Pyke et al. (1947) U.K.	8	50-77	1450
Ohlson et al. (1948) U.S.	10	52-74	1800
Ohlson et al. (1950) U.S.	13	51-77	1700
Bransby, and Osborne (1953) U.K.	101	60-69	1800
	50	70-74	1700
	27	75+	1600
Gillum and Morgan (1955) U.S.	105	55-64	1760
	68	65-74	1760
	36	75+	1490
Lyons and Trulson (1955) U.S.	69	65-83	1800
Durnin et al., (1957)	12	45-61	2100
Durnin et al., (1957) U.K.	12	16-27	2220
Durnin and Brockway (unpublished)	18	17-23	2220
Morgan (1959) U.S.	600	50-59	1800
	500	60-69	1600
Durnin, et al., (unpublished) Switzerland	8	50-65	2750
Fry et al. (1963) U.S.	14	64-74	1700
Stanton and Exton-Smith (1965) U.K.	60	70-94	1890
Steinkamp et al. (1965)* U.S.	60	69-78	1570
	35	79-88	1610
	7	89-93	1306

*Fourteen year follow-up of age groups in Gillum and Morgan (1955)

T7.24/T4

Table 7.25.(a): Selected studies of mean daily energy intake of women (1965-1986)

Source	Subjects No.	Subjects Age	Energy intake (kcal/day)
Exton-Smith et al. U.K. (1965)	24	70-73	2070
		74-77	1880
		78+	1670
DHSS (1972) U.K.	236	65-74	1790
	218	75+	1630
Macleod et al. U.K. (1974)	95	65-74	1790
	92	75+	1700
Lonergan et al. U.K. (1975)	190	62-74	1770
	73	75-90	1650
Jordan (1976) U.S.	78	65-89	1360
Lenner et al. Sweden + (1977)	117	50	2040
	95	54	1970
	36	60	1870
Jansen and Harrill U.S. (1977)	24	62-99	1380
Greger and Sciscoe U.S. (1977)	26	52-89	1850
Brown et al. U.S. (1977)	14	70-96	1630
Steen et al. Sweden+ (1977)	188	70	1928
Grotkowski & Sims U.S. (1978)	30	72	1363
DHSS (1979) U.K.	125	<80	1679
	71	≥80	1559

+Diet history method

T5/T7.25AB

Table 7.25(b): Selected studies of mean daily energy intake of women (1965-1986)

Source	Subjects No.	Subjects Age	Intake (kcal/day)
Vir and Love U.K. (1979)	27	65-89	1770
Yearick et al. U.S. (1980)	75	63-89	1590
Bingham et al. (U.K.) (1981)	10	20-39	2183
	14	40-59	1986
	7	60-79	1529
Garry et al. U.S. (1982)	145	60-80+	1653
Kim et al. (1984) U.S.	8	≤ 35	1893
	8	> 35	1803
Baseline Data From Two Intervention Studies			
Framingham Heart Study 1957-1960	28	37-39	2508
	111	40-44	2171
	100	45-49	2181
	90	50-54	2131
	63	55-59	2068
Lipid Research Clinics Program 1972-1975	277	37-39	1852
	293	40-44	1785
	295	45-49	1731
	249	50-54	1689
	243	55-59	1661

+Diet history method

T5/T7.25AB

Table 7.26: Co-efficients of variation from the means of energy intake of four groups of women expressed as a) mean kilocalories per day, b) mean of TEI factor computed from BMR (Fleisch, 1951), c) mean of TEI factor computed from BMR (FAO/WHO/UNU, 1985) and d) mean kilocalories per kilogram body weight.

Group	Coefficients of Variation(%)			
	Mean kcal/d	Mean Fleisch TEI factor	Mean "UNU" TEI factor	Mean kcal/ kilogram/d
Housewives 6th decade	20.1	18.1	18.4	22.1
Sewing machine workers	22.8	27.3	23.8	34.0
Bakery workers	21.3	21.5	21.0	26.6
Housewives 7th decade	16.8	16.4	16.0	19.8

T4/T7.26

Table 7.27: Normative*** energy requirements of four groups of women.

Group	BMI (W/H^2)	Actual weight kg.	Desirable weight kg.	Energy requirement at desirable weight: at "UNU" Work Levels 1.56	1.64	1.82	at TEE factor (level)**	Energy intake kcal/d	Energy expend kcal/d
Housewives 6th decade	24.5	60.4	50.0	1972	2073	N/A*	2174*** (1.72)	1939	2257
Sewing machine workers	26.6	62.7	51.3	1989	2091	N/A*	2091*** (1.64)	2126	2319
Bakery workers	25.8	61.9	50.4	N/A*	2079	2306	2293*** (1.81)	2208	2511
Housewives 7th decade	23.7	53.7	49.5	1741	1830	N/A*	1797*** (1.61)	1917	1987

* N/A - Not applicable.
** "UNU" TEE factor derived from mean TEE and BMR at actual weight.
*** Normative requirements i.e., energy requirements calculated from BMR at desirable weight and mean TEE derived from findings of the study (BMR x TEE factor).

T4/T7.27

Table 7.28 Selected studies of mean daily intake of protein, fat, calcium, and iron of men (1936 - 1965)

Source	Subjects		Protein		Fat		Calcium	Iron
	No.	Age	g.	% energy	g.	% energy	mg	mg
Widdowson (1936)	7	51-65	89	13	108	38	900	17
Pyke et al. (1947)	12	60-85	74	14	91	38	800	15
Bransby and Osborne (1953)	81	65-74	74	14	86	36	900	14
Bransby (1954)	152	20-40+	109	12	138	35	1300	21
Garry et al. (1955)	10	20-46	96	13	119	35	1100	16
	19	20-45	121	12	150	34	1500	21
Gillum and Morgan (1955)	73	55-64	92	14	107	38	--	16
	71	65-74	71	13	93	38	--	14
	31	75+	69	13	89	37	--	14
Lyons and Trulson (1955)	31	65-83	88	14	106	39	1000	14
Morris et al. (1963)	99	40-55	82	11	130	41	--	--
Steinkamp et al. (1965)*	37	69-78	81	15	--	--	800	13
	24	79-88	64	15	--	--	700	11
	5	89-93	64	13	--	--	900	10

*Fourteen year follow-up of Gillum and Morgan, 1955

T7.28/T4

Table 7.29: Selected studies of mean daily intake of protein, fat, calcium and iron of men (1965 - 1986)

Source	Subjects		Protein		Fat		Calcium	Iron
	No.	Age	g.	% energy	g.	% energy	mg	mg
McGandy et al. (1966)	52	45-54	98	16	116	43	790	15
	50	55-64	92	16	105	40	740	14
	50	65-74	92	16	99	39	910	14
	37	75-99	81	16	86	37	890	12
DHSS (1972)	231	65-74	75	13	110	42	910	12
	194	75+	68	13	98	42	880	11
Macleod et al. (1974)	45	65-74	81	14	109	42	960	13
	32	75+	75	14	103	42	820	12
Lonergan et al. (1975)	158	62-74	75	12	103	38	960	12
	54	75-90	70	13	91	38	960	11
DHSS (1979)	111	<80	71	13	100	41	890	12
	58	≤80	69	14	93	41	870	11
Vir and Love (1979)	10	65-89	72	11	--	--	1000	12
Singman et al. (1980)	681	50-59	114	19	106	39	--	--
Yearick et al. (1980)	25	66-96	94	17	88	36	973	15
Bingham et al. (1981)	13	20-39	77	13	105	39	934	13
	12	40-59	76	13	102	39	827	14
	7	60-79	77	13	106	40	974	12
Garry et al. (1982)	125	60-80	83	15	91	37	--	--

T7.29/T4

Table 7.30 Selected studies of mean daily intake of protein, fat, calcium and iron of women (1936 - 1965)

Source	Subjects No.	Subjects Age	Protein g.	Protein % energy	Fat g.	Fat % energy	Calcium mg	Iron mg
Widdowson and McCance (1936)	11	50-62	63	13	87	41	600	11
Pyke et al. (1947)	26	50-85	50	13	69	42	600	8
Ohlson et al. (1948)	10	52-74	61	13	--		900	-
Ohlson et al. (1950)	31	48-77	61	13	--		700	-
Bransby and Osborne (1953)	151	60-74	58	13	75	39	800	11
Gillum and Morgan (1955)	105	55-64	66	15	73	37	--	11
	68	65-74	65	15	74	38	--	11
	36	75+	61	15	58	35	--	9
Lyons and Trulson (1955)	69	65-83	66	14	81	40	900	10
Durnin et al. (1957)	12	45-61	66	13	91	41	700	12
Fry et al. (1963)	32	65-85	66	15	90	50	800	10
Stanton and Exton-Smith (1965)	60	70-94	57	12	74	39	860	10
Steinkamp et al. (1965)*	60	69-78	61	16	--	--	700	11
	35	79-88	61	15	--	--	600	11
	7	89-93	43	13	--	--	400	9

*Fourteen year follow-up of groups in Gillum and Morgan, 1955

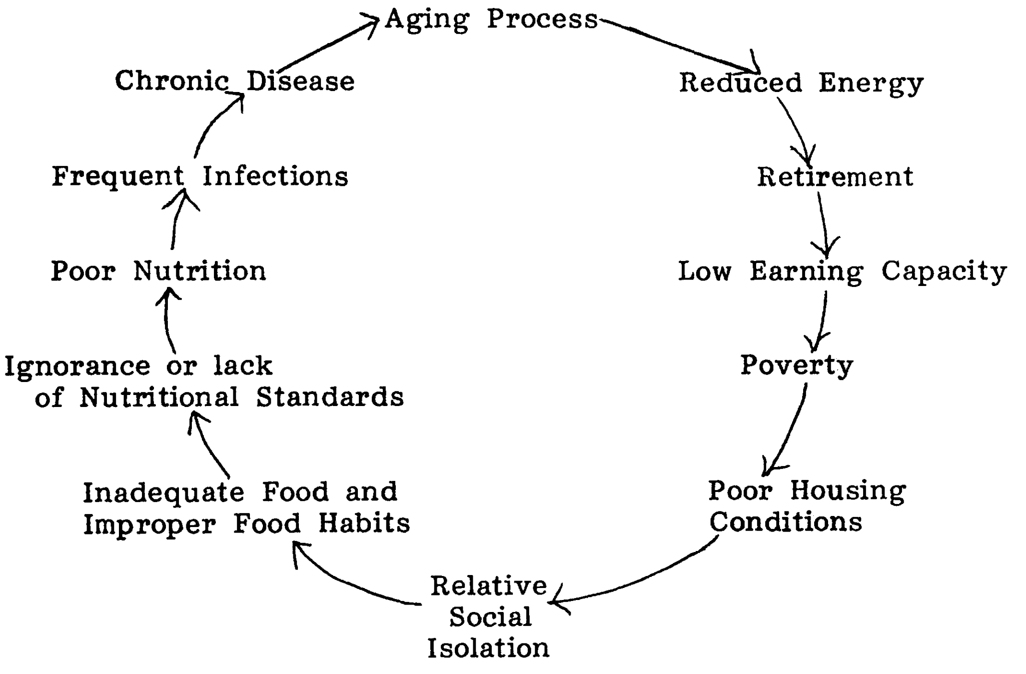
T7.30/T4

Table 7.31: Selected studies of mean daily intake of protein, fat, calcium, and iron of women (1965 - 1986)

Source	Subjects		Protein		Fat		Calcium	Iron
	No.	Age	g.	% energy	g.	% energy	mg	mg
DHSS (1972)	236	65-74	59	14	87	44	800	9
	218	75+	54	13	78	43	730	9
Macleod et al. (1974)	95	65-74	62	15	89	45	750	10
	92	75+	57	14	83	44	720	9
Lonergan et al. (1975)	190	62-74	58	13	85	43	800	10
	73	75-90	54	13	75	41	790	8
Lenner et al. (1977)	117	50	74	15	86	38	1000	16
	95	54	71	14	84	38	1000	14
	36	60	68	15	79	38	900	14
DHSS (1979)	125	<80	58	14	81	43	780	9
	71	≥80	53.	14	72	42	690	9
Vir and Love (1979)	27	65-89	70	12	-	-	710	9
Bingham et al. (1981)	10	20-39	71	13	101	42	989	12
	14	40-59	69	14	91	41	967	12
	7	60-79	58	15	71	42	725	12

T7.31/T4

Figure 3.1
Interrelation of health, economics, social conditions and disease in the aged*

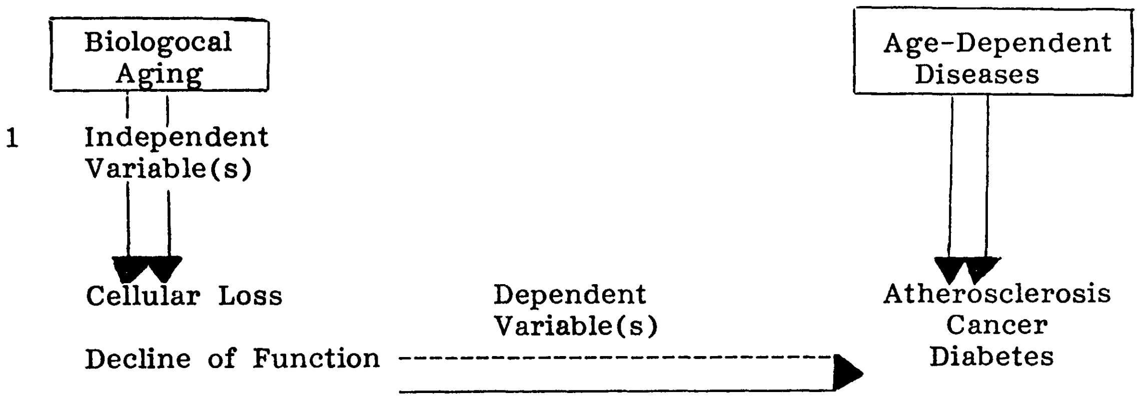


*Source: Rao, D.B.: Problems of nutrition in the aged. Am. J. of Geriatrics 21:364, 1973.

T5

Figure 3.2
Interrelationships between universal concomitants of aging and frequent pathological sequalae*

Biological Aging and
Age-Dependent Diseases



*Source: S. Goldstein. The cellular basis of aging Can. Fam. Phys. 30:585, 1984.

1 Including food intake, nutrition, exercise, energy expenditure.

T5

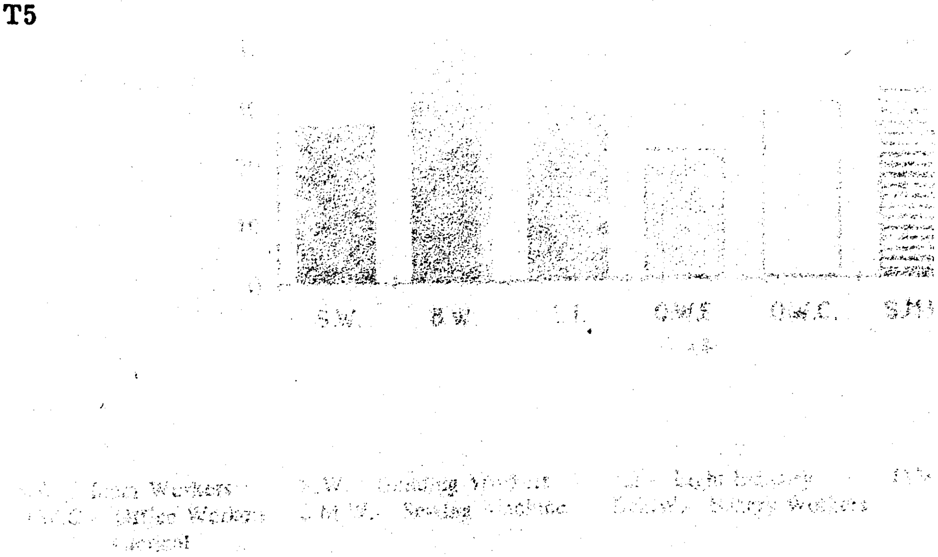
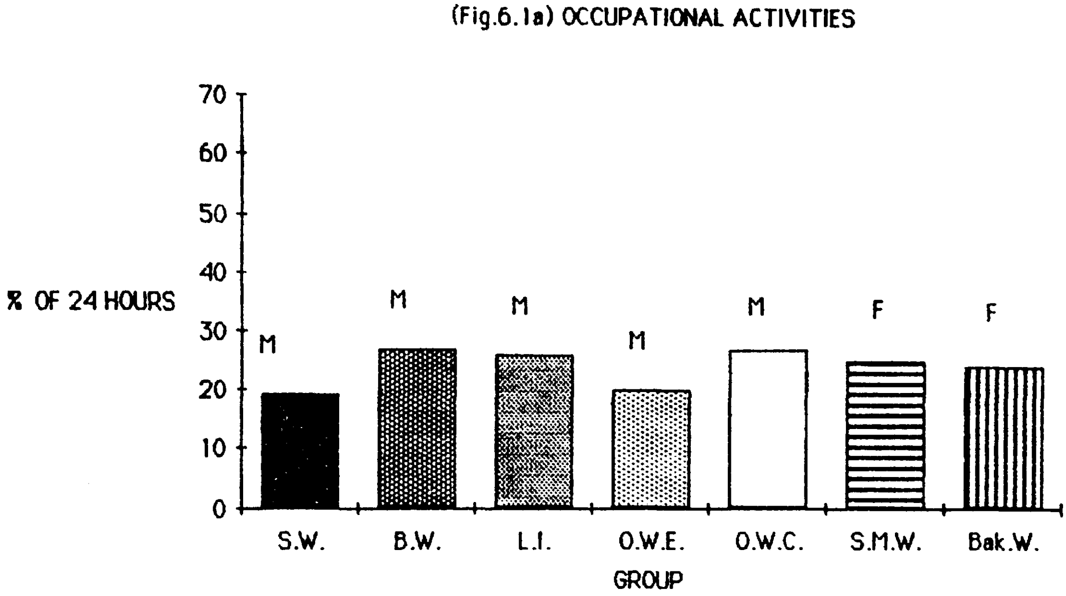
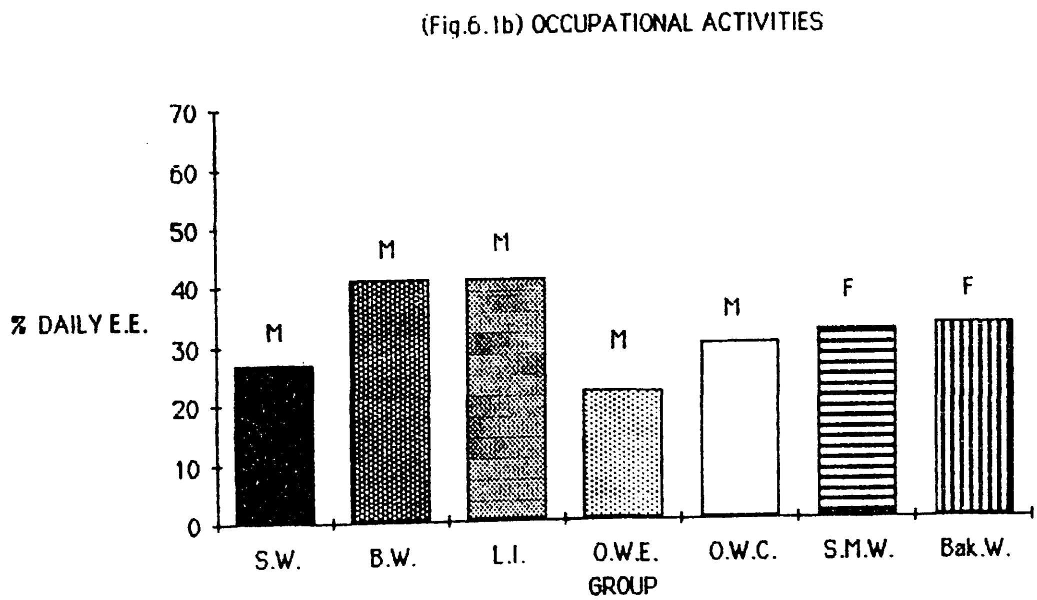


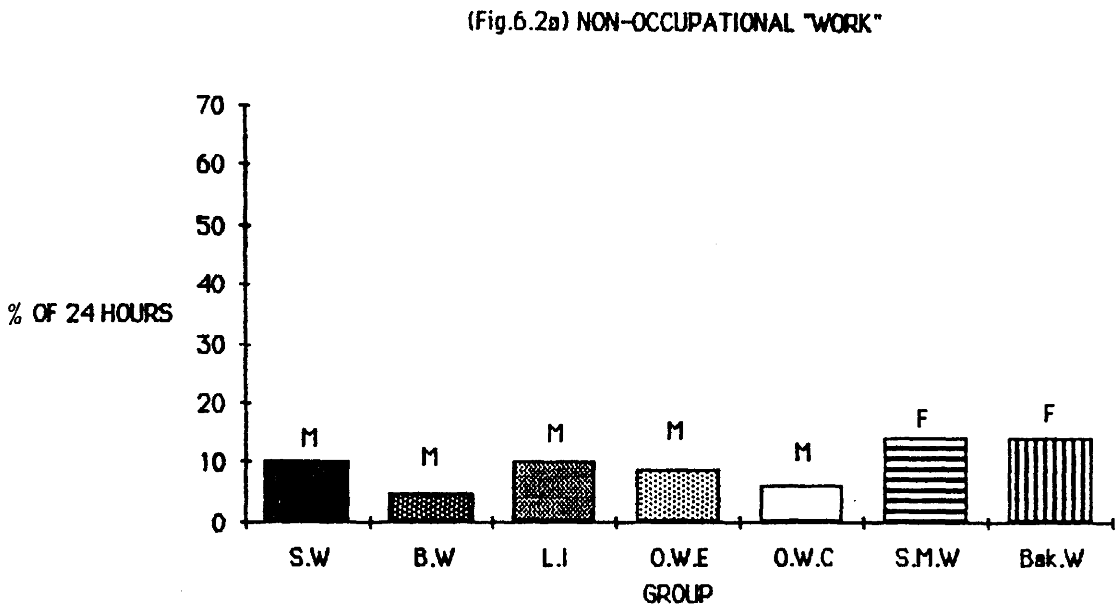
Figure 6.1(a,b) Percentage expenditure of time and energy in occupational activities.

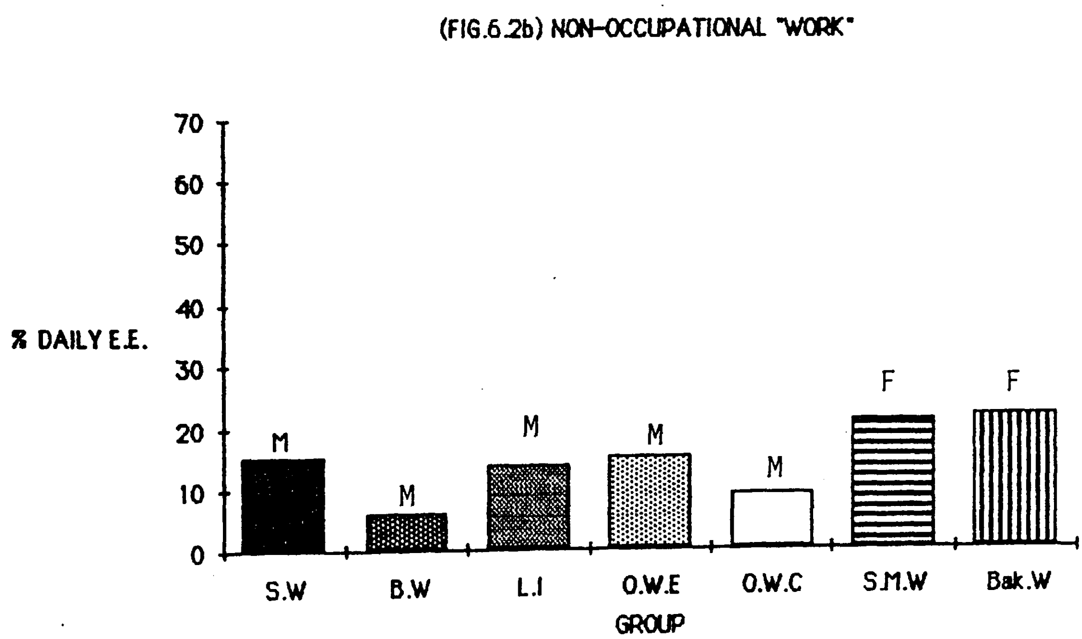




S.W.- Steel Workers
B.W.- Building Workers
L.I.- Light Industry
O.W.E.- Offic Workers Executive
O.W.C.- Office Workers Clerical
S.M.W.- Sewing Machine
Bak.W.- Bakery Workers

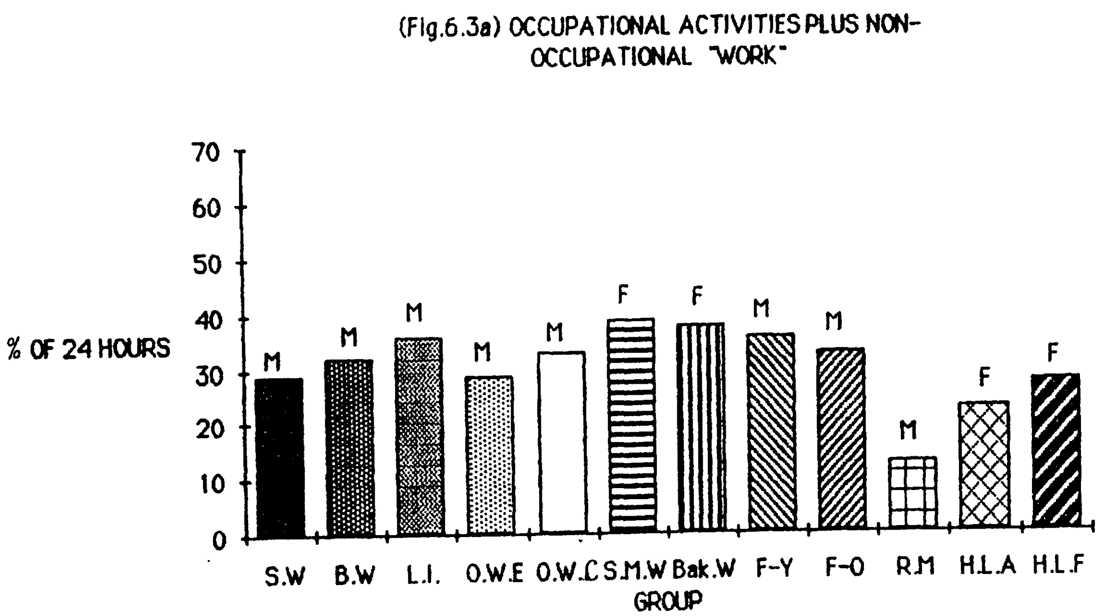
Figure 6.2(a,b) Percentage expenditure of time and energy in non-occupational "work".

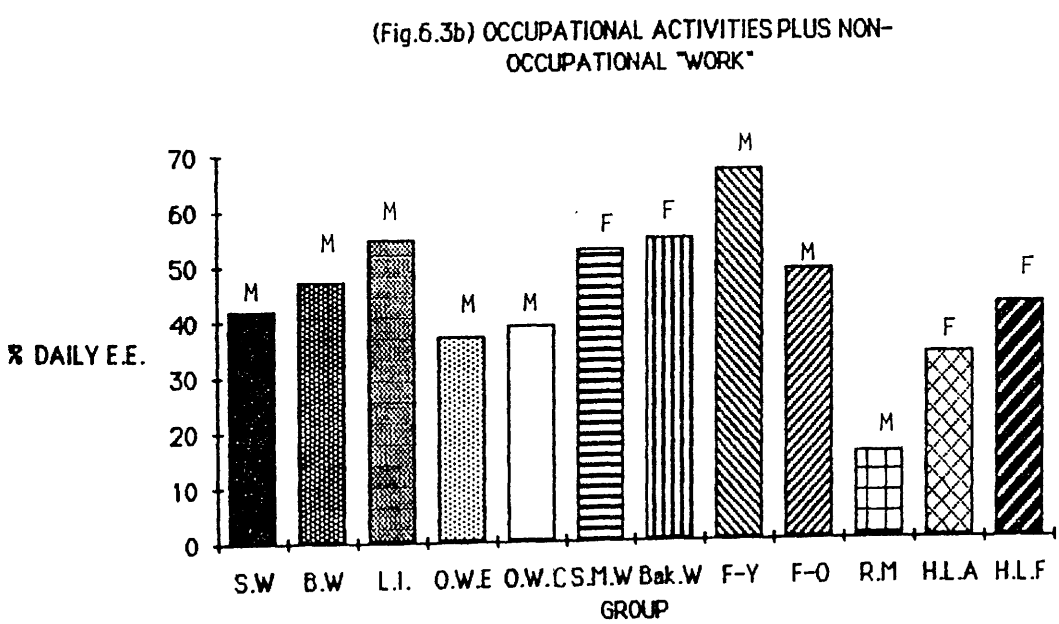




S.W.- Steel Workers
B.W.- Building Workers
L.I.- Light Industry
O.W.E.- Offic Workers Executive
O.W.C.- Office Workers Clerical
S.M.W.- Sewing Machine
Bak.W.- Bakery Workers

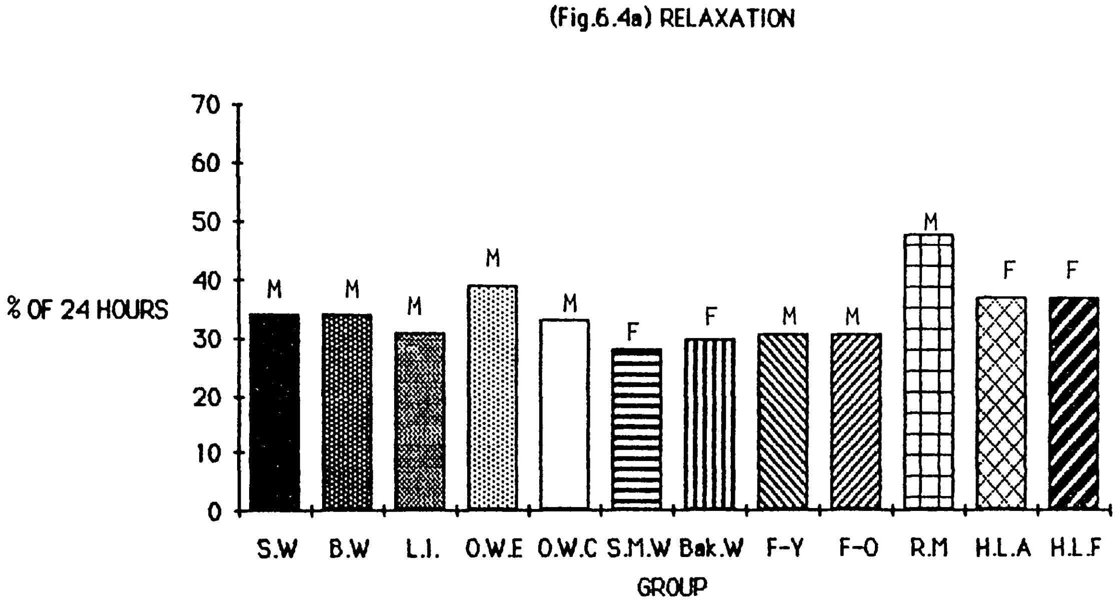
Figure 6.3(a,b) Percentage expenditure of time and energy in occupational activities plus non-occupational "work".

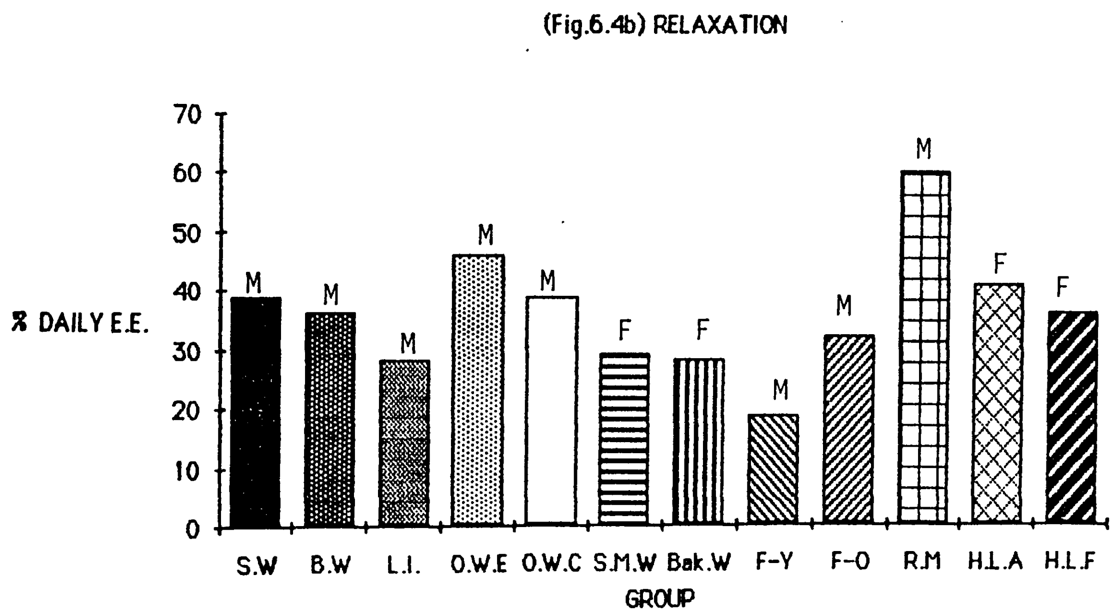




S.W.- Steel Workers
O.W.C.- Office Workers Clerical
H.L.A.- Housewives Living Alone
B.W.- Building Workers
S.M.W.- Sewing Machine
F.Y.- Farmers Young
H.L.F.- Housewives Living With Family
L.I.- Light Industry
Bak.W.- Bakery Workers
F.O.- Farmers Old
O.W.E.- Offic Workers Executive
R.M.- Retired Men

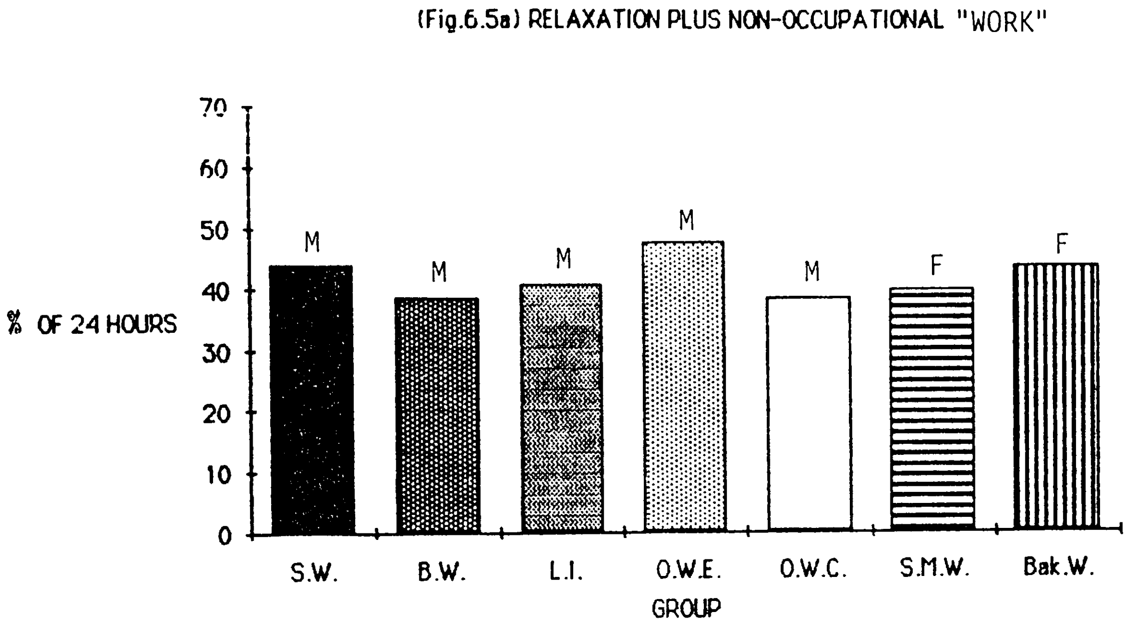
Figure 6.4(a,b) Percentage expenditure of time and energy in relaxation.

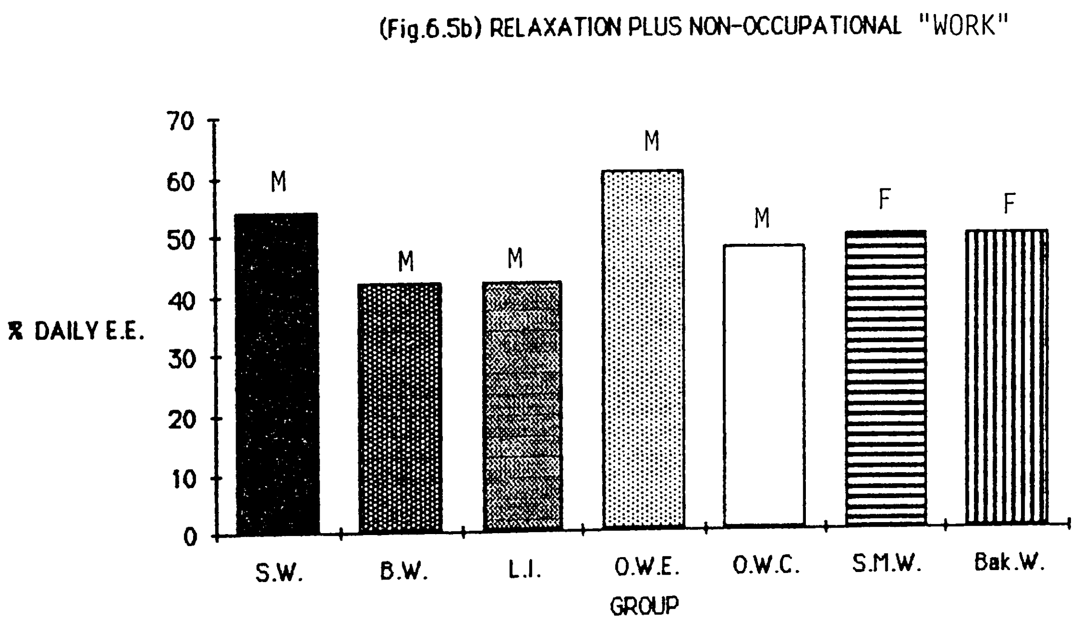




S.W.- Steel Workers
O.W.C.- Office Workers Clerical
H.L.A.- Housewives Living Alone
B.W.- Building Workers
S.M.W.- Sewing Machine
F.Y.- Farmers Young
H.L.F.- Housewives Living With Family
L.I.- Light Industry
Bak.W.- Bakery Workers
F.O.- Farmers Old
O.W.E.- Offic Workers Executive
R.M.- Retired Men

Figure 6.5(a,b) Percentage expenditure of time and energy in relaxation plus non-occupational "work".

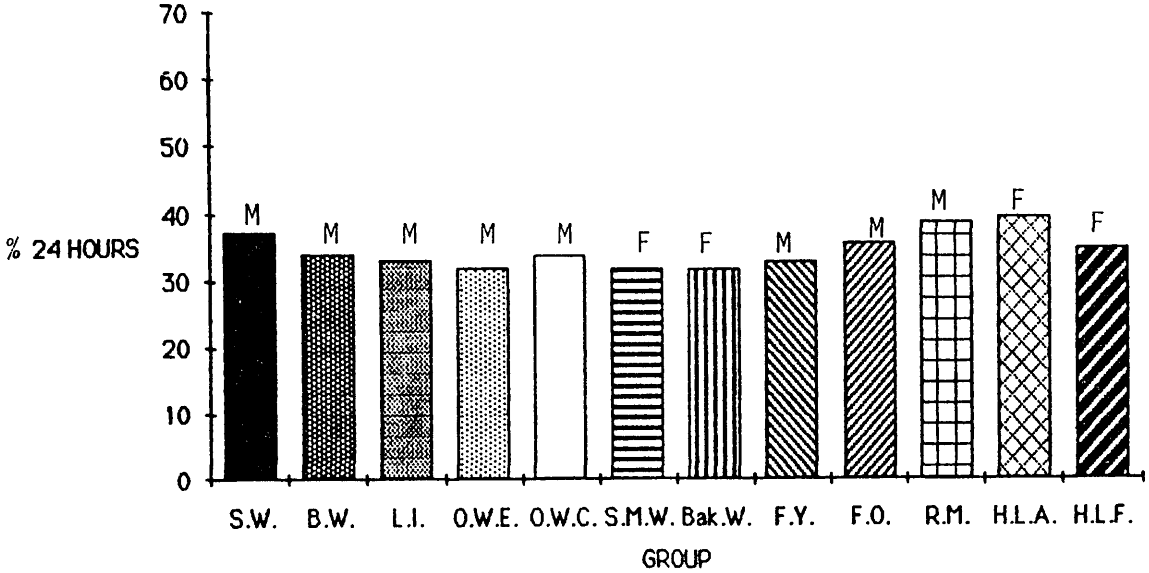




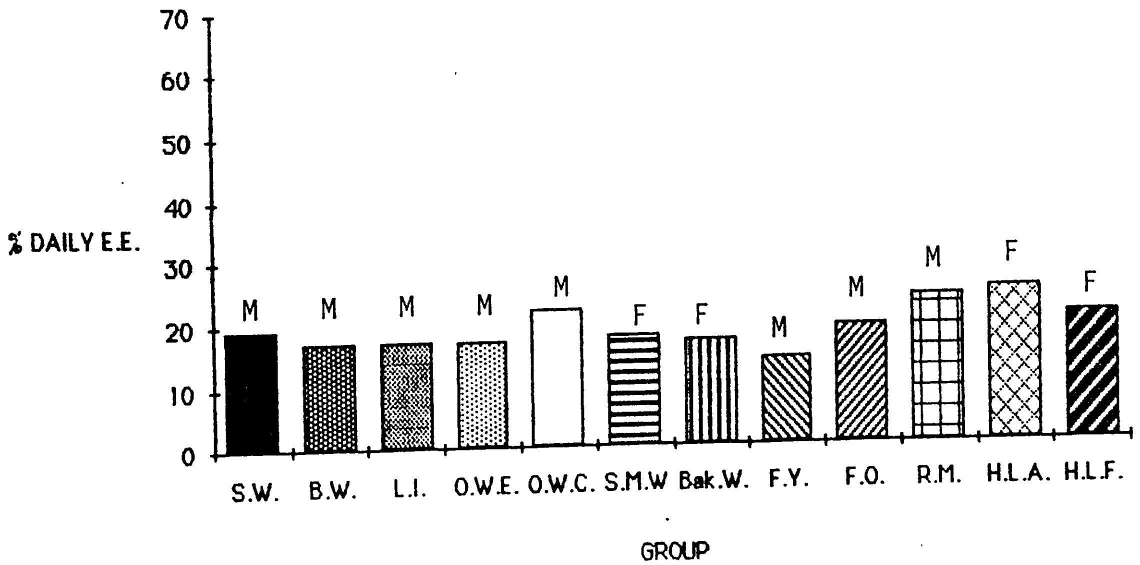
S.W.- Steel Workers
O.W.C.- Office Workers Clerical
B.W.- Building Workers
S.M.W.- Sewing Machine
L.I.- Light Industry
Bak.W.- Bakery Workers
O.W.E.- Offic Workers Executive

Figure 6.6(a,b) Percentage expenditure of time and energy in bed.

(Fig.6.6a) BED



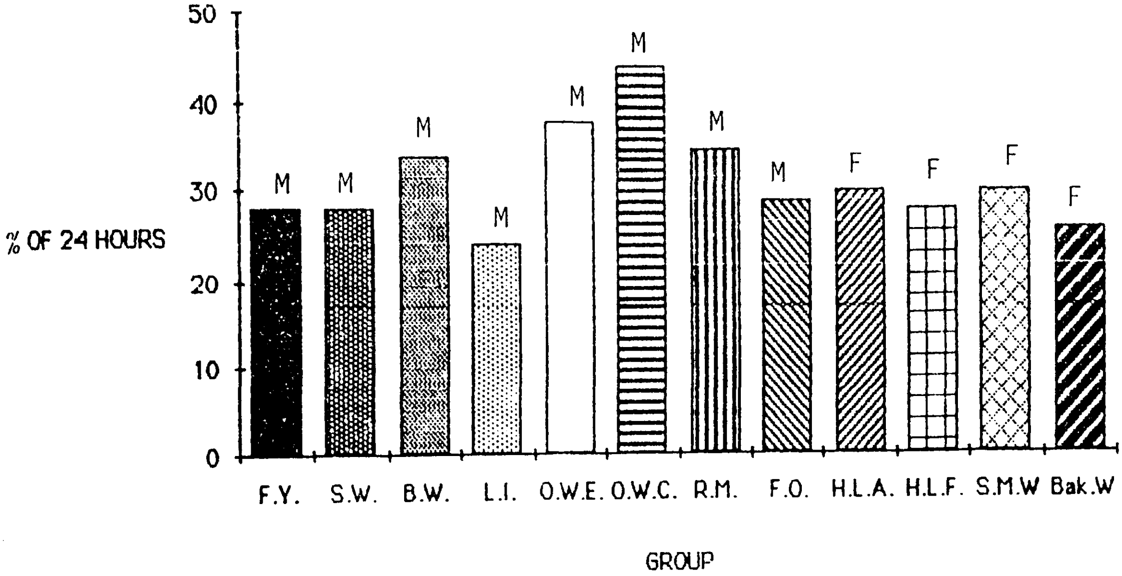
(Fig.6.6b) BED



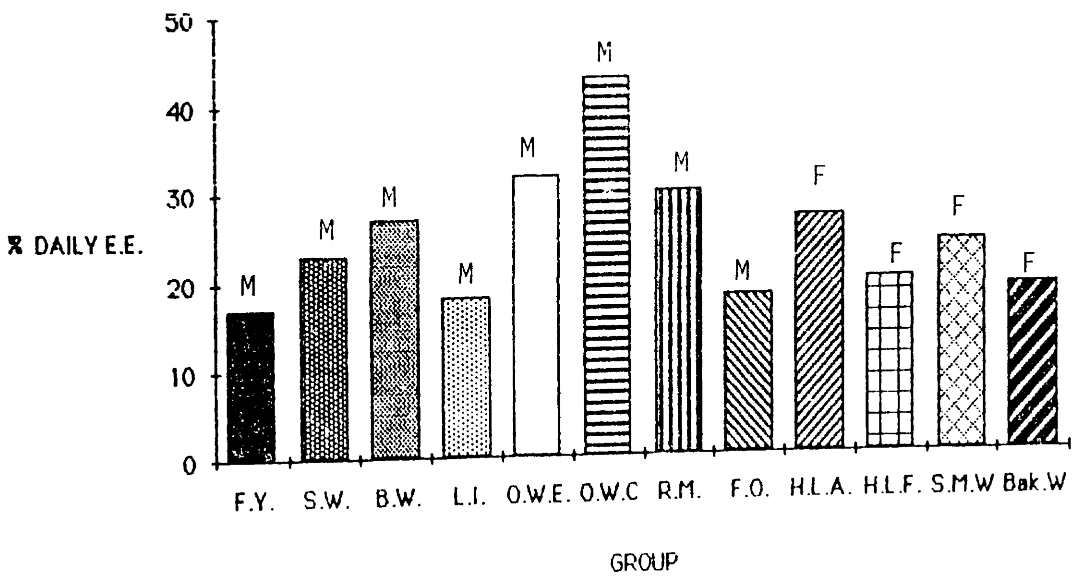
S.W.- Steel Workers
O.W.C.- Office Workers Clerical
H.L.A.- Housewives Living Alone
B.W.- Building Workers
S.M.W.- Sewing Machine
F.Y.- Farmers Young
H.L.F.- Housewives Living With Family
L.I.- Light Industry
Bak.W.- Bakery Workers
F.O.- Farmers Old
O.W.E.- Offic Workers Executive
R.M.- Retired Men

Figure 6.7(a,b) Percentage of time and energy expended in sitting activities

(Fig.6.7a) SITTING ACTIVITIES

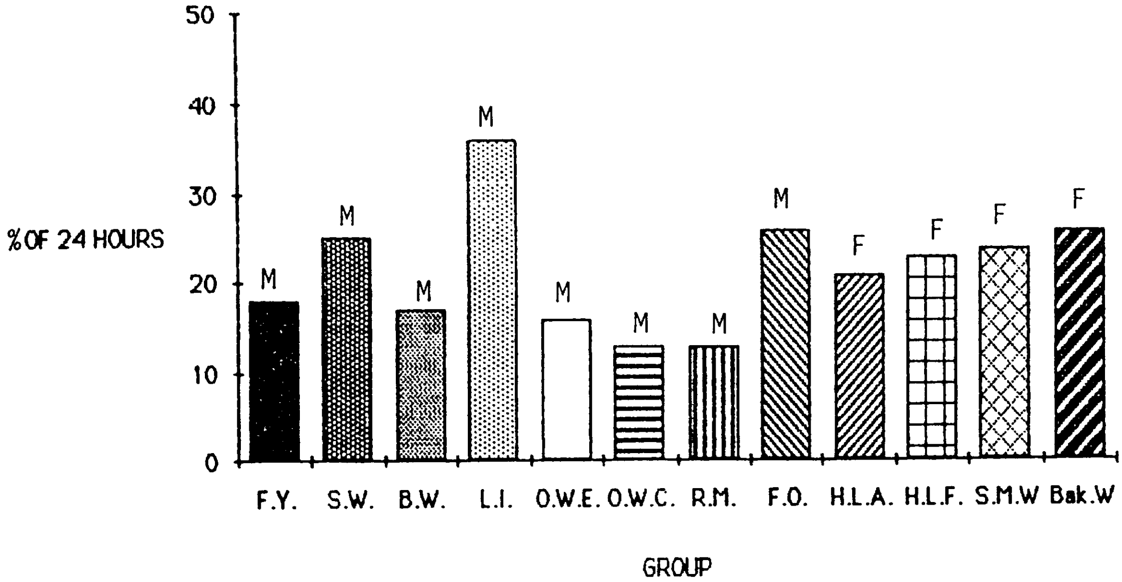


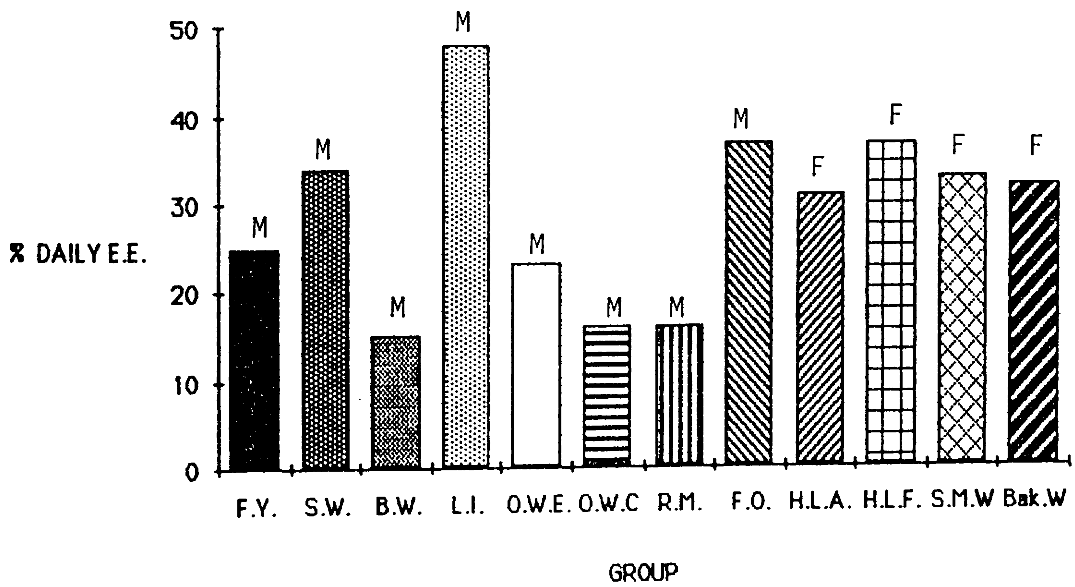
(Fig.6.7b) SITTING ACTIVITIES



S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

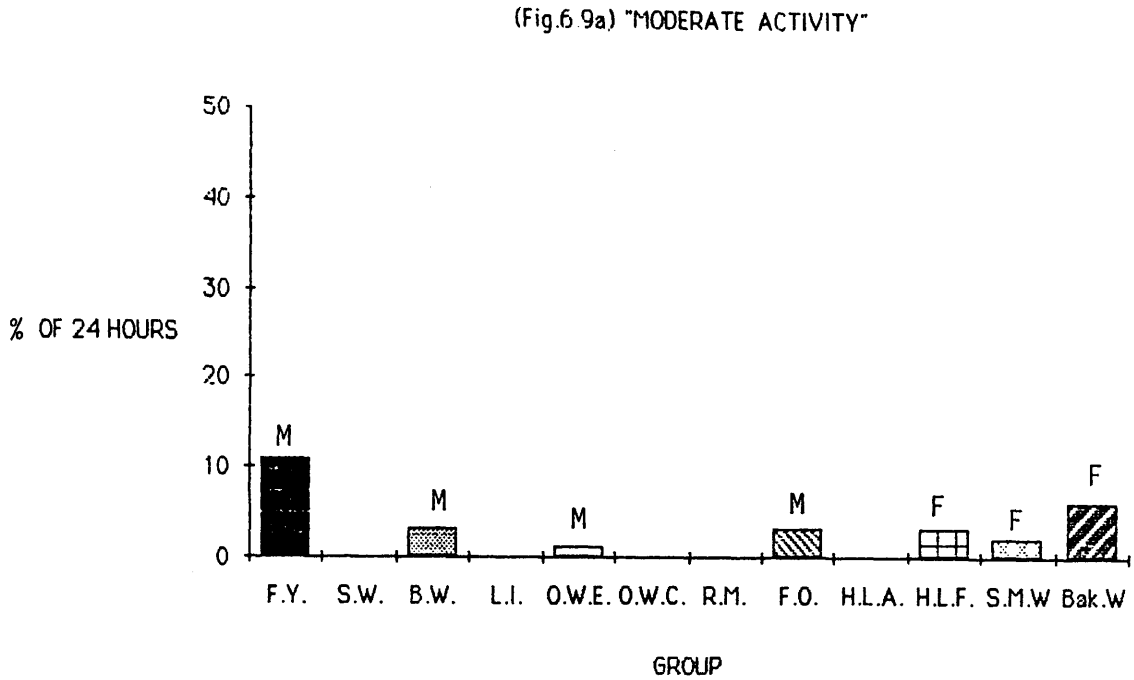
Figure 6.8(a,b) Percentage of time and energy expended in standing and "light activities"

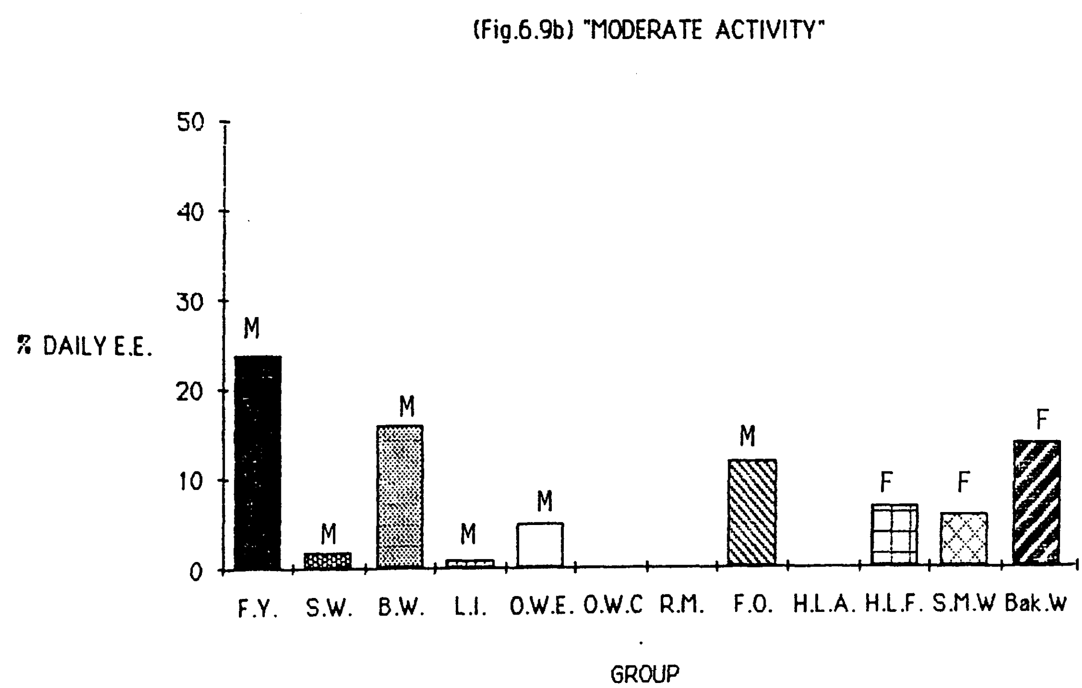




S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

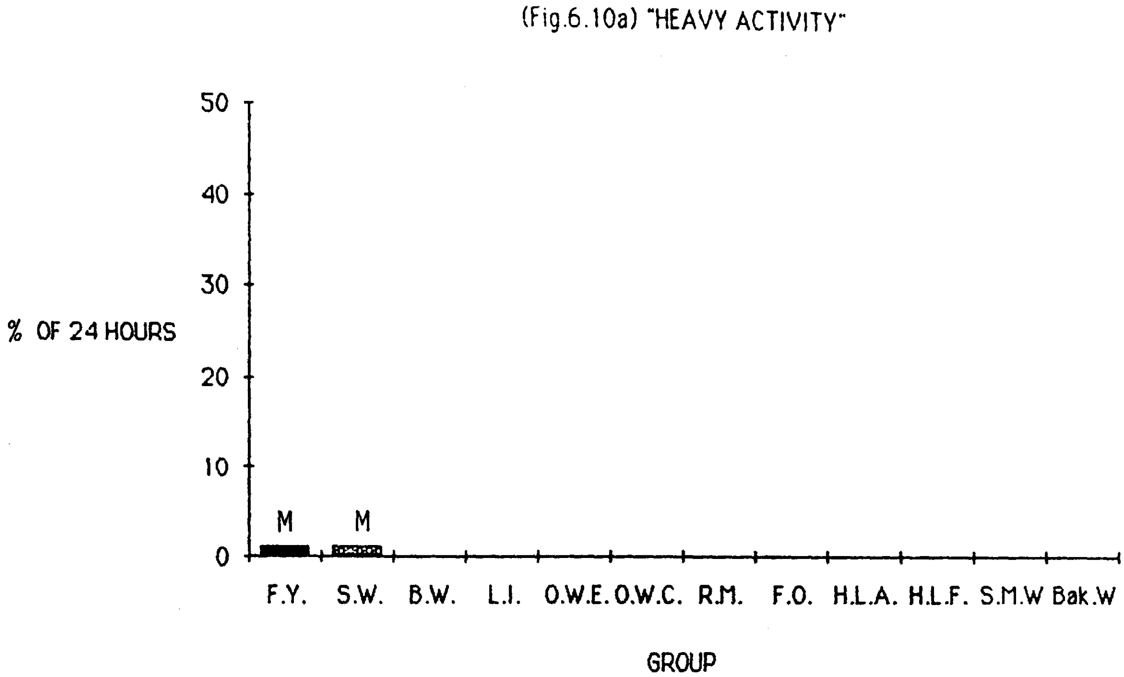
Figure 6.9(a,b) Percentage of time and energy expended in "moderate activities"

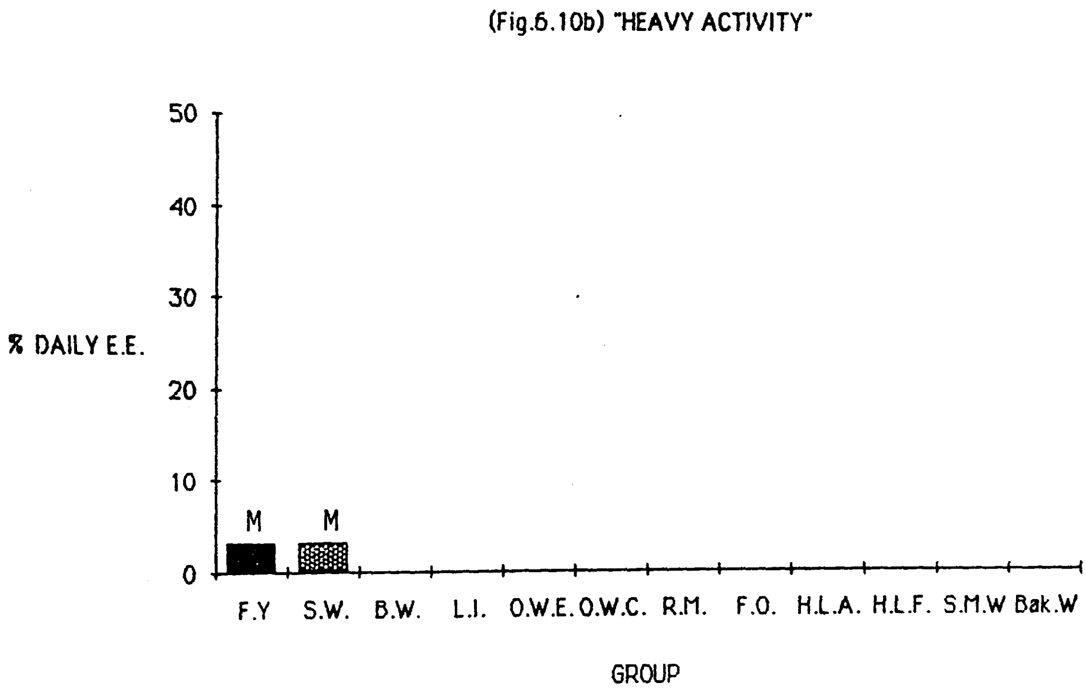




S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

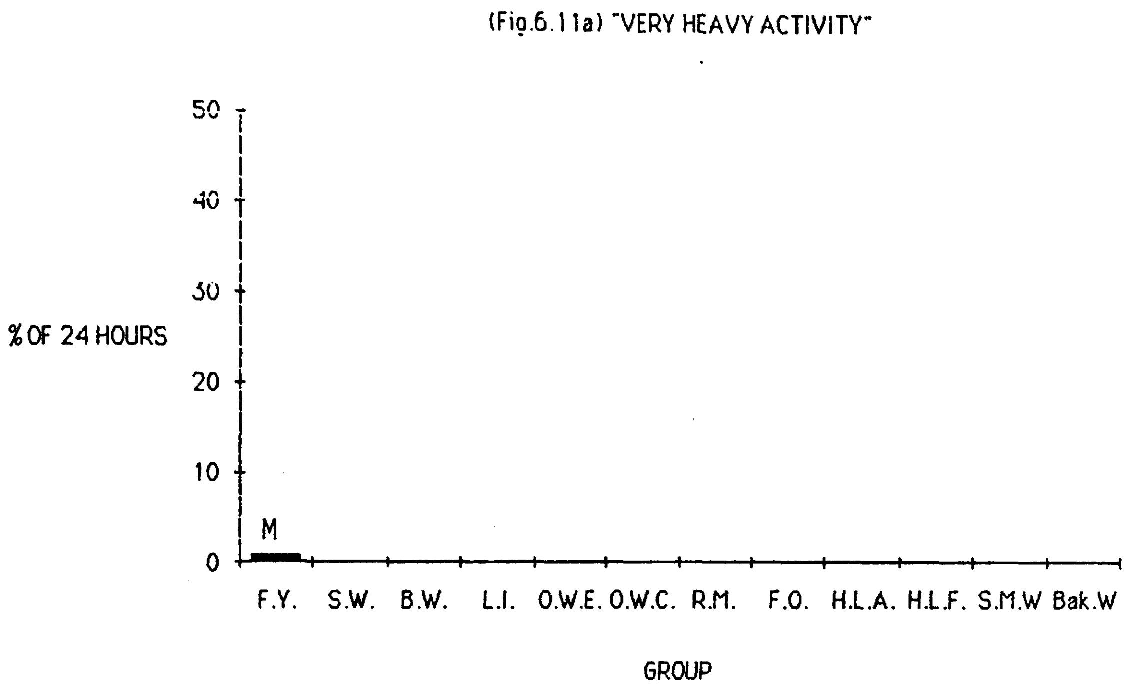
Figure 6.10(a,b) Percentage of time and energy expended in "heavy activities"

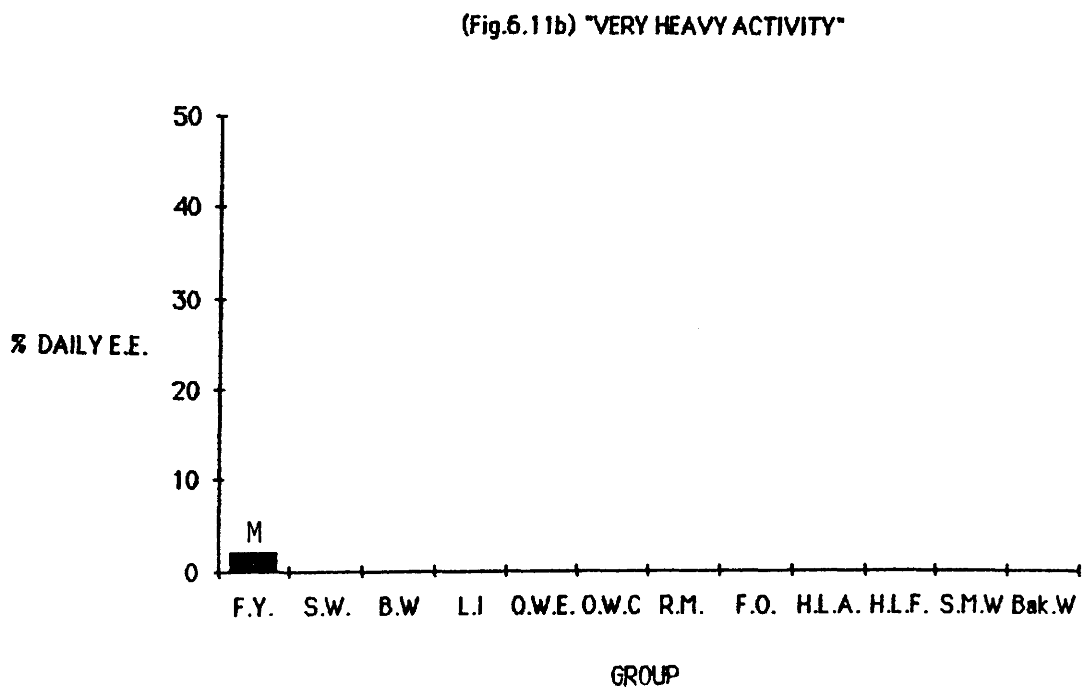




S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

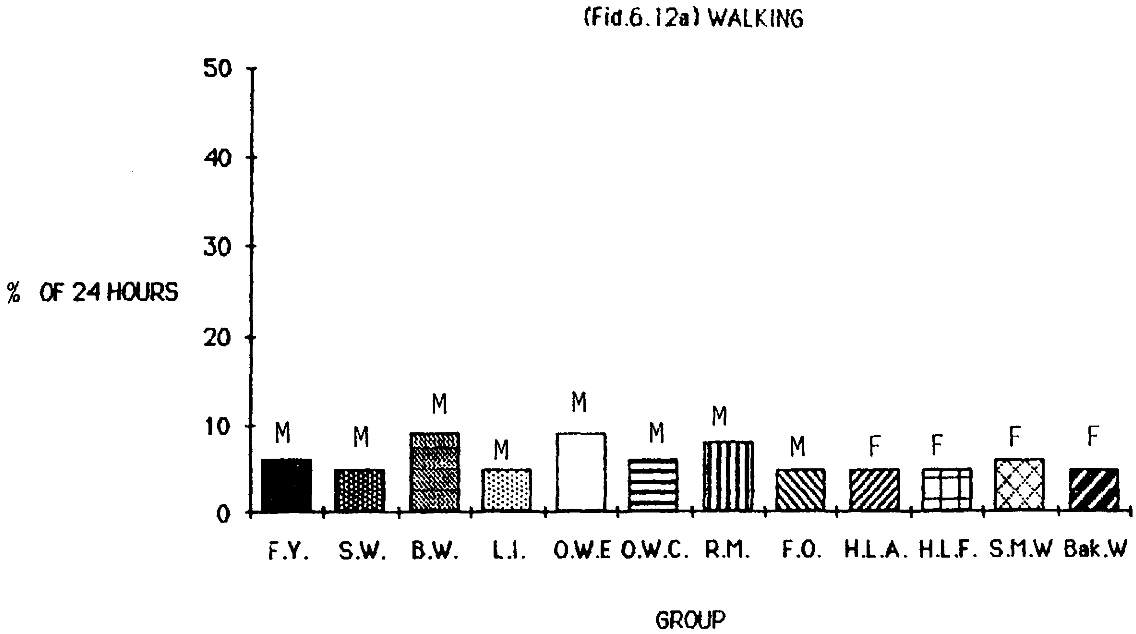
Figure 6.11(a,b) Percentage of time and energy expended in "very heavy activities"

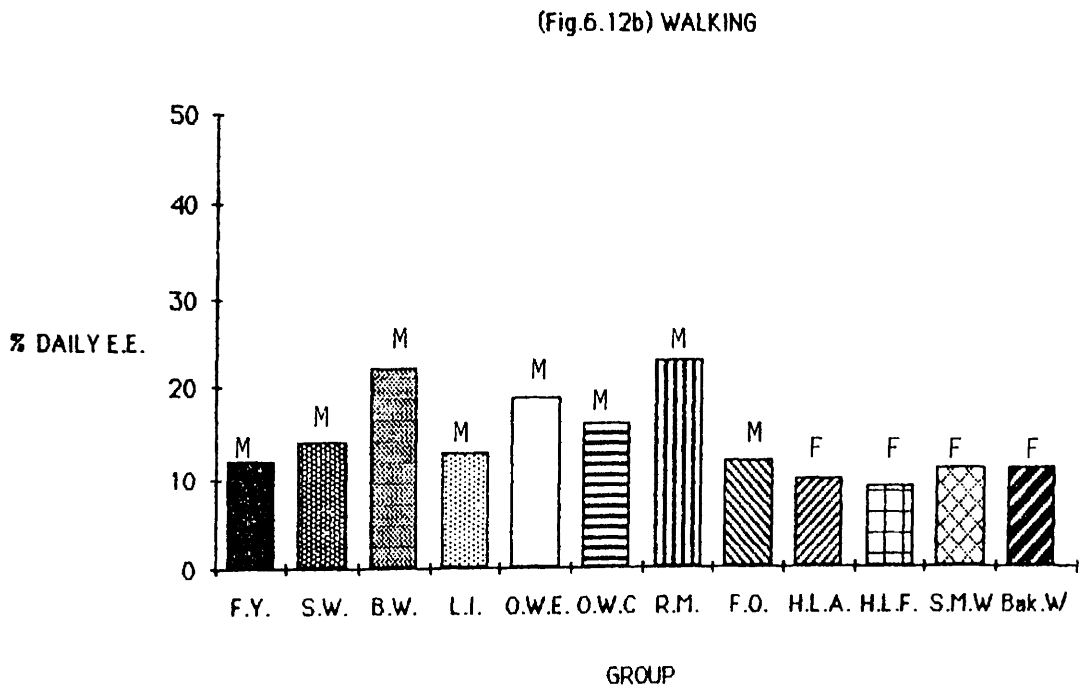




S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

Figure 6.12(a,b) Percentage of time and energy expended in walking

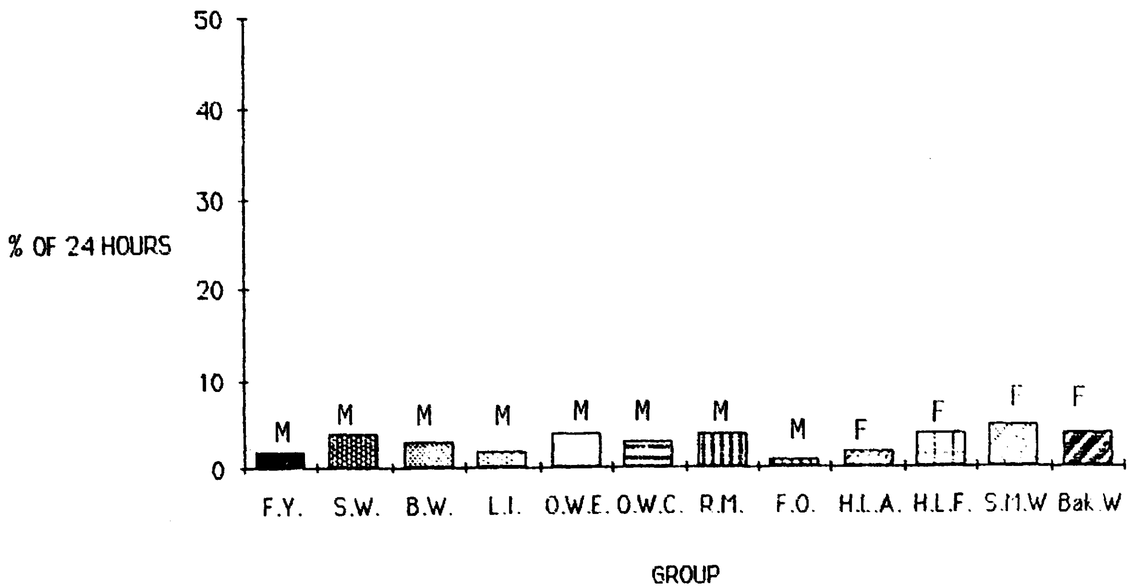




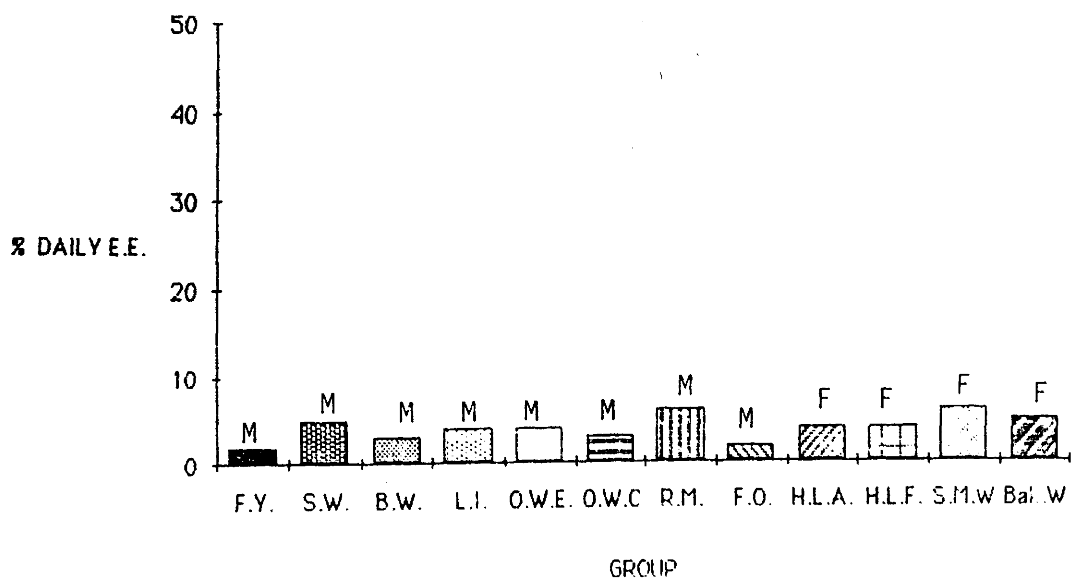
S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.- Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

Figure 6.13(a,b) Percentage of time and energy expended in personal and dressing

(Fig.6.13a) PERSONAL, DRESSING



(Fig.6.13b) PERSONAL, DRESSING

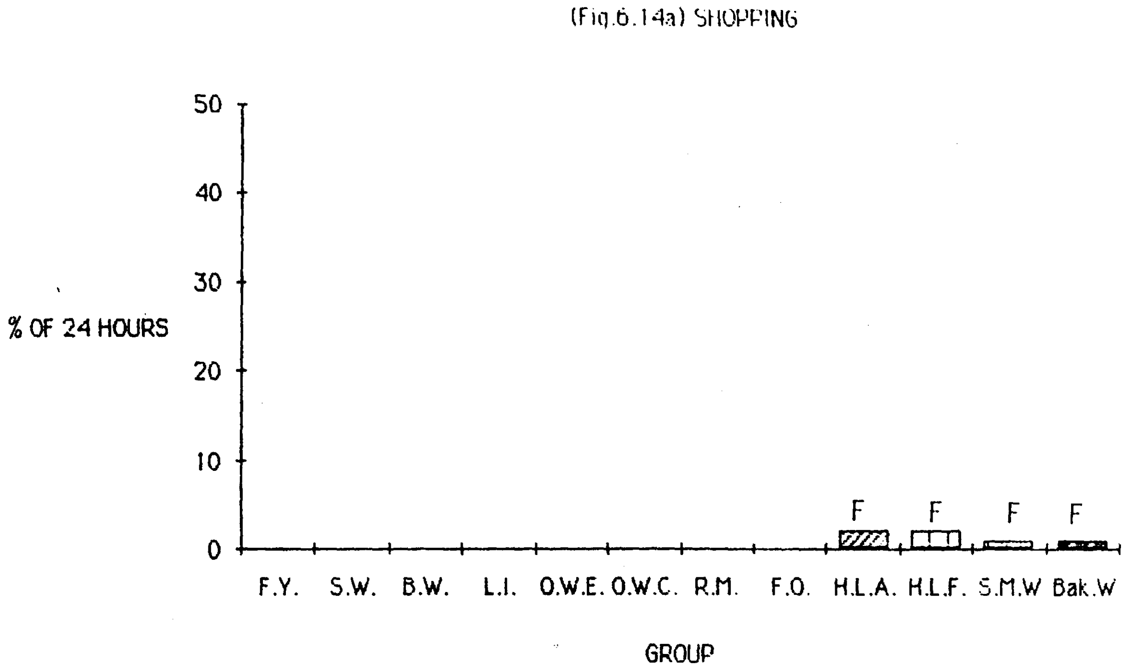


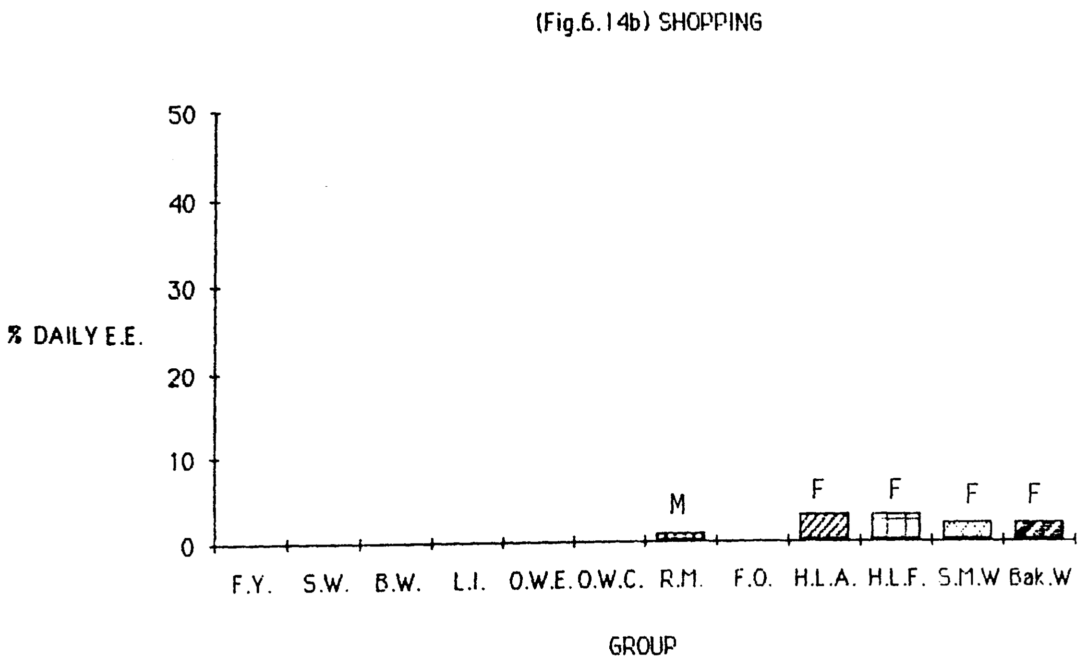
S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men

B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.- Housewives living alone

L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

Figure 6.14(a,b) Percentage of time and energy expended in shopping





S.W.- Steel workers
O.W.E.- Office workers executive
Bak.W.- Bakery Workers
R.M.- Retired men
B.W.- Building workers
O.W.C.- Office workers clerical
F.Y.- Farmers young
H.L.A.-Housewives living alone
L.I.- Light industry workers
S.M.W.- Sewing machine workers
F.O.- Farmers old
H.L.F. - Housewives living with family

APPENDIX I(a)

ORIGINAL DATA FOR INDIVIDUALS

APPENDIX I(a)
Table 1: Original data for individuals:
Light industry (0.1), farmers (1.1)

Study No. Subject No.	Sex	Age	Height	Weight	Protein	Fat	CHO.	Energy Intake	Energy Expend	Calcium	Iron	BMI	BMR
01001	1	64	166.0	71.2	83.7	93.8	337.8	2597	2797	913	15.9	25.04	1.10
01002	1	64	163.8	59.0	88.4	129.0	342.8	2836	2986	999	15.4	21.17	0.95
01003	1	63	176.0	82.5	105.1	159.2	342.0	3137	3320	1634	18.5	25.90	1.19
01004	1	55	160.0	56.7	101.5	106.9	346.5	2669	2825	794	18.1	21.29	0.94
01005	1	59	161.7	50.3	80.5	111.2	276.0	2516	2696	992	14.4	18.40	0.9
01006	1	60	162.5	66.7	83.9	123.8	357.2	2948	3079	664	15.4	24.40	1.01
01007	1	66	162.0	82.1	71.2	102.8	335.9	2471	2681	889	13.7	26.24	1.03
01008	1	60	168.3	87.5	80.3	142.6	364.4	2970	3150	1097	15.0	30.10	1.20
01009	1	56	158.3	83.0	90.4	122.0	502.9	3345	3526	855	20.2	32.24	1.08
01010	1	60	158.8	65.8	100.4	135.9	382.2	3115	3714	1124	18.4	25.22	0.98
01011	1	59	162.1	58.5	69.6	89.7	298.3	2204	2185	755	12.8	21.43	0.96
01012	1	57	156.5	66.3	83.9	125.4	329.9	2703	2923	878	13.8	26.47	0.97
01013	1	57	158.7	73.5	90.9	141.6	424.5	3232	2832	1252	17.8	28.30	1.06
01014	1	60	160.0	71.2	103.1	146.3	322.0	3010	2820	1458	15.7	26.95	1.06
01015	1	66	160.0	65.3	87.3	147.9	393.3	3157	2800	1034	16.3	24.65	0.98
01016	1	60	165.2	69.5	93.3	125.2	330.9	2813	2400	1267	17.7	24.66	1.06
01017	1	61	174.0	86.2	108.9	165.8	451.4	3656	3454	1653	15.8	27.74	1.19
01018	1	58	172.0	71.2	111.3	173.1	365.5	3376	2950	1577	19.5	23.30	1.08
01019	1	62	153.5	66.5	88.9	108.5	489.4	3168	2868	1149	18.4	27.47	0.95
01020	1	65	166.5	60.3	91.7	83.3	381.3	2658	2250	1272	16.2	20.96	0.99
01021	1	72	161.3	67.4	89.7	121.5	315.0	2663	2200	875	14.5	25.06	0.98
01022	1	63	170.0	57.5	89.0	121.1	343.9	2921	2621	1581	10.8	19.13	0.98
01023	1	62	170.1	66.3	83.9	137.8	369.8	3039	2750	984	15.9	22.18	1.10
01024	1	57	161.2	59.8	73.1	99.7	358.0	2575	2261	949	13.3	22.17	0.95
11001	1	50	169.3	71.8	113.9	157.7	430.9	3510	3227	2261	14.0	24.28	1.09
11002	1	60	170.7	62.7	124.0	173.5	354.0	3454	3489	1514	23.6	20.76	1.01
11003	1	58	160.0	67.3	107.5	145.2	412.3	3285	3484	1008	18.8	25.42	1.01
11004	1	49	166.6	63.6	91.9	185.1	372.4	3578	4353	750	20.9	22.12	1.02
11005	1	49	164.4	67.7	124.1	175.9	567.9	4210	4672	1990	20.5	24.23	1.04
11006	1	44	179.9	105.9	132.4	201.7	408.8	3881	4135	2272	20.0	32.04	1.35
11007	1	54	172.7	76.8	105.3	202.2	358.6	3613	3723	1056	18.1	25.01	1.12
11008	1	58	180.7	80.5	115.9	155.4	408.9	3398	3791	1625	19.9	23.78	1.20
11009	1	58	182.5	81.4	135.3	189.8	519.3	4224	4079	2078	28.4	23.77	1.21
11010	1	51	181.8	81.8	133.4	141.2	359.3	3318	3402	1031	25.6	24.08	1.21
11011	1	58	167.0	95.0	127.0	188.8	434.6	3840	4317	1784	19.9	33.27	1.18
11012	1	59	168.7	71.8	98.9	170.5	441.1	3587	4390	1533	19.1	24.45	1.06
11013	1	52	170.1	77.3	94.2	118.1	509.0	3386	4015	1105	18.2	25.75	1.12
11014	1	57	162.6	80.0	107.5	154.7	442.4	3483	4063	1105	25.6	29.42	1.10
11015	1	60	173.5	79.5	141.8	177.2	420.8	3805	3310	1736	21.0	25.67	1.13
11016	1	62	166.4	115.5	85.2	125.4	353.6	2815	3742	1098	14.6	40.91	1.27
11017	1	53	176.5	61.8	107.8	159.9	423.2	3459	2973	1477	20.6	19.13	1.04
11018	1	50	167.9	62.7	103.6	174.3	539.4	4007	3382	1418	21.3	21.46	1.02
11019	1	62	170.8	85.9	93.9	105.5	416.0	2194	3104	1170	15.3	28.69	1.15
11020	1	62	166.6	78.2	99.0	132.5	424.1	3190	3644	1522	18.2	27.38	1.08
11021	1	62	177.9	95.5	88.1	110.0	333.0	2592	3026	912	13.9	29.48	1.23
11022	1	54	166.6	63.2	117.6	147.2	424.3	3405	3278	1160	24.1	21.97	1.01

APPENDIX I(a)

Table 2: Original data for individuals:
Steel workers (2.1), building workers (3.1), executives (6.1),
Clerical workers (7.1), retired men (8.1), farmers over 65 years (9.1).

Study No. / Subject No.	Sex	Age	Height	Weight	Protein	Fat	CHO.	Energy Intake	Energy Expend	Calcium	Iron	BMI	BMR
21001	1	61	168.0	61.2	84.3	110.7	287.1	2733	2603	1134	12.0	20.90	0.98
21002	1	56	169.5	69.4	129.3	169.3	264.9	3036	3291	1493	23.2	23.39	1.06
21003	1	55	160.4	74.8	100.9	119.8	354.7	2939	3851	1323	16.4	26.22	1.08
21004	1	57	175.3	81.5	103.4	115.8	438.2	3324	3018	1169	19.4	25.81	1.16
21005	1	60	166.0	65.4	107.1	124.2	376.3	3200	3051	633	20.0	22.94	1.00
21006	1	56	165.0	100.0	136.2	162.4	379.2	3628	3707	1010	23.0	36.14	1.22
21007	1	58	168.5	90.4	109.1	135.2	361.6	3010	3958	1269	17.3	31.07	1.17
21008	1	58	163.0	67.5	111.1	148.7	421.9	3365	2598	1690	17.7	24.58	1.01
21009	1	63	176.5	76.3	122.9	172.1	469.8	3804	3408	1419	22.7	23.79	1.11
31001	1	53	165.0	88.5	70.6	103.5	297.9	2329	3318	977	13.9	31.70	1.18
31002	1	51	163.0	77.0	109.9	137.6	384.2	3167	3411	949	20.7	28.15	1.09
31003	1	57	168.0	82.5	96.5	148.4	297.6	2904	3308	1221	21.6	28.50	1.14
31004	1	51	161.0	77.0	111.9	166.1	498.9	4026	2818	1144	21.5	28.86	1.09
31005	1	51	168.0	67.0	96.1	144.6	591.0	3905	3732	1730	15.9	22.96	1.06
31006	1	52	165.0	63.5	81.0	101.3	310.6	2649	2440	835	14.9	22.52	1.01
31007	1	59	161.0	69.0	127.2	116.4	356.1	3111	3008	724	25.6	25.77	1.02
31008	1	50	167.0	77.5	95.6	128.7	297.4	2854	2787	965	17.1	26.99	1.12
31009	1	57	158.0	82.5	87.8	93.1	309.2	2740	2640	965	13.3	32.17	1.09
61001	1	59	168.0	75.5	74.4	127.1	358.4	2795	2917	842	14.0	25.97	1.08
61002	1	62	167.0	79.5	103.9	140.0	387.0	3218	3272	1461	18.3	27.72	1.09
61003	1	58	178.0	72.0	91.2	123.7	405.5	3000	3250	1285	17.2	22.03	1.08
61004	1	62	166.0	65.4	78.5	128.6	297.5	2637	2823	1003	16.1	22.93	1.00
61005	1	62	173.0	79.0	90.0	103.9	311.4	2509	2738	1243	20.0	25.66	1.12
61006	1	61	180.0	77.7	94.5	126.4	363.9	3003	3060	1187	17.5	23.30	1.14
61007	1	57	167.0	55.3	61.4	81.8	206.6	1757	2829	551	12.4	19.03	0.93
61008	1	60	173.0	57.9	85.9	106.7	366.7	2826	2606	1034	15.5	18.61	0.98
61009	1	55	169.0	56.3	71.9	107.8	351.3	2590	2405	977	14.1	18.94	0.96
61010	1	55	164.0	59.7	64.0	93.8	271.1	2118	2340	878	11.8	21.38	0.97
71001	1	56	162.0	67.5	71.3	95.8	250.1	2087	2101	1018	8.9	24.88	1.01
71002	1	51	163.0	60.0	103.1	135.6	392.2	3112	2292	974	18.6	21.75	0.99
71003	1	59	165.0	81.0	94.3	114.5	206.9	2181	2330	1056	15.8	28.94	1.11
71004	1	56	169.0	67.5	91.4	121.7	286.9	2728	2437	1075	15.1	22.86	1.05
71005	1	60	169.0	78.8	91.6	123.7	231.0	2349	2356	995	13.2	26.82	1.08
71006	1	56	161.3	66.0	59.4	98.8	289.4	2213	2022	450	11.5	24.52	0.99
71007	1	56	158.0	60.5	74.6	97.7	273.1	2212	2134	1053	14.6	23.35	0.95
71008	1	54	164.0	60.0	75.5	126.5	304.3	2583	2354	1257	11.3	21.49	0.98
71009	1	55	166.0	57.0	82.2	114.4	275.3	2393	1824	1054	16.3	19.89	0.96
71010	1	64	162.0	68.0	90.1	122.1	246.6	2577	2910	566	18.6	25.07	1.01
81001	1	76	156.2	53.2	55.5	71.1	225.1	1718	2152	811	8.2	20.90	0.84
81002	1	66	158.8	63.5	74.6	87.6	241.3	2017	2169	1067	11.7	24.31	0.94
81003	1	76	165.1	76.2	81.6	87.4	274.2	2138	2370	1077	19.3	27.15	1.02
81004	1	77	174.0	70.0	73.2	111.8	333.2	2547	2560	743	12.8	22.39	1.02
81005	1	66	168.3	79.8	65.5	84.1	206.6	1841	3068	735	12.0	27.40	1.09
81006	1	77	168.9	77.3	69.4	66.5	374.0	2280	2567	515	16.2	26.33	1.04
81007	1	64	146.7	67.3	57.8	61.7	175.5	1470	1754	527	10.6	30.25	0.92
81008	1	76	167.0	83.4	84.3	103.9	328.3	2499	2811	1024	15.8	29.15	1.07
81009	1	77	166.3	59.4	71.2	77.7	259.6	1961	2061	760	10.8	20.66	0.92
91001	1	68	185.2	83.2	100.0	113.0	380.0	2849	3392	1182	19.3	23.61	1.18
91002	1	71	159.6	71.4	87.0	111.0	250.0	2285	2448	976	15.0	27.17	0.98
91003	1	80	169.0	80.0	121.0	155.0	414.0	3436	3144	2094	19.0	27.23	1.05
91004	1	72	171.4	70.9	80.0	81.0	397.0	2535	2629	1275	14.3	23.38	1.02
91005	1	71	175.9	87.3	89.0	109.0	217.0	2230	3441	786	13.4	27.50	1.15

APPENDIX I(a)

Table 3: Original data for individuals:
Housewives alone (1.2), housewives with family (2.2).

Study No.	Subject No.	Sex	Age	Height	Weight	Protein	Fat	CHO.	Energy Intake	Energy Expend	Calcium	Iron	BMI	BMR
12001		2	68	148.5	66.3	57.2	69.0	168.5	1483	1555	732	10.6	29.30	0.85
12002		2	65	151.0	71.5	45.6	86.5	284.8	2028	2034	753	11.2	30.70	0.88
12003		2	66	151.0	50.8	61.3	91.6	249.4	2006	1934	781	10.6	21.62	0.78
12004		2	60	161.5	53.5	65.5	90.8	195.0	1810	1921	649	11.3	19.94	0.82
12005		2	66	159.0	50.8	75.3	105.7	262.4	2240	2409	1134	14.3	19.50	0.81
12006		2	64	161.5	70.8	84.7	105.8	273.6	2320	2239	997	15.2	26.57	0.96
12007		2	66	159.0	75.2	56.9	74.8	215.3	1709	1759	680	9.6	29.15	0.98
12008		2	68	151.0	41.7	29.8	52.4	139.5	1115	1581	746	3.2	17.63	0.75
12009		2	64	151.0	66.7	64.0	86.3	312.6	2206	2222	966	10.5	28.59	0.85
12010		2	63	161.5	60.3	78.1	102.4	282.3	2294	2279	1073	14.3	22.10	0.86
12011		2	69	151.2	49.0	58.7	72.4	242.6	1796	1891	617	9.7	21.22	0.77
12012		2	68	153.0	56.7	55.4	94.2	265.8	2068	1962	714	12.4	23.58	0.81
12013		2	65	162.5	76.1	59.0	82.1	216.2	1824	2196	1223	10.8	28.25	0.97
12014		2	69	161.6	80.0	52.8	96.7	202.0	2105	2016	1137	8.0	30.10	0.98
12015		2	69	153.0	58.5	72.1	93.0	267.0	2126	2000	612	15.4	24.35	0.82
12016		2	64	134.0	41.4	65.5	72.2	170.3	1552	1492	836	10.9	22.17	0.57
12017		2	69	153.5	61.2	61.8	76.9	209.6	1916	2093	851	10.9	25.34	0.84
22001		2	59	144.8	54.8	49.3	66.8	170.8	1437	2177	427	11.5	25.42	0.79
22002		2	54	154.5	54.0	42.2	61.2	160.1	1319	2438	490	9.1	21.99	0.84
22003		2	56	157.5	67.5	85.6	102.4	163.5	1878	2609	691	17.8	26.61	0.94
22004		2	60	149.9	63.5	52.0	83.8	168.4	1595	2219	707	8.2	27.59	0.86
22005		2	60	148.5	78.0	74.2	116.4	331.3	2590	2684	665	13.2	34.69	0.94
22006		2	66	165.5	75.8	67.1	94.0	248.9	2049	2378	1018	11.2	27.13	0.98
22007		2	59	156.4	68.5	68.2	93.8	263.5	2100	2496	690	11.4	27.39	0.92
22008		2	57	142.0	49.3	55.9	93.9	214.3	1874	2122	747	13.0	23.71	0.76
22009		2	66	156.2	62.2	71.6	104.8	304.5	2371	2398	1000	12.5	24.88	0.87
22010		2	55	156.5	57.1	72.1	92.2	289.7	2206	2373	925	11.9	22.70	0.87
22011		2	63	156.0	49.6	55.7	76.3	149.1	1469	2046	733	8.5	19.72	0.79
22012		2	55	147.3	49.5	51.9	75.8	203.5	1738	2123	548	12.1	22.13	0.78
22013		2	60	157.4	52.3	58.4	88.3	244.8	1947	1825	844	9.5	20.50	0.83
22014		2	55	156.0	64.9	82.3	131.3	336.8	2773	2926	1211	17.3	26.05	0.92
22015		2	65	156.0	54.0	40.9	87.2	252.6	1897	2000	936	7.9	21.57	0.83
22016		2	57	162.0	46.7	63.3	105.0	296.3	2315	1958	1265	8.7	17.22	0.81
22017		2	60	157.0	52.3	60.6	104.6	235.9	2069	2109	902	11.1	20.61	0.82
22018		2	62	158.0	74.5	85.6	85.6	256.8	2074	2543	600	14.6	29.24	0.96
22019		2	56	168.8	66.7	58.1	103.7	192.7	1978	2165	570	12.8	22.88	0.98
22020		2	62	151.1	70.8	45.6	60.5	159.4	1327	2018	638	7.4	30.35	0.9
22021		2	62	160.5	56.7	52.9	73.2	222.9	1708	1795	692	11.3	21.39	0.86

APPENDIX I(a)
Table 4: Original data for individuals
Sewing workers (3.2), bakery workers (4.2).

Study No. Subject No.	Sex	Age	Height	Weight	Protein	Fat	CHO.	Energy Intake	Energy Expend	Calcium	Iron	BMI	BMR
32001	2	55	148.5	60.2	76.1	108.8	186.7	2020	2020	623	17.4	26.62	0.86
32002	2	54	161.5	82.5	54.1	94.7	235.8	1968	2323	372	11.2	31.06	1.04
32003	2	55	151.0	69.9	56.4	106.1	165.4	1802	2179	601	9.6	29.99	0.92
32004	2	51	140.0	43.0	69.3	125.5	306.1	2644	2577	567	13.5	21.17	0.72
32005	2	56	156.5	59.9	79.1	122.6	256.6	2381	2035	916	14.4	23.84	0.88
32006	2	57	154.9	59.8	71.8	96.7	292.5	2255	2533	927	14.6	24.30	0.87
32007	2	60	163.0	70.6	65.7	97.6	304.3	2296	2352	1092	13.0	25.97	0.96
32008	2	55	152.4	87.4	62.8	104.3	281.3	2246	2409	877	11.4	36.98	1.02
32009	2	55	158.5	61.3	74.9	101.9	195.5	1951	2057	783	14.7	23.80	0.91
32010	2	59	159.9	68.8	67.5	97.1	291.4	2237	2249	866	11.8	26.32	0.94
32011	2	53	165.0	86.2	40.3	51.3	47.5	801	2492	458	4.2	31.10	1.09
32012	2	56	154.5	58.9	53.1	95.7	231.3	1942	2151	674	8.7	24.05	0.86
32013	2	58	154.9	58.8	60.9	106.2	262.1	2174	2507	822	12.0	23.88	0.86
32014	2	53	162.0	63.9	43.0	71.0	197.2	1555	2464	610	8.6	23.78	0.94
32015	2	52	160.0	73.2	69.2	112.7	227.0	2143	2249	992	11.6	28.01	0.99
32016	2	55	159.5	71.3	68.0	92.0	198.1	1841	2326	780	12.6	27.44	0.97
32017	2	53	148.0	53.5	90.0	132.1	377.5	2971	2018	1190	15.0	23.74	0.82
32018	2	57	168.0	72.5	93.5	124.6	263.9	2482	2172	1524	13.5	25.16	1.00
32019	2	52	176.5	91.3	83.5	141.4	368.0	2988	2981	1424	16.1	28.83	1.17
32020	2	58	163.0	67.8	52.0	76.8	246.3	1823	2345	617	11.1	24.95	0.96
42001	2	50	151.0	57.1	65.7	84.0	208.7	1802	2195	421	17.4	24.38	0.86
42002	2	54	148.0	44.5	37.0	59.2	204.3	1448	1982	351	7.1	19.63	0.75
42003	2	53	155.0	51.6	79.8	121.2	196.6	2144	2115	1080	12.0	20.85	0.83
42004	2	55	152.5	50.8	74.0	83.2	179.0	1711	2001	807	12.3	21.20	0.82
42005	2	50	154.0	66.5	80.4	119.4	260.7	2376	2390	833	17.3	27.40	0.93
42006	2	55	150.0	55.8	108.3	155.9	343.0	3143	2311	1159	21.2	24.13	0.83
42007	2	50	182.5	49.0	104.3	141.5	264.6	2706	2337	1602	16.9	20.42	0.81
42008	2	54	144.0	88.6	87.5	171.1	255.4	2849	3351	1119	14.3	42.00	1.01
42009	2	51	162.0	57.5	57.9	101.1	338.8	2421	3393	626	12.0	21.34	0.91
42010	2	56	155.5	64.2	75.2	75.2	366.5	2353	2873	1035	12.9	25.93	0.91
42011	2	60	146.5	62.5	41.7	61.9	202.9	1485	2168	575	8.4	28.42	0.84
42012	2	57	153.0	75.9	48.3	83.0	225.1	1808	2617	655	8.1	31.78	0.95
42013	2	60	153.5	55.0	70.4	114.7	255.5	2273	2403	946	13.7	22.70	0.83
42014	2	52	167.0	89.4	79.6	113.4	236.8	2219	2991	870	12.1	31.51	1.11
42015	2	57	164.5	74.9	87.8	128.9	214.5	2317	2636	807	13.8	27.12	1.00
42016	2	63	157.0	63.8	73.7	124.0	225.7	2253	2414	1017	14.2	25.27	0.92

APPENDIX I(a)

Table 5: Original data for individuals:

Middle-aged housewives (7.2), Daughters of middle-aged housewives (8.2).

Study No.	Subject No.	Sex	Age	Height	Weight	Protein	Fat	CHO.	Energy Intake	Energy Expend	Calcium	Iron	BMI	BMR
72001		2	58	160.0	67.3	65.4	113.9	219.5	2030	2000	776	12.2	25.60	0.98
72002		2	52	158.8	65.0	46.5	95.7	241.4	1920	1764	650	8.5	25.10	0.94
72003		2	51	160.0	69.5	76.1	76.2	275.0	2000	2120	564	14.1	26.60	0.97
72004		2	51	161.3	60.0	68.5	98.4	273.3	2360	2194	787	14.5	22.50	0.92
72005		2	61	167.6	65.9	64.5	110.7	238.7	2100	2191	969	11.3	23.00	0.95
72006		2	46	161.3	58.6	70.3	105.0	270.5	2250	2047	989	13.0	21.90	0.92
72007		2	53	160.8	60.0	72.7	96.8	301.9	2240	2089	974	12.2	22.50	0.91
72008		2	45	160.0	65.9	69.2	90.8	166.8	1590	1984	970	9.5	25.10	0.97
72009		2	53	152.4	73.2	75.6	98.2	193.6	1880	1896	483	15.4	30.70	0.95
72010		2	51	162.6	64.5	46.7	85.8	270.8	2010	2335	513	11.1	23.90	0.95
72011		2	50	151.1	73.6	60.9	118.6	300.7	2440	2288	944	12.4	31.50	0.96
72012		2	45	156.2	49.1	68.2	90.0	313.9	2410	2187	938	13.8	19.50	0.84
82001		2	20	162.6	52.0	-99	-99	-99	1777	2027	-99	-99	19.10	-99
82002		2	25	153.7	53.0	-99	-99	-99	1841	1995	-99	-99	21.90	-99
82003		2	20	167.6	51.5	-99	-99	-99	2080	2121	-99	-99	17.80	-99
82004		2	16	165.1	63.5	-99	-99	-99	2011	2848	-99	-99	22.80	-99
82005		2	26	167.6	56.5	-99	-99	-99	2377	2372	-99	-99	19.60	-99
82006		2	17	170.2	56.0	-99	-99	-99	2700	2497	-99	-99	18.90	-99
82007		2	23	175.4	73.0	-99	-99	-99	2332	2220	-99	-99	23.30	-99
82008		2	18	158.8	53.5	-99	-99	-99	2021	1819	-99	-99	20.80	-99
82009		2	20	167.6	70.5	-99	-99	-99	1857	2281	-99	-99	24.60	-99
82010		2	27	165.1	54.5	-99	-99	-99	2362	2272	-99	-99	19.40	-99
82011		2	17	152.4	46.0	-99	-99	-99	2720	2550	-99	-99	19.10	-99
82012		2	17	153.7	52.0	-99	-99	-99	2532	2067	-99	-99	21.50	-99

APPENDIX I(b)

DERIVED DATA FOR INDIVIDUALS

APPENDIX I(b)

Table 1: Derived data for individuals: Light industry (0.1), farmers (1.1)

Study No. / Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/ Weight	Protein/ 1000 kcal
01001	39.2	36.4	2697	1.76	1.17	32.2
01002	50.6	48.0	2911	2.18	1.49	31.1
01003	40.2	38.0	3228	1.93	1.27	33.4
01004	49.8	47.0	2747	2.08	1.79	38.0
01005	53.5	50.0	2606	2.08	1.60	32.0
01006	46.1	44.2	3013	2.11	1.25	28.4
01007	32.6	30.1	2576	1.80	.867	28.8
01008	36	33.9	3060	1.82	.918	27.0
01009	42.4	40.3	3435	2.26	1.09	27.0
01010	56.4	47.3	3414	2.63	1.52	32.2
01011	37.3	37.6	2194	1.58	1.19	31.5
01012	44.0	40.7	2813	2.09	1.26	31.0
01013	38.5	43.9	3032	1.85	1.23	28.1
01014	39.6	42.2	2915	1.84	1.44	34.2
01015	42.8	48.3	2978	1.98	1.33	27.6
01016	34.5	40.4	2606	1.57	1.34	33.1
01017	40.0	42.4	3555	2.01	1.26	29.7
01018	41.4	47.4	3163	1.89	1.56	32.9
01019	43.1	47.6	3018	2.09	1.33	28.0
01020	37.3	44.0	2454	1.57	1.52	34.5
01021	32.6	39.5	2431	1.55	1.33	33.6
01022	45.5	50.8	2771	1.85	1.54	30.4
01023	41.4	45.8	2894	1.73	1.26	27.6
01024	37.8	43.0	2418	1.65	1.22	28.3
11001	44.9	48.9	3369	2.06	1.59	32.5
11002	55.6	55.1	3472	2.40	1.98	35.9
11003	51.7	48.8	3384	2.39	1.59	32.7
11004	68.4	56.2	3965	2.96	1.44	25.6
11005	69.0	62.1	4441	3.11	1.83	29.4
11006	39.0	36.6	4008	2.12	1.25	34.1
11007	48.4	47.0	3668	2.30	1.37	29.1
11008	47.0	42.2	3594	2.19	1.43	34.1
11009	50.1	51.8	4151	2.34	1.66	32.0
11010	41.5	40.5	3360	1.95	1.63	40.2
11011	45.4	40.4	4078	2.54	1.33	33.0
11012	61.1	49.9	3988	2.87	1.37	27.5
11013	51.9	43.8	3700	2.48	1.21	27.8
11014	50.7	43.5	3773	2.56	1.34	30.8
11015	41.6	47.8	3557	2.03	1.78	37.2
11016	32.3	24.3	3278	2.04	0.74	30.2
11017	48.1	55.9	3216	1.98	1.74	31.1
11018	53.9	63.9	3694	2.30	1.65	25.8
11019	36.1	25.5	2649	1.87	1.09	42.8
11020	46.5	40.7	3417	2.34	1.26	31.0
11021	31.6	27.1	2809	1.70	.922	33.9
11022	51.8	53.8	3341	2.25	1.86	34.5

APPENDIX I(b)

Table 2: Derived data for individuals:
Steel workers (2.1), building workers (3.1), executives (6.1), Clerical workers (7.1), retired men (8.1), farmers over 65 years (9.1).

Study No. / Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/ Weight	Protein/ 1000 kcal
21001	42.5	44.6	2668	1.84	1.37	30.8
21002	47.4	43.7	3163	2.15	1.86	42.5
21003	51.4	39.2	3395	2.47	1.34	34.3
21004	37.0	40.7	3171	1.80	1.26	31.1
21005	46.6	48.9	3125	2.11	1.63	33.4
21006	37.0	36.2	3667	2.11	1.36	37.5
21007	43.7	33.2	3484	2.34	1.20	36.2
21008	38.4	49.8	2981	1.78	1.64	33.0
21009	44.6	49.8	3606	2.13	1.61	32.3
31001	37.4	26.3	2823	1.95	.798	30.3
31002	44.2	41.1	3289	2.17	1.42	34.7
31003	40.0	35.2	3106	2.01	1.17	33.2
31004	36.5	52.2	3422	1.79	1.45	27.8
31005	55.7	58.2	3818	2.44	1.43	24.6
31006	38.4	41.7	2544	1.67	1.27	30.5
31007	43.5	45.0	3059	2.04	1.84	40.9
31008	35.9	37.2	2835	1.72	1.23	33.1
31009	32	33.2	2690	1.68	1.06	32.0
61001	38.6	37.0	2856	1.87	.985	26.6
61002	41.1	40.4	3245	2.08	1.30	32.3
61003	45.1	41.6	3125	2.08	1.26	30.3
61004	43.1	40.3	2730	1.96	1.20	29.7
61005	34.6	31.7	2623	1.69	1.14	35.8
61006	39.3	38.6	3031	1.86	1.21	31.4
61007	51.1	31.7	2293	2.11	1.11	34.9
61008	45.0	48.8	2716	1.84	1.48	30.4
61009	42.7	46.0	2497	1.73	1.27	27.7
61010	39.1	35.4	2229	1.67	1.07	30.2
71001	31.1	30.9	2094	1.44	1.05	34.1
71002	38.2	51.8	2702	1.60	1.71	33.1
71003	28.7	26.9	2255	1.45	1.16	43.2
71004	36.1	40.4	2582	1.61	1.35	33.5
71005	29.8	29.8	2352	1.51	1.16	39.0
71006	30.6	33.5	2117	1.41	.900	26.8
71007	35.2	36.5	2173	1.55	1.23	33.7
71008	39.2	43.0	2468	1.66	1.25	29.2
71009	32	41.9	2108	1.31	1.44	34.3
71010	42.7	37.9	2743	2.00	1.32	34.9

APPENDIX I(b)
Table 2 Cont'd: Retired men (8.1) and farmers over 65 years (9.1)

Study No. Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/Weight	Protein/1000 kcal
81001	40.4	32.3	1935	1.77	1.04	32.3
81002	34.1	31.7	2093	1.60	1.17	37.0
81003	31.1	28.0	2254	1.61	1.07	38.1
81004	36.5	36.3	2553	1.74	1.04	28.7
81005	38.4	23.0	2454	1.95	.820	35.5
81006	33.2	29.5	2423	1.71	.898	30.4
81007	26.0	21.8	1612	1.32	.859	39.3
81008	33.6	29.9	2655	1.82	1.01	33.7
81009	34.6	33.0	2011	1.55	1.19	36.3
91001	40.7	34.2	3120	1.99	1.20	35.1
91002	34.2	32.0	2366	1.73	1.21	38.0
91003	39.3	42.9	3290	2.07	1.51	35.2
91004	37.0	35.7	2582	1.78	1.12	31.5
91005	39.4	25.5	2835	2.07	1.01	39.9

APPENDIX I(b)

Table 3: Derived data for individuals:
Housewives alone (1.2), housewives with family (2.2).

Study No.	Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/ Weight	Protein/ 1000 kcal
12001		23.4	22.3	1519	1.27	.864	38.6
12002		28.4	28.3	2031	1.60	.638	22.5
12003		38.0	39.5	1970	1.72	1.20	30.5
12004		35.9	33.8	1865	1.62	1.22	36.1
12005		47.4	44.1	2324	2.06	1.48	33.6
12006		31.6	32.7	2279	1.61	1.19	36.5
12007		23.3	22.7	1734	1.24	.757	33.3
12008		37.9	26.7	1348	1.46	.716	26.7
12009		33.3	33.0	2214	1.81	.960	29.0
12010		37.7	38.0	2286	1.84	1.29	34.0
12011		38.5	36.6	1843	1.70	1.19	32.6
12012		34.6	36.4	2015	1.68	.977	26.8
12013		28.8	23.9	2010	1.57	.776	32.3
12014		25.2	26.3	2060	1.42	.66	25.0
12015		34.1	36.3	2063	1.69	1.23	33.9
12016		36.0	37.4	1522	1.23	1.58	42.2
12017		34.1	14.9	1504	1.73	1.01	67.4
22001		39.7	26.2	1807	1.91	.899	34.2
22002		45.1	24.4	1878	2.01	.781	31.9
22003		38.6	27.8	2243	1.92	1.26	45.5
22004		34.9	25.1	1907	1.79	.82	32.6
22005		34.4	33.2	2637	1.98	.951	28.6
22006		31.3	27.0	2213	1.68	.885	32.7
22007		36.4	30.6	2298	1.88	.996	32.5
22008		43.0	38.0	1998	1.93	1.13	29.8
22009		38.5	38.1	2384	1.91	1.15	30.2
22010		41.5	38.6	2289	1.89	1.26	32.6
22011		41.2	29.6	1757	1.79	1.12	37.9
22012		42.8	35.1	1930	1.89	1.04	29.8
22013		34.8	37.2	1886	1.52	1.11	29.9
22014		45.0	42.7	2849	2.20	1.26	29.6
22015		37.0	35.1	1948	1.67	.758	21.5
22016		41.9	49.5	2136	1.67	1.35	27.3
22017		40.3	39.5	2089	1.78	1.15	29.2
22018		34.1	27.8	2308	1.83	1.15	41.2
22019		32.4	29.6	2071	1.53	.871	29.3
22020		28.5	18.7	1672	1.55	.644	34.3
22021		31.6	30.0	1751	1.44	.933	31.0

APPENDIX I(b)

Table 4: Derived data for individuals: Sewing workers (3.2), bakery workers (4.2).

Study No. Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/ Weight	Protein/ 1000 kcal
32001	33.5	33.5	2020	1.63	1.26	37.6
32002	28.1	23.8	2145	1.55	.656	27.5
32003	31.1	25.7	1990	1.64	.807	31.3
32004	59.9	61.5	2610	2.48	1.61	26.2
32005	33.9	39.7	2208	1.60	1.32	33.2
32006	42.3	37.7	2394	2.02	1.20	31.8
32007	33.3	32.5	2324	1.70	.930	28.6
32008	27.5	25.7	2327	1.64	.718	27.9
32009	33.5	31.8	2004	1.56	1.22	38.4
32010	32.6	32.5	2243	1.66	.981	30.1
32011	28.9	9.30	1646	1.58	.468	50.3
32012	36.5	32.9	2046	1.73	.902	27.3
32013	42.6	36.9	2340	2.02	1.03	28.0
32014	38.5	24.3	2009	1.82	.673	27.6
32015	30.7	29.2	2196	1.57	.945	32.2
32016	32.6	25.8	2083	1.66	.954	36.9
32017	37.7	55.5	2494	1.70	1.68	30.2
32018	29.9	34.2	2327	1.50	1.29	37.6
32019	32.6	32.7	2984	1.76	.914	27.9
32020	34.5	26.9	2084	1.69	.767	28.5
42001	38.4	31.5	1998	1.77	1.15	36.4
42002	44.5	32.5	1715	1.83	.832	25.5
42003	40.9	41.5	2129	1.76	1.54	37.2
42004	39.3	33.6	1856	1.69	1.45	43.2
42005	35.9	35.7	2383	1.78	1.20	33.8
42006	41.4	56.3	2727	1.93	1.94	34.4
42007	47.6	55.2	2521	2.00	2.12	38.5
42008	37.8	32.1	3100	2.30	.987	30.7
42009	59.0	42.1	2907	2.58	1.00	23.9
42010	44.7	36.6	2613	2.19	1.17	31.9
42011	34.6	23.7	1826	1.79	.668	28.1
42012	34.4	23.8	2212	.182	.636	26.7
42013	43.6	41.3	2338	2.01	1.28	30.9
42014	33.4	24.8	2605	1.87	.891	35.8
42015	35.1	30.9	2476	1.83	1.17	37.9
42016	37.8	35.3	2333	1.82	1.15	32.7

APPENDIX I(b)

Table 5: Derived data for individuals:
Middle-aged housewives (7.2), Daughters of middle-aged housewives (8.2).

Study No. Subject No.	TEE/Weight	TEI/Weight	TEE+TEI/2	TEE/BMR	Protein/ Weight	Protein/ 1000 kcal
72001	29.7	30.1	2015	1.41	.972	32.2
72002	27.1	29.5	1842	1.30	.716	24.2
72003	30.5	28.7	2060	1.51	1.09	38.0
72004	36.5	39.3	2277	1.65	1.14	29.0
72005	33.2	31.8	2145	1.60	.980	30.7
72006	34.9	38.3	2148	1.54	1.20	31.2
72007	34.8	37.3	2164	1.59	1.21	32.4
72008	30.1	24.1	1787	1.42	1.05	43.5
72009	25.9	25.6	1888	1.38	1.03	40.2
72010	36.2	31.1	2172	1.70	.725	23.2
72011	31.0	33.1	2364	1.65	.827	24.9
72012	44.5	49.0	2298	1.80	1.39	28.3
82001	38.9	34.1	1902	3.40	0	0
82002	37.6	34.7	1918	3.40	0	0
82003	41.1	40.3	2100	3.40	0	0
82004	44.8	31.6	2429	3.40	0	0
82005	41.9	42.0	2374	3.40	0	0
82006	44.5	48.2	2598	3.40	0	0
82007	3.01	31.9	1276	3.40	0	0
82008	34	37.7	1920	3.40	0	0
82009	32.3	26.3	2069	3.40	0	0
82010	41.6	43.3	2317	3.40	0	0
82011	55.4	59.1	2635	3.40	0	0
82012	39.7	48.6	2299	1.52	0	0

APPENDIX II

MANN-WHITNEY U AND P-VALUES

TABLE 1: MANN-WHITNEY U AND P-VALUES
H'wives Alone compared to all other groups
Base group: H'WIVES ALONE (N=17)

	0.1 Light Industry N=24		1.1 Farmers Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=9		7.1 Clerical Workers N=10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
Variable List	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	55.5	.000	5.0	.000	3.0	.000	0.0	.000	4.5	.000	4.0	.000	30.5	.01	5.5	.004	29.5	.000	.5	.000	2.5	.000
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F
HEIGHT (CM)	64.0	.000	5.0	.000	5.0	.000	17.0	.001	0.0	.000	14.0	.000	30.0	.01	5.0	.003	172.5	.9	125.0	.2	131.5	.9
WEIGHT (KG)	134.0	.06	56.0	.000	29.0	.01	20.0	.002	56.0	.1	59.0	.2	41.0	.06	8.5	.008	175.5	.9	115.5	.1	128.5	.8
PROTEIN (G)	17.0	.000	0.0	.000	1.0	.000	5.0	.000	22.5	.002	19.0	.001	45.0	.09	1.0	.001	167.0	.7	135.0	.3	78.0	.04
FAT (G)	28.0	.000	2.0	.000	0.0	.000	10.0	.000	18.0	.001	10.0	.000	67.0	.6	11.0	.01	152.5	.4	72.5	.003	77.0	.04
CARBOHYDRATE (G)	4.0	.000	0.0	.000	7.0	.000	5.0	.000	18.0	.001	46.0	.05	54.0	.2	16.0	.04	169.0	.8	148.0	.5	128.0	.8
ENERGY INTAKE (KCAL)	4.0	.000	4.0	.000	0.0	.000	0.0	.000	18.0	.001	16.0	.001	62.0	.4	5.0	.003	174.5	.9	115.0	.09	80.0	.04
ENERGY EXPENDITURE (KCAL)	14.0	.000	0.0	.000	0.0	.000	0.0	.000	2.0	.000	34.0	.01	31.0	.01	0.0	.001	89.5	.009	49.5	.000	36.0	.000
CALCIUM (MG)	92.0	.003	39.0	.000	23.0	.004	45.0	.09	44.0	.04	63.0	.3	69.0	.7	14.0	.03	136.0	.2	152.5	.6	131.0	.9
IRON (MG)	32.5	.000	11.0	.000	5.0	.000	10.0	.000	17.5	.001	33.5	.01	49.5	.2	9.0	.009	164.0	.7	118.0	.1	85.0	.07
BODY MASS INDEX	198.0	.9	162.0	.5	65.0	.5	48.0	.1	57.0	.2	76.0	.7	70.5	.8	37.0	.7	169.0	.8	131.0	.2	129.0	.8
BASAL METABOLIC RATE	30.0	.000	0.0	.000	1.0	.000	0.0	.000	11.0	.000	8.5	.000	20.5	.003	1.0	.001	149.5	.4	77.5	.005	98.5	.2
ENERGY EXPENDITURE /WEIGHT RATIO	64.0	.000	34.0	.000	17.0	.001	32.0	.02	15.0	.000	76.0	.7	72.0	.8	16.0	.04	101.0	.02	169.0	.98	54.0	.003
ENERGY INTAKE /WEIGHT RATIO	38.0	.000	51.0	.000	19.0	.002	34.0	.02	36.0	.01	53.0	.1	52.0	.2	39.0	.8	174.0	.9	157.0	.7	115.0	.5
ENERGY NEEDS	4.0	.000	0.0	.000	0.0	.000	0.0	.000	4.0	.000	19.0	.001	40.0	.05	0.0	.001	140.0	.3	80.0	.006	57.0	.004
PROTEIN / WEIGHT RATIO	84.0	.002	56.0	.000	14.0	.001	40.0	.05	53.0	.1	47.0	.06	72.0	.8	28.0	.3	173.0	.9	162.0	.8	116.0	.5
PROTEIN INTAKE PER 1000 KCAL	162.0	.3	185.0	.95	56.0	.3	70.0	.7	65.0	.3	59.0	.2	53.0	.2	22.0	.1	162.0	.6	149.0	.5	123.0	.6
CALCIUM INTAKE PER 1000 KCAL	123.0	.03	148.0	.3	55.0	.3	29.0	.01	58.0	.2	67.0	.4	59.0	.4	41.0	.9	136.0	.2	123.0	.2	95.0	.1
IRON INTAKE PER 1000 KCAL	149.0	.2	170.0	.6	76.0	.98	72.0	.8	84.0	.96	80.0	.8	61.0	.4	34.0	.5	176.0	.9	142.0	.4	131.0	.9
ENERGY BALANCE	167.0	.3	129.0	.1	60.0	.4	57.0	.3	60.0	.2	48.0	.06	27.0	.008	27.0	.2	82.0	.005	122.0	.1	67.0	.01
ENERGY REQUIREMENT	79.0	.001	12.0	.000	9.0	.000	30.0	.01	24.0	.002	54.0	.1	68.0	.7	9.0	.009	102.0	.02	151.0	.6	34.0	.000

TABLE 2: MANN-WHITNEY U AND P-VALUES
H'wives with Family compared to all other groups
Base group: H'WIVES FAMILY (N=21)

Variable List	0.1 Light Industry N=24 U	P	1.1 Farmers N=22 U	P	2.1 Steel Workers N=9 U	P	3.1 Building Workers N=9 U	P	6.1 Execu-tives N=10 U	P	7.1 Clerical Workers N=10 U	P	8.1 Retired Men N=9 U	P	9.1 Farmers >65 Yrs. N=5 U	P	1.2 H'wives Alone N=17 U	P	3.2 Sewing Workers N=20 U	P	4.2 Bakery Workers N=16 U	P
AGE	194.0	.2	135.0	.02	79.0	.5	23.0	.001	102.0	.9	62.0	.7	5.0	.000	0.0	.001	29.5	.000	74.0	.000	67.0	.002
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F
HEIGHT (CM)	70.0	.000	15.0	.000	11.0	.000	20.0	.001	6.0	.000	20.0	.000	318.5	.01	4.0	.002	172.5	.9	167.0	.3	146.0	.5
WEIGHT (KG)	142.0	.01	64.0	.000	30.0	.003	22.0	.001	57.0	.04	64.0	.08	45.5	.03	6.0	.003	175.5	.9	130.0	.04	155.0	.7
PROTEIN (G)	30.0	.000	2.0	.000	2.0	.000	9.0	.000	28.0	.001	25.0	.001	58.0	.1	3.0	.001	167.0	.7	164.0	.2	105.0	.05
FAT (G)	61.5	.000	6.0	.000	6.0	.000	26.0	.002	38.0	.004	29.0	.001	73.0	.3	21.0	.04	152.5	.4	123.0	.02	116.0	.1
CARBOHYDRATE (G)	17.0	.000	1.0	.000	10.0	.000	13.0	.000	23.0	.001	64.0	.08	63.0	.2	20.0	.03	169.0	.8	173.0	.3	138.0	.4
ENERGY INTAKE (KCAL)	16.0	.000	6.0	.000	1.0	.000	5.0	.000	24.0	.001	29.0	.001	78.0	.5	10.0	.006	174.5	.9	151.0	.1	106.0	.06
ENERGY EXPENDITURE (KCAL)	57.0	.000	0.0	.000	6.0	.000	9.0	.000	22.0	.001	104.0	.97	75.0	.4	7.0	.003	89.5	.009	178.0	.4	112.0	.09
CALCIUM (MG)	90.0	.000	31.0	.000	23.0	.001	37.0	.009	45.0	.01	58.0	.05	78.0	.5	14.0	.01	136.0	.2	194.0	.7	136.0	.3
IRON (MG)	54.0	.000	11.0	.000	13.0	.000	12.0	.000	29.0	.001	49.0	.02	73.0	.3	8.0	.004	164.0	.7	160.0	.2	110.0	.08
BODY MASS INDEX	242.0	.8	190.0	.3	75.0	.4	49.0	.04	78.0	.3	1000.0	.8	78.0	.5	36.0	.3	169.0	.8	140.0	.07	155.0	.7
BASAL METABOLIC RATE	29.0	.000	0.0	.000	1.0	.000	0.0	.000	11.0	.000	7.0	.000	28.5	.003	1.0	.001	149.5	.4	115.0	.01	147.0	.5
ENERGY EXPENDITURE /WEIGHT RATIO	164.0	.05	70.0	.000	42.0	.02	77.0	.4	59.0	.05	62.0	.07	53.0	.06	52.0	.97	101.0	.02	123.0	.02	134.0	.3
ENERGY INTAKE /WEIGHT RATIO	63.0	.000	75.0	.000	24.0	.001	45.0	.03	45.0	.01	66.0	.1	72.0	.3	45.0	.6	174.0	.9	191.0	.6	135.0	.3
ENERGY NEEDS	24.0	.000	2.0	.000	1.0	.000	5.0	.000	18.0	.000	50.0	.02	67.0	.2	6.0	.003	140.0	.3	146.0	.1	100.0	.04
PROTEIN / WEIGHT RATIO	75.0	.000	57.0	.000	6.0	.000	37.0	.009	52.0	.03	42.0	.008	89.0	.8	27.0	.1	173.0	.9	199.0	.8	120.0	.1
PROTEIN INTAKE PER 1000 KCAL	219.0	.5	210.0	.6	51.0	.05	85.0	.7	98.0	.8	68.0	.1	56.0	.08	20.0	.03	162.0	.6	179.0	.4	139.0	.4
CALCIUM INTAKE PER 1000 KCAL	212.0	.4	217.0	.7	89.0	.8	58.0	.1	94.0	.6	104.0	.97	92.0	.9	36.0	.3	136.0	.2	192.0	.6	148.0	.5
IRON INTAKE PER 1000 KCAL	206.0	.3	219.0	.8	91.0	.9	92.0	.9	94.0	.6	101.0	.9	77.0	.4	43.0	.5	176.0	.9	187.0	.6	160.0	.8
ENERGY BALANCE	112.5	.002	221.0	.8	58.0	.1	52.0	.05	77.0	.2	28.0	.001	93.0	.9	50.5	.9	82.0	.005	164.0	.2	160.0	.8
ENERGY REQUIREMENT	185.0	.1	34.0	.000	38.0	.01	64.0	.2	80.0	.3	37.0	.004	60.0	.1	31.0	.2	102.0	.02	146.0	.1	127.0	.2

TABLE 3: MANN-WHITNEY U AND P-VALUES
Sewing Workers compared to all other groups
Base group: SEWING WORKERS (N=20)

	0.1 Light Industry N=24		1.1 Farmers N=22		2.1 Steel Workers N=9		3.1 Buiding Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N=10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		4.2 Bakery Workers N=16	
Variable List	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	41.0	.000	199.0	.6	36.0	.01	56.5	.1	31.0	.002	73.5	.2	0.0	.000	0.0	.001	.5	.000	74.0	.000	141.0	.5
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F
HEIGHT (CM)	130.5	.01	35.0	.000	21.0	.001	39.0	.02	13.5	.000	42.5	.01	50.0	.06	12.0	.01	125.0	.2	167.0	.3	124.5	.3
WEIGHT (KG)	237.5	.95	129.0	.02	57.0	.1	52.0	.07	97.0	.9	90.0	.7	81.0	.7	22.0	.06	115.5	.1	130.0	.04	116.0	.2
PROTEIN (G)	48.0	.000	5.0	.000	2.0	.000	12.0	.000	45.5	.02	38.0	.006	72.0	.4	7.0	.004	135.0	.3	164.0	.2	119.5	.2
FAT (G)	120.0	.005	25.0	.000	21.0	.001	45.0	.03	68.0	.16	63.0	.1	40.0	.02	34.0	.3	72.5	.003	123.0	.02	144.0	.6
CARBOHYDRATE (G)	40.0	.000	11.0	.000	18.0	.001	18.0	.001	35.0	.004	76.5	.3	78.0	.6	24.0	.08	148.0	.5	173.0	.3	149.0	.7
ENERGY INTAKE (KCAL)	40.0	.000	14.0	.000	4.0	.000	13.0	.000	42.0	.01	55.0	.05	79.5	.6	20.0	.04	115.0	.09	151.0	.1	145.5	.6
ENERGY EXPENDITURE (KCAL)	67.0	.000	1.0	.000	2.0	.000	9.0	.000	21.0	.001	89.0	.7	78.0	.6	7.0	.003	49.5	.000	178.0	.4	127.0	.3
CALCIUM (MG)	11.5	.003	51.0	.000	30.0	.005	46.0	.04	55.0	.05	68.0	.2	86.0	.9	20.0	.04	152.5	.6	194.0	.7	142.0	.6
IRON (MG)	72.0	.000	19.0	.000	13.0	.000	20.0	.001	38.0	.006	61.5	.09	85.5	.8	16.5	.02	118.0	.1	160.0	.2	133.5	.4
BODY MASS INDEX	182.5	.2	193.0	.5	71.0	.4	71.0	.4	38.5	.007	58.0	.07	80.0	.7	42.0	.6	131.0	.2	140.0	.07	137.0	.5
BASAL METABOLIC RATE	113.5	.003	35.0	.000	21.0	.001	16.0	.001	43.5	.01	47.0	.02	64.0	.2	12.5	.01	77.5	.005	115.0	.01	109.0	.1
ENERGY EXPENDITURE /WEIGHT RATIO	85.0	.000	56.0	.000	21.0	.001	40.0	.02	23.0	.001	100.0	1.000	79.0	.6	21.0	.05	169.0	.98	123.0	.02	61.0	.002
ENERGY INTAKE /WEIGHT RATIO	69.0	.000	82.0	.000	27.0	.003	40.0	.02	46.0	.02	60.0	.08	70.0	.3	40.0	.5	157.0	.7	191.0	.6	129.0	.3
ENERGY NEEDS	34.0	.000	2.0	.000	2.0	.000	5.0	.000	23.0	.001	66.0	.1	84.0	.8	7.0	.004	80.0	.006	146.0	.1	120.0	.2
PROTEIN / WEIGHT RATIO	101.0	.001	69.0	.000	20.0	.001	44.0	.03	55.0	.05	51.0	.03	85.0	.8	29.0	.2	162.0	.8	199.0	.8	123.0	.2
PROTEIN INTAKE PER 1000 KCAL	235.0	.9	188.0	.4	50.0	.06	77.0	.5	99.0	.97	63.0	.1	48.0	.05	21.0	.05	149.0	.5	179.0	.4	131.0	.4
CALCIUM INTAKE PER 1000 KCAL	203.0	.4	197.0	.6	86.0	.9	62.0	.2	97.0	.9	83.0	.5	85.0	.8	28.0	.2	123.0	.2	192.0	.6	157.0	.9
IRON INTAKE PER 1000 KCAL	229.0	.8	213.0	.9	70.0	.4	78.0	.6	73.0	.2	88.0	.6	65.0	.2	29.0	.2	142.0	.4	187.0	.6	139.0	.5
.ENERGY BALANCE	154.0	.04	190.0	.4	69.0	.3	62.5	.2	97.0	.9	50.5	.03	69.0	.3	41.5	.6	122.0	.1	164.0	.2	120.0	.2
ENERGY REQUIREMENT	124.0	.006	28.0	.000	17.0	.001	37.0	.01	37.0	.006	43.0	.01	88.0	.9	15.0	.02	151.0	.6	146.0	.1	51.0	.001

TABLE 4: MANN-WHITNEY U AND P-VALUES
Bakery Workers compared to all other groups
Base group: BAKERY WORKERS (N=16)

	0.1 Light Industry N=24		1.1 Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N=10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20	
Variable List	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	47.5	.000	157.0	.6	31.5	.02	59.0	.5	30.0	.008	55.5	.2	0.0	.000	0.0	.000	2.5	.000	67.0	.002	141.0	.5
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F
HEIGHT (CM)	74.0	.001	33.0	.000	16.0	.002	22.5	.005	14.0	.001	27.0	.005	31.5	.02	7.0	.006	131.5	.9	146.0	.5	124.5	.3
WEIGHT (KG)	127.0	.07	70.0	.002	29.0	.02	27.0	.01	55.0	.2	55.0	.2	43.0	.1	14.0	.03	128.5	.8	155.0	.7	116.0	.2
PROTEIN (G)	83.0	.003	22.0	.000	9.0	.000	22.5	.005	61.0	.32	51.0	.1	59.0	.5	13.0	.03	78.0	.04	105.0	.05	119.0	.2
FAT (G)	125.0	.06	46.0	.000	33.0	.03	47.0	.2	70.0	.6	68.0	.5	40.0	.07	38.0	.9	77.0	.04	116.0	.1	144.0	.6
CARBOHYDRATE (G)	34.0	.000	7.0	.000	8.0	.000	16.0	.002	24.0	.003	49.0	.1	58.5	.4	17.0	.06	128.0	.8	138.0	.4	149.0	.7
ENERGY INTAKE (KCAL)	45.0	.000	15.0	.000	5.0	.000	14.0	.001	39.0	.03	60.0	.3	59.0	.5	20.5	.1	80.0	.04	106.0	.06	145.5	.6
ENERGY EXPENDITURE (KCAL)	109.0	.02	14.0	.000	18.0	.002	24.0	.007	43.0	.05	55.0	.2	62.0	.6	14.0	.03	36.0	.000	112.0	.09	127.0	.3
CALCIUM (MG)	111.1	.03	49.0	.000	25.0	.008	46.0	.1	50.0	.1	62.0	.3	61.0	.5	19.0	.08	131.0	.9	136.0	.3	142.0	.6
IRON (MG)	96.0	.01	32.0	.000	21.5	.004	26.0	.009	48.0	.09	65.0	.4	61.0	.5	18.5	.08	85.0	.07	110.0	.08	133.5	.4
BODY MASS INDEX	182.0	.8	165.0	.8	68.0	.8	47.0	.2	53.0	.2	70.0	.6	68.5	.8	34.0	.6	129.0	.8	155.0	.7	137.0	.5
BASAL METABOLIC RATE	53.0	.000	13.0	.000	9.5	.000	6.5	.000	19.0	.001	21.0	.002	29.5	.02	5.0	.004	98.5	.2	147.0	.5	109.0	.1
ENERGY EXPENDITURE /WEIGHT RATIO	164.0	.4	78.0	.000	47.0	.2	69.0	.9	59.0	.27	35.0	.02	27.0	.01	32.0	.5	54.0	.003	134.0	.3	61.0	.002
ENERGY INTAKE /WEIGHT RATIO	87.0	.004	85.0	.007	35.0	.04	47.0	.2	56.0	.2	71.0	.6	37.0	.05	40.0	1.000	115.0	.5	135.0	.3	129.0	.3
ENERGY NEEDS	63.0	.000	5.0	.000	4.0	.001	13.0	.001	37.0	.02	78.0	.9	59.0	.5	15.0	.04	57.0	.004	100.0	.04	120.0	.2
PROTEIN / WEIGHT RATIO	119.0	.04	94.0	.02	31.0	.02	56.0	.4	70.0	.6	62.0	.3	53.0	.3	34.0	.6	116.0	.5	120.0	.1	123.0	.2
PROTEIN INTAKE PER 1000 KCAL	143.0	.2	160.0	.6	62.0	.06	60.0	.5	54.0	.2	71.0	.6	59.0	.5	25.0	.2	123.0	.6	139.0	.4	131.0	.4
CALCIUM INTAKE PER 1000 KCAL	173.0	.6	155.0	.5	68.0	.8	51.0	.2	76.0	.8	68.0	.5	64.0	.7	24.0	.2	95.0	.1	148.0	.5	157.0	.9
IRON INTAKE PER 1000 KCAL	150.0	.3	159.0	.6	71.0	.96	72.0	1.000	79.0	.96	79.0	.96	59.0	.5	33.0	.6	131.0	.9	160.0	.8	139.0	.5
ENERGY BALANCE	91.0	.005	160.0	.6	48.0	.2	41.0	.08	56.0	.21	29.5	.008	62.0	.6	40.0	1.000	67.0	.01	160.0	.8	120.0	.2
ENERGY REQUIREMENT	189.0	.9	58.0	.001	45.0	.1	71.0	.95	77.0	.9	11.0	.000	22.0	.005	38.0	.9	34.0	.000	127.0	.2	51.0	.001

TABLE 5: MANN-WHITNEY U AND P-VALUES
Farmers compared to all other groups
Base group: FARMERS (N=22)

Variable List	0.1 Light Industry N=24		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N =10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	114.0	.001	75.0	.3	71.0	.2	66.0	.07	101.0	.7	0.0	.000	0.0	.001	5.0	.000	135.0	.02	199.0	.6	157.0	.6
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	97.0	.000	71.0	.2	36.0	.006	106.0	.87	33.0	.002	49.0	.03	48.0	.7	5.0	.000	15.0	.000	35.0	.000	33.0	.000
WEIGHT (KG)	160.0	.02	90.0	.7	99.0	1.0	58.5	.03	51.0	.02	66.0	.2	48.0	.6	56.0	.000	64.0	.000	129.0	.02	70.0	.002
PROTEIN (G)	71.0	.000	97.0	.9	58.0	.07	18.0	.000	18.0	.000	0.0	.000	25.0	.06	0.0	.000	2.0	.000	5.0	.000	22.0	.000
FAT (G)	100.0	.000	60.0	.1	37.0	.007	22.0	.000	22.0	.000	2.0	.000	14.0	.01	2.0	.000	6.0	.000	25.0	.000	46.0	.000
CARBOHYDRATE (G)	113.0	.001	65.0	.1	49.0	.03	26.0	.001	6.0	.000	7.0	.000	21.0	.03	0.0	.000	1.0	.000	11.0	.000	7.0	.000
ENERGY INTAKE (KCAL)	78.0	.000	59.0	.08	56.0	.06	19.0	.000	11.0	.000	3.0	.000	15.0	.01	4.0	.000	6.0	.000	14.0	.000	15.0	.000
ENERGY EXPENDITURE (KCAL)	41.0	.000	55.0	.06	32.0	.004	10.0	.000	0.0	.000	2.0	.000	18.0	.02	0.0	.000	0.0	.000	1.0	.000	14.0	.000
CALCIUM (MG)	144.0	.008	79.0	.4	43.0	.02	51.0	.016	34.5	.002	15.0	.000	43.0	.6	39.0	.000	31.0	.000	51.0	.000	49.0	.000
IRON (MG)	94.0	.000	84.0	.5	80.0	.4	38.0	.003	27.5	.001	17.0	.000	22.0	.04	11.0	.000	11.0	.000	19.0	.000	32.0	.000
BODY MASS INDEX	239.0	.6	98.0	.97	70.0	.2	60.0	.04	83.0	.3	98.0	.97	54.0	.95	162.0	.5	190.0	.3	193.0	.5	165.0	.8
BASAL METABOLIC RATE	116.0	.001	78.0	.4	83.0	.5	52.5	.02	29.5	.001	32.0	.003	41.0	.4	0.0	.000	0.0	.007	35.0	.000	13.0	.000
ENERGY EXPENDITURE /WEIGHT RATIO	145.0	.009	60.0	.09	47.0	.02	57.0	.03	18.0	.002	18.0	.000	17.0	.02	34.0	.000	70.0	.000	56.0	.000	78.0	.000
ENERGY INTAKE /WEIGHT RATIO	198.0	.2	77.0	.3	72.0	.2	55.0	.03	52.0	.02	21.0	.001	19.0	.02	51.0	.000	75.0	.000	82.0	.001	85.0	.007
ENERGY NEEDS	53.0	.000	51.0	.04	38.0	.008	11.0	.000	2.0	.000	1.0	.000	8.0	.003	0.0	.000	2.0	.000	2.0	.000	5.0	.000
PROTEIN / WEIGHT RATIO	176.0	.05	98.0	.97	68.0	.2	46.0	.001	60.0	.04	17.0	.000	23.0	.05	56.0	.000	57.0	.000	69.0	.000	94.0	.02
PROTEIN INTAKE PER1000 KCAL	213.0	.3	67.0	.2	95.0	.9	88.0	.37	77.0	.2	66.0	.2	24.0	.05	185.0	.95	210.0	.6	188.0	.4	160.0	.6
CALCIUM INTAKE PER 1000 KCAL	228.0	.4	87.0	.6	55.0	.06	97.0	.60	108.0	.9	93.0	.8	41.0	.4	148.0	.3	217.0	.7	197.0	.6	155.0	.5
IRON INTAKE PER 1000 KCAL	237.0	.6	85.0	.5	86.0	.6	93.0	.49	101.0	.7	77.0	.3	39.0	.3	170.0	.6	219.0	.8	213.0	.9	159.0	.6
ENERGY BALANCE	154.0	.02	76.0	.3	70.0	.2	92.0	.46	50.0	.01	98.0	.95	52.0	.9	129.0	.1	221.0	.8	190.0	.4	160.0	.6
ENERGY REQUIREMENT	90.0	.000	63.0	.1	39.0	.01	29.0	.001	4.0	.000	7.0	.000	20.0	.03	12.0	.000	34.0	.000	28.0	.000	58.0	.001

TABLE 6: MANN-WHITNEY U AND P-VALUES
Steel Workers compared to all other groups
Base group: STEEL WORKERS (N=9)

Variable List	0.1 Light Industry N=24 U	P	1.1 Farmers Farmers N=22 U	P	3.1 Building Workers N=9 U	P	6.1 Execu-tives N=10 U	P	7.1 Clerical Workers N =10 U	P	8.1 Retired Men N=9 U	P
AGE	59.0	.05	74.5	.3	13.0	.015	36.5	.5	30.0	.2	0.0	.000
SEX	M	M	M	M	M	M	M	M	M	M	M	M
HEIGHT (CM)	59.5	.05	70.5	.2	21.5	.09	34.0	.4	24.5	.09	29.0	.3
WEIGHT (KG)	68.0	.1	90.0	.7	36.0	.7	28.5	.2	22.0	.06	31.0	.4
PROTEIN (G)	27.0	.001	97.0	.9	22.0	.1	7.0	.002	6.0	.002	.5	.000
FAT (G)	77.0	.2	60.0	.09	28.0	.3	20.0	.04	20.0	.04	1.0	.001
CARBOHYDRATE (G)	92.0	.5	65.0	.1	37.0	.8	30.0	.2	13.0	.009	9.0	.005
ENERGY INTAKE (KCAL)	55.5	.034	59.0	.08	29.0	.3	11.0	.006	4.0	.001	0.0	.000
ENERGY EXPENDITURE (KCAL)	58.0	.04	55.0	.06	31.0	.4	22.0	.06	2.0	.00	6.0	.002
CALCIUM (MG)	73.0	.2	79.0	.4	22.0	.1	26.0	.1	16.0	.02	10.0	.007
IRON (MG)	49.5	.02	83.5	.5	33.0	.5	19.5	.04	13.0	.009	7.5	.004
BODY MASS INDEX	100.0	.75	98.0	.97	29.0	.3	23.0	.07	33.0	.3	40.5	1.00
BASAL METABOLIC RATE	62.0	.06	77.5	.35	37.0	.8	28.0	.2	20.5	.045	18.0	.05
ENERGY EXPENDITURE /WEIGHT RATIO	89.0	.4	60.0	.09	25.0	.2	40.0	.7	9.0	.003	5.0	.002
ENERGY INTAKE /WEIGHT RATIO	106.0	.9	77.0	.3	35.0	.6	27.0	.1	25.0	.1	2.0	.001
ENERGY NEEDS	43.0	.009	51.0	.04	27.0	.2	12.0	.007	2.0	.000	0.0	.000
PROTEIN / WEIGHT RATIO	59.0	.05	98.0	.97	26.0	.2	11.0	.006	20.0	.04	0.0	.000
PROTEIN INTAKE PER 1000 KCAL	47.0	.01	67.0	.2	25.0	.2	16.0	.02	42.0	.8	38.0	.8
CALCIUM INTAKE PER 1000 KCAL	95.0	.6	87.0	.6	28.0	.3	44.0	.9	42.0	.8	38.0	.8
IRON INTAKE PER 1000 KCAL	73.0	.2	85.0	.5	38.0	.8	40.0	.7	44.0	.9	33.0	.5
ENERGY BALANCE	86.0	.6	76.0	.3	38.0	.8	35.0	.4	38.0	.6	21.0	.09
ENERGY REQUIREMENT	64.0	.08	63.0	.1	25.0	.2	22.0	.06	3.0	.001	5.0	.002

Variable List	9.1 Farmers >65 Yrs. N=5 U	P	1.2 H'wives Alone N=17 U	P	2.2 H'wives Family N=21 U	P	3.2 Sewing Workers N=20 U	P	4.2 Bakery Workers N=16 U	P
AGE	0.0	.003	3.0	.000	79.0	.5	36.0	.01	31.5	.02
SEX	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	15.0	.3	5.0	.000	11.0	.000	21.0	.001	16.0	.002
WEIGHT (KG)	17.0	.5	29.0	.01	30.0	.003	57.0	.1	29.0	.02
PROTEIN (G)	9.0	.07	1.0	.000	2.0	.000	2.0	.000	9.	.000
FAT (G)	8.0	.05	0.0	.000	6.0	.000	21.0	.001	33.0	.03
CARBOHYDRATE (G)	18.0	.6	7.0	.000	10.0	.000	18.0	.001	8.0	.000
ENERGY INTAKE (KCAL)	8.0	.05	0.0	.000	1.0	.000	4.0	.000	5.0	.000
ENERGY EXPENDITURE (KCAL)	17.0	.5	0.0	.000	6.0	.000	2.0	.000	18.0	.002
CALCIUM (MG)	20.0	.7	23.0	.004	23.0	.001	30.0	.005	25.0	.008
IRON (MG)	11.0	.1	5.0	.000	13.0	.000	13.0	.000	21.5	.004
BODY MASS INDEX	19.0	.6	65.0	.5	75.0	.4	71.0	.4	68.0	.8
BASAL METABOLIC RATE	20.5	.8	1.0	.000	1.0	.000	21.0	.001	9.5	.000
ENERGY EXPENDITURE /WEIGHT RATIO	11.0	.1	17.0	.001	42.0	.02	21.0	.001	47.0	.2
ENERGY INTAKE /WEIGHT RATIO	6.0	.03	19.0	.002	24.0	.001	27.0	.003	35.0	.04
ENERGY NEEDS	8.0	.05	0.0	.000	1.0	.000	2.0	.000	4.0	.001
PROTEIN / WEIGHT RATIO	6.0	.03	14.0	.001	6.0	.000	20.0	.001	31.0	.02
PROTEIN INTAKE PER 1000 KCAL	15.0	.3	56.0	.3	51.0	.05	50.0	.06	62.0	.6
CALCIUM INTAKE PER 1000 KCAL	14.0	.3	55.0	.3	89.0	.8	86.0	.9	68.0	.8
IRON INTAKE PER 1000 KCAL	18.0	.6	76.0	.98	91.0	.9	70.0	.4	71.0	.96
ENERGY BALANCE	14.0	.3	60.0	.4	58.0	.1	69.0	.3	48.0	.2
ENERGY REQUIREMENT	10.0	.1	9.0	.000	38.0	.01	17.0	.001	45.0	.1

TABLE 7: MANN-WHITNEY U AND P-VALUES
Building Workers compared to all other groups
Base group: BUILDING WORKERS (N=9)

Variable List	0.1 Light Industry N=24		1.1 Farmers N=22		2.1 Steel Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N=10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	14.0	.000	71.0	.2	13.0	.015	9.5	.004	25.0	.1	0.0	.000	0.0	.003	0.0	.000	23.0	.001	36.5	.1	59.0	.5
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	100.0	.75	36.0	.006	21.5	.09	14.0	.01	44.0	.9	34.5	.6	8.0	.05	17.0	.001	20.0	.001	39.0	.02	22.5	.005
WEIGHT (KG)	60.0	.05	99.0	1.0	36.0	.7	25.0	.1	19.0	.03	27.5	.3	17.0	.5	20.0	.002	22.0	.001	52.0	.07	27.0	.01
PROTEIN (G)	75.0	.2	58.0	.07	22.0	.1	20.0	.04	23.0	.07	7.0	.003	20.0	.7	5.0	.000	9.0	.000	12.0	.000	22.5	.005
FAT (G)	104.0	.9	37.0	.007	28.0	.3	32.0	.3	30.0	.2	6.0	.002	17.0	.5	10.0	.000	26.0	.002	45.0	.03	47.0	.2
CARBOHYDRATE (G)	85.0	.4	49.0	.03	37.0	.8	43.0	.9	10.0	.004	16.0	.03	20.0	.7	5.0	.000	13.0	.000	18.0	.001	16.0	.002
ENERGY INTAKE (KCAL)	96.0	.6	56.0	.06	29.0	.3	26.0	.1	12.0	.007	2.0	.001	11.0	.2	0.0	.000	5.0	.000	13.0	.000	14.0	.001
ENERGY EXPENDITURE (KCAL)	82.0	.3	32.0	.004	31.0	.4	30.0	.2	4.0	.001	10.0	.007	22.0	.95	0.0	.000	9.0	.000	9.0	.000	24.0	.007
CALCIUM (MG)	94.5	.6	43.0	.02	22.0	.1	37.5	.5	41.0	.7	22.0	.1	15.0	.4	45.0	.09	37.0	.009	46.0	.04	46.0	.1
IRON (MG)	76.5	.2	80.0	.4	33.0	.5	31.0	.3	22.0	.06	12.0	.01	16.0	.4	10.0	.000	12.0	.000	20.0	.001	26.0	.009
BODY MASS INDEX	55.0	.03	70.0	.2	29.0	.3	12.0	.007	19.0	.03	27.0	.2	16.0	.4	48.0	.1	49.0	.04	71.0	.4	47.0	.2
BASAL METABOLIC RATE	55.0	.03	83.0	.5	37.0	.8	24.5	.09	12.0	.007	12.5	.01	20.0	.7	0.0	.000	0.0	.000	16.0	.001	6.5	.000
ENERGY EXPENDITURE /WEIGHT RATIO	89.0	.4	47.0	.02	25.0	.2	32.0	.3	18.5	.03	17.0	.04	20.0	.7	32.0	.02	77.0	.4	40.0	.02	69.0	.9
ENERGY INTAKE /WEIGHT RATIO	87.0	.4	72.0	.2	35.0	.6	40.0	.7	35.0	.4	9.0	.005	12.0	.2	34.0	.02	45.0	.03	40.0	.02	47.0	.2
ENERGY NEEDS	79.0	.2	38.0	.008	27.0	.2	25.0	.1	5.0	.001	2.0	.001	18.0	.6	0.0	.000	5.0	.000	5.0	.000	13.0	.001
PROTEIN / WEIGHT RATIO	96.0	.6	68.0	.2	26.0	.2	35.0	.4	38.0	.6	14.0	.02	17.0	.5	40.0	.05	37.0	.009	44.0	.03	56.0	.4
PROTEIN INTAKE PER 1000 KCAL	91.0	.5	95.0	.9	25.0	.2	37.0	.5	29.0	.2	24.0	.2	9.0	.07	70.0	.7	85.0	.7	77.0	.5	60.0	.5
CALCIUM INTAKE PER 1000 KCAL	76.0	.2	55.0	.06	28.0	.3	28.0	.2	29.0	.2	28.0	.3	7.0	.04	29.0	.01	58.0	.1	62.0	.2	51.0	.2
IRON INTAKE PER 1000 KCAL	82.0	.3	86.0	.6	38.0	.8	44.0	.9	43.0	.9	36.0	.7	18.0	.6	72.0	.8	92.0	.9	78.0	.6	72.0	1.00
ENERGY BALANCE	88.0	.4	70.0	.2	38.0	.8	35.0	.4	36.0	.5	19.0	.06	15.0	.3	57.0	.3	52.0	.05	62.5	.2	41.0	.08
ENERGY REQUIREMENT	105.0	.9	39.0	.01	25.0	.2	43.0	.9	5.0	.001	17.0	.04	20.0	.7	30.0	.01	64.0	.2	37.0	.01	71.0	.95

TABLE 8: MANN-WHITNEY U AND P-VALUES
Light Industry compared to all other groups
Base group: LIGHT INDUSTRY (N=24)

Variable List	1.1 Farmers Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N =10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	113.5	.001	59.0	.05	14.0	.00	86.0	.2	43.0	.003	9.0	.000	3.5	.001	55.5	.000	194.0	.184	41.0	.000	47.5	.000
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F
HEIGHT (CM)	97.0	.000	59.5	.05	100.0	.75	43.5	.004	107.0	.6	100.5	.85	28.0	.07	64.0	.000	70.0	.000	130.5	.01	74.0	.001
WEIGHT (KG)	160.0	.02	68.0	.1	60.0	.05	112.0	.8	110.0	.7	96.0	.6	23.0	.03	134.0	.06	142.0	.012	237.5	.95	127.0	.07
PROTEIN (G)	71.0	.000	27.0	.001	75.0	.2	86.0	.2	97.5	.4	21.5	.001	53.5	.7	17.0	.000	30.0	.000	48.0	.000	83.0	.003
FAT (G)	99.5	.000	77.0	.2	104.0	.9	88.5	.2	86.0	.1	16.0	.000	43.0	.3	28.0	.000	61.5	.000	120.0	.005	125.0	.06
CARBOHYDRATE (G)	113.0	.004	92.0	.5	85.0	.4	98.0	.4	23.0	.000	27.0	.001	57.0	.9	4.0	.000	17.0	.000	40.0	.000	34.0	.000
ENERGY INTAKE (KCAL)	78.0	.000	55.5	.03	96.0	.6	78.0	.1	37.0	.002	6.0	.000	39.0	.2	4.0	.000	16.0	.000	40.0	.000	45.0	.000
ENERGY EXPENDITURE (KCAL)	41.0	.000	58.0	.04	82.0	.3	120.0	1.00	36.0	.002	43.0	.01	48.0	.5	14.0	.000	57.0	.000	67.0	.000	109.0	.02
CALCIUM (MG)	144.0	.008	73.0	.2	94.5	.6	113.0	.8	101.0	.5	45.0	.01	50.0	.6	92.0	.003	90.0	.000	11.5	.003	111.1	.03
IRON (MG)	93.5	.00	49.5	.02	76.5	.2	110.0	.7	90.0	.3	52.0	.02	59.5	.98	32.5	.000	54.0	.000	72.0	.000	96.0	.01
BODY MASS INDEX	238.5	.6	100.0	.8	55.0	.03	81.5	.2	107.0	.7	95.0	.6	44.0	.4	198.0	.9	242.0	.8	182.5	.2	182.0	.8
BASAL METABOLIC RATE	115.5	.001	62.0	.06	55.0	.03	109.0	.7	119.0	.97	79.5	.3	42.0	.3	30.0	.000	29.0	.000	113.5	.003	53.0	.000
ENERGY EXPENDITURE /WEIGHT RATIO	145.0	.009	89.0	.4	89.0	.4	110.0	.7	37.0	.002	32.0	.002	36.0	.2	64.0	.000	164.0	.045	85.0	.000	164.0	.4
ENERGY INTAKE /WEIGHT RATIO	198.0	.2	106.0	.94	87.0	.4	74.0	.08	60.0	.02	5.0	.000	16.0	.01	38.0	.000	63.0	.000	69.0	.000	87.0	.004
ENERGY NEEDS	53.0	.000	43.0	.009	79.0	.2	97.0	.4	27.0	.000	18.0	.000	57.0	.9	4.0	.000	24.0	.000	34.0	.000	63.0	.000
PROTEIN / WEIGHT RATIO	176.0	.08	59.0	.05	96.0	.6	72.0	.07	90.0	.3	17.0	.000	33.0	.1	84.0	.002	75.0	.000	101.0	.001	119.0	.04
PROTEIN INTAKE PER 1000 KCAL	213.0	.3	47.0	.01	91.0	.5	119.0	.97	58.0	.02	43.0	.01	13.0	.007	162.0	.3	219.0	.5	235.0	.9	143.0	.2
CALCIUM INTAKE PER 1000 KCAL	228.0	.7	95.0	.6	76.0	.2	99.0	.4	102.0	.5	88.0	.4	30.0	.08	123.0	.03	212.0	.4	203.0	.4	173.0	.6
IRON INTAKE PER 1000 KCAL	237.0	.6	73.0	.2	82.0	.3	91.0	.3	92.0	.3	68.0	.1	30.0	.08	149.0	.2	206.0	.3	229.0	.8	150.0	.3
ENERGY BALANCE	154.0	.02	96.0	.6	88.0	.4	66.0	.041	105.0	.6	36.0	.004	35.0	.2	167.0	.3	112.5	.002	154.0	.04	91.0	.005
ENERGY REQUIREMENT	90.0	.000	64.0	.08	105.0	.9	118.0	.9	29.0	.001	49.0	.02	59.0	.95	79.0	.001	185.0	.1	124.0	.006	189.0	.9

TABLE 9: MANN-WHITNEY U AND P-VALUES
Executives compared to all other groups
Base group: EXECUTIVES (N=10)

	0.1 Light Industry N=24		1.1 Farmers Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		7.1 Clerical Workers N=10		8.1 Retired Men N=9		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
Variable List	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	86.0	.2	66.0	.07	36.5	.5	9.5	.004	29.0	.1	0.0	.000	0.0	.002	4.5	.000	101.5	.9	31.0	.002	30.0	.008
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	43.5	.004	106.0	.87	34.0	.4	14.0	.01	14.1	.006	24.0	.09	20.5	.6	0.0	.000	6.0	.000	13.5	.000	14.0	.001
WEIGHT (KG)	112.0	.8	58.5	.03	28.5	.2	25.0	.1	48.0	.9	39.0	.6	10.0	.07	56.0	.15	57.0	.04	97.0	.9	55.0	.2
PROTEIN (G)	86.0	.2	18.0	.000	7.0	.002	20.0	.04	45.0	.7	23.0	.07	14.0	.2	22.5	.002	28.0	.001	45.5	.02	61.0	.32
FAT (G)	88.5	.2	22.0	.000	20.0	.04	32.0	.3	47.5	.9	10.5	.005	25.0	1.000	18.0	.001	37.5	.004	68.0	.2	70.0	.6
CARBOHYDRATE (G)	98.0	.4	26.0	.001	30.0	.2	43.0	.9	24.0	.05	2.5	.055	21.0	.6	18.0	.001	23.0	.001	35.0	.004	24.0	.003
ENERGY INTAKE (KCAL)	78.0	.1	19.0	.000	11.0	.006	26.0	.1	31.0	.2	12.0	.007	24.0	.9	18.0	.001	23.5	.001	42.0	.01	39.0	.03
ENERGY EXPENDITURE (KCAL)	120.0	1.00	10.0	.000	22.0	.06	30.0	.2	10.0	.003	17.0	.02	17.0	.3	2.0	.000	22.0	.001	21.0	.001	43.0	.05
CALCIUM (MG)	113.0	.8	51.0	.016	26.0	.1	37.5	.5	45.0	.71	21.0	.05	22.0	.7	44.0	.04	45.0	.01	55.0	.05	50.0	.1
IRON (MG)	110.0	.7	38.0	.003	19.5	.04	31.0	.3	39.0	.4	23.0	.07	22.0	.7	17.5	.001	29.0	.001	38.0	.006	48.0	.09
BODY MASS INDEX	81.5	.1	60.0	.04	23.0	.07	12.0	.007	37.0	.3	25.0	.1	9.0	.05	57.0	.2	78.0	.3	38.5	.007	53.0	.2
BASAL METABOLIC RATE	109.0	.7	52.5	.02	28.0	.2	24.5	.09	43.0	.6	28.5	.2	16.5	.3	11.0	.000	10.5	.000	43.5	.01	19.0	.001
ENERGY EXPENDITURE /WEIGHT RATIO	110.0	.7	57.0	.03	40.0	.7	32.0	.3	12.0	.004	7.0	.002	12.0	.1	15.0	.000	59.0	.05	23.0	.001	59.0	.27
ENERGY INTAKE /WEIGHT RATIO	74.0	.08	55.0	.03	27.0	.1	40.0	.7	41.0	.5	8.0	.003	15.0	.2	36.0	.1	45.0	.01	46.0	.02	56.0	.2
ENERGY NEEDS	97.0	.4	11.0	.000	12.0	.007	25.0	.1	18.0	.02	12.0	.007	21.0	.6	4.0	.000	18.0	.000	23.0	.001	37.0	.02
PROTEIN / WEIGHT RATIO	72.0	.07	46.0	.001	11.0	.006	35.0	.4	42.0	.55	12.0	.007	25.0	1.00	53.0	.1	52.0	.03	55.0	.05	70.0	.6
PROTEIN INTAKE PER 1000 KCAL	119.0	.97	88.0	.37	16.0	.02	37.0	.5	28.0	.096	17.0	.02	5.0	.01	65.0	.3	98.0	.8	99.0	.96	54.0	.2
CALCIUM INTAKE PER 1000 KCAL	99.0	.4	97.0	.60	44.0	.9	28.0	.2	43.0	.6	42.0	.8	14.0	.2	58.0	.2	94.0	.6	97.0	.9	76.0	.8
IRON INTAKE PER 1000 KCAL	91.0	.3	93.0	.49	40.0	.7	44.0	.9	49.0	.94	36.0	.5	20.0	.5	84.0	.96	94.0	.6	73.0	.2	79.0	.96
ENERGY BALANCE	66.0	.04	92.0	.46	35.0	.4	35.0	.4	21.0	.03	25.0	.1	22.0	.7	60.0	.2	77.0	.24	97.0	.9	56.0	.21
ENERGY REQUIREMENT	118.0	.94	29.0	.001	22.0	.06	43.0	.9	7.0	.001	17.0	.02	24.0	.9	24.0	.002	80.0	.3	37.0	.006	77.0	.9

TABLE 10: MANN-WHITNEY U AND P-VALUES
Clerical Workers compared to all other groups
Base group: CLERICAL WORKERS (N=10)

Variable List	0.1 Light Industry N=24 U	P	1.1 Farmers N=22 U	P	2.1 Steel Workers N=9 U	P	3.1 Buiding Workers N=9 U	P	6.1 Executives N=10 U	P	8.1 Retired Men N=9 U	P	9.1 Farmers >65 Yrs. N=5 U	P	1.2 H'wives Alone N=17 U	P	2.2 H'wives Family N=21 U	P	3.2 Sewing Workers N=20 U	P	4.2 Bakery Workers N=16 U	P
AGE	43.0	.003	101.0	.7	30.0	.2	25.0	.1	29.0	.1	.5	.000	0.0	.002	4.0	.000	62.0	.07	73.5	.2	55.5	.2
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	107.0	.6	33.0	.002	24.5	.09	44.0	.9	14.1	.006	40.0	.7	10.0	.07	14.0	.000	20.0	.000	42.5	.01	27.0	.005
WEIGHT (KG)	110.0	.7	51.0	.02	22.0	.06	19.0	.03	48.0	.9	37.0	.5	5.0	.01	59.0	.2	64.0	.08	90.0	.7	55.0	.2
PROTEIN (G)	97.5	.4	18.0	.000	6.0	.002	23.0	.07	45.0	.7	16.5	.02	17.0	.3	19.0	.001	25.0	.001	38.0	.006	51.0	.1
FAT (G)	86.0	.1	22.0	.000	20.0	.04	30.0	.2	47.5	.9	6.0	.002	19.0	.5	10.0	.000	29.0	.001	63.0	.1	68.0	.5
CARBOHYDRATE (G)	23.0	.000	6.0	.000	13.0	.009	10.0	.004	24.0	.05	39.0	.7	17.0	.3	46.0	.05	64.0	.08	76.5	.3	49.0	.1
ENERGY INTAKE (KCAL)	37.0	.002	11.0	.000	4.0	.001	12.0	.007	31.0	.2	17.0	.02	17.0	.3	16.0	.001	29.0	.001	55.0	.05	60.0	.3
ENERGY EXPENDITURE (KCAL)	36.0	.002	0.0	.000	2.0	.000	4.0	.001	10.0	.003	35.0	.4	2.0	.005	34.0	.01	104.0	.97	89.0	.7	55.0	.2
CALCIUM (MG)	101.0	.5	34.5	.002	16.0	.02	41.0	.7	45.0	.71	32.0	.3	16.0	.3	63.0	.3	58.0	.05	68.0	.2	62.0	.3
IRON (MG)	90.0	.3	27.5	.001	13.0	.009	22.0	.06	39.0	.4	34.5	.4	17.0	.3	33.5	.01	49.0	.02	61.5	.09	65.0	.4
BODY MASS INDEX	107.0	.7	83.0	.3	33.0	.3	19.0	.03	37.0	.3	34.0	.4	13.0	.1	76.0	.7	100.0	.8	58.0	.07	70.0	.6
BASAL METABOLIC RATE	119.0	.97	29.5	.001	20.5	.045	12.0	.007	43.0	.6	38.0	.6	13.0	.1	8.5	.000	7.0	.000	47.0	.02	21.0	.002
ENERGY EXPENDITURE /WEIGHT RATIO	37.0	.002	18.0	.002	9.0	.003	18.5	.03	12.0	.004	92.0	.9	11.0	.09	76.0	.7	62.0	.07	100.0	1.000	35.0	.02
ENERGY INTAKE /WEIGHT RATIO	60.0	.02	52.0	.02	25.0	.1	35.0	.4	41.0	.5	17.0	.02	19.0	.5	53.0	.1	66.0	.1	60.0	.08	71.0	.6
ENERGY NEEDS	27.0	.000	2.0	.000	2.0	.000	5.0	.001	18.0	.02	31.0	.3	7.0	.03	19.0	.001	50.0	.02	66.0	.1	78.0	.9
PROTEIN / WEIGHT RATIO	90.0	.3	60.0	.04	20.0	.04	38.0	.6	42.0	.55	13.0	.009	20.0	.5	47.0	.06	42.0	.008	51.0	.03	62.0	.3
PROTEIN INTAKE PER 1000 KCAL	58.0	.02	77.0	.2	42.0	.8	29.0	.2	28.0	.096	39.0	.6	15.0	.2	59.0	.2	68.0	.1	63.0	.1	71.0	.6
CALCIUM INTAKE PER 1000 KCAL	102.0	.5	108.0	.9	42.0	.8	29.0	.2	43.0	.6	44.0	.9	18.0	.4	67.0	.4	104.0	.97	83.0	.5	68.0	.5
IRON INTAKE PER 1000 KCAL	92.0	.3	101.0	.7	44.0	.9	43.0	.9	49.0	.94	40.0	.7	23.0	.8	80.0	.8	101.0	.9	88.0	.6	79.0	.96
ENERGY BALANCE	105.0	.6	50.0	.01	38.0	.6	36.0	.5	21.0	.03	10.0	.004	11.0	.09	48.0	.06	28.0	.001	50.5	.03	29.0	.008
ENERGY REQUIREMENT	29.0	.001	4.0	.000	3.0	.001	5.0	.001	7.0	.001	25.0	.1	3.0	.007	54.0	.1	37.0	.004	43.0	.01	11.0	.000

TABLE 11: MANN-WHITNEY U AND P-VALUES
Retired Men compared to all other groups
Base group: RETIRED MEN (N=9).

	0.1 Light Industry N=24		1.1 Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=10		7.1 Clerical Workers N=10		9.1 Farmers >65 Yrs. N=5		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
Variable List	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**	**U**	**P**
AGE	9.0	.000	0.0	.000	0.0	.000	0.0	.000	0.0	.000	.5	.000	21.0	.8	30.5	.01	5.0	.000	0.0	.000	0.0	.000
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	100.5	.85	49.0	.03	29.0	.3	34.5	.6	24.0	.09	40.0	.7	8.0	.05	30.0	.01	38.5	.01	50.0	.06	31.5	.02
WEIGHT (KG)	96.0	.6	66.0	.2	31.0	.4	27.5	.3	39.0	.6	37.0	.5	10.0	.1	41.0	.06	45.5	.03	81.0	.7	43.0	.1
PROTEIN (G)	21.5	.001	0.0	.000	.5	.000	7.0	.003	23.0	.07	16.5	.02	2.0	.006	45.0	.09	58.0	.1	72.0	.4	59.0	.5
FAT (G)	16.0	.000	2.0	.000	1.0	.001	6.0	.002	10.5	.005	6.0	.002	7.0	.04	67.0	.6	73.0	.3	40.0	.02	40.0	.07
CARBOHYDRATE (G)	27.0	.001	7.0	.000	9.0	.005	16.0	.03	2.5	.055	39.0	.7	12.0	.2	54.0	.2	63.0	.2	78.0	.6	58.5	.4
ENERGY INTAKE (KCAL)	6.0	.000	3.0	.000	0.0	.000	2.0	.001	12.0	.007	17.0	.02	6.0	.03	62.0	.4	78.0	.5	79.5	.6	59.0	.5
ENERGY EXPENDITURE (KCAL)	43.0	.01	2.0	.000	6.0	.002	10.0	.007	17.0	.02	35.0	.4	6.0	.03	31.0	.01	75.0	.4	78.0	.6	62.0	.6
CALCIUM (MG)	45.0	.01	15.0	.000	10.0	.007	22.0	.1	21.0	.05	32.0	.3	7.0	.04	69.0	.7	78.0	.5	86.0	.9	61.0	.5
IRON (MG)	52.0	.02	17.0	.000	7.5	.004	12.0	.01	23.0	.07	34.5	.4	10.5	.1	49.5	.2	73.0	.3	85.5	.8	61.0	.5
BODY MASS INDEX	95.0	.6	98.0	.97	40.5	1.000	27.0	.2	25.0	.1	34.0	.4	20.0	.7	70.5	.8	78.0	.5	80.0	.7	68.5	.8
BASAL METABOLIC RATE	79.5	.3	32.0	.003	18.0	.05	12.5	.01	28.5	.2	38.0	.6	11.0	.1	20.5	.003	28.5	.003	64.0	.2	29.5	.02
ENERGY EXPENDITURE /WEIGHT RATIO	32.0	.002	18.0	.000	5.0	.002	17.0	.04	7.0	.002	92.0	.9	8.0	.05	72.0	.8	53.0	.06	79.0	.6	27.0	.01
ENERGY INTAKE /WEIGHT RATIO	5.0	.000	21.0	.001	2.0	.001	9.0	.005	8.0	.003	17.0	.02	12.0	.2	52.0	.2	72.0	.3	70.0	.3	37.0	.05
ENERGY NEEDS	18.0	.000	1.0	.000	0.0	.000	2.0	.001	12.0	.007	31.0	.3	5.0	.02	40.0	.05	67.0	.2	84.0	.8	59.0	.5
PROTEIN / WEIGHT RATIO	17.0	.000	17.0	.000	0.0	.000	14.0	.02	12.0	.007	13.0	.009	7.0	.04	72.0	.8	89.0	.8	85.0	.8	53.0	.3
PROTEIN INTAKE PER 1000 KCAL	43.0	.01	66.0	.2	38.0	.8	24.0	.2	17.0	.02	39.0	.6	19.0	.6	53.0	.2	56.0	.08	48.0	.05	59.0	.5
CALCIUM INTAKE PER 1000 KCAL	88.0	.4	93.0	.8	38.0	.8	28.0	.3	42.0	.8	44.0	.9	15.0	.3	59.0	.4	92.0	.9	85.0	.8	64.0	.7
IRON INTAKE PER 1000 KCAL	68.0	.1	77.0	.3	33.0	.5	36.0	.7	36.0	.5	40.0	.7	22.0	.95	61.0	.4	77.0	.4	65.0	.2	59.0	.5
ENERGY BALANCE	36.0	.004	98.0	.95	21.0	.09	19.0	.06	25.0	.1	10.0	.004	20.0	.7	27.0	.008	93.0	.9	69.0	.3	62.0	.6
ENERGY REQUIREMENT	49.0	.02	7.0	.000	5.0	.002	17.0	.04	17.0	.02	25.0	.1	6.0	.03	68.0	.7	60.0	.1	88.0	.9	22.0	.005

TABLE 12: MANN-WHITNEY U AND P-VALUES
Farmers >65 Yrs. compared to all other groups
Base group: FARMERS >65 YRS. (N=5)

	0.1 Light Industry N=24		1.1 Farmers N=22		2.1 Steel Workers N=9		3.1 Building Workers N=9		6.1 Execu-tives N=9		7.1 Clerical Workers N=10		8.1 Retired Men N=9		1.2 H'wives Alone N=17		2.2 H'wives Family N=21		3.2 Sewing Workers N=20		4.2 Bakery Workers N=16	
Variable List	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P	U	P
AGE	3.5	.001	0.0	.001	0.0	.003	0.0	.003	0.0	.002	0.0	.002	21.0	.8	5.5	.004	0.0	.001	0.0	.001	0.0	.001
SEX	M	M	M	M	M	M	M	M	M	M	M	M	M	M	F	F	F	F	F	F	F	F
HEIGHT (CM)	28.0	.07	48.0	.7	15.0	.3	8.0	.05	20.5	.6	10.0	.07	8.0	.05	5.0	.003	4.0	.002	12.0	.01	7.0	.006
WEIGHT (KG)	23.0	.03	48.0	.6	17.0	.5	17.0	.5	10.0	.07	5.0	.01	10.0	.1	8.5	.008	6.0	.003	22.0	.06	14.0	.03
PROTEIN (G)	53.5	.7	25.0	.06	9.0	.07	20.0	.7	14.0	.2	17.0	.3	2.0	.006	1.0	.001	3.0	.001	7.0	.004	13.0	.03
FAT (G)	43.0	.3	14.0	.01	8.0	.05	17.0	.5	25.0	1.00	19.0	.5	7.0	.04	11.0	.01	21.0	.04	34.0	.3	38.0	.9
CARBOHYDRATE (G)	57.0	.9	21.0	.03	18.0	.6	20.0	.7	21.0	.6	17.0	.3	12.0	.2	16.0	.04	20.0	.03	24.0	.08	17.0	.06
ENERGY INTAKE (KCAL)	39.0	.2	15.0	.01	8.0	.05	11.0	.2	24.0	.9	17.0	.3	6.0	.03	5.0	.003	10.0	.006	20.0	.04	20.5	.1
ENERGY EXPENDITURE (KCAL)	48.0	.5	18.0	.02	17.0	.5	22.0	.95	17.0	.3	2.0	.005	6.0	.03	0.0	.001	7.0	.003	7.0	.003	14.0	.03
CALCIUM (MG)	50.0	.6	43.0	.6	20.0	.7	15.0	.4	22.0	.7	16.0	.3	7.0	.04	14.0	.03	14.0	.01	20.0	.04	19.0	.08
IRON (MG)	58.5	.98	22.0	.04	11.0	.1	16.0	.4	22.0	.7	17.0	.3	10.5	.1	9.0	.009	8.0	.004	16.5	.02	18.5	.08
BODY MASS INDEX	44.0	.4	54.0	.95	19.0	.6	16.0	.4	9.0	.05	13.0	.1	20.0	.7	37.0	.7	36.0	.3	42.0	.6	34.0	.6
BASAL METABOLIC RATE	42.0	.3	41.0	.4	20.5	.8	20.0	.7	16.5	.3	13.0	.1	11.0	.1	1.0	.001	1.0	.001	12.5	.01	5.0	.004
ENERGY EXPENDITURE /WEIGHT RATIO	36.0	.2	17.0	.02	11.0	.1	20.0	.7	12.0	.1	11.0	.09	8.0	.05	16.0	.04	52.0	.97	21.0	.05	32.0	.5
ENERGY INTAKE /WEIGHT RATIO	16.0	.01	19.0	.02	6.0	.03	12.0	.2	15.0	.2	19.0	.5	12.0	.2	39.0	.8	45.0	.6	40.0	.5	40.0	1.00
ENERGY NEEDS	57.0	.9	8.0	.003	8.0	.05	18.0	.6	21.0	.6	7.0	.03	5.0	.02	0.0	.001	6.0	.003	7.0	.004	15.0	.04
PROTEIN / WEIGHT RATIO	33.0	.1	23.0	.05	6.0	.03	17.0	.5	25.0	1.00	20.0	.5	7.0	.04	28.0	.3	27.0	.1	29.0	.2	34.0	.6
PROTEIN INTAKE PER 1000 KCAL	13.0	.007	24.0	.05	15.0	.3	9.0	.07	5.0	.01	15.0	.2	19.0	.6	22.0	.1	20.0	.03	21.0	.05	25.0	.2
CALCIUM INTAKE PER 1000 KCAL	30.0	.08	41.0	.4	14.0	.3	7.0	.04	14.0	.2	18.0	.4	15.0	.3	41.0	.9	36.0	.3	28.0	.2	24.0	.2
IRON INTAKE PER 1000 KCAL	30.0	.08	39.0	.3	18.0	.6	18.0	.6	20.0	.5	23.0	.8	22.0	.95	34.0	.5	43.0	.5	29.0	.2	33.0	.6
ENERGY BALANCE	35.0	.2	52.0	.9	14.0	.3	15.0	.3	22.0	.7	11.0	.09	20.0	.7	27.0	.2	50.5	.9	41.5	.6	40.0	1.00
ENERGY REQUIREMENT	59.0	.95	20.0	.03	10.0	.1	20.0	.7	24.0	.9	3.0	.007	6.0	.035	9.0	.009	31.0	.2	15.0	.02	38.0	.9

APPENDIX III

BMR (FAO/WHO/UNU, 1985) and factors for total energy expenditure and total energy intake derived from them for each individual

APPENDIX III

Table 1: Individual basal metabolic rate calculated from prediction equations (FAO/WHO/UNU, 1985) ("UNU") and factors for total energy expenditure and total energy intake derived from them.

Study No.* Subject No.	"UNU" BMR	"UNU" energy intake factor	"UNU" energy expenditure factor
01001	1448	1.79	1.93
01002	1284	2.21	2.33
01003	1601	1.96	2.07
01004	1537	1.74	1.84
01005	1462	1.72	1.84
01006	1653	1.78	1.86
01007	1595	1.55	1.68
01008	1894	1.57	1.66
01009	1842	1.82	1.91
01010	1642	1.90	2.26
01011	1558	1.42	1.40
01012	1648	1.64	1.77
01013	1732	1.87	1.64
01014	1705	1.77	1.65
01015	1369	2.31	2.05
01016	1685	1.67	1.42
01017	1650	2.22	2.09
01018	1705	1.98	1.73
01019	1385	2.29	2.07
01020	1301	2.04	1.73
01021	1397	1.91	1.57
01022	1263	2.31	2.07
01023	1382	2.20	1.99
01024	1573	1.64	1.44
11001	1712	2.05	1.88
11002	1606	2.15	2.17
11003	1660	1.98	2.10
11004	1617	2.21	2.69
11005	1664	2.53	2.81
11006	2107	1.84	1.96
11007	1770	2.04	2.10
11008	1813	1.87	2.09
11009	1823	2.32	2.24
11010	1828	1.82	1.86
11011	1981	1.94	2.18
11012	1712	2.10	2.56
11013	1776	1.91	2.26
11014	1807	1.93	2.25
11015	1801	2.11	1.84
11016	2046	1.38	1.83
11017	1596	2.19	1.89
11018	1606	2.50	2.11
11019	1647	1.33	1.88
11020	1543	2.07	2.36
11021	1776	1.46	1.70
11022	1612	2.11	2.03

*Light industry (0.1) and farmers (1.1)

APPENDIX III

Table 2: Individual basal metabolic rate calculated from prediction equations (FAO/WHO/UNU, 1985) ("UNU") and factors for total energy expenditure and total energy intake derived from them.

Study No.* Subject No.	"UNU" BMR	"UNU" energy intake factor	"UNU" energy expenditure factor
21001	1313	2.08	1.98
21002	1684	1.80	1.95
21003	1747	1.68	2.20
21004	1824	1.82	1.65
21005	1638	1.95	1.86
21006	2046	1.77	1.81
21007	1928	1.56	2.05
21008	1662	2.03	1.56
21009	1517	2.50	2.25
31001	1906	1.22	1.74
31002	1772	1.79	1.93
31003	1836	1.58	1.80
31004	1772	2.27	1.59
31005	1656	2.36	2.25
31006	1616	1.64	1.51
31007	1679	1.85	1.79
31008	1778	1.61	1.57
31009	1836	1.49	1.44
61001	1775	1.59	1.66
61002	1560	2.06	2.10
61003	1714	1.75	1.90
61004	1370	1.93	2.06
61005	1554	1.62	1.76
61006	1536	2.00	1.99
61007	1520	1.16	1.86
61008	1551	1.82	1.68
61009	1532	1.69	1.57
61010	1572	1.35	1.49
71001	1662	1.26	1.26
71002	1575	1.98	1.46
71003	1819	1.20	1.28
71004	1662	1.64	1.47
71005	1793	1.31	1.31
71006	1645	1.35	1.23
71007	1581	1.40	1.35
71008	1575	1.64	1.49
71009	1540	1.55	1.81
71010	1405	1.83	2.07
81001	1205	1.43	1.79
81002	1344	1.50	1.61
81003	1516	1.41	1.56
81004	1432	1.78	1.79
81005	1564	1.18	1.96

*Steel workers (2.1), Building workers (3.1), executives (6.1), clerical workers (7.1), retired men (8.1), and farmers over 65 years (9.1).

APPENDIX III

Table 2 (Continued): Individual basal metabolic rate calculated from prediction equations (FAO/WHO/UNU, 1985) ("UNU") and factors for total energy expenditure and total energy intake derived from them.

Study No.* Subject No.	"UNU" BMR	"UNU" energy intake factor	"UNU" energy expenditure factor
81006	1531	1.49	1.67
81007	1396	1.05	1.26
81008	1614	1.55	1.74
81009	1289	1.52	1.60
91001	1610	1.77	2.11
91002	1451	1.61	1.73
91003	1567	2.19	2.01
91004	1444	1.76	1.82
91005	1666	1.34	2.07

*Steel workers (2.1), Building workers (3.1), executives (6.1), clerical workers (7.1), retired men (8.1), and farmers over 65 years (9.1).

APPENDIX III

Table 3: Individual basal metabolic rate calculated from prediction equations (FAO/WHO/UNU, 1985) ("UNU") and factors for total energy expenditure and total energy intake derived from them.

Study No.* Subject No.	"UNU" BMR	"UNU" energy intake factor	"UNU" energy expenditure factor
12001	1292	1.15	1.20
12002	1347	1.51	1.51
12003	1129	1.78	1.71
12004	1158	1.56	1.66
12005	1129	1.98	2.13
12006	1339	1.73	1.67
12007	1386	1.23	1.27
12008	1034	1.08	1.53
12009	1296	1.70	1.71
12010	1229	1.87	1.85
12011	1111	1.62	1.70
12012	1191	1.74	1.65
12013	1395	1.31	1.57
12014	1436	1.47	1.40
12015	1210	1.76	1.65
12016	1031	1.51	1.45
12017	1239	1.55	1.69
22001	1306	1.10	1.67
22002	1299	1.02	1.88
22003	1416	1.32	1.84
22004	1381	1.15	1.61
22005	1508	1.72	1.78
22006	1392	1.47	1.71
22007	1425	1.47	1.75
22008	1258	1.49	1.69
22009	1249	1.90	1.92
22010	1326	1.66	1.79
22011	1116	1.32	1.83
22012	1260	1.38	1.68
22013	1284	1.52	1.42
22014	1394	1.99	2.10
22015	1163	1.63	1.72
22016	1235	1.88	1.59
22017	1284	1.61	1.64
22018	1378	1.51	1.85
22019	1409	1.40	1.54
22020	1339	0.99	1.51
22021	1192	1.43	1.51

*Housewives alone (1.2), housewives with family (2.2).

APPENDIX III

Table 4: Individual basal metabolic rate calculated from prediction equations (FAO/WHO/UNU, 1985) ("UNU") and factors for total energy expenditure and total energy intake derived from them.

Study No.* Subject No.	"UNU" BMR	"UNU" energy intake factor	"UNU" energy expenditure factor
32001	1353	1.49	1.49
32002	1547	1.27	1.50
32003	1437	1.24	1.52
32004	1204	2.20	2.14
32005	1350	1.77	1.51
32006	1349	1.68	1.88
32007	1442	1.59	1.63
32008	1589	1.41	1.51
32009	1362	1.42	1.49
32010	1428	1.55	1.57
32011	1579	0.51	1.58
32012	1341	1.47	1.60
32013	3341	1.64	1.87
32014	1385	1.11	1.78
32015	1466	1.46	1.54
32016	1449	1.29	1.60
32017	1294	2.22	1.56
32018	1460	1.69	1.48
32019	1623	1.84	1.84
32020	1419	1.28	1.65
42001	1326	1.36	1.66
42002	1216	1.19	1.63
42003	1278	1.68	1.65
42004	1271	1.35	1.57
42005	1408	1.69	1.70
42006	1314	2.39	1.76
42007	1255	2.16	1.86
42008	1600	1.78	2.09
42009	1329	1.82	2.55
42010	1388	1.70	2.07
42011	1373	1.08	1.58
42012	1489	1.21	1.76
42013	1308	1.74	1.84
42014	1607	1.38	1.86
42015	1481	1.56	1.78
42016	1384	1.63	1.74

*Sewing workers (3.2), bakery workers (4.2).

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