THE CALORIE INTAKE OF

THE

BRITISH SOLDIER

BY

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FOREWORD.

The transition of an army from a war time to a peace time footing is always a difficult period. During the war years the Armed Forces received generous ration scales, which compared favourably with those eaten by civilians. When "Peace" arrived in 1945, however, the Army ration scales were ruthlessly cut by the Treasury and the Ministry of Food. By 1947 it had become apparent to Brigadier Richmond C.B.E. K.H.S., Director of Hygiene, the Army, that the ration scales issued were quite insufficient to satisfy the needs of the soldier.

The Ministry of Food, however, would not accept this opinion of the medical branch and claimed that they had equated the ration of the soldier with that of the average civilian. To prove the injustice of this state of affairs, which placed a large, and inequitable, strain on the slender resources of the soldier, an investigation was instigated.

For this purpose the Medical Research Staff Team (Nutrition) was formed in Spetember 1947. The personel on this team were one Major R.A.M.C. (specialist in physiology in command); one sgt., R.A.F, and four N.C.O.s. from the R.A.M.C. In addition other officers, N.C.O.s

and/

and men were temporarily attached to the team in each Command as required.

Whilst the primary task of the team was to find the answer to a practical problem, every effort was made to obtain the maximum amount of scientific data at the same time. Mention must be made of the assistance given the team in analysing foods of unknown constitution, by the Royal Army Medical College, Millbank.

Not all of the work was considered suitable for publication, but the bulk of the facts discovered are presented herein.

This work could not have been completed through the normal official channels. A 'carte blanche', was given to the team by Brigadier Richmond and the G.O.s.C. of the various Commands. To them therefore is due much of the credit for this work.

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PART I

CALORIE REQUIREMENTS AND AVAILABILITY

Before embarking on a detailed study of the diet of individuals or groups in the army, it is well to review briefly the situation in Britain as a whole.

In assessing the state of food supplies in any country two postulates are fundamental; namely, the total requirement of the population, and the total food available to that population.

These two factors will first be considered in relation to the civil and military populations of Britain, and then, in relation to one another.

A. RELATIVE CALORIE REQUIREMENT OF CIVIL AND MILITARY POPULATION.

It has long been felt, by Army Medical Departments, that the attempt to equate the daily ration of the soldier with that of the "average" civilian (i.e. of all ages and both sexes) is invidious and invalid. In view of this a conversion factor has been sought which, when applied to the overall civilian average daily Calorie requirement level, will express the overall military requirement per head calculated on a similar basis.

Cathcart and Murray (1931), The National Research Council (1943), and other workers, have, from time to time, produced a table of "man-values", expressing the average Calorie requirement of women, and children of various ages, in terms of an arbitrary standard requirement for the adult male.

Thus if the daily Calorie requirement of the average adult male is expressed as unity, then the requirement of women, children and old persons can be expressed as a fraction of this figure e.g.:

Daily Calorie Requirement of Adult Woman = 0.83 x Adult Male Requirement
" " " " 6 yr old boy = 0.53 x " " "
" " " " 16 " " " = 1.27 x " " "

(National Research Council 1943).

Thus where the average adult male intake is "M" Cals., the average adult female should, if distribution is equitable, and on a physiological basis, receive (M x 0.83) Cals. daily.

This principle has been adapted here, but the basic unit has been taken as the average daily Calorie requirement per head of population, and the needs of each sex, at all ages, expressed in terms of this figure.

Statistical Basis.

The Calorie intake for the total civilian population is usually expressed (M.O.F. 1945, etc.) as a single figure, representing the overall mean daily intake. This mean figure embraces, at lower end of the requirement scale, the very young and very old, and at the upper, the young workers and adolescents, representing a widely divergent range (roughly 1,000 - 4,500 Cals.)

Females, in all age groups, require much less than comparable males; this difference becoming very marked when once the age of fourteen is passed. (Widdowson 1947).

Since Calorie requirements vary so greatly from age group to age group, and between the male and female sex, a valid comparison of requirements of any two populations must take into account the age and sex structure of each of the two populations under review.

To obtain the mean requirement of any given population two series of facts must be taken:-

(a) A standard table of Calorie requirements, by ages and sex.

(b) The age and sex composition of the population.

A weighted average may then be computed as follows -

If the Calorie requirements of male civilians at the ages 1, 2, 3, 4 ...... n, are C_1, C_2, C_3, C_4 ...... C_n; and if the numerical strengths of the corresponding age groups are S_1, S_2, S_3, S_4 ..... S_n, then the overall male requirement will be :

$$(C_1 \times S_1) + (C_2 \times S_2) + (C_3 \times S_3) + (C_4 \times S_4) \; ..... + (C_n \times S_n) = CM.$$

Similarily the total female daily requirement would be C.F; the overall total daily requirement (CM + CF); and the overall average daily requirement $\frac{(CM + CF)}{(SM + SF)}$; where SM and SF are the total male and female populations respectively.

Let $\frac{CM + CF}{SM + SF}$ = A. (Average Cal. requirement per head of population.)

In a similar fashion, the weighted average requirement (A_1), of any other population can be computed by applying the same Calorie requirement tables, to the differing age and sex composition of the second population.

Thus the mean requirement of the second population may be expressed, in terms of the first population, as $\frac{A_1}{A}$.

This ratio, known as the Physiological Correction Factor (or P.C.F.) is now in use in Army Dietetics, for all comparisons of populations. Thus when the per head allocation of Calories to a standard population is decided, the equivalent figure for a population of differing age and sex distribution, based on physiological considerations, can readily be obtained by multiplying the standard figure by the appropriate P.C.F.

Practical Application.

The mean overall civilian requirement standard (i.e. A) has been calculated from the following data (see table I):

Population, age and sex distribution:

Return of Registrar General 1947 (June).

Calorie Requirement of Various Age and Sex Groups.

The table of Holt and Fales (1921) for ages 1 - 65, modified by the factor of Cathcart and Murray (1933) for those over 65 years of age (i.e. 0.75 x Adult Value).

TABLE I

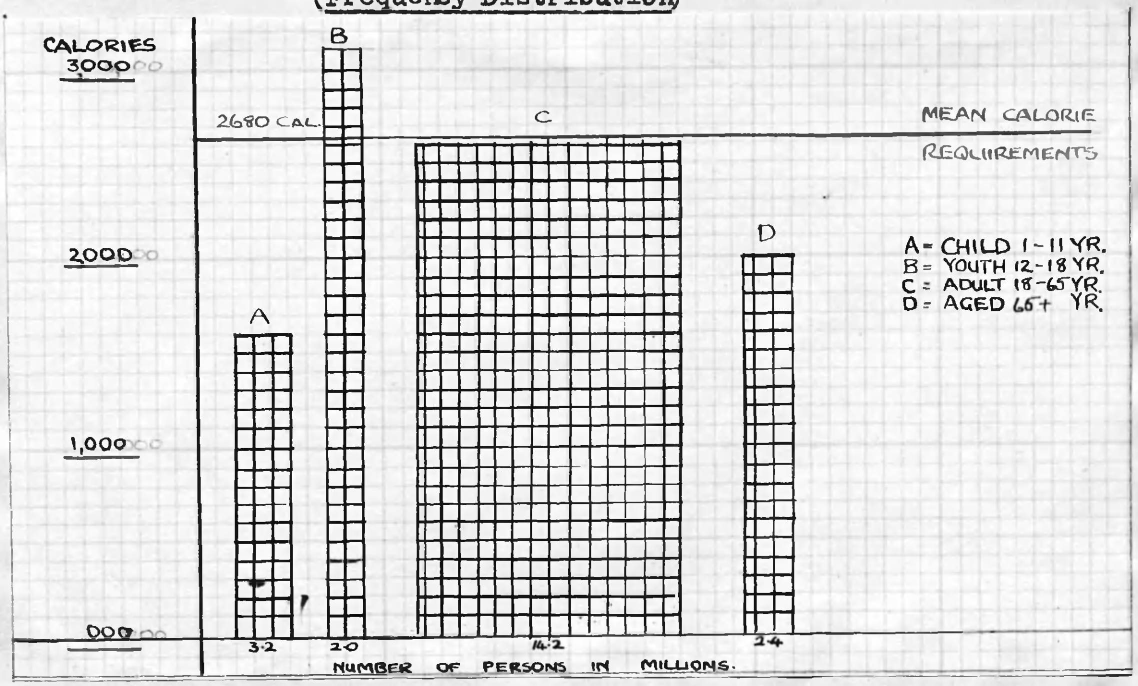
DAILY CALORIE REQUIREMENT OF CIVILIAN POPULATION

	Males			Females		
a	b	c	d	e	f	g
Age	Strength (in 1,000s)	Calorie Requirement	b x c	Strength (in 1,000s)	Calorie Requirement	e x f
1	345	950	327,750	328	940	308,320
2	346	1,135	392,710	326	1,110	361,860
3	346	1,275	441,150	330	1,230	405,900
4	328	1,380	452,640	313	1,300	406,900
5	296	1,490	441,040	284	1,410	400,440
6	274	1,600	438,400	264	1,520	401,280
7	289	1,745	504,305	278	1,660	461,480
8	295	1,920	566,400	285	1,815	517,275
9	296	2,110	624,560	286	1,990	569,140
10	288	2,330	671,040	279	2,195	612,405
11	283	2,510	710,330	275	2,520	693,000
12	280	2,735	765,800	271	2,860	775,060
13	275	3,040	836,000	266	3,210	853,860
14	278	3,400	945,200	273	3,330	909,090
15	288	3,855	1,110,240	282	3,235	912,270
16	291	4,090	1,190,190	291	3,160	919,560
17	276	3,945	1,088,820	291	3,060	890,460
18	160	3,730	596,800	286	2,950	843,700
19 - 65	12,338	3,265	40,283,570	14,233	2,640	37,575,120
65 +	1,738	2,449	4,356,362	2,432	2,024	4,922,368
Totals	19,310		56,643,307	21,873		53,739,488

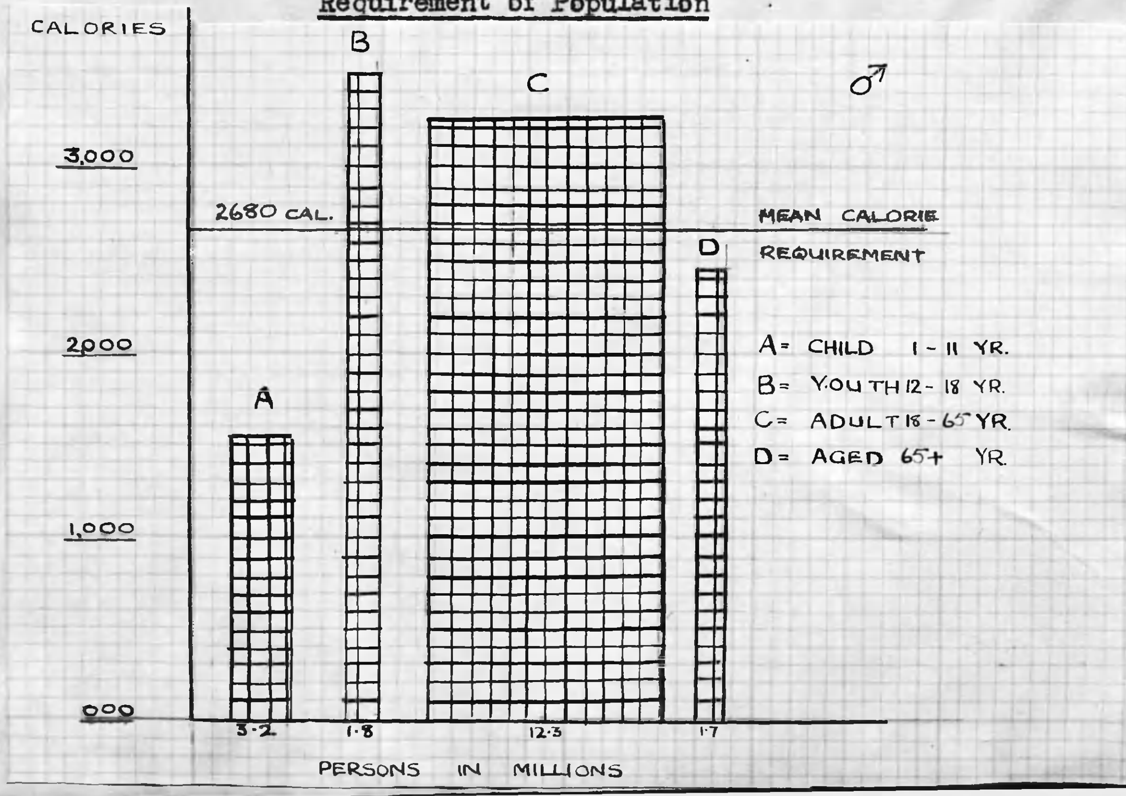
Mean Male Daily Requirement = 2,933 Cals.
Mean Female Daily Requirement = 2,457 Cals.
Overall Mean Daily Requirement = 2,680 Cals.

Having obtained this mean requirement as a guide, it is interesting to review graphically the relation of each age and sex group to this figure. (see Figs. 1A and 1B)

Relation of Female Requirements to Mean Calorie Requirement of Population (Frequency Distribution) — Fig. 1A.



Relation of Male Requirements to mean Calorie Requirement of Population — Fig. 1B.



Thesefigures clearly illustrate the three classes to whom supplementary food is essential, i.e. adolescent males and females, and adult males.

It is, of course, patent that these are average figures, which must be reviewed if applied to any specific occupation. Thus while the average adult male may require 3,250 Cals., miners may require 4,500 Clas. and clerks only 2,500 Cals.

It is important to note that the entire population of the Army falls into groups c and d (Fig. 1B), which require more than the average intake.

Let us now consider the requirement of the army population, calculated from the same tables (Holt and Fales 1921) and based on the army population age grouping at December, 1947. (Table II).

TABLE II

DAILY CALORIE REQUIREMENT OF ARMY POPULATION

Age	Strength 000s	Calorie Require-ments	b x c
17	19	3,945	74,955
18	97	3,730	361,810
19+	650	3,265	2,122,250
Totals	766		2,559,015

Mean Daily Calorie Requirement of Soldier = 3,341 net Cals (A).

Thus while the average daily civilian requirement, per head of population (A) is 2,680 Cals, that of the average soldier is 3,341 Cals. (A_1). Therefore the P.C.F. (Physiological Correction Factor) = $\frac{3,341}{2,680} = 1.25$

This figure has now been adopted by the Army for all comparisons and has recently been recognised by the Scientific Adviser to the Ministry of Food. It should be noted that this factor is independent of absolute values, and whilst the Calorie requirements as laid down may be regarded as too high or too low, they apply to both numerator and denominator.

In actual fact, whether the table of Holt and Fales (1921) or that of the National Research Council (1943), or that of the Rowett Research Institute be taken, this ratio

$$= \frac{\text{Average daily requirement of Soldier}}{\text{Average daily requirement of Civilian}} \text{ (in Cals)}$$

remains constant at 1.25 : 1.

Factors Modifying Comparison of Military and Civilian Calorie Requirements.

1. Occupation.

Since all the requirements quoted above are average values for varied occupations, it is necessary, if a comparison is to be valid, for the two populations to employ their men on work involving comparable exertion. In fact, this assumption flatters the civilian, for the army works longer hours, has a large proportion of its men on intensive training, and, even where men are on sedentary tasks, they still perform fatigues, guards, picquets and drill. In addition the soldier is driven to exert himself, be he willing or not.

2. Construction of Age and Sex Groups in Calculation (see Table I).

It will be noted that ages 19 - 65 yrs. above are given a flat rate of Calorie requirement. In actual fact this is not correct, as requirement falls fairly rapidly from 19 - 24 years and then, more slowly thereafter. Since 75% of the Army is between the age of 19 and 24, and the corresponding groups in civilian life are greatly reduced in consequence, this fact biases the result in favour of the civilian.

3. Pregnancy.

It is apparent that the possible influence of Pregnancy in raising the requirement of the total population must be considered. Widdowson, McCance and Verdon-Roe (1936) however, showed that the diet of 120 pregnant women, as calculated by the individual method, was, on the average, less than 2,500 net. Cals. daily. Garry & Stiven (1936) suggest that, while there is undoubtedly a rise in basal metabolism in the latter half of pregnancy (Sandiford et alia, 1924-25), this is apparently compensated by diminished muscular activity in the pregnant woman.

Even if an allowance of 300 Cals. extra per day, during the last 20 weeks of pregnancy, is made the product of this, and the daily birth rate (2,563 for 1947) is merely 107,646,000 Cals. per day. This figure is too small to effect the P.C.F. which remains at 1.25.

4. Disease.

The effects of diseases on Calorie requirement are so variable that it appears beyond computation. Both army and civil patients are placed on special ration scales of great complexity. Army patients, as a rule, however, are suffering from trauma or acute febrile conditions, whilst a large percentage of civilians have chronic neoplastic and degenerative ailments which tend to depress metabolic rates.

B. AVERAGE DAILY FOOD INTAKE OF CIVILIAN POPULATION.

From time to time statements of the average daily Calorie intake per head of population are issued by the Ministry of Food. This level at present is said to be 2,800 Cals. Before accepting this figure however, it behoves us to carefully examine the premises and significance of this figure. It is at once apparent (see
that what this published Calorie level actually is, is the result of the following Calculation.

Daily Average Calorie Intake of Civilian =

$$\left(\frac{\text{Total Food Consumption known to M.O.F.}}{\text{Total Population of Britain}}\right)$$

When we look at the data quoted a little more closely it becomes apparent that many of the estimations involved are little more than guesswork. For instance, how is the produce of gardens and allotments to be measured? How can a check be kept on domestic egg production or small farms outside the pool system? What check is there on food parcels from abroad, or on game shot in this country?

Whilst the Ministry of Food can undoubtedly assess with considerable accuracy the food moving into this country from abroad, this is not possible for home produce. No one who has had recent contact with farms and farmers can doubt that vast quantities of food, of potatoes, of corn, of milk, of eggs, of bacon and of butter are in circulation of which the Ministry has certainly no knowledge. To label this supply as "Black Market" and thereafter ignore its existence shows little appreciation of a very considerable and understandable reaction of Human Nature to short supply of commodities.

How much credence can we place on these figures? There is no doubt, that as a comparative index, with figures obtained in a similar fashion, this figure is a valuable indication of the trend available food supplies. It would be unwise however, to accept it as an absolute or accurate figure or to attempt comparison with carefully carried out dietary surveys.

It is probably fair to say that this figure (2,800 Cals.) can be accepted as the minimum level of available food in the country.

CORRELATION OF AVERAGE CIVILIAN REQUIREMENT AND INTAKE.

Before the figures for intake and requirement can be related, it is essential that they be expressed in comparable units. The figures issued by the M.O.F. (V.S.) are based on supplies at a wholesale level. Allowance is made for refuse, but no allowance is made for waste (as defined by Atwater & Bryant 1896).

For a considerable period the convention persisted that 10% should be deducted for edible waste (in cooking and plate waste). Doubt was thrown on this by Atwater & Bryant (1896) who considered 5% to be nearer the mark. Cathcart & Murray, 1939 proved this point and showed (for diets of the type then prevalent) that 2 - 3% was nearer the figure of waste in the homes of unemployed persons. They concluded 5% to be an ample allowance, for edible waste.

If we accept this figure for the civilian population then actual daily intake is (2,800 x 95/100) Cals. = 2,660 Cals.

It will be recalled (V.S.) that the overall civilian requirement was calculated to be 2,680 Cals. (Table I). It would, therefore, appear if the M.O.F. is accurate in its statements, that intake and requirement for the population are almost in equilibrum. In actual fact, since 2,800 is the minimum value, it appears probable that a considerable (and essential) safety margin exists. This margin is, of course essential to ensure equitable distribution.

DISTRIBUTION OF AVAILABLE FOOD.

The problem of feeding the population of Britain can best be illustrated by comparison with feeding a family. In a family, whilst the "per head" daily average intake is 2,660 Cals. in actual fact the father and adolescents eat more and the grandparents, children and mother less. Thus, if the family intake is equal to the family requirement, then all may receive a fair share, provided the distribution is equitable. Should the intake fall below requirement, for the family, then one, or more member must be underfed.

Similarily, on a nation-wide scale, it is clear that the same factors apply. Some groups (e.g. miners, agricultural workers, adolescents, lactating women etc.) require more than average whilst others (senescents, bedridden patients and children) require less.

Thus in theory, if intake equals requirement on a nation wide basis, then all could receive enough, but only providing distribution is perfect. In actual fact, since this can never be so, it is essential that a very considerable safety margin should exist. Obviously, if intake is less than requirement then some or all classes must suffer.

CLOSED COMMUNITIES.

A very pressing problem is that of the homogenous group of the population whose requirements all exceed the average. Such groups are college students, (at residential universities) and, above all, the armed forces. Obviously, where the need of each individual is in excess of the average requirement no give and take is possible.

It is for this reason that the Army is so insistent that the healthy young males, of whom it is composed, should be fed according to their needs, and not equated to a vague, overall civilian figure. In actual fact the Army says that if the civilian average intake is 2,660 net Cals. then the average soldier should receive (2,660 x 1.25) = 3,325 net Cals. daily.

This is not a new problem; Cathcart & Orr said in 1919:-

> ".... In spite of the drastic reductions effected (in the rations) it was still claimed that the Army was overfed in comparison with the civilian population. No notice was taken of the fact that the two cases were not comparable. Many civilians were in receipt of large wages and could supplement their rations by the purchase of non-rationed foodstuffs, and the non-working part of the population, could, to some extent, by reducing their activities, adjust their requirements to the food available. Neither way of escape from the consequences of insufficient rations was open to the soldier."

These words are as true to-day as when they were written and it is a great pity that more attention was not paid to them by the responsible authorities after this war.

C. THE CALORIE REQUIREMENT OF THE SOLDIER.

Since the responsibility for the adequate feeding of the men rests squarely on the shoulders of the Army Authorities it is essential that some criteria of Calorie requirement on an absolute basis must be laid down. In actual fact, a great deal of time and thought has been given to the problem and many varied suggestions put forward. The widely held impression of one flat scale existing for all soldiers is of course entirely erroneous. Alterations to the ration scale are actually in existence for physiological, climatological and political reasons, as well as for reasons of supply and of morale. A few examples of each type of modification are quoted below to give some idea of the complexity of army dietetics.

(a) PHYSIOLOGICAL: Special supplements are given to men on hard outdoor work and to recruits on intensive training. A smaller supplementary ration is given to sea-going troops.

(b) CLIMATOLOGICAL:

Tropical - Foods less liable to deteriorate in heat and which will remain palatable are issued.

Arctic - High Calorie, low weight rations are issued, with care to avoid excessive ketogenesis.

Native Troops - Foodstuffs, which are not only adequate, but will be eaten by native troops must be issued (e.g. vegetable oils).

(c) SUPPLY: Specially packed compact rations must be supplied for Paratroops, Commandos and Special Air Service troops, to minimise volume and weight of food carried. A great deal of work has been done in this field and lightweight packs are now available which will sustain men almost indefinitely, and which will be eaten by the men (a very practical point!)

(d) MORALE: Occupation troops in Germany, Palestine and Greece, filling a waiting role, without spur of imminent battle and in the latter two countries subjected to constant sniping, mining and subversive propaganda are very subject to deterioration of morale. With a view to combating this, augmented and more attractive rations are issued.

(e) POLITICAL: The recent cuts in meat, bacon etc. which have "equated" the military ration of those commodities to the scale of the civilian is an example of this influence. Despite the fact that the soldier's ration is his total intake, whilst that of the civilian can be augmented in industrial canteens, supplementary rations and offal, the "levelling off" process was enforced on the army. Again, the limited spending power of the low-paid soldier, precludes their purchasing food, to any large extent, in civilian restaurants.

It is patent, that with so many modifications in force a sound basis from which to calculate is essential. A vast amount of work has been done on the subject, and some of the relevant methods and data under consideration are shown below.

A. CALORIE REQUIREMENT OF AVERAGE MAN AS STATED BY VARIOUS AUTHORS.

1. Light to moderate work.

Source.	Net. Cals.
League of Nations (1935)	2,800 - 3,200
National Research Council (1943)	3,000 - 3,500
Stiebeling (1941)	3,000
Atwater (1895)	2,700 - 3,400
Bull U.S. Med.War Dept. (1944)	2,500 - 3,300
Arithmetic Mean	2,800 - 3,350

2. Hard Work

Source	Net. Cals.
M.O.H. & B.M.A. (1934)	3,400 - 4,000
League of Nations (1935)	3,200 - 4,000
National Research Council (1943)	3,500 - 4,500
Stiebeling (1941)	3,400 - 4,500
Atwater (1895)	3,400 - 4,100
Bull U.S.War Med. Dept. (1944)	3,300 - 4,600
Arithmetic Mean	3,370 - 4,280 Net. Cal.

It would appear, from an averaging of these tables that the standards should be, for the average man :

	Net. Cals. Daily
Light to moderate work	2,800 - 3,350
Hard work	3,370 - 4,280

B. DIETARY SURVEYS.

Two notable surveys have been carried out on groups of military personnel. These are :-

(a) United States Army Survey (Howe& Berryman 1945)

TABLE III

Results

Type of Occupation	No. of Messes	Cals. per head per day
Induction Centre	5	3,132
Army Artillery	68	3,295
Miscellaneous	3	3,298
Medical	24	3,623
Transport	37	3,655
Coast Artillery	45	3,711
Military Police	11	3,719
Signals	18	3,779
Air Corps	27	3,801
Headquarters	16	3,836
Ordnance	5	3,836
Engineers	18	3,845
Cavalry	7	3,878
A.F.Us.	30	3,880
Quartermaster	61	3,908
D.E.M.L.	3	4,135

Weighted mean intake of all Classes = 3689 Cals.

(b) Intake of R.A.F. personnel in England (Macrae 42).

This described a survey of four R.A.F. Camps and places the average daily intake at approx. 3,200 Calories per head.

Civilian Surveys.

(a) Individual Technique (Widdowson E.M. 1936)

TABLE IV.

Occupation	No. of Men	Calorie Intake
Doctors	4	2,460
Teachers	3	2,486
Stokers	2	3,012
Students	15	3,126
Porters	6	3,126
Clerks	3	3,146
Research Workers	6	3,172
Mechanics	2	3,222
Lab. Technicians	6	3,808

It must be noted that the numbers in each group are extremly small; the occupations are mainly sedentary and the men are much older than their army counterparts.

(b) Industrial Workers (Pyke 1945)

TABLE V

Occupation	Net Calorie Intake
Mule Spinners	4,030
Goods Yardsmen	3,550
Goods Yardsmen (b)	3,480
Shipyard Workers	3,340
Steel Rollers	4,150

The occupation of these men approximates more closely to the activities of the soldier.

Energy Expenditure (Calculated).

The work of Cathcart and Orr (1919) and Richardson (1928) (see Part III) gave the British Army a flying start in this field of investigation. Unfortunately this lead has not been maintained in recent years and it is on the work of the pioneers we must rely. The average results ontained, for energy expenditure of troops in training by these workers is shown below.

1. Energy Expenditure of Infantry Recruit (Cathcart and Orr 1919).

Mature Recruit = 3,574 Cals. Daily
Young Recruit = 3,376 Cals. Daily

2. Energy Expenditure of British Troops in India (Richardson 1928).

Infantry Soldier = 3,660 Cals. Daily.

(c) Investigations of Energy Expenditure in Relation to Calorie Intake.

The work carried out by Lt.Col. Melville, R.A.M.C. (1910) produced some very interesting results. In the first experiment 26 men, on a daily calorie intake of 3,489 gross Cals., and external energy expenditure calculated to be 1034 Cals, lost on the average 0.69 Kilos. in weight, over a period of fouteen days. This loss was accompanied by noticeable distress and humger in the men concerned.

When, under similar circumstances the experiment was repeated with a gross daily Calorie Intake of 4,511 Cals. and a daily external energy expenditure of 1,419 Cals. the men gained 0.16 kilos., on the average, in the same period. The men were well and felt fit.

During the recent war (1941-45) the U.S. Army conducted a series of large-scale experiments, on similar lines, to test the adequacy of existing ration scales as supplied to their men. An example of this work is the report on Project 30, by the Armoured Medical Research Laboratory (1944). In this a battalion of men were placed on definite ration scales; one third of the battalion on each of the three scales in turn. A large team of scientists calculated energy expenditure on the spot (by Douglas-Haldane bag) whilst others kept a strict check on the physical and functional state of the men and computed their Calorie, vitamin and mineral intake and output on each type of scale.

The average daily expenditure of the men was 3,800 Cals. daily, and it was found that only on a ration scale of 4,400 gross (4,000 net) Cals. was positive health maintained.

Conclusions.

Whilst no one of the foregoing results is in itself conclusive, the similarity of results arrived at by widely differing methods builds up a very strong case on which to base arbitrary absolute Calorie requirements. With all these results quoted above in mind the following figures were accepted by the army (A.M.D.5 1946) for future guidance.

Average Daily Requirement of Soldier on light work = 2,950 net. Cals.
" " " " " " heavy " = 3,700 net. Cals.

How far these figures agreed with actual consumption will be seen in Part VI.

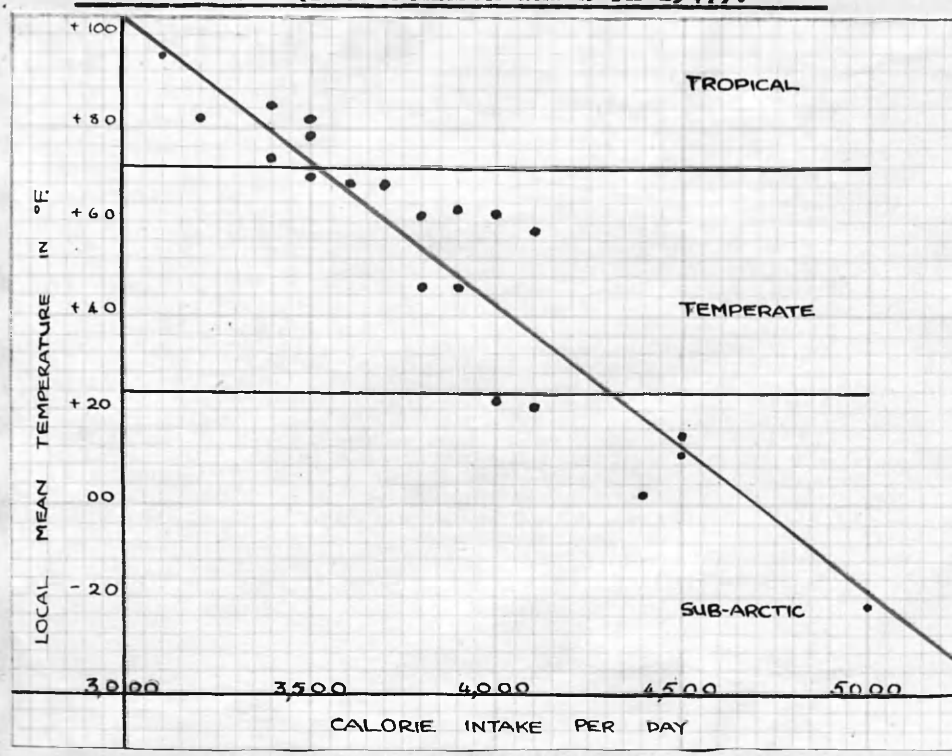
D. EFFECT OF ENVIRONMENT ON CALORIE INTAKE.

Johnson and Kark (1947) have drawn attention to the great variation of average Calorie intake of Soldiers, in varying climatological conditions. Their study shows, that, as the mean environmental temperature falls from 92°F to -30°F the Calorie Intake rises sharply from an average of 3,100 to one of 4,900 Cals. daily. Obviously this cannot be explained on the basis of altered basal metabolism, which could only account for a 20% (or 400 Cal) rise. The explanation appears to lie in the maintenance of body temperature at a normal level and in the increased effort required to perform work in Arctic clothing.

Figure II illustrates the scatter of intake against environmental conditions as found by these workers.

= Figure II.

Relation of net calorie intake to climatological conditions. (From Johnson and Kark 1947).



Unfortunately, no figures are quoted by which the occupations of the men in the various theatres can be compared, and one cannot help but feel the lethargy common to men in tropical conditions may have influenced the results.

PART II.

FOOD INTAKES: METHODS OF SURVEY AND OF MEASUREMENT.

Dietary surveys may be carried out on subjects of widely varying constitution by any one of the variety of methods now in use. Some of the more common types of survey and methods ofmensuration of Food intake are discussed below.

A. POPULATION TO BE SURVEYED.

The subjects may be investigated as a group or as individuals. If the former method is used it may be subdivided into two classes e.g.

(a) Homogenous Groups

(b) Heterogenous Groups

In type (a) all subjects are of a similar age, sex and occupation; the arithmetic mean of the group results will express the average intake of each member with some accuracy.

In type (b) different ages, sexes and occupations will be included and some form of weighted mean must be obtained before valid comparison can be made with other groups.

A typical example of a group (a) survey would be that carried out by Macrae (1942) on members of the Royal Air Force; of a group (b) survey that of Cathcart and Murray (1931) or of Orr and Clark (1930) both carried out on families. Surveys on Individuals is typified by the survey of McCance, Widdowson and Roe (1938) onpregnant women.

B. MENSURATION OF FOOD INTAKE:

When the population to be surveyed has been determined and a decision as to whether group or individual investigation is to be pursued, has been made, we must then consider the method to be employed. Four principle groups of methods can be cited, as below :-

(1) By direct analysis of samples of diet, e.g. (Macrae 42)
(2) By weighing all food and computation from Food Tables (e.g. (Widdowson 36).
(3) By gross overall average methods, e.g. (Howe & Berryman 45).
(4) By questionnaire or dietary history, e.g. (Pyke 1943).

The pros and cons of each of these methods will now be briefly considered, in turn.

(1) Direct Analysis of Samples of Diet.

This method undoubtedly gives the most accurate results and is of great use when employed to find the average food, vitamin and mineral content of a complete diet. This was the use Macrae (42) put it to, and his freeze-dry technique appears very sound indeed.

In individual surveys, however, the analysis of each separate diet would be a truly Herculean task, and in view of the accurate tables now available, giving the Calorie, fat, protein, carbohydrate, mineral and vitamin content of every conceivable foodstuff; quite unjustifiable. (Widdowson 43). Examples of these tables are :-

(1) Chemical Composition of Foods. (McCance & Widdowson 46)
(2) Nutritive Value of Foodstuffs. (A.M.D.5 War Office 45)
(3) Nutritive Value of Wartime Foods (Medical Research Council 45).

(2) Weighing of Food and Computation from Food Tables.

Into this group fall many varying techniques, only a few of which will be considered here.

(A) FAMILY METHOD.

Generally, in this method, a diary is kept by the mother, showing the weight and type of all food consumed by the family over a given period. This must include both food from store cupboards and any food bought or grown. From this data the nutritive value of the food consumed is calculated. The family intake is then reviewed with reference to the actual make up of the family in terms of man-value. For this purpose a large number of scales have been drawn up, expressing the man-value (for Calorie requirements) of women and children of various ages in terms of the male adult taken as unity. The best known of these are as follows -

(a)	Royal Society	1917
(b)	Cathcart and Murray	1931 (a)
(c)	Stiebeling and Ward	1933
(d)	League of Nations	1936
(e)	Canadian Dietary Standard	1941
(f)	National Research Council	1943

Unfortunately these tables vary considerably, and this fact, coupled with the fact that some investigations express results in net Cals, and some in gross Cals, has led to considerable confusion.

Even when the total family intake, as a unit, or in terms of "man-value" is found, no individual data can be extracted. It is obvious that in so small a sample as a family is, even if one member grossly over-eats and another starves the overall result will be a normal average intake, whether expressed in man values or not.

An interesting variant is the work of Clements (1940) where families of a similar age and sex structure are compared; with none of the usual assumptions as to man-values. There is no doubt that the family method is important as a rough and rapidly calculated guide to average intake but several inaccuracies are liable to occur e.g.:-

(a) The record of weights of foods moving in and out of stores is liable to considerable inaccuracy, especially with housewives of low intelligence.

(b) One or more of the family may eat a meal at a canteen or restaurant.

(c) Waste and Refuse may not be accurately noted.

(d) Animals or Visitors may consume part of the food.

Subject to these limitations the method is practical and yields results on a grand scale.

(B) <u>WEIGHING OF EACH INDIVIDUALS DIET</u>.

This method is not new, an excellent review being given of the literature by Widdowson in her Study of English Diets, Part I (1936). It has been very much inevidence however in the past 15 years (Widdowson 1936, Widdowson & McCance 1936, McCance, Widdowson & Verdon-Roe 1938, Widdowson & McCance 1942 etc.). In all the above cited surveys the same general method was used; to each of the subjects a sheet of instructions, record sheets and a spring scale, weighing by $\frac{1}{4}$oz. to 1 lb. was given. The subjects kept a note of all food eaten for a week and from these figures their food intake was calculated.

Whilst this method gives more accurate results with reference to individual variation, several inaccuracies are still present e.g.

(a) The completeness, accuracy and value of results depends entirely on the integrity, intelligence and education of the subject

(b) The subject were not used to reading or handling delicate scales or recording results

(c) The scales could not be zeroed or their accuracy checked, at short intervals

(d) A great deal of variation of opinion amongst subjects as to what was waste, must have existed

(e) Recipes must all be "assumed".

(C) THE PRESENT INVESTIGATION

In the present survey all food and all waste for each individual was weighed by a highly trained member of the research team, using frequently zeroed and standardised scales reading to $\frac{1}{8}$ of an ounce. This "central weighing" technique is only possible if carried out at high speed and with the aid of a hot-plate for large numbers. In addition all foods were prepared according to known recipes. In this way it was hoped to overcome the disadvantages and inaccuracies of both methods A and B.

Whatever method is used to obtain the amount of food consumed difficulty arises with the calculation of compound dishes. This problem is discussed in detail in part V.

(3) OVERALL GROSS AVERAGE METHOD

This method has been employed by the American Army in World War 2 (1941 - 45). The methods were described by Berryman & Chatfield (1943) and by Howe, Pritchett and Berryman (1944). Broadly speaking all foodstuffs are classified into one of nineteen groups such as citrus fruits; fats; meat; chicken and fish; etc. The qualitative and quantitative structure of the diet is taken, 10% allowed for waste and another allowance made for refuse, depending on the constitution of the actual diet.

This method can be only of very limited accuracy and is of use on a comparative basis and not for absolute data. Such results were published for vast numbers of U.S. Soldiers (Howe & Berryman 1945) who provided the homogenous group essential to such a study.

(4) DIETARY HISTORY OR QUESTIONNAIRE METHOD.

In this method, an estimation is made by the subject of the amount of each type of food which he has eaten in a specified period beforehand. Although at one time used extensively by the Ministry of Food, who augmented the subjects' memories by plastic models of the various foods, it has now been discarded by them (Personal Communication, Dr. Pyke.)

Another survey in which this method was used was that of Wiehl (1942), who produced the astounding result that 40% of the aircraft workers subsisted on a net Calorie intake equivalent (of 1.4 x Basal Metabolism). This result confirms the frequently expressed opinion that such methods are quite inaccurate.

From the above discussion it becomes fairly clear that to obtain accurate results the following criteria must be observed.

(a) An accurate system of weighing.
(b) A skilled person weighing.
(c) A lucid record of all food and drink taken.
(d) Recipe and method of cooking all foods to be recorded.
(e) An accurate set of Food Tables.
(f) Some method of analysing any "unknown" foods which may be met with.

With these criteria in view the method described in part V was evolved.

PART III

THE ASSESSMENT OF ENERGY EXPENDITURE.

The experimental marches, carried out in 1909 - 1910 by Lt.Colonel Melville (1910), brought into sharp focus the inadequacy of Army rations at that time. At the conclusion of the World War (1914 - 18) Brig. Gen. Horrocks, in a similar fashion, again drew attention to the insufficiency of rations.

It was at this point that Cathcart & Orr commenced their investigation into the energy expenditure of recruits by indirect Calorimetry. They used the Douglas-Haldane bag, and the method of calculation of Zuntz and Schunberg (1901), fully described in the R.A.M.C. Journal (1918) by Cathcart. So comprehensive was this work that now, 30 years later, it is still the most useful publication, of its kind on military energy expenditure.

It was pointed out by these workers that such experiments must perforce be adapted to fit military exigencies. They felt, and rightly so, that it was better to retain contact with reality, rather than become too academic. Below is shown the calculation by which they assessed the weekly timetable of the recruits, a method of calculation which has been adopted in the present survey.

/Cathcart

(Cathcart and Orr 1919, P.63 Table LXXII)

Appendix I:- Mature Recruits

Weekly Energy Expenditure.

Sleep	56 hours	at 69 Cals/Hr	=	3,864 Cals.
Meals	21 "	" 108 " "	=	2,268 "
Cleaning	7 "	" 130 " "	=	910 "
Fatigues	2 "	" 207 " "	=	414 "
Free Time (a) ...	18 "	" 75 " "	=	1,350 "
Free Time (b) ...	18 "	" 300 " "	=	5,400 "
Drill	46 "	" 235 " "	=	10,810 "

Total Weekly Expenditure = 25,016 Cals.

Daily Expenditure = 3,574 Cals.

It should be noted that, since this work was done when the men were not in a post-absorptive state, no allowance need be made for specific dynamic action (see Orr and Leitch 1938). Cathcart and Orr found that the average Basal Metabolism of recruits was 37.8 Cals per square metre of surface area, per hour. Unfortunately the age groups of their subjects was high, and it is probable, that for the average recruit aged 19 years the figure of 39 Cals. per square metre per hour, as quoted by Du Bois (1936) is the more typical.

Richardson and Campbell (1927) carried out by similar methods a more detailed study of the energy expenditure of men of the Infantry and Royal Artillery in India. It is interesting, in view of the American work on the fluctuation of Calorie intake with environmental temperature, to find that differing temperature conditions affected the energy expenditure quite markedly.

e.g. Average Daily Energy Expenditure.
(Richardson & Campbell 1928).

Infantry
- Cold Season = 3,815 Cals.
- Hot Season = 3,525 Cals.

Royal Artillery
- Cold Season = 4,527 Cals.
- Hot Season = 4,253 Cals.

Cathcart, Lothian and Greenwood (1920) applied similar methods to a study of the energy expenditure of marching; they concluded that 65 - 80 yards per minute was the optimal speed for efficient marching.

An excellent review of the literature was made by Orr and Leitch (1938): they assessed the energy expenditure involved in a diversity of civilian occupations, by applying a uniform method of calculation to the results obtained by other workers. An example of their method of calculation is shown below, as a contrast to that of Cathcart and Orr.

Energy Expenditure of Unemployed Men.

Surface area = 1.69 square metres. (Orr & Leitch).

Source of Expenditure	Cals/day.
B.M.R. + 10% (for S.D.A.) @ 70 Cals/Hr	1680
1 hour dressing and undressing	32
5 hours sitting	72
2 hours walking slowly	220
3 hours gardening	306
3 hours standing	57
	2367 Cals.

It will be noted that this method consists of adding values to a uniform basal metabolism. A ten per cent allowance for specific dynamic action is the first addition, following by allowances for external energy expenditure. This method is open to criticism. The average surface area taken (1.69) is much smaller than the present army average, and no allowances are made for such necessary actions as eating and washing.

With the mechanisation involved in the second World War (1939 - 45) investigation into the energy expenditure of vehicle drivers, A.F.V. crews and many other new occupations was necessary. The Armoured Medical Research Laboratory at Fort Knox, Kentucky studied this problem and their report on Project No.5 is the most comprehensive on this subject. Their method was a replica of that used by Cathcart and Orr.

PART IV.

THE PRESENT INVESTIGATION.

A. OBJECTS OF INVESTIGATION.

(1) To investigate the calorie intake of the British soldier, serving at home, with regard to:-

(a) Adequacy of existing ration scales, and degree of supplementation of same.

(b) Type of army occupation of men.

(c) Age; weight and other anthropometry of men.

(2) To examine the extent of variation in the calorie intake of individuals amongst soldiers engaged on similar work, under similar environmental conditions.

(3) To report on the actual calorie value of:-

(a) The Home Service Ration Scale.

(b) Supplementary food bought by soldiers.

(4) To define the contribution of plate waste to the total loss in calorie value of the ration from "wholesale" to "consumer" level.

(5) To investigate the purchasing power of the penny in Canteens.

B. METHODS OF INVESTIGATION.

I. GENERAL APPROACH.

(a) Selection of Units for investigation.

In undertaking the survey care had to be taken to make it as representative as was practicable. For this reason it was essential; (a) that the units investigated should be as widely distributed throughout England & Scotland as possible; (b) that units engaged in work varying from sedentary to very active be studied. Map A. shows the distribution of camps visited in the course of the year.

Map A. (Geographical Location of Camps.)

Since a complete record of food intake was required it was essential that the men were in isolated camps. Only there could all avenues of calorie consumption (Rations, canteens & parcels from home) be efficiently controlled. The environment of each camp had therefore to be considered carefully, before the commencement of a survey.

b. Preliminary "Instruction" of Units.

Before any such investigations could be made it was a "Sine qua non" that the co-operation of many people be obtained. The Commanding Officer of the Unit, the Messing Officer, the cooks, the Canteen Managers, and the actual subjects, had all to be interviewed, interested, and finally enthused, before work could even be commenced. The role of each is outlined below.

(1) O.C. Unit:-

To provide N.C.O.s to assist research team, to confine men entirely to camp for 1 week, to ensure that the junior officers and N.C.O.s strictly supervised the activities of the men during the week in question and kept us informed of same.

(2)/

(2) Messing Officer.

To ensure that the diet served was typical of the Home Service Ration Scale (henceforth H.S.R.S.) and consisted of the exact amounts of food laid down by regulation. This was invariably checked for a period of several weeks to prevent any attempts to mislead us.

(3) Cooks:-

To ensure the accurate weighing of all foods prepared, weighing of porridge, vegatables, etc., before and after cooking.

(4) Canteen Managers.

Although the support of N.A.A.F.I., H.Q. was freely given, it was essential that each manager assisted us by ensuring that no food was purchased except under our supervision and after weighing by us.

(5) Men:-

Despite the very complete supervision of all activities of the men it was very important to obtain their co-operation, otherwise deliberate attempts to mislead our results might have been made.

....

Anyone familiar with conditions of army life will readily appreciate the important contribution of each of/

of each of these individuals to the scheme as a whole, and also the tact and persuasive powers required to obtain the goodwill of each. This would be quite impossible for any person not familiar with all aspects of army life and "psychology".

....

(C) The time-table of the men.

The training officer placed i/c of the men for the week was responsible for a detailed, timed, programme of the men's activities during that period. In addition their off-duty was closely studied by selected N.C.O.s (since the men were confined to camp this was greatly facilitated).

(d) Temperature, Relative Humidity and Barometric Pressure.

By special arrangement with the Air Ministry Meteorological service the mean temperature, Relative Humidity and Barometric pressure at each camp for the period of survey was recorded. This was considered important in view of the American contention (v.s.) that climatic variations alter calorie intake.

II. INDIVIDUAL SURVEYS.

In this type of survey the actual weight of all food eaten and wasted by each man over a period of one/

one week was found. This weighing of rations, of N.A.A.F.I. purchases, and of parcels from home was made on every constituent of the diet. To ensure complete supervision of food entering camp by parcel post, all parcels were opened in front of a member of the research team. This full and tedious exactitude in assessing the total intake was only made possible by the "central weighing" technique, described below.

(a) SUBJECTS.

1. Selection:-

Subjects were selected by numerical random sampling of a nominal roll of all men in the occupation to be surveyed.

2. Occupation:-

This varied from sedentary to extremely active. Account was taken of recreational and outside activities.

3. Age, Previous Occupation etc. of Subjects.

The age distribution of individuals was purely fortuitous, but was found to correspond to that of the Army in Britain as a whole. Note was made of the physical condition and intelligence of each subject. A history of civilian occupation and athletic activity, if any, was also obtained.

4. Physical Examination of Subjects:-

A routine clinical examination was made to ensure physical fitness; the man's height (to 0.5 cm.) and his weight were checked. Weighing was done with subjects naked, after urinating and before breakfast, at the beginning and end of the survey. Weighing was done to 50 G (= 2 oz.). Any man taken ill during the week of survey was excluded from results.

The following additional data was noted:-

a Sitting Height.

b Cristal Height:- (From Ant. Sup. Spine of Ilium to ground, vertically).

c Leg Length:- (From Great Trochanter to ground, vertically.)

d Chest Circumference:- (Maximal on inspiration and expiration.)

e Abdominal Girth:- (Maximal).

....

(b) Technique of Weighing Food.

All food consumed by any of the subjects during the week in question was weighed, by one of the research team, immediately prior to being eaten. The food left was then weighed and the difference between food served and plate waste gave the weight of food eaten by the subject. Each man's plate was numbered/

numbered and care was taken to see no man ate from or deposited waste on another's plate. This is felt to be much more accurate than the method used by Widdowson (1936) etc., when plate waste was merely estimated.

The weights actually recorded for each man were:

(a) Weight of each foodstuff as served on plate.

(b) Weight of each foodstuff left as plate waste.

(a-b) is food actually eaten; ($\frac{b}{a}$ x 100) the % plate waste by weight.

Before any surveys were attempted care was taken to ensure that the men of the research team were completely accurate in their weighing technique. Standard weights (of unknown size) were weighed repeatedly by each man, on each balance, until complete uniformity of results was obtained. During the period of the survey this practice was continued, not only as a check on the men, but also on the machines.

Type of Balance Used.

These were of the Salter Diabetic Type, weighing from 0-16 oz. but readable to an accuracy of 1/16 oz. (2G). The scales were frequently

zeroed/

zeroed and tested by standard weights. The saucer was of light plastic and a considerable number (36) were carried for rapid weighing. Accuracy at all times was the watchword. This type of scale, shown in photograph (A) is strongly recommended for anyone carrying out a similar survey.

PHOTOGRAPH (A) Salter Diabetic Spring Balance.

(c) <u>Method of Recording Results:-</u>

This became a serious problem, with vast numbers of weighings accruing. The most efficient system was found to be to keep a concurrent record in book form, translating these figures each night to a record card (A) for each man. On the left hand side was entered the weight of food <u>eaten</u> and, on the right, the calorie value of the said food.

<u>RECORD CARD (A).</u>

① F.G.	WEIGHT IN 1/8 oz.							CALORIES							
FOODSTUFF	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	WEEKLY TOTAL
BREAD	13	11						117	99						
MARGARINE	4	5						113	141						
JAM	3	5						30	50						
SUGAR															

Such a card was complete for Army rations, for canteen purchases and for parcels from home, daily, and the totals crosschecked for days and weeks.

These data were then translated on to a final record card (B) shown below (reduced size).

Record Card (B)

Record of Subject and calorie intake.

DAY	CAL(RATIONS)	CAL./NAAFI	CAL/HOME	TOTAL CAL.
1	2,239	2,263	–	4,502
2	2,913	1,094	–	4,007
3	3,076	350	–	3,426
4	2,917	815	–	3,732
5	2,867	–	–	2,867
6	3,132	882	–	4,014
7	2,647	2,168	–	4,815
TOTAL	19,791	7,572	–	27,363
MEAN	2,827	1,082	–	3,909

Record Card B.

Obverse side.

(1) F.G.		NOTES.	Ht.	166 Cm.
			Wt.	61·47 Kg.
3909	Total Cal.		Surface Area	1·67 Sq.M.
2341	Cal/Sq.M.		Nutrition Index	204
63·6	Cal/Kg.		Change in Wt.	+0·68 Kg.
23·5	Cal/Cm		Age	18 4/12

Further facts which were obtained from the data collected were:-

(1) The daily cash expenditure of the troops on all forms of food supplement.

(2) The purchasing power (in cals) of the penny in N.A.A.F.I. canteens.

(3) The opinion of experienced Medical Officers, Commanding Officers and men on the adequacy of present ration scales.

III. "Overall" Surveys.

This type of survey aimed at providing a picture of the calorie intake of the average person in each camp. Where individual surveys were carried out an overall survey was undertaken concurrently, in order to ensure that the mean intake of the sample of the population approximated to the mean for the total population.

The procedure followed was:-

ARMY RATIONS.

Five random smaples of average helpings were selected by each of three observers, employing differing selection technique at each meal. Each component of every plate was weighed to 2 G. The average calorie content of these portions were then calculated by the method described below.

In addition, a note of the total calorie value of the rations consumed by the camp was made, by weighing all food removed from store for cooking, during the week. This provided a further check. The plate waste involved was allowed for in each camp.

CANTEENS.

The calorie value of each food and the total weight of each food sold in the canteen during the week in question was ascertained. From these data the average calorie intake of each man from this source was calculated.

....

The sum of the average intake from Army Rations and from canteens, gave an indication of the average total daily net calorie intake of the men. One correction had, however, to be made. Inevitably some persons from camp at one or more meals outside camp in the course of the overall. Where 1/14 of the total number of meals eaten inside the camp were consumed outside, the result as arrived at above, was multiplied by 14/13 as a corrective factor.

COMPOSITION OF FOODS EATEN.

(1) Supervision of Recipes.

In each case a N.C.O. of the Army Catering Corps. was made solely responsible for the accurate weighing and recording of all recipes, under the writer's personal supervision. This involved not merely the weighing of each constituent, and of the compound before and after cooking, but keeping a lucid record of the same.

(2) Serving of food.

A separate hot plate and dining hall was very desireable, enabling the food for the subjects to be kept hot, and the subjects to eat under normal conditions, apart from our presence, without being subjected to the stares and ribald "wit" of their comrades.

(3) Calculation of Calorie Content of Foodstuffs.

To arrive at results in an individual type of investigation it was essential that one or another of the various tables of food values must be used. In this case the tables were "The Chemical Composition of Foodstuffs", (McCance and Widdowson 1946). Whilst aware that the methods of calculating these tables have been called to question (Maynard 1944, Keys 1945) it appeared that, apart from Atwater's (1899) table, no other sufficiently comprehensive datum is to hand.

Three/

Three types of food were met with in the survey;

(a) Standard Foods.

(b) Foods made from standard constituents.

(c) Foods of unknown composition.

(a) Standard Foods:

Such foods as bread, margarine, jam, toast, cheese, apple, chocolate, etc. etc. Values for these are obtained direct from food tables without difficulty

(b) Prepared Foods made from Standard Constituents.

The vast majority of dishes fall into this category. The weight and composition of each constituent is known, the weight of the compound before and after cooking ascertained, and the composition of an ounce of the finished product calculated from these data as shown below.

Example (a) Porridge: Weight of oatmeal used = O oz.
" " sugar " = S oz.
Wt. of cooked porridge = P oz.

∴ P oz. of porridge contains O oz of oatmeal and S oz of sugar.

∴ 1 oz of porridge contains $\frac{O}{P}$ oz. of oatmeal and S/P oz of sugar.

Let a and b be the calorie value, per oz. of oatmeal and sugar respectively.

Then the calorie value of P oz. of porridge = $(O \times a) + (S \times b)$ Cal.

∴ Calorie value of 1 Oz. of Porridge = $\left[\frac{(O \times a) + (S \times b)}{P}\right]$ Cal.

This method assumes a homogenous distribution of constituents in the cooked compound.

....

The method becomes complicated where one or more of the constituents is a fluid and final measurements are avoirdupois. This arises in such foods as gravy, where weight is avoirdupois and fluid stock a component (see example B.) It does not occur in soup, tea, beer etc. where measurments were in fluid oz.

Example B: The first step is to ascertain the calorie content per fluid ounce and then the specific gravity of the stock used, from this, the calorie content per ounce avoirdupois can be calculated as before. e.g.

Let	Calorie	content	of	stock	(1 oz.	avoirdupois	= S Cal.
"	"	"	"	Flour	"	"	= F Cal.
"	"	"	"	Carrot	"	"	= C Cal.
"	"	"	"	turnip	"	"	= T. Cal.

Let the weight of stock, flour, carrot and turnip used be w, x, y & z oz. avoirdupois respectively.

Then total calories involved = $(S \times w) + (F \times x) + (C \times y) + (T \times z)$

$\therefore$ Calorie content per oz. (av.) of finished product

$$= \frac{Sw + Fx + Cy + Tz}{G} \text{ Cal.}$$

where G oz. is the weight of finished product.

In/

In actual fact, the fat, carbohydrate and protein content of each food was calculated at the same time.

....

These calculations were made for every one of 473 cooked dishes involved, which gives an idea of the amount of data involved, and the need for clear records.

(c) Foods of unknown constitution.

These were analysed by the Royal Army Medical College, Millbank. The methods used for analysis and calculation were similar to those used in compiling the food tables as described by Widdowson & McCance (1946).

V. THE ASSESSMENT OF ENERGY EXPENDITURE.

In order that as complete a record of activity as possible of the subjects would be obtained, a N.C.O. was appointed to time and record all activities of the men during their training period. This included details of occupation, dress, and time engaged in occupation, e.g.

(1) Marching (on level) at rate 120, pace 30 inches;

Drill Order, rifles ; 40 minutes.

(2) Sitting, writing and listening; Fatigue Dress:

1 hour 5 minutes.

In/

In addition all activities of the men in their spare time was carefully noted. From these data, and using the method of Cathcart & Orr, (see part III) it was hoped that a reasonably accurate assessment of energy expenditure could be made.

VI. STATISTICAL METHODS.

(a) Selection of Subjects for Individual Method.

Where the number in camp was N and the number of subjects required n, a nominal roll of all persons in alphabetical order was numerically sampled by the factor $\left(\frac{N}{n} \right)$.

(b) Selection of average helpings (overall method).

Three persons, each employing a different method of randomisation, selected five helpings of each food as served to individuals. Two observers sampled numerically and one on a time basis; results in all cases showed no significant deviation from observer to observer.

(c) Calculation of Average Values.

Unless otherwise stated results are quoted as the means for the particular range of results: the mean deviation from the mean, standard deviation and coefficient of variation are also quoted. $\left(\sigma = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n}} \right)$

Significance of Deviation of Means:-

This was calculated by the following method. Let A & B be the means of two series to be compared and σ_a & σ_b the standard deviations of A & B respectively

Then Standard Error of Difference = $\sqrt{\frac{\sigma_a^2}{n_a} + \frac{\sigma_b^2}{n_b}}$

Where $\pm(A-B) > \left(2 \times \sqrt{\frac{\sigma_a^2}{n_a} + \frac{\sigma_b^2}{n_b}}\right)$ the the difference is statistically significant.

. . . .

PART V.

RESULTS.

In view of the importance of the results to the future discussion of the subject, and their very considerable extent, it has been decided to include them here, rather than in an appendix.

The interpretation of the various values, and headings in the following tables (VII - XXIV) will be assisted by the following notes on the significance of these.

Terms used, Tables VII - XXIV.

Age: to nearest month.

Height: to nearest 0.5 cm.

Weight: to nearest 50G.

Surface Area: From height and weight by formula of Du Bois.

Weight Change: = Alteration in weight of subject during week of survey.

Calories: all values are net calories, i.e. as actually eaten.

Total Calorie Intake = intake from Army Rations, Canteens and Food Parcels.

Supplement = intake from Canteens and Food Parcels.

Energy/

Energy Expenditure:

Programme: Calculated to nearest 30 min. for weekly programme and then resolved to average daily expenditure.

Calories:- to nearest cal/sq.M./Hour.

A. FORT GEORGE.

Unit:- No. 72 Primary Training Centre.

No. of men in Camp = 308

Location:- Moray Firth, Inverness-shire.

Altitude:- 30 ft. above sea level.

Date of Survey:- Dec. 1st - 21st 1947.

Meteorological Conditions.

Mean Barometric pressure	=	1015 millibars,
Mean Temperature	=	37.5°F
Mean Relative Humidity	=	88%

Individual Survey.

Fifty-five recruits were selected, undergoing their third and fifth weeks of training (squads A & B respectively) These men were the entire number of recruits in camp on our arrival. During the course of the week 13 men had to be eliminated, on account of illness, accident and posting. Results for 42 recruits were thus completed. It is worth recording that to weigh actual intake and waste, of these men, for one main meal required 1,000 weighings.

PHYSICAL CHARACTERISTICS OF SUBJECTS.

Squad A.

TABLE VII (a)

No. in Survey	Age Yrs. Mnths.	Height Cm.	Weight kg.	Surface Area Square M.	Change in Weight Kg.
1	18.4	165.7	61.47	1.67	+ 0.68
2	18.8	177.8	62.44	1.77	− 0.34
3	18.6	173.4	66.82	1.78	+ 0.45
4	18.1	161.5	60.0	1.62	+ 0.45
5	18.3	166.4	60.34	1.65	+ 0.68
6	18.5	173.4	66.08	1.77	+ 1.02
7	19.3	169.2	60.40	1.68	− 0.11
8	18.6	173.4	59.94	1.70	+ 0.11
9	18.4	173.4	64.37	1.75	+ 0.11
10	18.3	157.4	50.39	1.49	+ 0.11
11	18.6	167.6	62.90	1.69	− 0.11
12	18.2	171.45	64.43	1.74	− 0.23
13	18.4	166.0	60.51	1.66	+ 0.11
14	19.3	185.4	75.28	1.97	− 0.56
17	19.4	175.3	60.62	1.72	+ 0.11
19	18.6	177.2	70.79	1.86	− 0.23
20	18.4	170.8	64.77	1.65	− 0.45
21	18.3	166.0	54.88	1.59	− 0.45
22	18.2	178.1	66.37	1.81	+ 0.91
23	18.8	164.8	55.96	1.60	− 0.56
24	18.6	161.3	52.73	1.54	+ 0.23
25	18.4	163.2	57.33	1.60	+ 0.79
26	19.0	171.7	74.78	1.86	+ 0.68

SQUAD B. TABLE VII.

No. in Survey	Age. Yrs. Mnths.	Height Cm.	Weight Kg.	Surface Area Sq. M.	Change in Weight Kg.
27	18.8	184.2	63.75	1.83	- 0.68
31	19.0	179.4	54.60	1.68	+ 0.79
32	18.1	182.9	73.41	1.94	+ 0.45
33	18.2	161.9	55.10	1.57	+ 0.68
34	18.4	160.7	51.24	1.52	0.0
36	18.3	191.1	81.75	2.08	- 0.56
37	18.10	170.0	60.57	1.68	+ 0.23
39	18.2	172.7	55.68	1.80	0.0
41	18.4	161.0	56.75	1.58	+ 0.11
42	18.6	175.3	68.20	1.81	+ 1.14
43	18.6	175.3	64.88	1.77	+ 0.91
44	18.10	174.6	60.45	1.72	- 1.82
45	18.2	159.0	49.55	1.49	- 0.91
46	18.10	181.0	71.59	1.90	- 0.91
47	18.1	172.4	60.91	1.70	+ 0.68
50	19.3	170.2	52.73	1.59	- 0.91
52	19.1	169.5	63.41	1.72	0.0
54	18.6	181.6	58.46	1.72	- 0.11
55	19.2	160.0	57.55	1.58	- 0.79

Average of Both Squads.

Table VII. (c)

	Mean	Mean Dev. From Mean	Standard Deviation	COEFFT. of Var.
Age (years)	18.5	± 0.29	0.31	1.68%
Weight Kg.	61.80	± 4.7	6.4	10.3%
Height cm.	171.30	± 6.7	8.1	4.7%
Surface Area	1.67 Sq.M.	± .10 Sq.M.	.125 Sq.M.	7.5%
Alteration in Wgt. (Kg)	+ 0.08	/	/	/

Daily Calorie Intake of Individuals.

SQUAD A.

TABLE VIII. (a)

	Sun Cals.	Mon Cals.	Tues, Cals.	Wed. Cals.	Thur. Cals.	Fri. Cals.	Sat. Cals.	Cals. Week.	Cals. Day Average.
1.	4502	4007	3426	3732	2867	4014	4815	27,363	3909
2.	4541	3948	2086	3718	2892	3543	4677	24,405	3487
3.	2820	4237	3182	4046	3276	6691	4313	28,465	4066
4.	2577	3511	3212	3002	2749	5619	3527	24,197	3456
5.	4274	4775	3816	4760	4955	4843	4407	31,830	4547
6.	2638	3707	4092	5215	3090	5117	2532	26,391	3770
7.	4626	3473	2956	3589	4518	6507	4601	30,270	4324
8.	3442	3666	2738	3507	3032	5540	3384	25,309	3616
9.	3744	2713	4925	3629	5000	4214	4497	28,722	4103
10.	5178	3341	3673	3350	4040	4299	3672	27,553	3936
11.	3249	4868	3870	4106	4650	4496	4883	30,122	4303
12.	3421	3191	4532	3845	3798	3339	4413	26,546	3792
13.	3414	2887	5243	4257	3400	5854	3257	28,312	4044
14.	2887	3682	5180	4764	3135	4938	2331	30,917	4417
17.	5648	4940	3790	4919	2287	5350	3738	30,672	4362
19.	4370	4235	2200	4224	2819	5763	5994	29,605	4086
20.	2749	4344	4260	4435	3780	4732	5385	29,685	4239
21.	3531	2071	3296	3824	3280	3606	4380	23,985	3427
22	4284	3423	2862	3824	2709	5697	4815	27,614	3945
23.	4063	4160	4353	4964	4932	3973	3786	30,231	4318
24.	2583	2898	4063	4086	3258	5004	2475	24,367	3481
25.	3651	4402	4028	4647	2959	5906	3502	29,095	4156
26.	4425	4755	4605	3801	4840	4577	2912	32,915	4702
Total	86617	87241	86388	94244	82266	113619	99296	648,571	92,506
Mean	3766	3793	3756	4093	3577	4940	4317	28,199	4022.

SQUAD B.

TABLE VIII. (b)

	Sun	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Calories Week	Cals/Day Average.
27.	3730	4030	1907	3961	4915	4212	5028	27,783	3967
31.	3217	3457	2263	3935	3985	3569	3936	24,363	3480
32.	4669	3147	3365	3836	3697	4786	5303	28,803	4115
33.	4639	2527	3934	4365	3461	7188	4626	30,739	4391
34.	5476	3345	4453	3961	3095	5049	3066	28,445	4064
36.	3454	3530	2628	5098	4605	5512	6806	32,633	4662
37.	5361	3906	2807	4138	3618	4385	3645	27,860	3980
39.	4820	3014	3710	3271	2084	5493	3808	26,200	3743
41.	3977	3038	3211	4137	2679	3675	3649	24,366	3481
42	4738	4911	5577	3413	4364	5334	3516	31,853	4550
43.	3835	4182	3260	4211	2918	7710	4092	30,208	4315
44.	3017	4456	2860	4201	4367	6502	3341	28,744	4107
45.	4110	3049	3704	4324	2297	4484	4510	26,478	3783
46.	3597	4990	3289	4224	2833	5289	3817	28,039	4006
47.	4141	3083	2816	4217	3425	4727	3611	26,022	3717
50.	3719	2826	3077	3948	2809	6095	4296	26,770	3825
52.	3654	3120	3372	3919	2702	4606	4514	25,887	3699
54.	3310	3712	3321	4399	5620	3478	4786	28,526	4089
55.	4445	4432	2310	3393	4148	4537	5537	28,797	4114
Total	77,909	68,754	61,864	76,953	67,622	97,626	81,887	532,516	76,089
Mean.	4100.4	3617.5	3256	4050.1	3569	5138.2	4309.8	28,062.2	3999.4

Both Squads.

Total	164,526	155,995	148,252	171,197	149,888	211,245	181,183	1,181,087	168,595
Mean	3917.3	3714.1	3529.9	4076.1	3568.9	5029.7	4311.5	28121.1	4014.1

Average Daily Net Calorie Intake (Squads A & B)

= 4014 Cals.

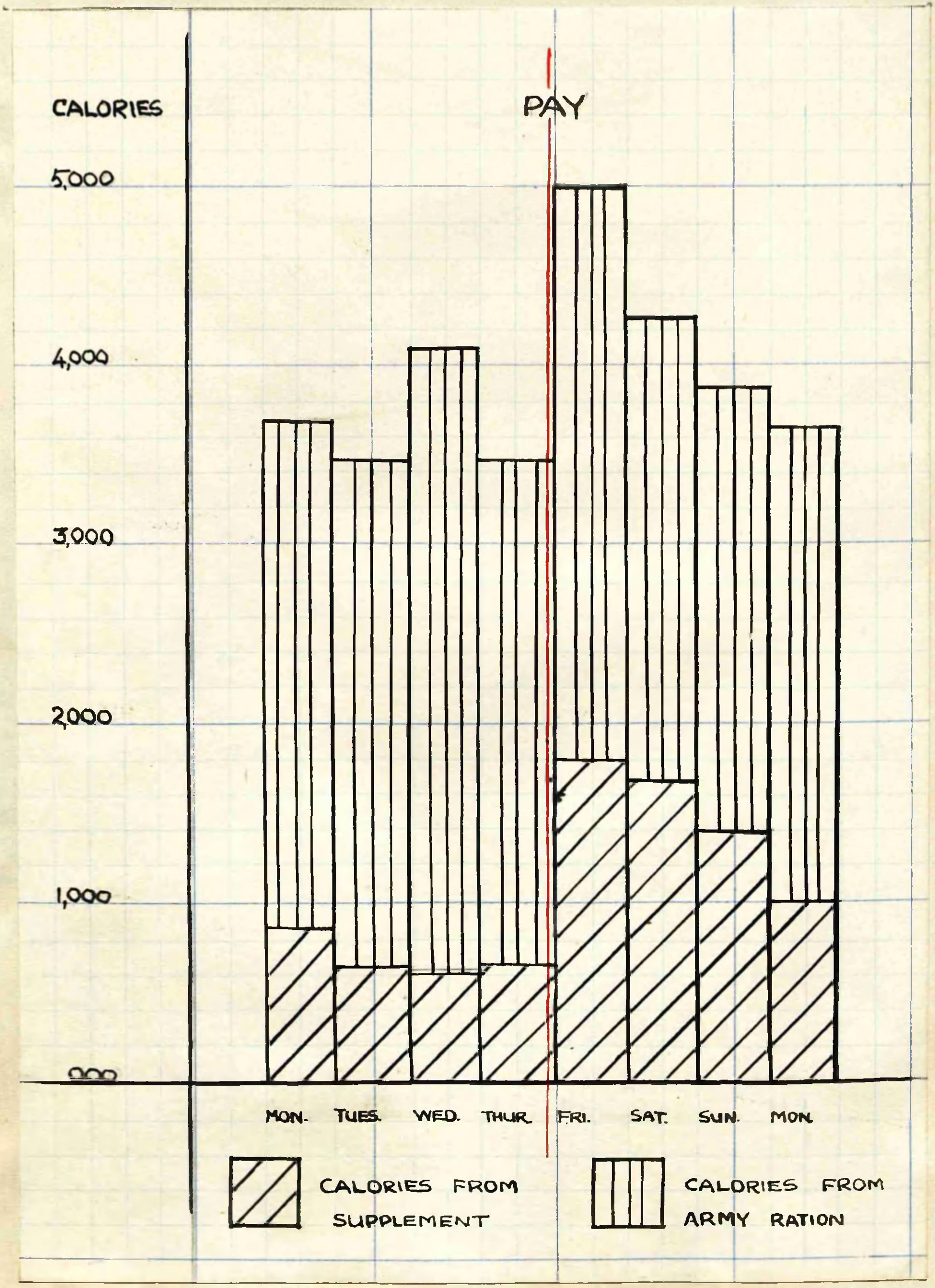
Mean Deviation	=	± 268 Cals.
Standard Deviation	=	328 Cals.
Coefficient of variation.	=	8.17%

....

It is of great interest to note the variation of daily calorie intake on the day on which pay is received. The great rise of calorie intake on this day is succeeded by a steady fall, (in canteen foods) as the week progresses. This trend was traced for 15 weeks, by N.A.A.F.I. statistics, and figure (3), for the week of the individual survey, was quite typical, and clearly shows the relation of total and supplementary intake to pay-day.

FIGURE. (3)

Daily Fluctuation of Calorie Intake.



Relation of Calorie Intake to Height, Weight and Surface Area, of Subjects.

TABLE IX (a) Squad A.

No. in Survey.	Cals.	Cals. Sq.m.	Cals. Kg.	Cals. cm.
1	3909	2341	64	24
2	3487	1971	56	20
3	4066	2284	66	23
4	3456	2133	58	21
5	4547	2756	75	27
6	3770	2130	57	22
7	4324	2574	72	26
8	3616	2127	60	21
9	4103	2345	64	24
10	3936	2642	78	25
11	4303	2546	68	26
12	3792	2180	59	22
13	4044	2436	67	24
14	4417	2242	59	24
17	4382	2548	72	25
19	4086	2197	58	23
20	4239	2569	65	25
21	3427	2155	62	21
22	3945	2180	59	22
23	4318	2699	77	26
24	3418	2260	66	22
25	4156	2598	73	76
26	4702	2528	63	27

TABLE IX. (b) SQUAD. B.

No. in Survey.	Cals.	Cals/ Sq.M.	Cals/ Kilo.	Cals/ cm.
27	3967	2168	62	22
31	3480	2071	64	19
32	4115	2121	56	23
33	4391	2797	80	27
34	4064	2674	79	25
36	4662	2241	57	24
37	3980	2369	66	23
39	3743	2282	67	22
41	3481	2203	61	22
42	4550	2514	67	26
43	4315	2438	67	25
44	4107	2388	68	24
45	3783	2539	76	24
46	4006	2108	56	22
47	3717	2186	61	22
50	3825	2406	73	23
52	3699	2151	58	22
54	4082	2373	70	23

Mean Values for Both Squads. (the differences between squads A & B are not statistically significant.)

	Mean	Mean Deviation	Standard Deviation	Co.efft. Variation
Calories.	4014.0	± 268	328	8.17%
Cals/Sq.M. Surface Area.	2357.0	± 182	236	10.02%
Cals/ Kg.	66.0	± 5.8	6.95	10.5%
Cals/ cm.	24.0	± 1.7	2.18	9.1%

The spread of calorie intake distribution is probably more easily grasped by histogram, accordingly Figure 4a and b displays the calorie intake per person and per square metre of surface area of individuals, per day.

Figure IV a.

Frequency distribution of Daily Net Calorie Intake, per head.

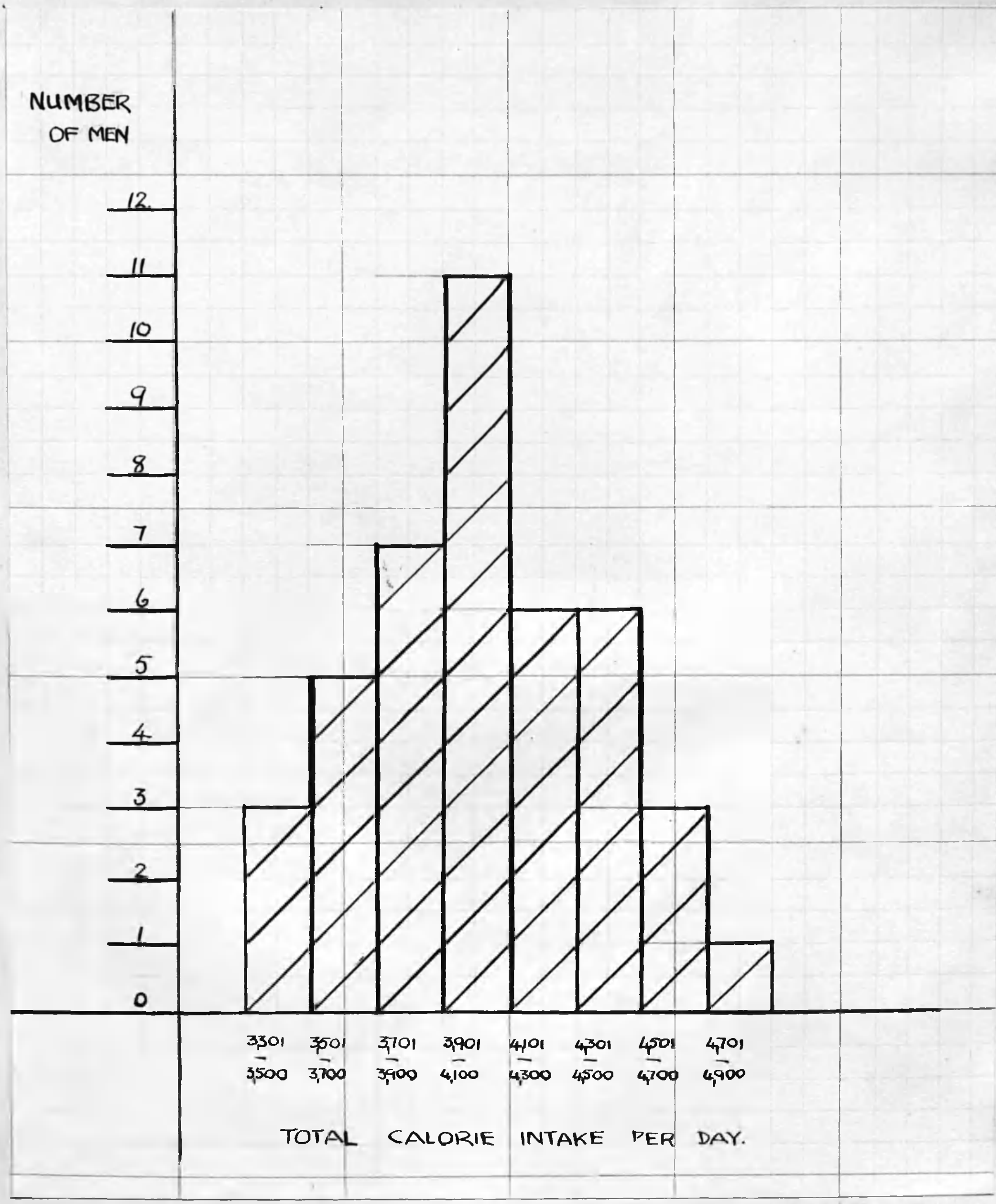
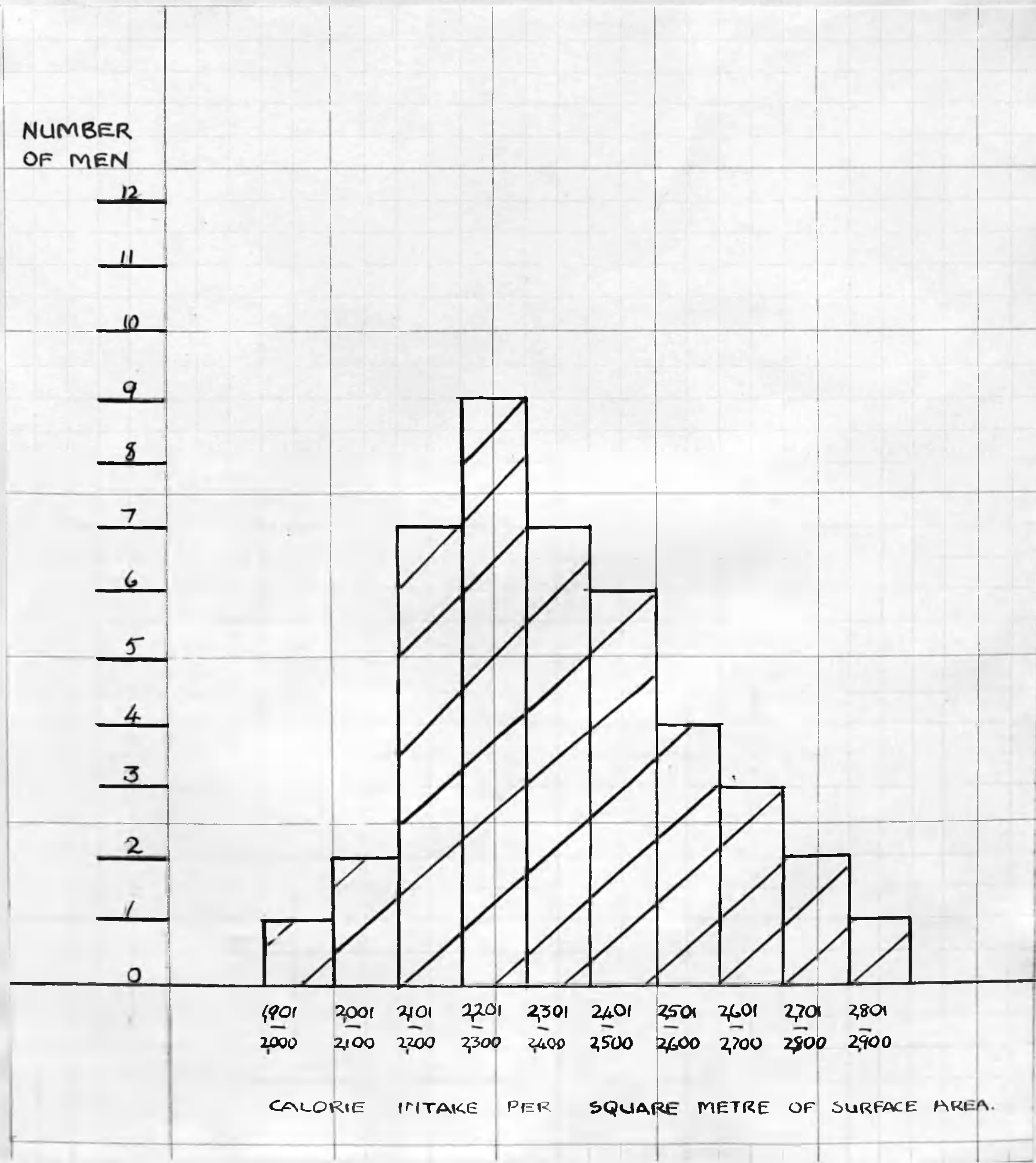


Figure IV b.

Frequency distribution of daily net Calorie intake per sq. Metre of Surface Area.



Overall Average Technique.

The overall average intake per man in camp was checked for a period of two weeks by the method described in part IV.

The following results were obtained:-

No. of men investigated.	Week Ending.	Aver. Cal. Value of Rations.	Aver. Cal. Value of Supplement.	Total Calorie Intake.
282	7.12.47	3008	932	3940
335	14.12.47	3014	941	3955
617	Mean	3011	937	3948

The degree of supplementation is lower than by the individual method, but the correcting factor for the average of 2 meals, eaten outside the camp, has yet to be applied to the supplement.

Corrected Average Result.

Average Daily Cal. Intake (Army Rations)	=	3,011 Cals.
Average Daily Cal. Intake (elsewehre)	=	1,008 Cals.
Total Intake Daily	=	4,019 Cals.

This figure almost coincides with that obtained by the individual method. (4014 Cals/day).

Energy Expenditure of Recruits.

As described in part IV an accurate timetable of the average time spent by each recruit on all forms of activity was recorded. Details of this are laid out below (Table X) with calculated energy expenditure.

TABLE X. Energy Expenditure of Recruits. 72.P.T.C.

Occupation.	Hours per Week.	Cal. per Sq.M. per hour.	Cal. per 1.77 Sq.M. per Week.
Sleeping	56	39	3864
Eating	21	61	2268
Washing	7	73	910
Free Time (A)	22	40	1650
" " (B)	16	132	4800
Drill with (arms)	5	140	1239
Physical Training.	6	141	4344
Fatigues	10	136	2311
Doubling	2	372	1317
Sitting	8	49	690
Mushetry	6	100	1062
Route March	4	258	1830
Bayonet Drill	4	121	860
Kit Inspection	2	74	260
	168		27,405

Calories per week = 27,405.

Calories per day = 3917.

By these computations the Net Daily Calorie Intake is 4014 Cals and expenditure 3917 Cals; this leaves a positive balance of only 97 Calories.

It is worthy of comment that there existed a considerable difference in the weight-change pattern of squads A & B. Whereas squad A, in its fifth week of training, showed 60% gaining weight and 40% losing weight, with an overall average gain of 0.15 Kilos, Squad B, in its third week of training, had 50% losing weight and 50% gaining, with an average loss of 0.09 Kilos.

This was not due to a more strenuous programme, nor to a greater Calorie intake, absolutely, or relative to height or weight.

This point was further investigated at 9 P.T.C. (Arneil & Waller 1947) and the fact established that under present conditions of training and food consumption the recruit loses weight for two weeks, and then commences to gain, finishing training with an appreciable overall gain in weight. It appears possible that an initial mechanical inefficiency is gradually resolved, with consequently more efficient utilisation of Calories. Alternatively, the initial fall may be due to utilisation of/

of interstitial fat, later to be compensated by muscular eutrophy.

B. **Army School of Education.**

Unit:- Royal Army Education Corps.

Number of Men: = 624

Location: Buchanan Castle, Stockiemuir.

Altitude: 350 Ft. above sea level.

Date of Survey: 15- 31st January, 1948.

Meteorological Conditions obtaining.

Mean Barometric Pressure	=	992 millibars
Mean Temperature	=	35.7° F.
Mean Relative Humidity	=	81.1 %

INDIVIDUAL SURVEY.

The men, when surveyed, were engaged on sedentary work, with an admixture of physical exercise. Numerical random sampling of a nominal roll was used to select subjects. Twelve were selected, but one fell ill and had to be excluded.

PHYSICAL CHARACTERISTICS OF SUBJECTS.

TABLE XI.

No. in Survey	AGE Yrs.	Mnths.	HEIGHT cms.	WEIGHT. Kg.	SURFACE AREA Sq.M.	ALTERATION IN WEIGHT.
1	19	5	171	70.7	1.89	+ 0.26
2	19	9	172	67	1.77	+ 0.57
3	20	3	168	58.3	1.65	+ 0.58
5	20	7	170	56.6	1.65	+ 0.68
6	20	0	183.5	62.7	1.81	+ 0.49
7	19	9	171.5	63.8	1.73	+ 0.55
8	19	11	168	58.5	1.65	-0.75
9	21	5	175	66.5	1.79	-0.68
10	19	9	190	86.4	2.51	+ 0.51
11	20	1	177	66	1.80	+ 0.13
12	19	9	170.5	70.8	1.80	+ 0.68

Average Age = 20 years 1 month.

Average Height = 174.2 cms.

Average Weight = 66 Kg.

Average Surface Area = 1.77 Square Metre.

Average Weight Change = + 0.41 Kg.

TOTAL CALORIE INTAKE OF INDIVIDUALS (DAILY). TABLE X11.

No.	Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.	Cals/ week	Cals/ Day.
1	3707	4644	4609	4651	4600	4007	3995	30213	4316
2	3893	3373	3185	3347	4745	2898	3200	24641	3520
3	3152	4252	4310	4134	4118	3586	3621	27173	3882
5	4445	2735	3961	3962	4371	3185	3245	25904	3701
6	4366	2595	3778	4013	4918	3555	3900	27125	3874
7	3106	3217	4797	3657	2792	5072	4335	26976	3854
8	3035	4000	3547	3767	3968	3761	4241	26319	3760
9	4663	3982	4045	3031	4632	4752	2829	27934	3991
10	5352	4160	3840	3790	4948	3955	5010	32055	4580
11	4283	4207	4757	3757	3902	4175	3152	27761	3966
12	4049	5130	5059	4685	4531	3569	4700	31723	4532

Average Daily Intake = 3998 Cals.
Mean Deviation from mean = ± 243 Cals.
Standard Deviation = 298 Cals.
Coefft. of Variation = 7.5 %

Calorie Intake in relation to Height, Weight and Surface Area. TABLE X111

	Cals.	Cals/Sq.M.	Cals./Kilo.	Cals./Cm.
1	4316	2284	61	25
2	3520	1989	53	21
3	3882	2311	67	23
5	3701	2243	65	22
6	3874	2140	62	21
7	3854	2228	60	22
8	3760	2279	64	22
9	3991	2229	60	23
10	4580	2135	53	24
11	3966	2204	60	22
12	4532	2518	64	26
Mean	3998	2233	61	23
Mean Dev. From Mean	±243	±91.6	±3.3	±1.3
Standard Deviation.	298	135	4.3	1.54
Coefft. Variation.	7.5%	6.0%	7.1%	6.8%

Overall Average Method.

The total Calorie consumption per person in camp was calculated as before (v.i.).

TABLE XIV. Calorie Intake, (Overall Method) R.A.E.C.

No. of Men.	Week Ending	Av. Cals from Army Ration.	Av. Cals. Supplement.	Total Cals.
625	23.1.48	2680	967	3647
623	30.1.48	2667	948	3615
1248		2673	958	3631

Again we must correct the supplement to allow for 2 meals per week eaten out of camp (average). The supplement then becomes 1032 Cals. and the total intake = 3705 Cals.

This figure is markedly below the result obtained by the individual method. This fact is discussed below.

TABLE XV.

ENERGY EXPENDITURE OF TRAINEES.

Occupation.	Hours per Week.	Cals. per Sq. Metre per Hr.	Cals per 1.77 Sq.M. Per Week.
Sleeping	56	39	3864
Eating	21	61	2268
Washing	7	73	910
Free Time(A)	15	40	1125
Free Time (B)	20	132	6000
Drill	5	180	1593
Fatigues	7	136	1687
Sitting	28	49	2638
P.T.	3	142	929
Guards	6	102	1087
Total	168		22101

Energy Expenditure per week = 22,101 Cals.

Energy Expenditure per day = 3157 Cals.

The discrepancy between average intake and output is therefore no less than 841 Cals per day. This is reflected in a very considerable average weight gain, i.e. 0.41 Kilos per person in a seven day period.

At/

This excessive intake was at first considered to be due to over eating. On further enquiry however we found that the men investigated by the individual method had, up till 7 days before the commencement of the investigation, been involved in severe muscular exercise. Whether these men ate more because of an elevated B.M.R., or to replace depot fat previously utilised or merely because of habit is not known. It is worthy of note that the men only gained 1.5 Kg. in the previous 3 months.

This unintentional selection of subjects apparently accounted for the discrepancy in the mean results, as arrived at by the two methods.

C. FIGHTING VEHICLE PROVING ESTABLISHMENT.

Unit: Royal Armoured Corps.

Number of men in Camp: = 83.

Location: Netherlaw House, Kirkcudbright.

Altitude: 70 ft. above sea level.

Date of Survey: 19th Feb. - 5Th Mar., 1948.

Meteorological Conditions obtaining.

Mean Barometric Pressure	=	1029 Millibars.
Mean Temperature	=	36.3°F.
Mean Relative Humidity	=	70.6%

This unit consists of 83 men, some engaged on sedentary and some on active work. It is typical of the small units scattered throughout the country.

By random sampling of a nominal roll, four sedentary and seven active workers were selected, this being the proportion of men engaged on each type of work.

PHYSICAL CHARACTERISTICS OF SUBJECTS. TABLE. XVIA

No.	Type of Work.	Age. Yrs.	Mnth.	Height cm.	Weight Kg.	Surface Area Sq.M.	Alteration in Weight. (Kg)
1	Light	28	2	169.5	64.8	1.73	-0.55
2	Heavy	19	7	176.5	64.8	1.78	+0.10
3	Heavy	23	9	171	62.8	1.72	+0.55
4	Heavy	20	5	172.5	63.5	1.74	+0.07
5	Light	19	7	168	66	1.73	+0.14
6	Light	24	9	174	74	1.87	+0.33
8	Heavy	21	4	176	70.1	1.84	+0.24
9	Light	20	5	165.5	69.2	1.75	+0.12
10	Heavy	20	1	184	71.9	1.93	+0.13
11	Heavy	19	6	172	71.2	1.82	+0.35
12	Heavy	20	5	171	65.4	1.75	+0.57

TABLE XV1B   Average Results.

	Light Workers.	Heavy Workers.	All Workers.
Average Age.	23 Yr. 3 Mnth.	20 Yr. 9Mnth.	21Yr. 8 Mnth.
Average Height (Cm)	169.3	174.8	172.6
Average Weight (Kg)	68.5	67.1	67.6
Average Surface Area (Sq.M.)	1.77	1.80	1.79
Average WT., Change (Kg)	+0.04	+ 0.28	+ 0.19

TOTAL DAILY CALORIE INTAKE.

TABLE XV11 A.

No.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Sun.	Cals/ week.	Cals/ Day.
1	2445	2645	2782	2851	2808	3393	3669	20593	2942
2	3300	2998	3381	4769	3633	3919	4026	26026	3718
3	4363	2867	3989	4227	6185	3867	3026	28524	4075
4	4819	3076	3084	3813	3135	4045	3844	25816	3688
5	4082	3156	3279	3427	3508	2714	2560	22726	3246
6	4000	3233	3650	3139	3042	4113	3479	24656	3522
8	3298	2897	4659	3900	5722	4256	2532	27264	3894
9	3973	3387	2000	4744	3658	3205	3452	24419	3488
10	3773	3336	4640	4985	3665	4321	3153	27873	3983
11	3755	3839	3957	4645	4971	3726	4233	29126	4160
12	4042	3317	3622	3266	3937	4237	3877	26298	3757

TABLE XV11 B. Average Results.

	Light Work.	Heavy Work.	All Types.
Cals/Day	3299	3896	3679
Mean Deviation	± 206	±137	±267
Standard Deviation	227	152	337
Coefft. Var.	6.9%	4.0%	9.2%

TABLE XV111.

Variation of Calorie Intake in Relationship to Height, Weight and Surface Area.

No. in Survey.	Cals.	Cals/Sq.M.	Cals/Kg.	Cals/Cm.
1	2942	1707	45	17
2	3718	2089	56	21
3	4075	2369	65	24
4	3688	2119	58	21
5	3246	1876	49	19
6	3522	1834	50	20
8	3894	2116	56	22
9	3488	1987	50	22
10	3982	2063	55	22
11	4160	2286	59	24
12	3756	2146	63	22
Mean	3679	2054	55	21.3
Mean Deviation	± 267	± 124	± 4.7	±1.54
Standard Deviation	337	168	5.9	1.98
Coefft. of Variation.	9.15%	8.12%	11.4%	9.3%

Overall Average Method.

The average for the entire camp was as below:-

Average Daily Army Ration	=	2680	Cals.
Average Daily Supplement	=	949	Cals.
Total Calorie Intake	=	3629	Cals.

Once again 2 meals per week per head were eaten out of camp, giving a corrected supplementary figure of 1,031 Cals. Daily. Thus the average total daily intake by this method is 3,711 Cals, agreeing closely with that of the individual method (3,679) Cals.

Energy Expenditure of Men at F.V.P.E.

LIGHT WORKERS. TABLE XlXa

Occupation	Hours per Week.	Cals. per Sq.M/Hour	Cals/Week For 1.77 Sq.M.
Sleeping	56	39	3864
Eating	21	61	2268
Washing	7	73	910
(A) Free Time	21	40	1500
(B) Free Time	18	132	4200
Drill	2	130	460
Fatigues	5	136	1205
Sitting	32	49	2764
P.T.	2	142	501
Marching	4	180	1274
Total	168		20,221
Cals	Per	Week =	20,221
"	"	Day =	2,889

HEAVY WORKERS. TABLE X1X b

Occupation	Hours per Week.	Cals. per Sq.M. per Hr.	Cals/Week For 1.77 Sq.M.
Sleeping	56	39	3864
Eating	21	61	2268
Washing	7	73	910
Free Time (A)	20	40	1500
Free Time (B)	14	132	4200
Drill	2	130	460
Fatigues	20	136	4820
Guards	8	102	1448
P.T.	2	142	501
Marching	4	180	1274
Field Work	14	187	4621
Total	168		25,866

Cal. per week = 25,866

Cal. per day = 3,695

Average Daily Calorie Expenditure:-

Light Worker	=	2,889 Cals.
Heavy Worker	=	3,695 Cals.
Average Overall	=	3,328 Cals.

....

The difference between intake and output is apparently 410 Cals. for light workers, 201 Cals. for those on heavy work and 277 Cals. for the average person.

D. SURVEY TRAINING CENTRE.

Unit: Royal Engineers.

Number of Men: 406

Location: Longleat Estate, Warminster.

Altitude: 300 ft. above Sea Level.

Date of Survey: 1st - 16th April, 1948.

Meteorological Conditions Obtaining.

Mean Barometric Pressure	=	1018 millibars
Mean Temperature	=	47° F.
Mean Relative Humidity	=	60%

....

The work at this camp is almost entirely sedentary. Men study the theory of using such instruments as the Theodolite. Fourteen men were selected by random sampling, one developed a root abcess and was excluded from results.

....

PHYSICAL CHARACTERISTICS OF SUBJECTS. TABLE XVll.

No.	Age. Yrs.	Age. Mths.	Height Cm.	Weight Kg.	Surface Area Sq.M.	Alteration in Weight Kg.
1	19	9	188	76.9	2.01	0.0
2	18	9	176.5	76.1	1.92	+0.06
3	19	2	176.5	69.4	1.84	+0.05
4	19	4	182	73.5	1.93	+0.15
5	18	10	179	70.9	1.88	+0.28
6	18	9	167.5	57.4	1.63	0.0
7	18	9	168.5	60.7	1.68	+0.28
8	18	10	164	63.6	1.66	0.0
10	20	1	165	64.4	1.69	+0.28
11	18	10	183	65.3	1.84	+0.63
12	20	-	169	57.4	1.64	+0.34
13	19	4	169.5	58.7	1.66	+0.29
14	18	11	182	67.1	1.87	-0.20

Average Age = 19 yrs. 0 Mths.

Average Ht. = 176.6 Cms.

Average Wt. = 66.3 Kg.

Average Surface Area. = 1.80 Sq.M.

Average Weight Change. = + 0.09 K.G.

TOTAL CALORIE INTAKE OF INDIVIDUALS. TABLE XV111.

No.	Thurs.	Fri.	Sat.	Sun	Mon.	Tues.	Wed.	Cals/ Week	Cals/ Day.
1	4352	4088	3084	4005	3437	4020	2874	25860	3694
2	4452	4405	3539	4774	3551	3705	3198	27624	3946
3	4018	2237	3426	3747	3966	2615	2731	22740	3249
4	3034	3001	3239	3899	3475	2971	4305	23924	3418
5	3569	3996	2751	2839	4302	2594	2414	22465	3209
6	3139	2336	3120	3060	2565	2693	2319	19232	2748
7	4340	3518	2969	3235	3237	2341	2287	21927	3132
8	3131	2083	3578	3096	2925	2609	2757	20179	2883
10	2890	4159	3154	3032	2945	2559	3368	22107	3159
11	3868	3029	3566	3601	3650	2413	3109	23236	3319
12	4070	3434	2656	2953	2750	2729	3476	22068	3153
13	3866	3260	2446	3917	3081	2821	2872	22263	3180
14	4154	3783	3714	4230	3405	2947	2862	25095	3585

Average Daily Intake = 3283 Cals.
Mean Deviation from mean = $\pm$239 Cals.
Standard Deviation = 314 Cals.
Coefficient of Deviation = 9.6 %

TABLE XIX

RELATION OF CALORIE INTAKE TO HEIGHT WEIGHT AND SURFACE AREA OF MEN.

No.	Cals.	Cals/Sq.M.	Cals/Kg.	Cals/Cm.
1	3694	1838	48	20
2	3946	2055	52	22
3	3249	1765	47	18
4	3418	1792	47	19
5	3209	1760	45	18
6	2748	1686	48	16
7	3132	1864	52	19
8	2883	1737	45	18
10	3159	1869	49	19
11	3319	1804	51	18
12	3153	1923	55	19
13	3180	1922	54	19
14	3585	1927	53	20
Mean.	3283	1842	49.7	18.8
Mean Deviat-Ion.	± 239	±78	±3.0	±0.95
Standard Deviat-ion.	314	95	3.3	1.41
Coefft. Variat-ion.	9.6%	5.2%	6.6%	7.5%

Overall Average Method.

The corrected figures for this camp (406 persons) were:

Average Daily Value Rations	=	2,404 Cals.
Average Daily Value of Supplement	=	813 Cals.
Total Daily Value	=	3,217 Cals.

The individual method, it will be remembered, gave the closely corresponding result of 3283 Cals.

TABLE XX.

ENERGY EXPENDITURE AT S.T.C.

Occupation.	Hours per week.	Cals. per Sq.M. per Hour.	Cal. Per week per 1.77 Sq.M.
Sleeping	56	39	3864
Eating	22	61	2376
Washing	7	73	910
Free Time (A)	21	40	1575
Free Time (B)	18	132	5400
Drill	1	180	219
Fatigues	5	136	1205
Sitting	30	49	2591
Guards	3	102	543
P.T.	3	142	751
Marching	2	180	637
Total	168		20,171

Energy Expenditure for week = 20,171 Cals.

" " per day = 2,882 Cals.

Daily Calorie intake was assessed at 3283 Cals. giving a positive balance of 401 Cals. per head per day.

E.

NO. 598 COMPANY, MOTOR TRANSPORT (COMMAND).

Unit:- Royal Army Service Corps.

Number of men in Camp = 250.

Location:- Denbury, Devon.

Altitude:- 300 ft. above sea level.

Date of Survey:- 1st April - 24th May 1948.

Meteorological Conditions Obtaining.

Mean Barometric Pressure	=	1013 millibars.
Mean Temperature	=	45° F.
Mean Relative Humidity	=	58% .

This camp contained 250 men employed largely on driving and maintenance tasks, with however, a certain amount of Drill and Military Training.

PHYSICAL CHARACTERISTICS OF RECRUITS. TABLE XX1.

	Age Yr. Mth.	Height Cm.	Weight Kg.	Surface Area Sq. M.	Alteration in Weights. Kg.
1	18 7/12	171	69	1.79	+0.68
2	18 8/12	172.5	58.1	1.67	+0.45
3	18 8/12	188.5	80	2.05	+0.0
4	18 7/12	167	54	1.53	+0.68
5	18 7/12	167	58.1	1.64	0.0
6	18 9/12	172	66.8	1.77	0.0
7	18 8/12	169	64.6	1.72	+0.23
8	18 8/12	172.5	61.4	1.72	+0.92
9	18 6/12	167	56.1	1.61	-0.45
10	18 8/12	168	62.9	1.70	-0.91
11	18 7/12	173	61	1.71	+0.14
12	18 8/12	169	58.4	1.66	+0.45
13	18 8/12	168.5	59.5	1.67	+0.45
14	18 8/12	175	67.0	1.79	-0.23
15	19 4/12	164	58.5	1.62	-0.23
16	18 8/12	172	70.4	1.81	0.0
17	18 8/12	168	61.4	1.68	0.0
18	18 6/12	172.5	58.1	1.78	+0.45
19	18 8/12	178	73	1.89	-0.45
20	18 8/12	171	67.8	1.77	-0.68
21	18 7/12	186	79.6	2.02	-0.45
23	18 2/12	166	59.1	1.64	-0.45
24	23 6/12	161.5	64.8	1.67	-0.45
25	18 8/12	184	79.7	2.01	-0.45

Average Age = 18 Yrs. 10 Mths.
Average Height = 172.2 cm.
Average Weight = 64.55 Kg.
Average Surface Area = 1.747 Square Metres.
Average Alteration of Weight = -0.01 Kg.

TOTAL DAILY CALORIE INTAKE OF INDIVIDUALS.

TABLES XX11.

No.	Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.	Cals./Wk.	Average Cals/Day.
1	3450	3435	4786	4570	5566	3320	3759	28886	4127
2	3125	2372	3847	3198	4839	3679	4647	25707	3672
3	3701	2197	4341	5691	5439	4409	4004	29782	4254
4	4306	3276	3145	3446	3083	4487	3838	25581	3654
5	4161	3038	3769	4321	4613	3719	3336	26957	3851
6	3579	4044	4958	3185	4450	4409	4157	28782	4112
7	2818	2235	4183	3462	6170	3487	3603	25958	3708
8	3978	3293	4475	2902	4039	4138	2598	25423	3623
9	2783	2509	4427	2976	3397	3009	2877	21978	3140
10	4555	3104	4586	3665	3435	3739	3387	26471	3782
11	3193	2853	4551	3181	3342	3266	4480	24866	3552
12	3254	2519	5317	3343	3958	2813	3478	24682	3526
13	3904	3088	3041	3223	5088	4865	3479	26688	3812
14	4284	3487	4769	3955	4924	3349	3563	28331	4047
15	3675	4322	4181	2319	4307	4482	3202	26488	3785
16	2984	2846	3864	4168	4480	4725	4605	27672	3953
17	3240	2756	4330	4161	3189	4357	4052	26085	3726
18	3750	2566	4630	4844	3868	5635	4579	29872	4268
19	2860	3195	5009	3349	4032	4728	3314	26487	3783
20	5839	3169	4539	4179	4497	3627	3196	29046	4149
21	3479	4703	4216	2388	3483	4280	3305	25854	3694
23	4932	3292	4632	3424	5485	3611	4203	29579	4225
24	3039	3056	3314	5340	4294	4112	4154	27309	3901
25	5235	4817	3973	3742	4633	3353	3377	29130	4161
Total	90124	76172	102883	89032	104611	95599	89193	647614	92505
Mean	3755	3174	4287	3709	4359	3983	3716	26942	3438

Relation of Calorie Intake to Height, Weight and Surface Area of Subjects.

TABLE XX111.

No.	Cals.	Cals/Sq.M.	Cals/Kg.	Cals/Cm.
1	4127	2310	59	24
2	3672	2180	64	21
3	4254	2090	53	23
4	3654	2390	68	21
5	3851	2310	66	23
6	4112	2315	62	24
7	3708	2150	57	22
8	3632	2105	59	21
9	3140	1970	56	18
10	3782	2225	60	23
11	3552	2080	58	21
12	3526	2120	60	21
13	3812	2280	64	23
14	4047	2260	60	23
15	3785	2240	65	23
16	3953	2143	56	23
17	3726	2220	60	22
18	4268	2450	74	25
19	3783	2035	52	21
20	4149	2350	61	24
21	3694	1840	46	19
23	4225	2520	71	26
24	3901	2340	60	24
25	4161	2060	52	23
Mean	3855	2210	60.1	22.2
Mean Deviation from Mean.	± 331	± 124	± 4.5	± 1.5
Standard Deviation.	251	152	6.18	1.75
Coefft. of Variation	6.5%	6.9%	10.3%	7.9%

Overall Average Method.

No. of Persons in Camp	=	250.
Average Value Army Ration	=	3,007 Calories.
Average Value of Supplement	=	743 Calories.
Total Value of intake	=	3,750 Calories.

Once again the men spent two evenings per week out of camp, providing a corrected figure of :-

Value of Army Rations	=	3,007 Cals.
Supplement (X 7/6)	=	868 Cals.
Total Value	=	3,875 Cals.

This is very close to the mean figure of 3,855 Cals. established by the individual method.

Energy Expenditure of men at 598 Coy. R.A.S.C.

TABLE XX1V

Occupation.	Hrs. Per Week	Cals. Per Sq. Metre Per Hr.	Cals. Per 1.77 Sq.M. Per Week.
Sleeping	56	39	3864
Eating	21	61	2268
Washing	7	73	910
Free Time (A)	17.5	40	1313
Free Time (B)	18	132	5400
Drill	17.5	180	5575
Fatigues	19	136	4579
Sitting	4	102	724
Guards	2	49	174
Driving	6	75	796
Total	168		25603

Energy Expenditure for Week = 25,603 Cals.
Average Daily Energy Expenditure = 3,658 Cals.

Since the average man consumed 3,855 Cals per day a positive balance of 197 Cals is present between intake and expenditure.

PART Vl.

A DISCUSSION OF THE RESULTS OF THE SURVEYS.

A. The Total Calorie Intake of the Soldiers.

1. The Sample Selected for Investigation.

Before embarking on a discussion of the results obtained from the individual surveys it is wise to study the validity of the sample investigated. 101 men were chosen, by random sampling, from a population of 2,578 men in five different camps. Of these men 17 were engaged on sedentary work, 42 on moderately hard work and 42 on very hard work. Whether this is the typical distribution of occupations in the Army in Britain it is not possible to say. A large proportion of the troops at home, however, are the National Service Conscripts, undergoing intensive training, and the proportions appear reasonable to the Statistics Branch of the War Office.

The age distribution of the subjects was purely fortuitons and resulted in the following figures:

Number	of	men	aged	18-19	years	63
"	"	"	"	19-20	years	22
"	"	"	"	20-21	years	10
"	"	"	"	21	years	6

Again, since men are aged 18 when conscripted, and serve for 18 months these results are not unreasoable. This is especially so as all boys aged 18 are kept in Britain, at the present time.

The following table (overleaf) shows the mean values for the age, height, weight and surface area of the 101 men;

It is interesting to note that these figures closely correspond to the height, weight and surface area of the average recruit, as found by Major Stalbow in 1947.

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AVERAGE AGE, HEIGHT, WEIGHT & SURFACE AREA OF SUBJECTS.

	Mean Value.	Mean Deviation.	Standard Deviation.	Coefft. of Variation.
Average Age.	19 VR. 1 Mth.	± 9 Mth.	13·3 Mth.	5·6 %.
Average Height.	173·1 Cm.	± 5 Cm.	7·1 Cm.	4·1 %.
Average Weight.	64·08 Kq.	± 5·65 Kq.	7·5 Kq.	11·7 %.
Average Surface Area.	1·73 Sq.M.	± 0·1 Sq.M.	0·13 Sq.M.	7·6 %.

2. The Actual Calorie Intake of Individual Men and at Various Camps.

The variation in total calorie intake amongst individuals was considerable, ranging over approximately 1,000 Cal. at each camp. The mean, individual, calorie intake, at each camp showed a coefficient of variation of from 6.5% to 9.5% . The mean value for all 101 subjects had a coefficient of variation of 9.85% . This is very much smaller than the figure of 20.4% found by Widdowson (1947) in boys aged 18. This smaller deviation is almost certainly due to the more accurate weighing, recording, and supervision of men which was possible in these army surveys.

The actual mean value for total net calorie intake at each camp is shown in table XXV.

A histogram of individual daily calorie intake is shown overleaf (Fig. V), which demonstrates not only normal frequency distribution, and the mean lying within the mode but also the position of the intake of sedentary men in relation to the intake of the other men surveyed.

TABLE XXV.

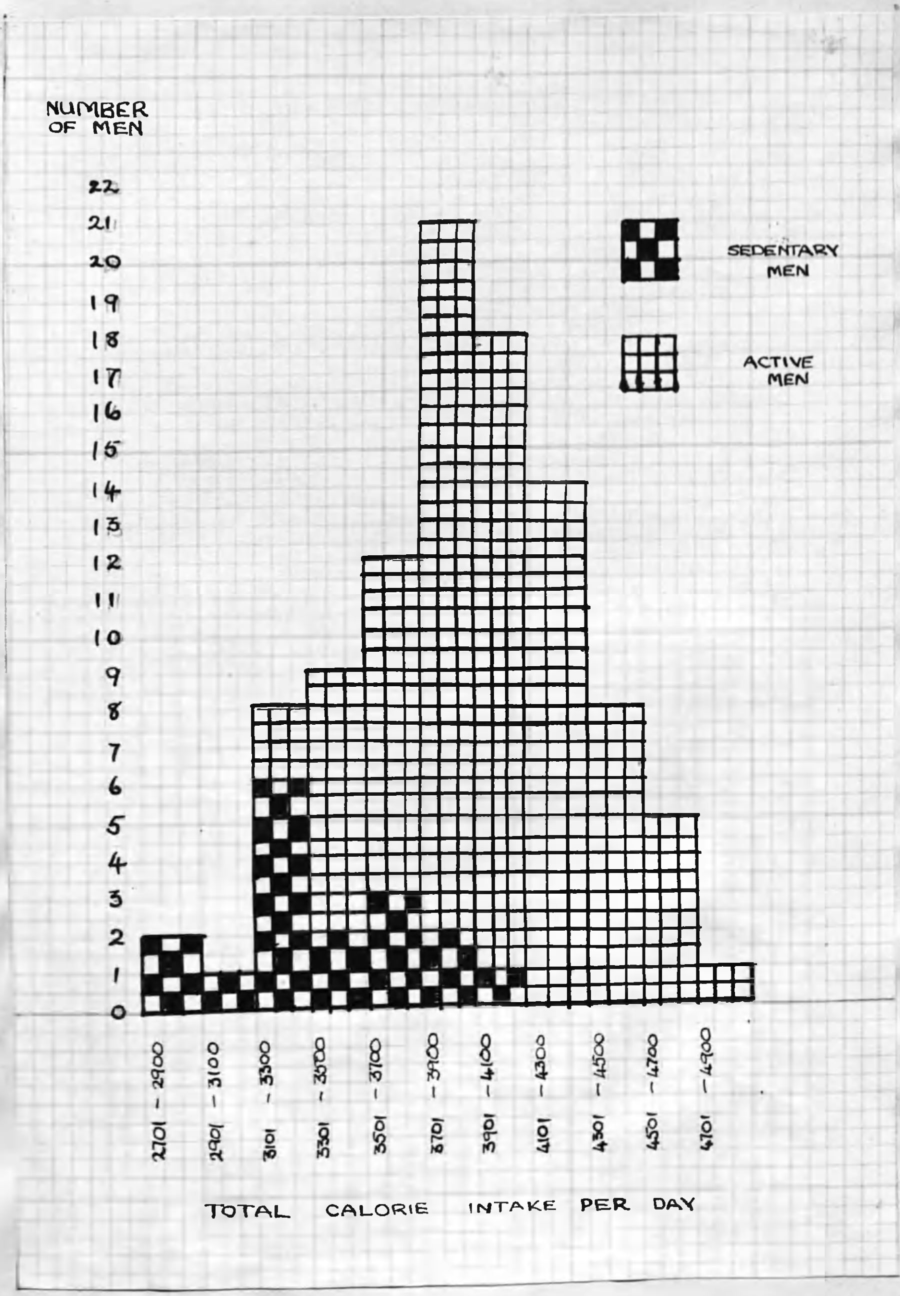
The Mean Total Calorie Intake of Individuals at Various Camps.

Camp.	Mean Daily Cal. Intake.	Mean Deviation (Cal.)	Standard Deviation (Cal.)	Coefficient of Variation.
Fort George.	4,014	± 268	328	8·2 %.
Buchanan Castle.	3,998	± 243	298	7·45 %.
Netherlaw House.	3,679	± 267	337	9·01 %.
Warminster.	3,283	± 239	314	9·50 %.
Denbury.	3,855	± 221	251	6·50 %.
Mean.	3,838	± 302	378	9·85 %.

FIGURE V.

The Distribution of Daily Calorie Intake

of 101 Individuals.



The mean daily calorie intake is 3838 Cal., with a mean deviation of 302 Cal. a standard deviation of 378 Cal. and a coefficient of variation of 9.85% .

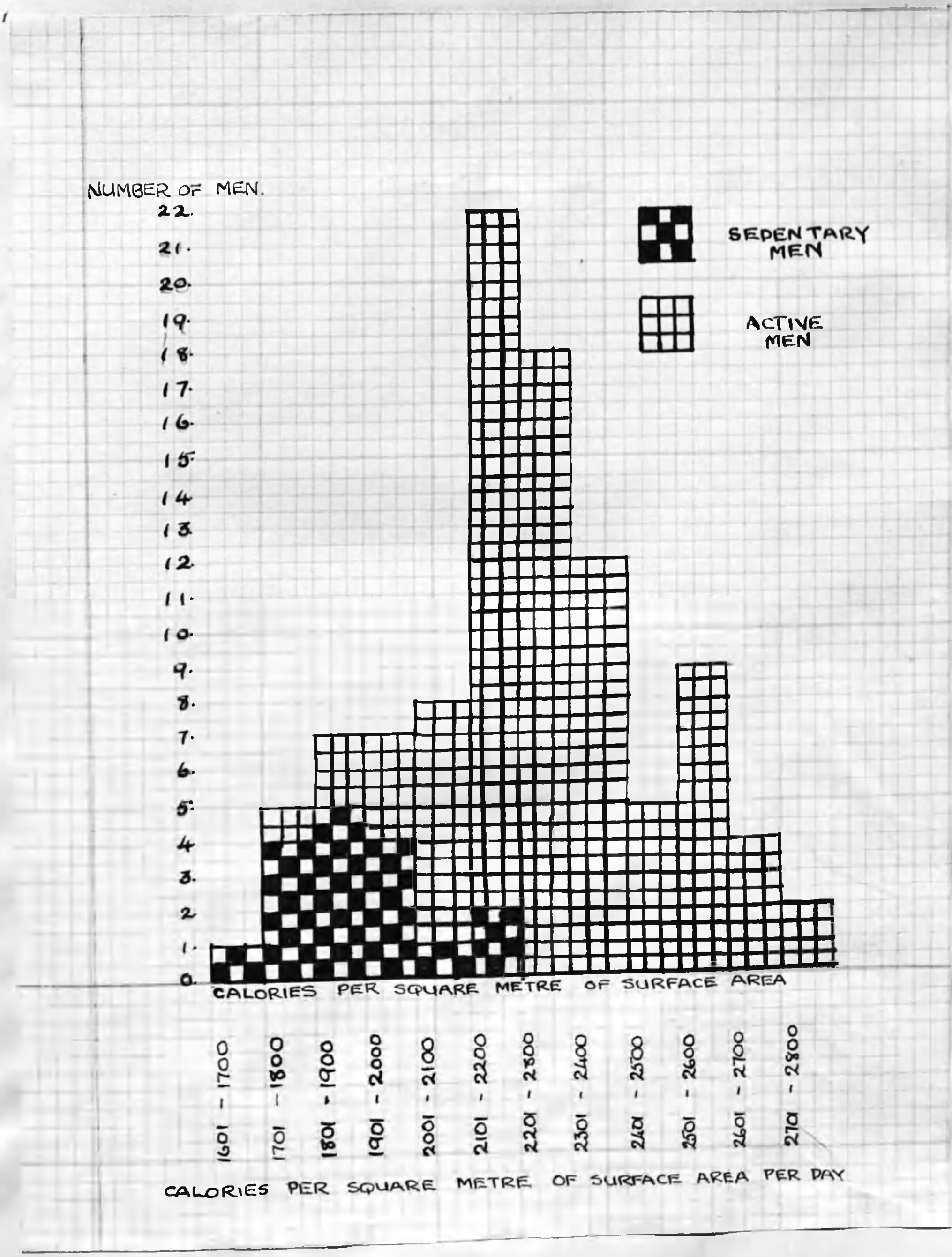
....

Whilst the influence of the body size of the individual on his calorie intake is described in greater detail below, it is, perhaps, permissible to refer to it here. Accordingly the intake of individuals, per square metre of surface area, is demonstrated in Figure VI.

The range of calorie intake per square metre of surface area is therefore approximately 1200 Cal., agreeing closely with the spread of 2,100 Cal. found for the average man of 1.73 Sq. M. surface area.
In this case the mean intake of 2218 Cal. has a mean deviation of 101 Cal., a standard deviation of 179 Cal., and a coefficient of variation of 8.07% .

FIGURE. V1.

Daily Net Calorie Intake of 101 Individuals/Sq.M. of Surface Area.



3. Factors Influencing the Calorie Intake of Individuals.

Three principle factors were considered as possibly modifying the intake of an individual soldier. These were:-

a. The age of the subject.

b. The occupation of the subject.

c. The Height, Weight and Surface Area of the subject.

Each of these factors will be considered separately and then in relation to the other two.

(A) The age of the Individuals.

The Calorie intake of subjects in relation to their age is shown in table XXVl.

Although the average intake falls slightly with increasing age the difference was not sufficient, (largely owing to the small sample) to be statistically significant. Consequently no conclusions may be drawn from these figures.

(B) The Occupation of the Subjects:-

At three of the camps, where all the men investigated were on similar work, in which they had been previously employed for some weeks, and were not changing in weight inordinately, it was considered that a state of calorie equilibrium had been reached with intake equalling

TABLE XXVI.

The Relation of the Age of Individuals to their total Calorie Intake.

Age (Years)	Number of Men.	Total Net Daily Calorie Intake.	Mean Deviation (Cal.)	Standard Deviation (Cal.)	Coefft. of Variation
18 - 19	63	3,864	$\pm$ 293	369	9·6 %.
19 - 20	22	3,907	$\pm$ 317	407	10·4 %.
20 - 21	10	3,662	$\pm$ 243	287	7·6 %.
21 - 28	6	3,721	$\pm$ 325	387	10·4 %.

requirements. The relevant figures for these camps are given in Table XXV11, where mean calorie intake and mean estimated energy expenditure are shown.

The difference between the mean daily calorie intakes at Fort George and Denbury is statistically significant $\left(M_1 - M_2 = 159; \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}} = 72\right)$

The difference between Denbury & Warminster is also statistically significamt, $\left(M_2 - M_3 = 572; \sqrt{\frac{\sigma_2^2}{n_2} + \frac{\sigma_3^2}{n_3}} = 101\right)$

There is <u>but one chance in a thousand</u> of this difference having arisen by chance.

The difference between the mean intakes at Fort George and Warminster is of course very significant indeed, $\left(M_1 - M_3 = 731; \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_3^2}{n_3}} = 100.5\right)$ only by <u>one chance in ten thousand</u> could it have arisen fourtuitously.

The interesting fact thus evolves that an apparent difference of 269 Cal. (3917-3648) in daily energy expenditure was sufficient to produce a difference of 159 Cal. in net calorie intake; a statisically significant figure. A further difference of calculated energy expenditure/

TABLE XXVII.

The mean total Net Calorie Intake of Three Camps in Relation to the Energy Expenditure of the Men in Same.

	Camp.	M. Mean Daily Net Cal. Intake.	6. Standard Deviation.	A. Estimated Energy Expenditure.	N. Number of Men Investigated.
1.	Fort George.	4,014	328	3,917	42.
2.	Denbury.	3,855	314	3,648	24.
3.	Warminster.	3,283	251	2,869	13.

expenditure of 779 Cal. (3648-2869) produced a very significant difference in net calorie intake of 572 Cal. It is reasonable to assume, therefore, that the influence of occupation is of considerable importance on calorie intake in soldiers.

The daily net calorie intake at camps varied from 3283 to 4014 Cal., as the work changed from sedentary to very hard.

The Relation of Calorie Intake to total Calorie Utilisation.

It will be noted, in table XXV11, that column A represents the estimated energy expenditure of the men at each camp. This is actually a measure of their calorie expenditure on basal metabolism, Specific Dynamic Action (of foods, especially protein) and on external work. A further source of calorie utilisation is for the growth of the individuals, and this fact must be considered in drawing up a final balance sheet.

Rubner (1908) stated that to lay down 1,000G of tissue in the human (= 30 G of Nitrogen or 1722 Cal). 10,332 Cal. were required. Using these figures as a basic for calculating calorie expenditure on anabolism (or eutroply) the following results are obtained.

TABLE XXVIII.

The Relation of Calorie Intake to Calorie Utilisation in Growth and Energy Expenditure.

			Intake	Expenditure.				
Camp.	No. of Men	Mean Weight gain (Kg). (in I Week)	Total Mean Cal. Intake Daily (0)	Energy Expenditure (Cal.) Daily.	Energy Utilisation on Growth (Cal.) Daily.	Total Energy Utilisation (b)	(a-b)	$\frac{a}{b}$
Fort George.	42	0·08	4,014	3,917	118	4,035	_ 21	0·99
Buchanan Castle.	11	0·41	3,998	3,157	605	3,762	236	1·06
Netherlaw House.	11	0·19	3,679	3,402	281	3683	-4	1.00
Warminster.	13	0·09	3,283	2,869	133	3002	281	1.09
Denbury.	24	-0·01	3,855	3,648	-15	3633	222	1.06

Even when allowance for this weight gain is made, however, the average net daily intake exceeds the average total energy utilisation of the subjects.

<u>Mean Values for 101 men.</u>

Mean daily Energy Expenditure	=	3,579 Cal.
Mean daily Weight gain = 0.015 Kg.	=	153 Cal.
∴ Total Daily utilisation	=	3712 Cal.
Mean Total Calorie Intake	=	3838 Cal.
∴ Excess of Intake over output	=	126 Cal.

Any one or more of the following three reasons may explain this difference:-

1. As Maynard (1944) & Keys (1945) suggested, the tables of McCance & Widdowson may be giving fallaciously high readings. This would be in consequence of the peculiar system of calculating carbohydrate content of the foods used in these tables.
2. It may be that we have failed to achieve a comprehensive timetable of activity.
3. It may be, as Melville (1910) and the Armoured Research Laboratory (1943) suggested, that a positive calorie balance is essential if positive health, or eutrophy, is to be assured.

This problem is one which will require a great deal of further study.

Since we have dealt with the relationship of the average weight gained by individuals to their calorie intake, it would perhaps be not inappropriate to consider here the problem of how much weight the soldier does and should gain.

Very little information is to hand on how much weight is actually gained by recruits. Cathcart & Orr (1919) suggested 2.4Kg as the average weight gain in the first year of training. This is equal to 0.05 K per week, rather less than the value found in the present survey. This however was for men aged 20, whereas our subjects were mainly 18. The same writers however found an average weight gain of 0.111 Kg. per week (=.978 lbs per month) for the 1,595 recruits aged 18.3/12 whom they studied. The present finding was 0.104 Kg. per week, a not unreasonable figure. Schmidt as quoted by Schwiening (1910) found that the average guardsman gained 0.16 Kg. per week. Recently work has been commenced (at the writer's instigation) to investigate fully the average weight gain of recruits at the present time. Full results will not be available for over a year yet, but preliminary findings confirm the results which were obtained in this survey.

THE INFLUENCE OF THE HEIGHT, WEIGHT AND SURFACE AREA OF THE INDIVIDUAL ON HIS DAILY CALORIE CONSUMPTION.

I. HEIGHT.

The heights of the subjects were distributed over a range from 158 cm. to 194 cm. These subjects were classified to groups covering a range of 3 cm. each. The mean intake of individuals falling into each group is shown on Table XX1X.

It is at once obvious that no significant rise in Total Calorie intake is present until the upper limit of height is approached. (See figure V11.).

Figure V111 shows that the calorie intake per kilogram of weight falls as height increases; whilst the calorie intake per cm. does not. The explanation of this is discussed further on.

TABLE XXIX.

Relation of Height of Subjects to their Total Calorie Intake.

Height Cm.	No. in Group.	Total Calorie Intake (Mean.)	Calorie Intake Per Cm. (Mean.)	Calorie Intake Per Kilo. (Mean.)	Calorie Intake Per Sq. M. (Mean).
155·1 - 158	1	3,936	25·0	78·1	2,642
158·1 - 161	3	3,987	24·9	75·7	2,594
161·1 - 164	6	3,811	23·5	66·3	2,388
164·1 - 167	10	3,779	23·0	62·6	2,264
167·1 - 170	19	3,556	21·2	59·0	2,132
170·1 - 173	26	4,085	23·4	63·1	2,297
173·1 - 176	10	3,948	23·0	62·2	2,266
176·1 - 179	8	3,764	22·4	54·4	2,051
179·1 - 182	5	3,672	20·3	57·6	2,048
182·1 - 185	6	3,809	20·8	54·9	2,014
185·1 - 188	3	4,031	21·5	53·3	2,048
188·1 - 191	3	4,176	22·3	51·5	2,021
191·1 - 194	1	4,662	24·4	57·0	2,241

FIGURE X11.

Total Calorie Intake in relation to Height of Subjects.

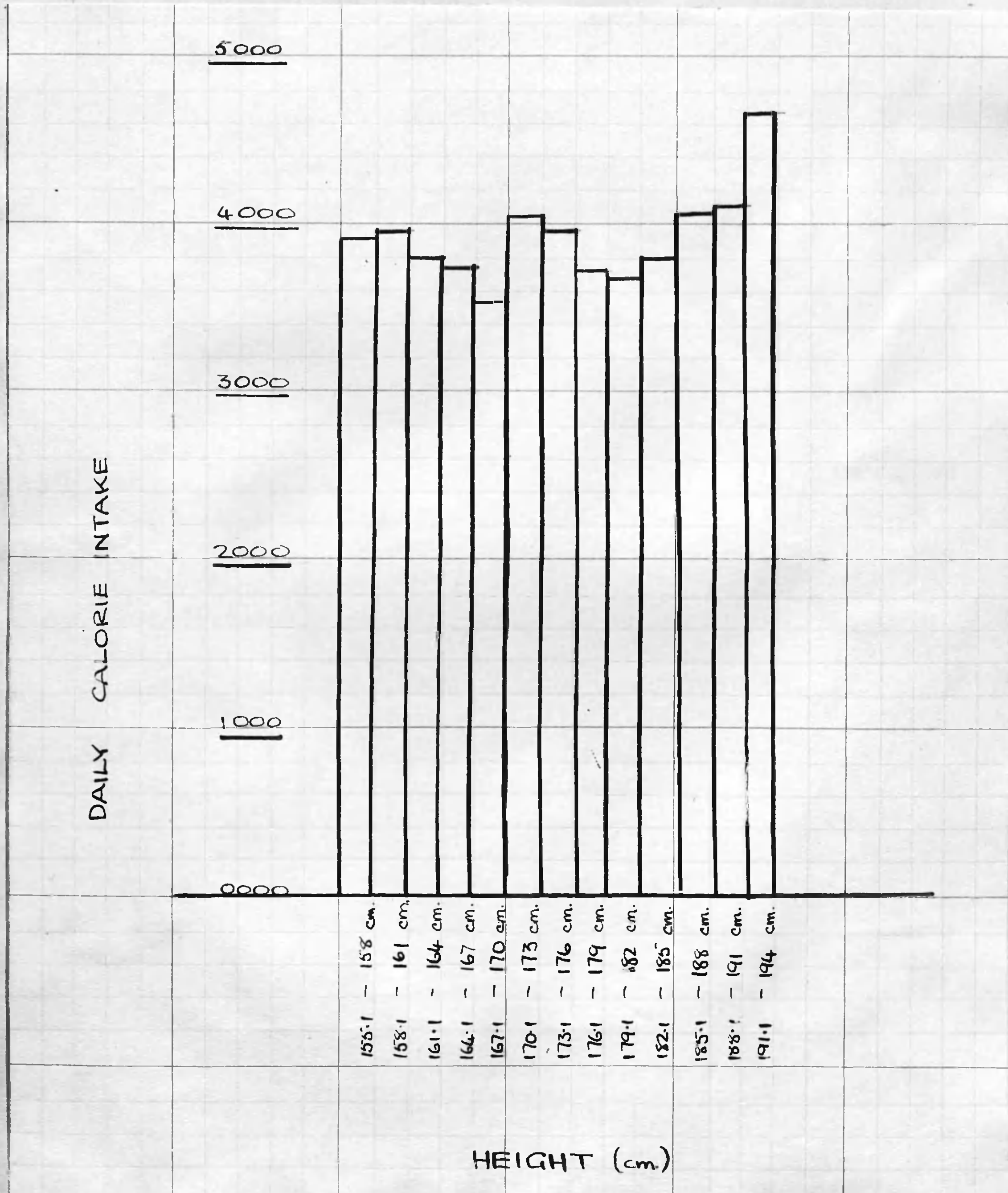
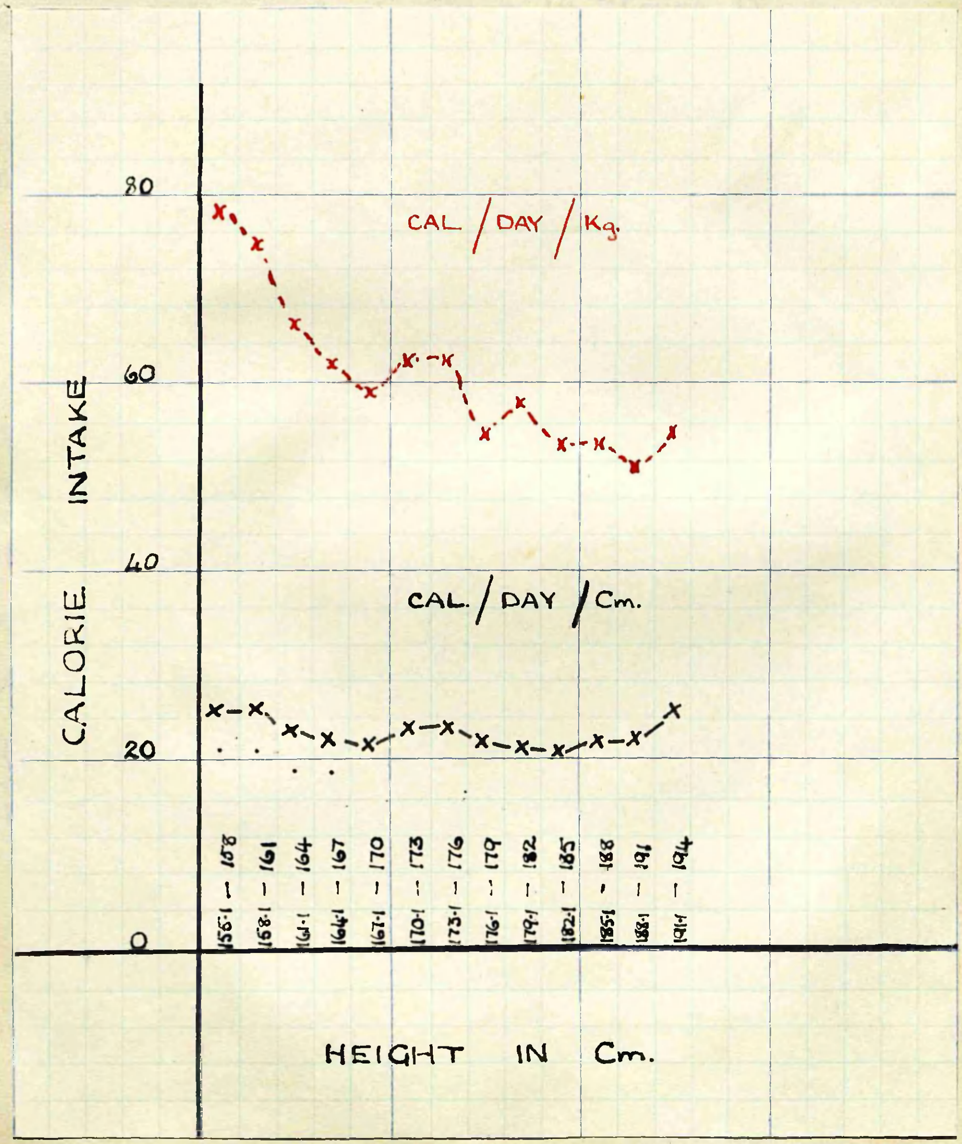


FIGURE V111.

Cal. Intake per Kg. and per cm. in relation to Height of Subjects.



II. WEIGHT.

The range of weights of the subjects was from 50-87 Kg. The subjects were divided into groups of 3 kg. each.

The graphical correlation of weight and total calorie intake of individuals is shown in Figure IX.

Again no significant rise is present until the upper range of weights (78 Kg.) is reached.

A very interesting and instructive relationship is that between the average calorie intake per Kg. and the total body weight.
It will be noticed that a clean cut fall is found in the intake per Kg. as the total weight of the rises (see figure X). This fall is reflected in the intake per Sq.M. but not in the intake per cm.

TABLE XXX.

Calorie Intake in Relation to Weight of Men.

Weight Kq.	No. of Persons in Group.	Total Calorie Intake (Mean.)	Calorie Intake Per cm. (Mean.)	Calorie Intake Per Kilo. (Mean.)	Calorie Intake Per Sq. M. (Mean).
48.1 - 51	2	3,860	24.4	77.2	2,641
51.1 - 54	3	3,790	23.1	72.6	2,447
54.1 - 57	9	3,704	21.9	66.8	2,312
57.1 - 60	16	3,739	22.3	64.1	2,233
60.1 - 63	18	3,891	22.9	63.4	2,292
63.1 - 66	18	3,681	21.4	57.2	2,118
66.1 - 69	11	3,988	22.8	59.7	2,225
69.1 - 72	11	3,898	22.4	55.3	2,116
72.1 - 75	5	3,908	22.0	53.6	2,062
75.1 - 78	3	4,014	22.0	53.0	2,045
78.1 - 81	3	4,036	21.8	50.0	1,997
81.1 - 84	1	4,662	24.4	57.0	2,241
84.1 - 87	1	4,580	24.1	53.0	2,135

FIGURE IX.

Total daily Calorie Intake of Subjects in relation to their Weight.

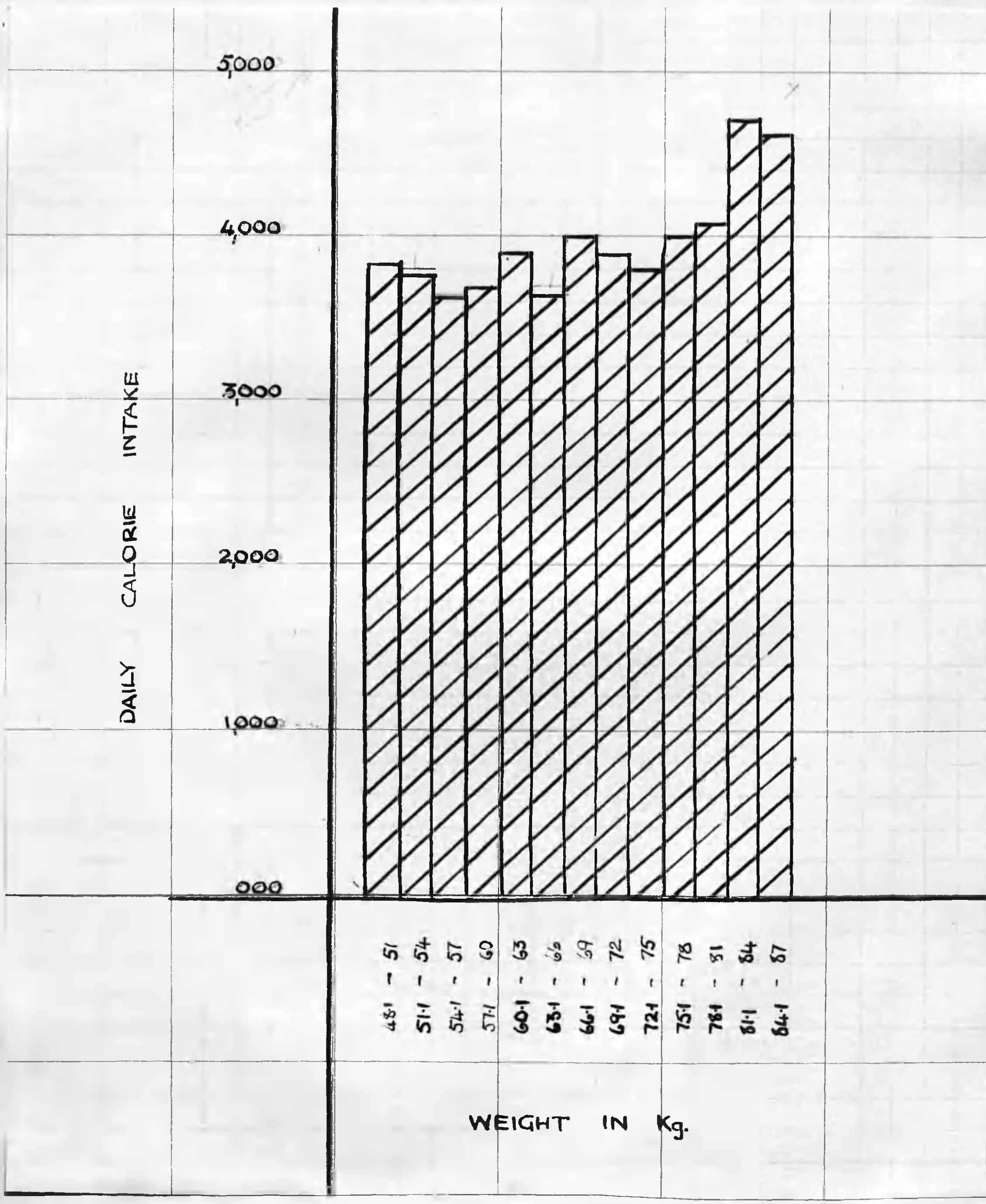
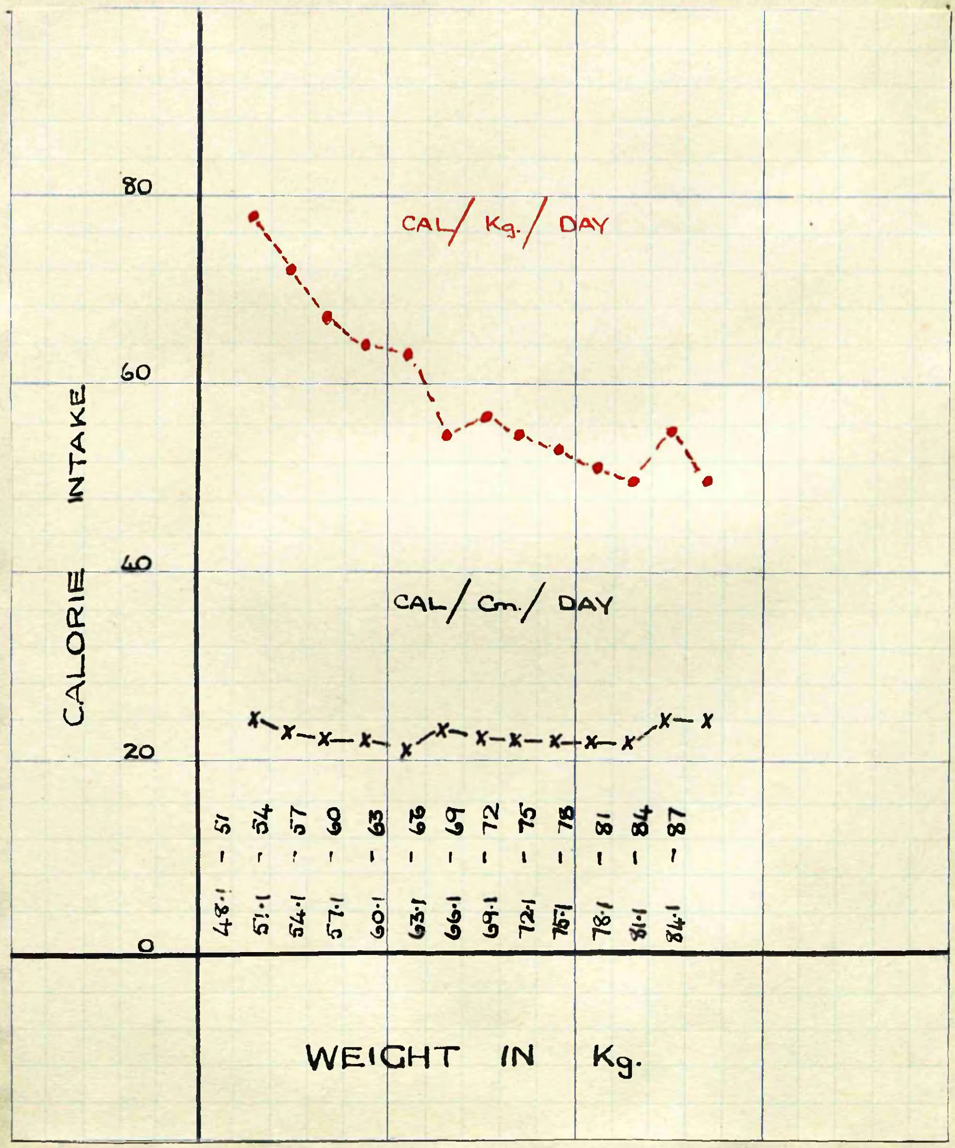


FIGURE X.

Daily Calorie Intake per Kg. and per cm. in Relation to Weight of Subjects.



111. SURFACE AREA.

The range of surface area was from 1.47 sq.M. to 2.14 Sq.M. with a mean value of 1.73 Sq.M. The relation of the surface area of individuals to their total calorie intake is shown in table XXX1.

A glance at this table shows that a slight increase in total calories occurs as the Surface Area of the person becomes greater, becoming more marked as the upper range is reached. (See figure X1).

On this occasion the intake required to satisfy basal metabolism is also plotted.

(x Basal metabolism taken as 37.8 Cal/Sq.M/ (Cathcart and Orr 1919) 10% for Specific Dynamic Action (Orr and Leitch 1931) This figure is used hereafter).

It will be apparent that the rise in calorie intake with increase in surface area appears to be no more than could be accounted for by Basal Metabolism.

This fact is of great importance and is fully discussed below.

A significant relationship is the marked drop in calorie intake per Kg. of body weight, as the Surface Area of the subject increases (See figure X11). This drop does not occur in calories per cm. as seen also in the figure X11.

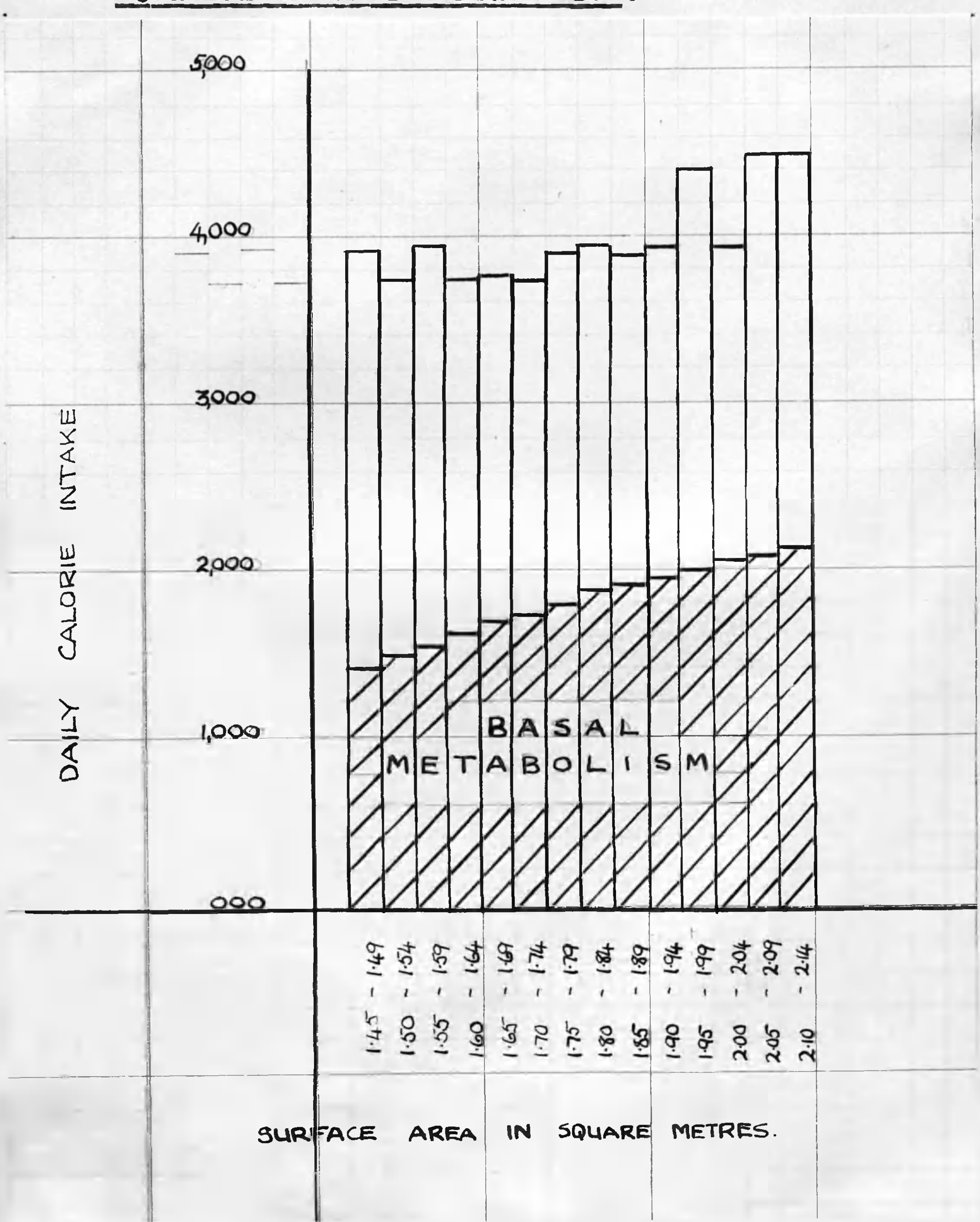
TABLE XXXI.

Relation of Surface Area of Subjects to Total Calorie Intake.

Surface Area in Sq. M.	No. in Group.	Total Calorie Intake (Mean.)	Calorie Intake Per Cm. (Mean).	Calorie Intake Per Kilo. (Mean.)	Calorie Intake Per Sq. M. (Mean.)
1·45 - 1·49	2	3,860	24·4	77·2	2,591
1·50 - 1·54	3	3,733	22·6	71·1	2,441
1·55 - 1·59	5	3,848	23·5	69·5	2,433
1·60 - 1·64	10	3,657	22·0	63·5	2,236
1·65 - 1·69	20	3,758	22·3	62·2	2,251
1·70 - 1·74	16	3,742	21·8	60·0	2,176
1·75 - 1·79	15	3,928	22·8	60·5	2,219
1·80 - 1·84	11	3,946	22·3	58·5	2,171
1·85 - 1·89	7	3,886	22·1	54·7	2,052
1·90 - 1·94	5	3,893	21·5	53·1	2,028
1·95 - 1·99	1	4,417	23·8	58·7	2,242
2·00 - 2·04	3	3,850	20·6	48·1	1,913
2·05 - 2·09	2	4,458	23·7	55·0	2,156
2·10 - 2·14	1	4,580	24·1	53·0	2,135

FIGURE XI.

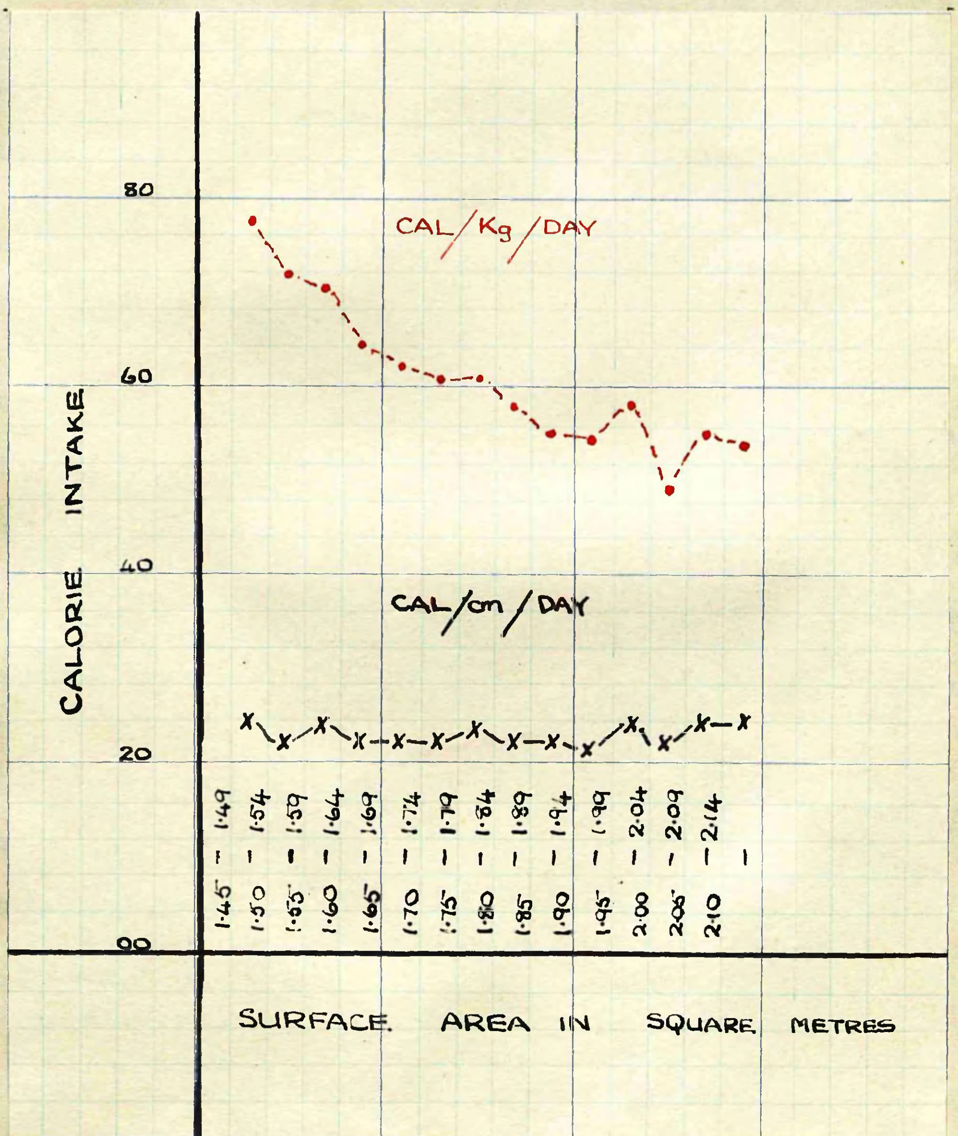
Total Calorie Intake of Individuals in Relation to their Surface Area.



This drop in calories per kilo is reflected in calories per Sq.M. and is discussed fully later.

FIGURE X11.

CAL/Cm. AND CAL/Kg. IN RELATION TO SURFACE AREA OF SUBJECTS.



DISCUSSION.

Figures V111, X and X11 show that whilst the calorie intake per cm. is not altered by increase in height, weight or surface area, the calorie intake per kilo and per Sq.M. of Surface Area steadily falls as height, surface area and especially weight increases. This fact can be explained along the following lines.

Each individual consumes calories for two main purposes,

1. to enable basal metabolism x to be maintained
2. to perform external work.

Supposing intake for both these purposes is related to surface area, then the total intake will be proportional to surface area and the relationship of Cal/Sq.M. to the total surface area will be constant.

But we have already noted this is not so (see above) Therefore one at least of these intakes is not directly related to the surface area of the subject.

We already know (Du Bois etc.) that basal metabolism is directly related to surface area therefore the intake for external energy can not be.

Two possibilities remain; either the calorie intake for Energy Expenditure does not alter with increasing surface/

area or it may actually decrease with increasing size.

The statistical interpretation and resolution of this problem is shown in table XXXll Basal Metabolism is, as before, taken as 37.8 Calories per Sq.M. per hour with a 10% allowance for Specific Dynamic Action. This means that if the intake for external energy expenditure is independent of surface area then the mean daily intake for such a purpose is 2,038 Cal., the standard deviation 114 Cal., and the coefficinet of variation only 5.59%. This low coefficient implies a very high probability that the intake for energy expenditure is independant of the surface area of the individual.

We thus arrive at the conclusion that the calorie intake of individuals rises with increasing surface area only to that extent which would be required to satisfy the increase in basal metabolic rate. The intake of the individual for use as external energy is not related to the rise of the individual.

The explanation of the fall in Cal./Kg. as total body weight increases is now obvious.

Suppose the daily energy expenditure on external work is E. Cal. (constant) and on basal metabolism B.Cal. per Sq.M. per day

A man of "X" Sq.M. surface area requires (E+Bx) Cal. daily, and his intake per Sq.M. $= \left(\frac{E}{x} + B\right)$ Cal. Daily.

A man of 1.5x Sq. M. surface area requires
(E + 1.5 Bx) Cal. Daily and his intake per Sq.M. will be
$\left(\frac{E}{1.5x} + B\right)$ Cal. daily.

Thus as x becomes larger the daily calorie intake per square metre of surface area becomes smaller, for while B remains constant $\frac{E}{nx}$ is diminishing.

This result is so striking that it was decided to analyse the results for each of the three large camps separately; to ascertain if the same result would be obtained from each of these smaller samples. By a calculation similar to that in Table XXXll.

The results for Fort George and Denbury Camps will be seen to correspond closely to the mean results, but piquancy is added by the result for the Warminster camp. At this camp. which is on entirely <u>sedentary</u> work the calorie intake for external energy expenditure <u>does</u> rise with increasing surface area, the increase being in the region of 82.0 Cals. per day per increase of 1/10 Sq.M. in the Surface Area of the subjects.

TABLE XXXII.

Relation to External Energy Expenditure to Surface Area of Subjects.

Surface Area Sq. M.	n No. in Group.	a Total Calorie Intake Daily.	b Basal X Cal. Daily.	x (a-b)	n(a-b)	d (x-x̄)	nD	nD^2
1·44 - 1·49	2	3,860	1,522	2,338	4,676	300	600	180,000
1·50 - 1·54	3	3,733	1,573	2,160	6,480	122	366	44,652
1·55 - 1·59	5	3,848	1,625	2,223	11,115	185	925	171,125
1·60 - 1·64	10	3,657	1,676	1,980	19,800	58	580	33,640
1·65 - 1·69	20	3,758	1,728	2,030	40,600	8	160	1,280
1·70 - 1·74	16	3,742	1,779	1,989	31,824	49	784	38,416
1·75 - 1·79	15	3,928	1,831	2,097	31,455	59	885	52,215
1·80 - 1·84	11	3,946	1,882	2,064	22,044	26	286	7,436
1·85- 1·89	7	3,886	1,934	1,952	13,664	86	602	51,772
1·90 - 1·94	5	3,893	1,985	1,908	9,540	130	650	84,500
1·95 - 1·99	1	4,417	2,037	2,380	2,380	342	342	287,964
2·00 - 2·04	3	3,850	2,088	1,762	5,286	276	828	228,528
2·05 - 2·09	2	4,458	2,140	2,318	4,636	280	560	156,800
2·10 - 2·14	1	4,580	2,191	2,399	2,399	361	361	129,960
				Total	205,899		7,929	1,297,328
				Mean	2,038		78·5	12,845

Mean daily excess of Calorie intake over Basal Metabolism = 2,038 Cal = x̄
Mean Deviation = ± 78.5 Cal.
Standard Deviation = 114 Cal.
Coefficient of Variation = 5.59 %.

TABLE XXXIII.
Calorie Intake for External Expenditure at three Camps.

Surface Area.	Fort George No. in Group.	Fort George x (a-b)	Denbury No. in Group.	Denbury x (a-b)	Warminster No. in Group.	Warminster x (a-b)	All Camps. No. in Group.	All Camps. Calorie Intake for ex. Energy.
1·45 - 1·49	2	2,337	0	-	0	-	2	2,338
1·50 - 1·54	2	2,200	1	2,081	0	-	3	2,160
1·55 - 1·59	5	2,222	0	-	0	-	5	2,223
1·60 - 1·64	3	2,301	4	2,074	2	1,274	10	1,980
1·65 - 1·69	9	2,335	5	1,999	4	1,361	20	2,030
1·70 - 1·74	7	2,135	4	1,890	0	-	16	1,989
1·75 - 1·79	5	2,118	5	2,216	0	-	15	2,097
1·80 - 1·84	4	2,254	1	2,071	2	1,407	11	2,064
1·85 - 1·89	0	-	1	1,849	2	1,454	7	1,952
1·90 - 1·94	2	2,075	0	-	2	1,677	5	1,908
1·95 - 1·99	1	2,380	0	-	0	-	1	2,380
2·00 - 2·04	0	-	2	1,840	1	1,606	3	1,762
2·05 - 2·09	1	2,522	1	2,063	0	-	2	2,318
2.10 - 2.14	0	-	0	-	0	-	1	2,399
Mean Value	2,236 Cal.		2,028 Cal.		1,436 Cal.		2,038 Cal.	
Mean Dev. From Mean.	± 86-8 Cal.		± 83 Cal.		± 107 Cal.		± 78.5 Cal.	
Standard Deviation.	96 Cal.		99 Cal.		131 Cal.		114 Cal.	
Coefft. of Variation.	4.29 %		4.89 %		9.12 %		5.59 %.	

This was a most unexpected series of results. It appears that, in camps engaged on hard work, calorie intake, (apart from basal metabolism), was not related to body size. In the camp engaged on sedentary work it appears that calorie intake was related to the size of the men. This ispossibly because sedentary work more closely resembles basal metabolic conditions.

The active men have many factors affecting them, such as, the mechanical efficiency of the man in the particular movements involved; the amount of training, and athletic activity the man has had, etc.

With all these factors operating the connection between calorie intake and body size may be lost in the many other variations arising. This explanation is, of course, very tentative, and much further work is required.

B. The Actual Calorie Value, to the Soldier, of the Present Ration Scales.

a. The Extent and Causation of Calorie Loss.

Cathcart & Orr (1919) pointed out the folly of assuming that the Calorie value of a ration scale, as presented on paper, in fact represented the actual calorie value as eaten by the men. They considered that there had to be allowed a depreciation of 1/6 in the calorie value of the scale, if all sources of waste, refuse and distributory losses, were to be allowed for. This fact was neglected until Macrae (1942) demonstrated the truth of this statement for food served in airmen's messes. Therefore, in the course of our survey a great deal of attention was given to this problem.

The theoretical value in calories of the rations issued as compared to their actual net calorie value to the soldier are shown in Tables XXXIV A & B.

Each camp was surveyed for a period of seven days, the average daily figure per head being calculated from this data.

We have thus found the average "Loss" in Calorie value of the ration, from the calculated to the/

TABLE XXXIV A.

Camps Assayed by Both Individual and Overall Technique.

		Individual Method.			Overall Gross Method.		
Unit.	Theoretical Cal. Value of Rations (A)	Actual Cal. Value of Rations (B)	% Cal. Loss ($\frac{A-B}{A}$ x 100)	No. of men surveyed.	Actual Cal. Value of Rations (C)	% Cal. Loss ($\frac{A-C}{A}$ x 100)	No. of men surveyed.
No. 72 P.T.C.	3307	2932	11.4%	55	3011	8.8%	617
Army School of Education.	2907	2748	5.5%	12	2673	8.0%	1228
Fighting Vehicle Proving Estab. ✱	3048	2798	8.3%	12	2780	8.8%	83
Survey Training Centre (RE)	2900	2279	18.0%	14	2410	17.2%	400
598 Coy. C.M.T. ✱	3480	3016	13.3%	25	3009	13.8%	250
				118			2578

✱ = Overdrawing rations at time of survey.

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TABLE XXXIV B.

Camps Surveyed by Gross Overall Technique only.

Unit.	Calculated Cal. Value of Rations (A)	Actual Cal. Value of Rations. (B)	% Cal. Loss $\left(\frac{A-B}{A} \times 100\right)$	No. of men surveyed.
9 P.T.C.	3307	2907	12.1%	400
6 A.F.V.D. (R.A.O.C.)	2907	2650	8.5%	100
No. 2 Military Port.	3300	2850	13.6%	350
1026 Port Coy. R.E.	2900	2700	6.9%	200
Para. Training Centre.	3300	2901	12.1%	600
598 Coy RASC.	2993	2666	10.9%	260
				1910

The actual net value, for 11 camps, containing 4,488 men, each surveyed for 1 week. This figure is therefore representative of 31,416 rations for one day.

Average Cal. Loss	=	11% of Nominal Value
Mean Deviation	=	$\pm$2.54%
Standard Deviation	=	2.95%

This result is in close accord with that of Macrae (1942) who established the % loss in Calorie Value, of food served in R.A.F. Messes, as 10 - 15% .

Cathcart and Orr (1919) mooted 16.7% as the safety margin to be allowed for this loss.

CONCLUSION.

Under present cicumstances the system of calculating Calorie value of ration scales is giving misleading results. The true value of the ration, as eaten, is 11% ($\pm$2.54%) below the calculated level.

NOTES.

(A) The sources of this Calorie loss are;)

1. Underdrawal of rations;
2. Losses in Distribution;
3. Losses in Preparation and cooking;
4. Messing Officers not using ration cash allowance to best advantage;
5. Plate Waste.

This investigation was not concerned with the first four factors mentioned, but a few comments on each can be made.

(1) Underdrawal of Rations:- This was negligible, with the exception of cocoa.

(2) Losses in Distribution:- These are variable, being considerable for bread and vegetables and less for meat and dairy products. Improved containers to move goods from stores and depots to camps are long overdue.

(3) Losses in Preparation & Cooking:- These are variable, depending on the efficiency of the N.C.O. Much of the kitchen equipment is old, inefficient and obsolete. Many kitchens are dingy ill-planned, ill-ventilated and with poor facilities for food storage. The present policy appears to be to train men of low intelligence (and apparently cleanliness) as cooks. All these points help to produce a considerable wastage.

(4) Misuse of Ration Cash Allowance.

This is not frequent, but one example may be cited where this was spent on very strong pickles, which only 7% of the men would eat.

b. The Contribution of Plate Waste to the Depreciation of the Calorie Value of the Ration Scales.

Since the work of Cathcart and Murray (1939) and Andross (1946) there has been a dearth of information on the loss of calories due to plate waste of the edible portion of foodstuffs. The following data was abstracted from this survey, using the methods of Atwater and Bryant (1896) as quoted by Cathcart and Murray (1939) viz.

For each foodstuffs:-

a. Percentage Plate Loss of Edible Material

$$= \frac{\text{Total Weight of Plate Waste}}{\text{Total Weight of Food Issued}} \times 100$$

b. Percentage Calorie Waste

$$= \frac{\text{Total Calorie Value of Plate Waste}}{\text{Total Calorie Value of food issued}} \times 100$$

The values found at the five units are given in Table XXXV. It is interesting to compare these results with those obtained by Cathcart and Murray (1939) Those workers found plate wastage varying from 0.60% to 2.89% of the calorie value of foods eaten. It is only to be anticipated, however, that in such homes a combination/

TABLE XXXV.

Plate Waste and Calorie Waste from Plate Waste.

Unit.	No. of men in sample.	% Plate Waste.	% Calorie Loss by Plate Waste.	Calorie Value of Army Ration.
Fort George.	55	4.92	2.35	2932
Buchanan Castle.	12	6.01	1.57	2748
Netherlaw House.	12	11.70	6.23	2798
Warminster.	14	9.28	3.68	2279
Denbury.	25	7.31	2.04	3016
Mean.		6.27	2.76	

combination of economic circumstancies; cooking, serving and choosing food suitable for small groups of persons will result in a lower plate waste rate than in the Army Dining Hall; or any large catering establishment. Additionally, large scale catering makes for cold plates, and this together with the very old kitchens and dining halls, and obsolescent ovens, in use at some army units, makes for higher waste. This loss was marked at Netherlaw, and to a less extent at Warminster.

Another point to be considered is the differing proportions of various types of food in the diet of men now, as compared to 1939. Cathcart and Murray observed a high amount of waste in bread and vegetables, and it is these constituents of the diet which have been increased (relatively at least) by the present food policy in Britain.

Table XXXVl shows the percentage plate waste of various foods and demonstrates the wide fluctuations of waste at various camps, depending on the standard of servive of food. (And also on the quality of the food and of the cooking. Some of the meat issued was of a degree of inferiority unrecognised before the days of the Ministry of Food). In agreement with Cathcart & Murray's findings/

TABLE XXXVI.

Percentage Plate Waste of Various Foods (by weight).

	Food.	Fort George.	Buch. Castle.	Netherlaw.	Warminster.	Denbury.	Mean.
Cereals.	Bread.	1.33	4.65	10.5	5.38	2.94	4.96
	Porridge.	4.00	-	1.14	-	2.76	2.63
Meats.	Liver, Bruised.	7.68	-	-	7.29	9.57	8.18
	Lamb Roast.	6.88	-	32.00	29.5	7.40	18.9
	Beef Roast.	1.97	0.80	3.45	24.3	-	7.63
	Sausage.	1.10	0.94	1.90	1.63	-	1.39
Vegetables.	Potatoes (Boiled).	4.51	1.06	4.95	5.50	1.42	3.49
	Cabbage.	8.13	4.95	2.99	22.90	4.84	8.76
	Carrot	7.89	3.68	24.00	11.10	-	11.70
	Turnip.	8.01	-	12.60	-	-	10.30
	Peas.	2.62	1.05	2.42	-	0.19	1.57
Fats.	Margarine.& Butter.	2.30	1.98	1.25	1.12	0.14	1.36
Miscellaneous.	Custard.	5.31	-	0.18	5.2	-	3.56
	Gravy.	1.62	1.21	1.79	1.95	-	1.64

TABLE XXXVII.

Comparison of percentage plate waste of American Students and British Soldiers.

Food.	Gray and Dubois.	Present Investigation.
Bread.	20	4.96
Potatoes, (Boiled)	20	3.49
Carrots.	10 +	11.7
Cabbage.	10 +	8.76
Meat.	20 +	1.39 - 18.9
Peas.	10 +	1.57

(+ sign indicates preceding figure is lowest value.)

findings a great deal of the loss is seen to be due to bread and vegetables.

Gray and Dubios (1947) studied the percentage plate waste of American students; a comparison of their results with those of the present investigation are given in Table XXXVll. It appears that the bread and potatoe waste, at least, of the British Soldier, is well below that of the American Students.

Application of Results to Service Dietetics.

It appears that of the 11% total depreciation in the calorie value of the ration 2.76% is due to plate waste and 8.24% to other causes.

Certain steps, such as new dining halls, stoves and equipment and better trained cooks, would doubtless lower plate waste, but in present circumstances such steps are impossible. We must therefore, for the moment, accept the existence of this gap, and whilst trying to decrease it, allow a reasonable safety margin to cover its existence (say 4%)

C.

The Amount of Supplementary Food purchased by the soldier to augment the present Ration Scale.

(a) Data obtained.

We have previously dealt only with the total Calorie intake of the men; let us now turn our attention to the actual source of the food consumed. The Basic Home Service Scale, at the commencement of this investigation theoretically represented a gross daily calorie value of 2907 Cals. For Camps engaged on very severe work an additional 400 gross Cal. is given daily to augment intake. These, it is repeated, are gross values.

It was estimated, by the Director of Hygiene, that if a 10% deduction was made from these figures to obtain the net Calorie value of the ration scale, this would give a reasonably correct result. This calculation gave the net value of 2.605 Cal. to the B.H.S.R.S. and 2966 net Cal. to those on the hard work supplement. This was considered much too low and quite inadequate by the medical authorities. This attitude has been completely vindicated by the present survey. The difference between the theoretical and actual value of the ration was found to be 11% (see above) and the troops as shown below, are being forced to augment their inadequate rations by very large canteen purchases. This is demonstrated in Tables XXXV111 A & B.

TABLE XXXVIII A.

Supplementation of Army Rations.

(Camps surveyed by two methods.)

	Individual Method.				Gross Method.				
	No. of Men.	Army Rations (Cals)	Supple-ment (Cals)	Total (Cals)	No. of Men.	Army Rations (Cals)	Supple-ment (Cals)	Total (Cals)	% of Total by Supple-ment.
No. 72 P.T.C.	42	2932	1082	4041	617	3011	1008	4019	24.9
Army School of Education,	11	2748	1250	3998	1228	2673	1032	3705	27.8
F.V.P.E. (R.A.C.) *	11	2798	881	3679	83	2780	931	3711	25
Survey Trng. Centre, RE.	13	2279	1004	3283	400	2410	807	3217	25.1
598 Coy. R.A.S.C. *	24	3016	839	3855	250	3009	866	3775	22.7

* indicates units overdrawing rations.

TABLE XXXVIII B.

Supplementation of Army Rations.

(Camps surveyed by one method only.)

Unit.	Strength.	Daily Army Rations (Cal.)	Daily Supplement (Cal.)	Daily Total (Cal.)	% of Total Cal. from Supplement.
9 P.T.C.	412	2907	1150	4057	28.3%
6 A.F.V.D. (R.A.O.C.)	101	2650	787	3437	22.9%
No. 2 Military Port.	346	2844	906	3750	24.1%
Para. Training Centre.	611	2901	1146	4047	28.3%
1026 Port Coy. R.E.	206	2700	960	3660	26.2%
598 Coy. R.A.S.C.	260	2666	1098	3764	29.3%

The fact that two units overdrew rations, probably means that the figures for supplementation tend, if anything, to be on the low side. Figures as obtained by both methods, correspond closely.

The explanation of the large extent of this supplementary feeding is simple.

The average intake (which) presumably approximate to the Calorie requirement) of the individual on light duties has been found to be 3,283 net cal. The Army ration only provides 2,606 net cal. leaving a gap of 677 cal. between food provided and food required.

Similarly the man on very hard work was found to have an intake of 4,014 net cal. daily but received only 2966 net cal. The calorie deficiency in his case is therefore 1,048 cal.

Thus, from theory alone, we should expect a range of supplementation of from 677-1,048 cal. daily. In actual fact the range found in this investigation was 787-1,150 not disimilar figures.

....

In other words not only is the net Calorie value of the basic ration scale below the requirement of sedentary youths but the hard work supplement (360 net cal.) is less than half the amount required to bridge the gap between sedentary and very active workers.

This state of affairs is reflected in the higher intake and greater expenditure on food by hard worked men. It is only necessary for an observer to go to a basic training unit on the night before pay day to see real hunger in the penniless recruits. At 72 P.T.C. some of the ravenous recruits ate as much as 7500 Cals on pay day; surely proof of an energy debt and hunger state. It is of course obvious that, however satisfactory the diet is, a certain amount of food will always for social reasons, be eaten in Canteens. No one familiar with army life will deny this, but when the average daily calorie intake rises above 1,000 Cal. and when, from a daily pay rate of 2/6 net, 1/2 is spent on supplementary food, by men who are constantly complaining of hunger, (72 P.T.C.) it is time action was taken. There is no doubt that the present ration scale is so low that men are compelled to eat in the canteen whether they want to or not to maintain a balanced metabolic state. In fact, the army at present is dependent on the canteens to feed its men adequately, an invidious situation!

The justification for paying soldiers so poorly is the statement that his pay is pocket money, board and lodging being supplied. This is not now true; either his pay must be raised to allow him to purchase in civilian market, or an immediate increase in army rations should be made. It is not/

not sensible to reduce rations, for the result is <u>not</u> that the men eat less but that they forage more.

Most important of all at the present time is the bad effect of lowering the value of the man's pay since one shilling per day <u>must</u> be spent on food. The childlike simplicity of the Ministry of Food, in assuming that if they cut Army rations, the troops will obediently lower their total daily Calorie consumption is laughable. Any practical man could have told them long ago that the troops will not go hungry but will "scrounge" food:- and the only place they can "scrounge" from is the Civilian Market (or Black Market) !

(b) <u>The Source of the Supplement.</u>

The Navy, Army, and Air Force Institutes (N.A.A.F.I.) has always been assumed to play by far the biggest part in providing food supplements for the men but this part has probably been exaggerated. In the present investigation 68% of supplementary foods came from N.A.A.F.I. This is not typical, however, as the camps selected were all very isolated and the men had little chance of eating at Civilian restaurants. Even then other canteens (e.g. Y.M.C.A. Church Army etc.) were often in camp.

It was the opinion of the Research Team that not more than 55% of the average supplement purchased by troops in Britain is derived from N.A.A.F.I.

Assuming this figure to be correct, we should expect the daily calories purchased from N.A.A.F.I. by the average man to be $(\frac{55}{100} \times 973) = 536$ Cal.

The cost of this to the individual would be

$\frac{536}{80} = 6.7$ per day (1d = 80 Cal. in N.A.A.F.I.).

In actual fact the value given by N.A.A.F.I. is 7.1d per day again a not dissimilar figure. At this point it is perhaps not out of place to commend the efficient running and excellent service of the N.A.A.F.I. organisation. Photograph II gives an impression of the very attractive appearance of a N.A.A.F.I. canteen and this is matched by the service and good cooking which appears ubiquitous in these canteens. This organisation has been much maligned but presents an excellent example of how efficicnetly large scale catering may be run. The armed forces have much to learn from these methods.

PHOTOGRAPH B.

Interior of N. A. A. F. I. Canteen.

It is interesting to compare the findings of this series of surveys with those arrived at by American workers in the last two wars. Table XL clearly shows this point.

TABLE XL.

A Comparison of Results, with those of Previous American Workers.

	Murlin and Hildebrandt.	Howie and Berryman.	Present Investigation.
No. of Messes.	455	455	11
Year.	1917 - 19	1941 - 43	1947 - 48
Method.	Calculated	Calculated	Weighed
Type of Unit.	All Types	All Types	All Types
Average Intake (Cal.)	3,600	3,785	3,807
Intake from Army Rations.	3,250	3,385	2,834
Intake from Canteen (Cal.)	350	400	973
Intake Range (Cal.)	3,132 - 4135.	3,000 - 4,500.	3,283 - 4014.

Again the extra burden in providing food supplements borne by the British soldier at present (973 Cal daily as opposed to 350-400 Cal. daily) is clearly shown.

The average total calorie intake of the British soldier is slightly higher (3838 Cal. compared to 3600-3785 Cal.) but three reasons could easily explain this:-

1. The younger age group of the Britons (Average age 18-21 yrs. c.f. 19-30 yr.)
2. The more active British training programme.
3. The more complete supervision and more comprehensive investigation during the present investigation.

D.

Suggested Modifications of the Present Army Ration Scales.

(In calculating these scales, it is assumed that the army is to provide all the man's intake (i.e. as in warfare). If it is decided that men should supply a certain amount of their own food then allowance at 80 Cal. / penny should be made.)

In view of the findings of the present survey the following three calorie values are suggested, for the army rations of the future.

Daily Net Calorie Ration:-

Men on light work .... 3,200 Cal.
Men on Heavy Work .... 3,600 Cal.
Men on Very Heavy Work .... 4,000 Cal.

Since these are all net values they must be translated to theoretical values, as calculated on the ration scales (i.e. x $\frac{100}{89}$) This calculation gives the following value, for the scales, on paper.

Men on Light work .... 3,618 gross Cal.
Men on Heavy Work .... 4,067 Gross Cal.
Men on Very Heavy Work .... 4,516 Gross Cal.

These figures may appear high to the observer, but one must remember that it is a highly active, adolescent population, undergoing training, which we are dealing with. The insidious and unrelenting story of low Calorie intake, supported by very scanty proof, which we have listened to for 10 years from the Ministry of Food, should not be allowed to influence our judgement. Calorie levels should be scientific measures and not political barometers. The National Research Council (1945) considered 3,800 Cal. as a suitable average level.

To demonstrate how far present ration scales are below the levels, suggested above as necessary to satisfy the appetites of the men, a comparison is made in Table XXXIX.

The approximate difference (a-b) between the scales is 711-1,209 Cal., a figure which closely corresponds with the figures obtained in this investigation, for supplementation of rations by the troops. (787-1150 Cal.)

It is suggested that the ration scale for very hard/

TABLE XXXIX.

Present and Proposed Scale of Rations.

	Calculated Gross Calories per Day.			
	Suggested Scale (A)	Present Scale (B)	(a-b)	$\frac{b}{a} \times 100.$
Light Work.	3,618	2,907	711	80%
Heavy Work.	4,067	3,307	760	81%
Very Heavy Work.	4,516	3,307	1,209	73%

hard workers should be given to all recruits in their first 3 months of intensive training (i.e. At A.B.T.U.); to O.C.T.U.'s, to the Army Physical Training Centre; to the Paratroops training Centre, and to others at the discretion of D.D.'s.M.S. (Deputy Directors of Medical Services).

The reason for including all recruits in this scale is their mechanical inefficiency in performing the unwonted tasks which they are compelled to undertake.

If the authorities decide that the men must pay for part of their own feeding then the rations may be scaled down accordingly. 80 Cal. (5) was found to be the purchasing power of a penny in N.A.A.F.I. canteens.

Finally let us glance at a quite different method of arriving at a comprehensive scale of rations. The weekly basic programme of all army units is identical, for all practical purposes, and in fact, has changed little since the days of Cathcart & Orr (1919).

This basic programme is:- (Calculated as in Part III)

Weekly Programme.	Hours.	Cal. Expenditure 1.77 Sq.M. min.
Sleeping	56	3864
Eating	21	2268
Washing	7	910
Leisure (A)	18	1350
Leisure (B)	18	5400
		12,792

The daily average expenditure is therefore 1,827 Cal. on these basic activities. Now let us take the extremes of a very active and a sedentary man.

(a) Very Active Man. 48 hour week.

Marching, Full kit .... 48 hrs. 19,776 Cal.

(b) Sedentary Man 48 hour week.

Fatigues 4 hours	1820 Cal.
Sitting 44 hours	3802 Cal.
	5622 Cal.

Thus the extreme ranges of expenditure are (12,792 19,776) Cal. to (12,792 5,622) Cal. per week. That is 2,630-4,652 Cal. daily.

To these figures two allowances must be added; in arriving at a theoretical calorie value for a ration scale, these are:-

1. Allowance for growth
2. Allowance for 11% loss in Calorie value from theory to practice (V.S.).

If we allow a weight gain 0.104 Cal Kg. per week, as found in this survey, then the extremes of range become 5,314 - 3,070 Cal. daily. In actual fact these extremes are not met in practice, but our range of 3,618-4,516 gross Cal. as calculated above, lies well within their range.

E.

SUMMARY OF RESULTS.

Individual Survey.

The mean calorie intake of 101 men investigated was 3838 net Cal. with a standard deviation of 378 Cal daily. The average surface area of these men was 1.73 Sq.M. 17 were engaged on sedentary work, 42 on moderately hard work and 42 on very hard work. The average weight gain was 0.104 Kg. per week.

The variation of net daily calorie intake due to differing occupation was 731 Cal. daily. The variation due to differing size of subjects was 187 net Cal. daily. This rise could be accounted for by increased basal metabolic requirement alone.

The average age of the men was 19.1 yrs. no significant difference in calorie intake was present between the ages of 18 and 21.

The calculated energy expenditure of the men at each camp was very slightly below their actual intake. This difference was largely explained by the energy required for anabolism.

Overall Average Survey.

The average daily net calorie intake of 4,488 men calculated by this method was 3807 Cal.

The/

The army ration scale was found to be grossly deficient in calorie value. The average man of 4,488 was purchasing 973 Cal. daily to supplement his rations at a daily cost of 12.9 pence. This average supplement was equal to 34.4% of the average daily calorie value of food supplied by the army.
68% of supplementary food was purchased in N.A.A.F.I. canteens, this is considered to be more than the usual (55%) proportion because the camps were isolated.

The actual calorie value of the ration was 11% below the calculated calorie value 2.76% of this is due to plate waste of edible food.

CONCLUSION.

The net daily calorie intakes which are considered necessary to satisfy the needs of soldiers on light, moderately hard and very hard work is 3,200 Cal. 3,600 Cal. & 4,000 Cal. respectively.

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