ANTHROPOMETRIC STANDARDS FOR LIBYAN CHILDREN AGED 6 TO 17 YEARS

by

SADIK SADIK ABOUNAJA

A Dissertation submitted to the

University of Glasgow

for the Degree of

Doctor of Philosophy

Glasgow

December 1986

SUMMARY

The physical growth and development of children is well known as a sensitive index of the health and nutrition of a population. Information on growth and development of children is increasingly used in developing countries for assessing and improving their health standards. Satisfactory growth standards are available for many developed countries and for some developing countries. In Libya at present the standards in use for school-age children are those of Tanner, based on a sample of English school children in 1966.

There have been two small studies based on Libyan children and the growth standards in current use for pre-school children are based on one of these.

There is however, a need for standards for school age children based on a large local sample. This study describes the design and conduct of two surveys and the results obtained from them.

The first is a cross-sectional growth survey of 8566 Libyan school children, aged 6-17 years, carried out from September 1983 to February 1984 in Tripoli to determine distance growth standards. The second is a follow-up survey after an interval of about one year to construct velocity standards for growth.

In the first survey, eight anthropometric measurements were recorded: height and weight, biceps, triceps, subscapular and suprailiac skinfolds, arm and calf circumferences. The measurements were taken for every child by trained observers using regularly tested and calibrated standard equipment and standardised techniques. Also recorded were date of birth, age at menarche, race and twelve socio-economic variables which were family size, total number of

children, number of live childrem, birth order, father's and mother's education, father's and mother's occupation, house type, number of bedrooms and father's and mother's income. This information was obtained from a form completed by parents. The results of the cross-sectional study in 1983 showed that:

(i) There are differences between the English standards which are currently in use in Libya and the results of this study for all of the anthropometric variables studied. For example, for height the English boys and girls are rather taller than Libyan boys and girls by about 7.0 cm. at age 17 years. For weight the situation is different: For boys there is little difference between the Libyan and English 97th percentile throughout the whole range. However, the English 3rd and 50th percentiles exceed the Libyan 3rd and 50th percentiles, the difference reaching about 6 kg by age 16 years. For girls, the English 3rd and 50th percentiles of weight are slightly higher than the Libyan 3rd and 50th percentiles while the Libyan 97th percentile is higher than the English 97th percentile for girls over 13 years.

(ii) When the skinfold thickness from the present study was compared with those obtained in an earlier study of Libyan boys in 1957, there is a very large significant difference in the distribution of skinfold thickness between the 1957 and 1983 studies. This confirms the improvement in the nutrition, health, education and income levels in Libya during this period of time.

(iii) The distribution of height and weight of Libyan children aged 6 to 17 years are similar to those for the neighbouring Arabic countries of Egypt and Tunisia.

For calculating the percentiles of variables which do not follow Gaussian distribution, logarithmic trnasformation of the form log (variable-constant) was used to produce approximately a Gaussian distribution in each age-sex subgroup. The method of profile likelihood is used in estimating the value of the constant for each variable by age and sex, and therefore for choosing the best constant to use in transformation.

To examine the influence of the socio-economic variables on Libyan children's growth, the effect of each of the socio-economic variables on children's height was examined, and each of these variables individually has an effect on height. Analysis of covariance was used to look at the joint effect of the socio-economic variables on height after allowing for age. The sample was divided into three age groups: 6-11 years, 12-14 years and 15-17 years within which the relationship between the mean height and age is roughly linear. Only father's and mother's education, house type and crowd index (based on number of bedrooms and total family size) have significant effects on height. Of these factors, mother's education seemed to be the most important since it had the largest effect on height in 4 out of the 6 age-sex subgroups examined after allowing for age and the other factors.

The second survey in this study was the follow-up growth survey. It was the first survey carried out in Libya for growth velocity. It started at October 1984 to January 1985, when 4848 schoolchildren aged 6 to 17 years were remeasured after an interval of about one year. The same eight anthropometric variables were remeasured for each child by trained observers using the same equipment and techniques used in the first survey.

The results of the follow-up survey showed:

(i) Local growth velocity standards for Libyan schoolchildren have been established for weight, skinfold, arm and calf circumferences. Unfortunately results for height velocity were not obtained because of an error in calibration of the stadiometer counters before the start of the follow-up survey. More work is needed to establish height velocity standards.

(ii) Comparison between the Libyan and English weight velocity standards showed that although there is little difference between the weight velocities at the pre-adolescent stage, there are quite substantial differences at adolescence and after, where the Libyan children were heavier than the English children.

(iii) The comparison between Libyan and Dutch velocity of skinfolds and arm and calf circumferences showed that the Libyan children have larger velocity than Dutch children, which is most likely due to nutritional and environmental factors. These differences emphasise the need for local velocity standards in addition to local distance standards to replace the English standards in current use in Libya.

ACKNOWLEDGEMENTS

I am greatly indebted to all people involved in this study by participating or by advising, especially the heads, members and interns of the Community Medicine Department, Alfateh University, Professor T.P. Jain, Dr. M. Baccuch, Dr. I. Zafer, Sister B.A. Marzok, Dr. J. Shakshoki, Dr. S. Jehani and Dr J. Haraisha. Thanks also are due to all headmasters, teachers, social workers, students and their parents. Thanks are also due to Dr. S. Hudairi, Dr. I. Fahail-Elboum Dr. M. Najah and Mr. M. Zaini.

My great thanks to my Supervisor, Mr. H. Gilmour, Professor D.M. Titterington, head of the Statistics Department, Professor J.V.G.A. Durnin, head of the Physiology Department at Glasgow University, Dr. N. Cameron, Institute of Child Health, University of London, Miss M. Nisbet, secretary of the Statistics Department of Glasgow University, and the typists, Mrs. L. Williamson and Miss E. Barry.

Finally, I thank my wife and children who encouraged me and made sacrifices for me.

CONTENTS

List of Tables and Figures | Page

Chapter One

Tables

Figures

Chapter Two

Tables

Figures		Page

Chapter Six | Page

Tables

Figures

Chapter Seven

Tables:

CHAPTER ONE

INTRODUCTION

1.1 Background:

Every human being is unique in his beginning as well as his end. Thus persons who are genetically similar grow up resembling each other more closely than those who are genetically far apart, even in an optimal environment (Eveleth and Tanner, 1976).

Growth is the most useful index of health and nutrition because it is a continuing process involving changes in body size, form, physiological function and biological maturity. This process in turn depends on general nutritional status, calorie content of diet, clean environment and freedom from disease.

Regular monitoring of growth in children can be used as a preventive measure because it helps to detect undernourished cases in low social classes, and also overnourished ones in high classes, where obesity is a large problem. It is well known that obesity is a risk factor associated with many diseases, such as diabetes mellitus and coronary heart disease, especially in adults (Rona and Altman, 1977). On the other hand, at a curative level, using information on indices of growth as part of a medical examination could help the physician to make a more accurate diagnosis.

In developing countries where children up to school leaving age comprise more than 50% of the total population (W.H.O., 1980) there is a heavy burden on the shoulders of the authorities in the fields of nutrition, health, education and welfare, to provide good services to this age group, in order to build a society which is healthy, physically and mentally, educated and free from diseases.

In Libya, millions of Libyan Dinars (L.D.) are spent each year in the field of health, on hospital construction, medical and para-medical staff and free medicine. This is a good effort, but its benefit is limited.. It would be better and cheaper to concentrate on prevention by giving priority to maternal and child health and to the improvement of the socio-economic conditions of the family (Tajouri, 1979). Also millions of Libyan Dinars are spent each year in subsidising the principal foods like meat, milk, oil and others to provide a balanced diet for every person in the country, but on the other hand the provision of school meals, which are very necessary for school children, was stopped. The monitoring of growth of children is an important and useful indicator for assessment of the benefit of these services as well as allowing early detection of individual children at risk.

1.2 The Use of Standards:

In order to monitor growth, it is necessary to have growth standards based on a suitable population with which the growth of individual children can be compared. An example of a standard growth chart showing the relationship between age and height from birth to age 19 years based on the English population (Tanner et al., 1966) is shown in Figure 1.2.1.

Growth standards are used in the nutrition and health fields:-

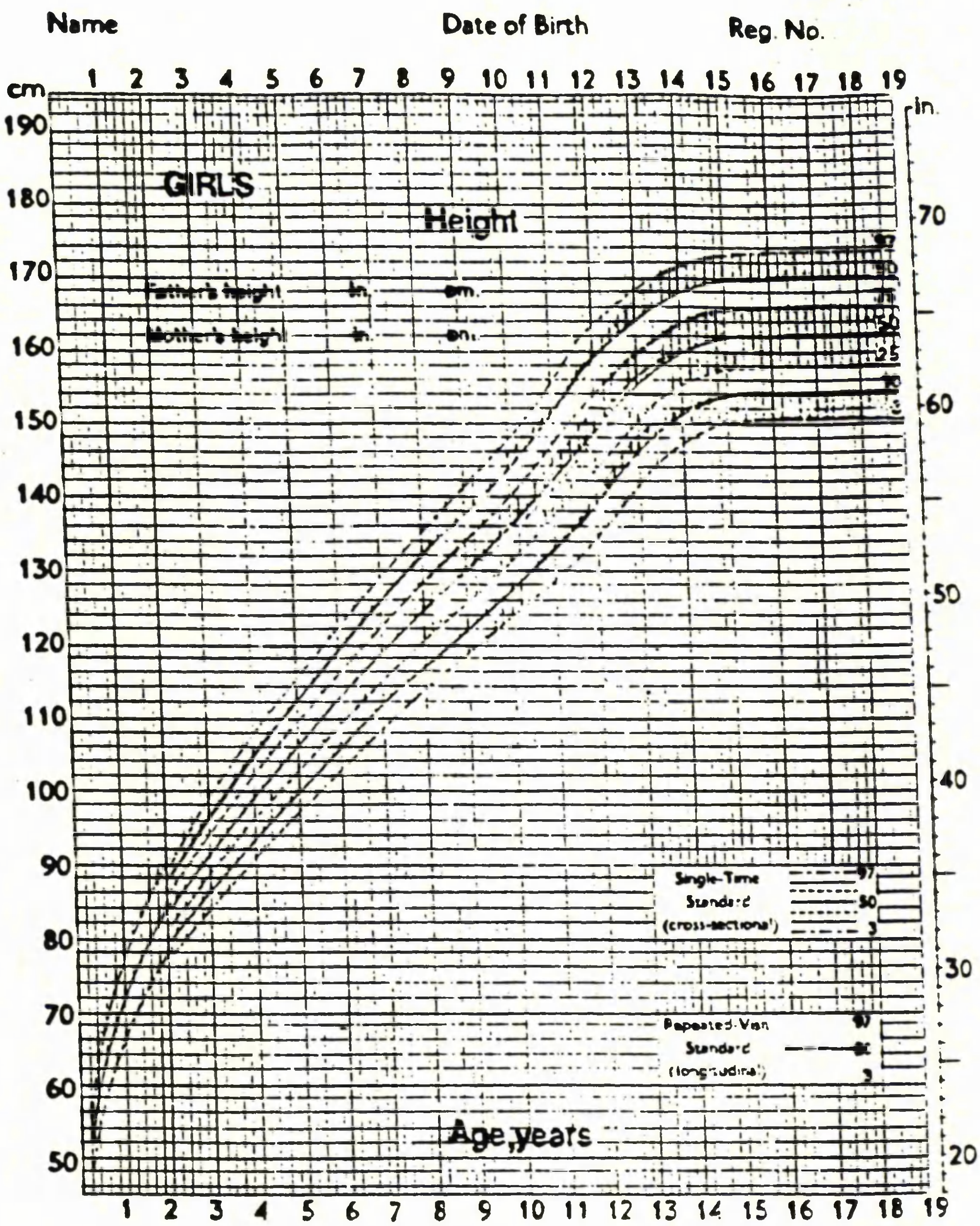
(i) as a guide for monitoring a child's growth relative to one of the reference percentiles. If he is growing parallel to any of the reference percentiles he is well nourished.

(ii) as a tool for comparing growth between different populations or between individuals within a population.

(iii) as an indicator to assess the nutritional and health status in a community.

The use of standard values as ideal or target values is highly controversial because it is not clear what the optimum size is for a child at any given age. Aiming for target values which are too high could result in obesity rather than ideal growth. Growth charts derived from the standard data are valuable if they are used as stated in (i) - (iii) above to help in detecting any changes in growth, health, and nutritional status due to changes in social and environmental conditions (Altman and Cook, 1973).

Figure 1.2.1: The British Standard Chart (Tanner et al., 1966) of Height by age - Girls.



1.3 Existing growth standards:

For establishing growth standards many people (Stuart, 1946; Jelliffe, 1966; Waterlow, 1977) have described the important parts of the body to be measured, and the method of measurement to be used in order to obtain good quality data. These are discussed in detail in Chapter Two. Standards should be obtained by measuring a statistically adequate sample containing at least 200 cases for each age - sex group (Jelliffe, 1966; Kemm, 1982) of healthy, well nourished children whose ages are known with certainty.

The most commonly used charts show how height, weight, arm, calf, head and chest circumferences, and biceps, triceps, subscapular and suprailiac skinfold thicknesses vary according to age and sex. If the data are to be used to prepare cross-sectional standards, then the reference sample should also be cross-sectional. The sampling procedure should be defined and reproducible. All measurements should be carefully made by trained observers using regularly tested and calibrated equipment and standardised techniques.

The best known standard data which meet these requirements are data on an Iowa population (Stuart and Meredith, 1946), and on a Boston population (Stuart and Stevenson, 1959) for the U.S.A. They are used in many countries as malnutrition standards. In the U.K. the widely used reference data are the London data (Tanner, Whitehouse, Takaishi, 1966). There is also the National Study of Health and Growth (NSHG) in the U.K. (Rona and Altman, 1977). In developed countries growth charts from birth to maturity in different colours for both sexes, are usually available, at primary health care level as well as at paediatric hospitals, and most of the charts in use are derived from data drawn from their own population.

In developing countries local reference standards and growth charts are less likely to be available, and if they are, in most situations it will be for pre school age children, which is the critical age for malnutrition. Most of the uses of these standards in these countries are on the preventive side (Morley, 1977). They use them in specific (maternity and child health) units and for some growth retarded cases in paediatric hospitals. Some of these countries are using either the British standards or U.S.A. standards. Eveleth and Tanner (1976) have listed most of the standards available in both developed and developing countries.

1.4 The need for local standards:

Local standards are desirable because of the environmental and genetical factors which affect the general growth of the child. Many people (Jelliffe, 1966; Watson, 1977; Marshand, 1980; Goldstein and Tanner, 1980; Jones et al., 1981) recommended the use of local standards in assessing the nutritional and health status of the community, although the international standards may be used to compare the results of surveys conducted at different times and places. Jelliffe (1966), stated "It should be the ultimate aim of nutritionists to prepare and use local standards for different ethnic groups with potentially different patterns of growth". It has been argued (Habicht et al., 1974; Gaitcer and Gentry, 1981) that the ethnic differences in growth rate were almost entirely due to environmental differences and that a population could be considered malnourished if its growth rate was not equal to that of Boston or some similar Caucasian population. In spite of that, it is undeniable that ethnic differences occur in degree of skin pigmentation, hair structure, facial characteristics, frequency of blood groups, and other genetic markers and it is generally accepted that both genetic and environmental factors have an effect on growth (Eveleth and Tanner, 1976; Rona, 1981; Kemm, 1982).

In Libya there is a paucity of national studies in the field of growth. There are only two known published studies. The first was "A study of skinfold thickness of schoolchildren in some developing countries, I. Skinfold thickness of the Libyan boys" (Ferro-Luzzi,1962). The second was "Cross-sectional study of growth in urban pre-school children in Libya" (Tajouri, 1979). The use of growth charts based on the pre-school study started in the Tripoli Paediatric Hospital (AL-IJLA) only in 1984. For school-age children the British standards (Tanner et al., 1966) are still in use.

1.5 Objectives of the study:

The present study involves two surveys. The first is a cross-sectional survey to determine distance growth standards. The second is a follow-up survey after an interval of about one year to find velocity growth standards. The study will cover schoolchildren between 6 and 17 years of age in Tripoli City - a metropolitan town in Libya. This group of children comprises 15% of all Libyan schoolchildren who number about one million.

The first survey included the recording of name, date of birth, sex, birth order and maturity of child. It included also socio-economic variables such as family size, number of siblings, parents' education, parents' occupation, family income and standard of dwelling, along with anthropometric measurements including height, weight, skinfold thicknesses, upper arm circumference and calf circumference. The second survey which involved a sub sample of those in the first survey took place after about one year and included the recording of name, date of birth, sex and anthropometric variables. The objectives of the study are:

(1) To set up reference standards for height, weight, skinfold thicknesses, upper arm circumference, and calf circumference for school age children in Tripoli.

(2) To construct growth charts of school age children of Tripoli.

(3) To estimate the velocity (rate of change), of growth of the children under study.

(4) To study the effect of socio-economic variables on anthropometric variables.

(5) To compare the results of this study with:

(a) the previous study carried out for Libyan school children in 1957 (published in 1962).

(b) British standards.

(c) available data from neighbouring Arabic countries.

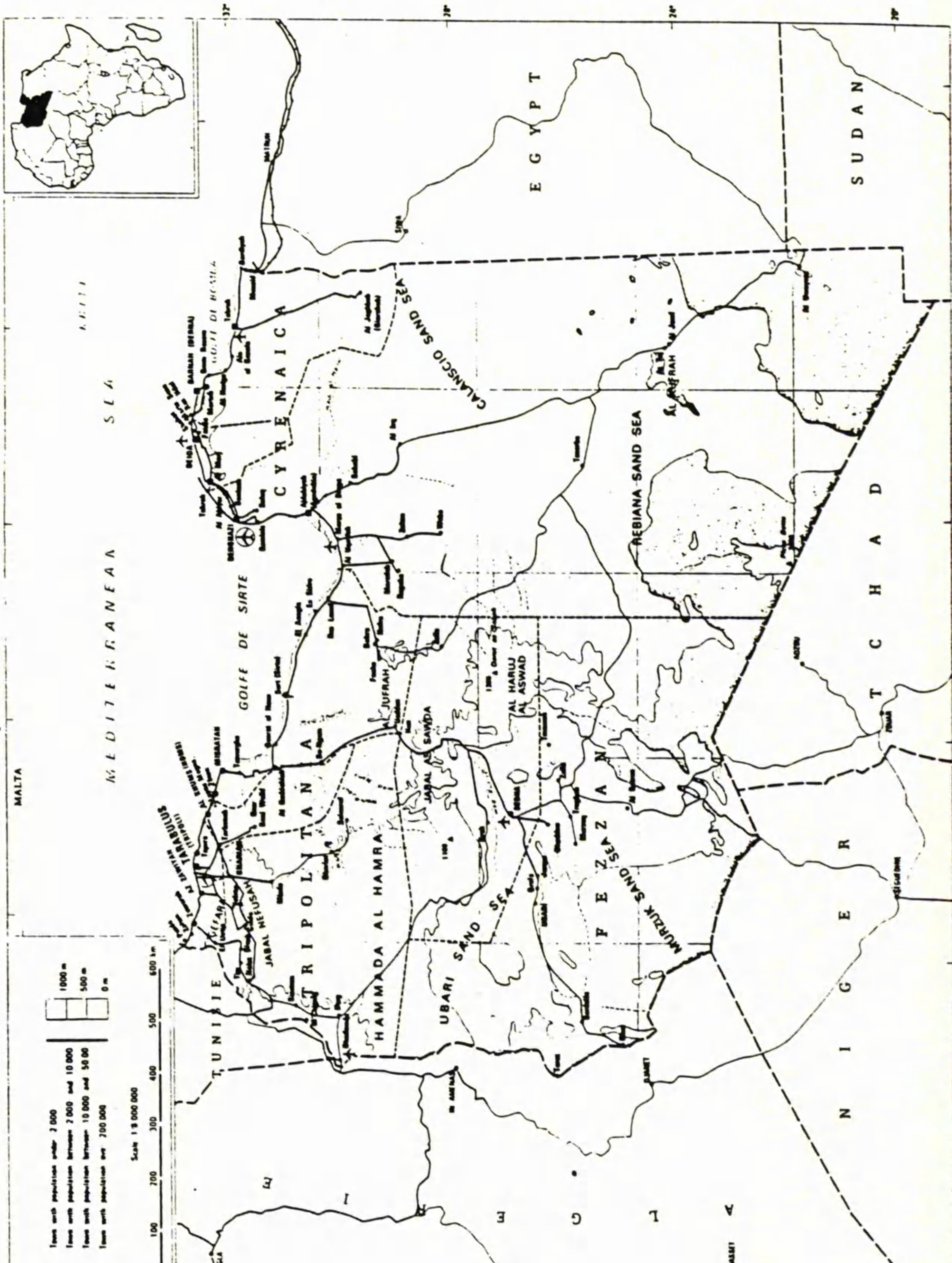
1.6 Demography of Libya:

Libya is a northern country in the Continent of Africa. It is located between 9^{O}E and 25^{O}E longitude, and 18^{O}N to 33^{O}N latitude. It has borders with six African countries. To the north it is bounded by the Mediterranean Sea, to the east by Egypt and a small corner of Sudan, to the south it borders on Niger, Chad and Sudan. In part of the south and west it borders on Algeria and in the north-west borders on Tunisia. (Figure 1.6.1). Libya is the fourth largest African country amounting in area to 1,760,000 square kilometres. It has a long Mediterranean coast line of 1900 kilometres (Ministry of Health, 1979). It comprises plateaux, hills, mountains, and vast desert. The temperature in the coastal plain is warm in winter and tends to be hot in summer. In the south it is cold in winter and hot in summer. Rain falls on the coastal area during winter.

The population of Libya is about 3,668,000 people (Preliminary Results of 1984, Department of Census), with an overall population density of two persons per square kilometre. The vast majority, however, live on the coastal plain with about one and a half million people living in the two major cities - Tripoli and Benghazi.

The Libyan people descend from Arabic origin, their language is Arabic and their religion is Islam. In Libya 33% of the population are between 5 and 17 years old. The sex ratio is 940 females to every 1000 males. Life expectancy is about 52 years for males and 55 years for females (Ministry of Health, 1983). The average Libyan family size is 7 persons (Personal Communication Census Department, Ministry of Planning). Population growth rate is 4.2% per year with a crude birth rate of 44.8 per thousand and a crude death rate of 5.0 per thousand. The infant mortality

Figure 1.6.1: Map of Libya.



rate is 37.3 per thousand live births. The hospital bed ratio is 6.8 beds to every one thousand population and with one physician (general and specialist) to every 788 people (Ministry of Health, 1979).

The leading causes of death in childhood in Libya in order of importance are:-

(a) Gastro enteritis.

(b) Meningitis meningococcus.

(c) Trauma; car accident; foreign body inhalation.

(d) Congenital abnormalities.

(e) Blood diseases, i.e. leukaemia and haemophilia.

(f) Infection, i.e. pneumonia, tuberculosis.

(Personal Communication, Al-IJLA - Paediatric Hospital, Tripoli).

Thus Libya is typical of most developing countries, with a high proportion of its population under 15 years of age, a high population growth rate and high infant mortality rate, and low expectation of life, although the bed ratio and the ratio of doctors per thousand population are high, reflecting the large amounts of money spent in this field.

1.7 Nutrition in Libya:

Physical stature is the end result of what we eat in relation to our physical activities. A healthy diet is essential for attainment of normal growth and development, while an unhealthy diet will lead to malnutrition which affects growth and development causing:

(1) growth disorders during pregnancy resulting in still-birth and low-birth weight babies.

(2) delay in physical and mental growth during early childhood.

(3) disorders in physical growth and development, intellectual development, learning and behaviour in schoolchildren.

(Zaheer et al., 1982).

Ferro-Luzzi (1957) described the nutritional status of Libyan schoolchildren. In about 33% of children it was rated as either moderate or poor. He mentioned that the most common signs of malnutrition can be attributed to deficiencies of calories, protein and vitamin A in the Libyan diet.

In Libya, before 1965, i.e. before the discovery of oil, the levels of income, education, housing, medical services, food production and food consumption were very low. Malnutrition diseases such as kwashiorkor, marasmus, anaemia, vitamin deficiency were the leading causes of morbidity and mortality in infancy and childhood (Ministry of Health, 1973). After 1970 when the ecological factors improved, diseases associated with malnutrition decreased and diseases associated with over-nutrition, such as obesity and its complications, cariovascular disease, hypertension and diabetes increased (Zaheer et al., 1982). Because of scarcity of epidimiological and nutritional surveys and because of the poor quality of hospital statistics, the prevalence of disease associated with malnutrition in Libya is not accurately known.

One of the most important goals of this growth study is to set up local growth standards to be used as an index of malnutrition assessment in the important stage of our children's life, which is school age. There is no published information about the nutritive value of the diet of Libyan children. However Zaheer et al (1982) give the nutritive value of the adult Libyan diet (Table 1.7.1). He also shows the recommended diet for the average Libyan adult, compared with the U.K. average adult diet (Table 1.7.2). Tajouri (1979) in his growth study of urban pre-school children in Libya, made some important recommendations to improve the Libyan children's diet such as enrichment of flour with iron and of other food stuffs with high-quality proteins, provision of school meals and mass treatment of iron deficiency in school children. Information from growth studies should help to assess the effectiveness of measures such as these.

Table 1.7.1: Nutritive value of adult Libyan diet compared with the adult U.K. diet.

Nutrients	LIBYA 1978		U.K. 1979
	Intake**	%	Intake*
Total energy (Kcal)	3183.0	100	2726.0
" energy from carbohydrate (Kcal)	2121.0	66.5	-
" energy from protein (Kcal)	293.0	9.2	272.0
" energy from fats (Kcal)	779.0	24.4	-
Total protein (g)	73.3	100.0	68.2
" animal protein (g)	22.6	30.8	-
Total fats (g)	86.5	100.0	-
" animal fats (g)	22.6	26.1	-
" vegetable fats (g)	63.9	73.9	-

** Zaheer at al 1982. Textbook on Community Medicine.

* For adults of U.K. Department of Health & Social Security, Report 15. on Health and Social subjects.

Table 1.7.2: Recommended nutritional requirements for an average adult in Libya and U.K.

Nutrient	LIBYA 1978**	U.K. 1979*
Energy Kcal	2500 (M) 2200 (F)	2726 (M) 2230 (F)
Protein (g)	60 (M) 45 (F)	68 (M) 55.6(F)
Fats (g)	40-60	-
Calcium (mg)	450-500	500
Iron (mg)	12-20	10-15
Retinol (mcg)	750	750
Thiamine (mg)	1	1.2
Riboflavin (mg)	1.4	1.6
Niacin (mg)	15	18
Vitamine C (mg)	30	30

M = Male, F = Female

** Zaheer et al. 1982 Textbook on Community Medicine

* Department of Health and Social Security of U.K. Report 15, 1979.

[Note: In both Tables "-" means "information not available"]

CHAPTER TWO

SAMPLING AND DATA COLLECTION

A. Cross Sectional Survey September 1983-February 1984

2.1 Estimation of target sample size:

In order to achieve a reasonable level of precision with small standard errors for estimates of percentiles, the sample size within each age - sex group must be reasonably large. A figure of 200 is often mentioned (Jelliffe, 1966; Kemm, 1982). For variables with a Gaussian distribution, such as height, the percentiles of the distribution are estimated with greatest precision using the sample mean and standard deviation (Healy, 1974). For example the $(100\ k)^{th}$ percentile of the distribution is estimated by

$$\bar{x} + \Phi^{-1}(k)s$$

where $\bar{x}$ is the sample mean

s is the sample standard deviation.

Φ is the distribution function of a standard Normal random variable.

The standard error of $\bar{x} + \Phi^{-1}(k)s$ is given by

$$s\sqrt{(1+\frac{1}{2}[\Phi^{-1}(k)]^2)/n}$$

which increases as k moves away from 0.5 towards 0 or 1.

For example, suppose that the mean height of boys at age 8 years was 126.0 cm. and the standard deviation was 5.75 cm and the sample size was 200. Then by using the above formula, the estimated standard error is 0.7 cm for the 3rd and 97th percentiles and 0.4 cm for the 50th percentile. If the sample size is 1000 children, then the estimated standard error is 0.3 cm for 3rd and 97th percentiles, and 0.18 cm for the 50th percentile.

It is clear from this example that the standard error for the 3rd and 97th percentiles is greater than the standard error of the median. It was planned in this study to examine as many Libyan schoolchildren from each age - sex group as possible in the time available, because clearly the sample size should be as large as possible. After the pilot study we felt that it would be possible to handle 8400 children over a period of 120 days at a rate of 70 children per day. This would allow us to examine roughly 350 children in each age - sex group, so that from a typical age - sex group, assuming, for height, a standard deviation of 5.75 cm, the standard error of the mean would be 0.3 cm, and the standard errors of the 3rd and 97th percentiles would be 0.5 cm.

Because the rate of growth in children is approximately uniform between 5 years and pre-adolescence, and it accelerates during adolesence (Nelson, 1954; Goldstein, 1979) where the variability within each age group increases, a larger sample is required in the older age groups to achieve the same degree of precision of estimation. Table 2.1.1 shows the numbers and the percentage distribution of the target sample by age and sex. Age is grouped in the standard way as follows; 5.50 years to 6.49 years as 6 years, 6.50 years to 7.49 years as 7 years,...15.5 years to 16.49 years as 16 years, 16.50 years to 17.49 years as 17 years.

Table 2.1.1: Distribution of the target sample by age and sex.

Age Group	BOYS		GIRLS	
	Number	%*	Number	%
6	280	6.7	280	6.7
7	280	6.7	280	6.7
8	280	6.7	280	6.7
9	280	6.7	280	6.7
10	280	6.7	280	6.7
11	400	9.5	400	9.5
12	400	9.5	400	9.5
13	400	9.5	400	9.5
14	400	9.5	400	9.5
15	400	9.5	400	9.5
16	400	9.5	400	9.5
17	400	9.5	400	9.5
TOTAL	4200	100.0	4200	100.0

*(Cameron, Personal Communication).

2.2 How the sample was chosen:

In Libya there are more than one million schoolchildren, 15% of whom are in Tripoli city. The cross-sectional growth study was carried out at the beginning of the education year in September 1983, and continued for six months. Standards representative of the whole population of Libya are required but clearly it was not practical to carry out this study on a nation-wide basis. Tripoli city was chosen as the area for study because, as the capital city, it contains people from all areas and all different races within Libya, and so should be representative of the whole population. It has also been argued (Jordan et al., 1975) that in a developing country the capital city is the best area on which to base growth standards since the children who live there are better nourished than those from rural areas.

Within Tripoli city there are three different education boroughs (Figure 2.2.1). Each borough within itself is fairly homogeneous with respect to education, housing and income levels. There is one education office (Mactib Taliem) in each borough, which supervises all the schools in that borough. The boroughs are named below in order of their rank from high standard to low standard:

1 - AL-ANDOLOS Education Borough.

2 - TRIPOLI-CENTER Education Borough.

3 - ABU-SALEM Education Borough.

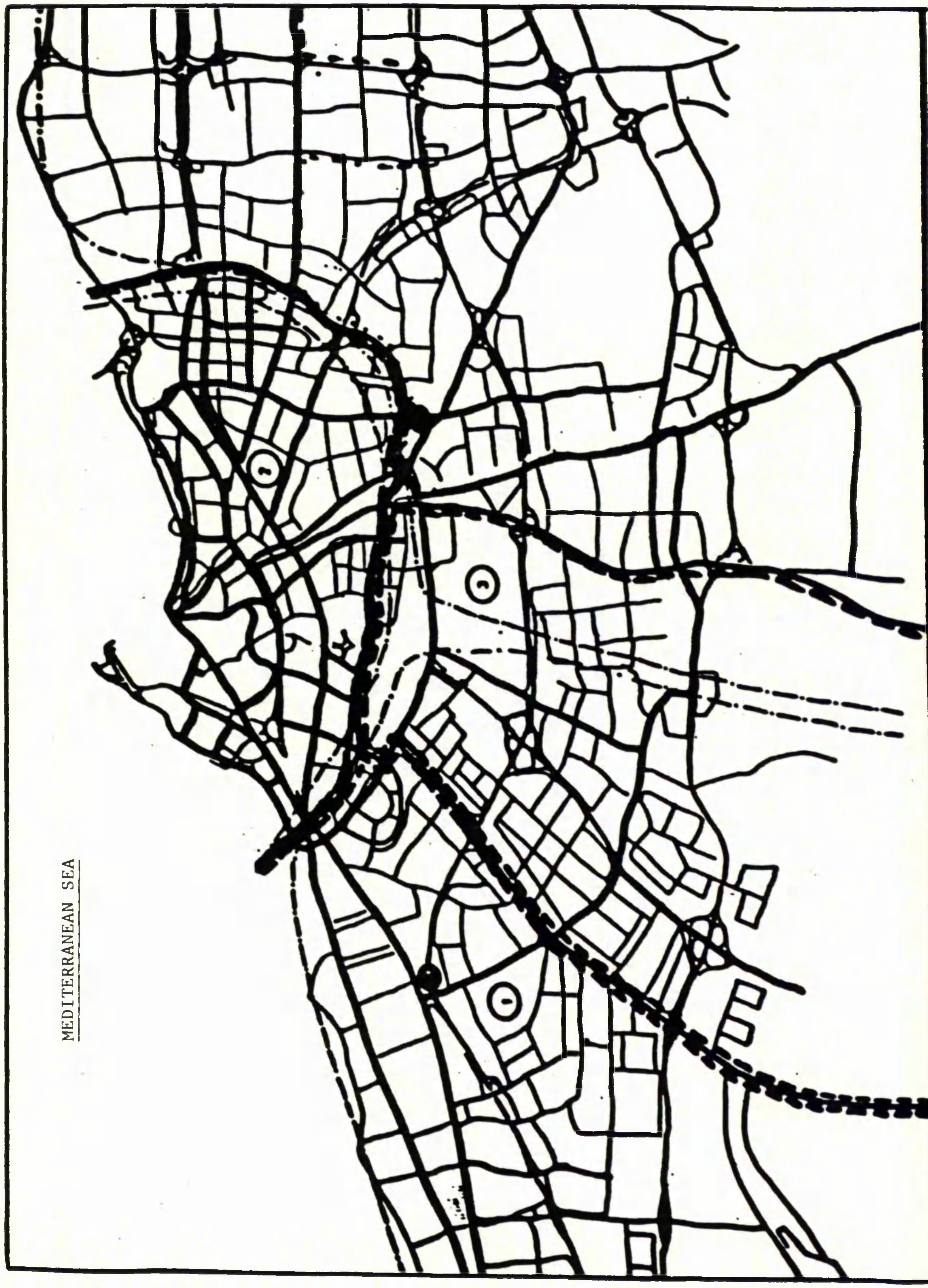
The education system in Libya before University is in three stages:

(a) Primary stage which starts at age 6 years and continues for six years.

(b) Preparatory stage which starts at age 12 years and continues for three years.

(c) Secondary stage which starts at age 15 years and continues for three years.

Figure 2.2.1: Tripoli City, showing the location of the 3 education boroughs.



Primary and preparatory stages are obligatory for Libyan children. Table 2.2.1 shows the distribution of schoolchildren in Tripoli city by age and sex. Table 2.2.2 shows the distribution of schoolchildren in Tripoli city by borough of education.

A multi-stage sampling procedure was used. Firstly, from each of the three types of school and from each sex separately, a simple random sample of schools of each type was selected from all schools in each borough and Table 2.2.3 shows the sample of schools which were chosen in each borough. From each school a random sample of classes were chosen for each age group in the school, and all healthy children in these classes were examined. Unhealthy children who had skin diseases, paralysis, deformities of the thorax, etc. were excluded from this study, as were non-Libyan children.

An interview was held with the head of the borough of education (Ameen-Mactib) in each area, to inform him of the purpose of the study. All of them were very cooperative and helpful. Each of them circulated a letter to the selected schools in his area. A copy of these letters and their English translations are shown in Figure 2.2.2.A,B and C. Another interview was held with the headmaster (Modeer) of each school two days in advance, to tell him about the aim of the survey, and let him know how many children will be examined in each age group. He was also asked to provide a room to measure the children, to instruct the children on the way to fill in form F2 (Figure 2.2.3) which is described later, and to explain to the children the purpose of the examination so that they would come in suitable clothes on the examination day.

It is my pleasure to report here that, during the survey, everybody including heads of borough of education, headmasters, teachers and school

Table 2.2.1 Distribution of schoolchildren in Tripoli city by age and sex (December 1981)

Age Group	Schoolchildren in Tripoli City *			
	Boys	Girls	Total	%
6	8425	8327	16752	11.52
7	7951	7312	15263	10.50
8	8339	8397	16736	11.50
9	7424	7820	15244	10.50
10	8168	7582	15750	10.73
11	8306	8104	16410	11.30
12	7035	7528	14563	10.00
13	7041	6210	13251	9.11
14	5920	4762	10682	7.34
15	3347	2378	5725	4.00
16	1643	1230	2873	2.00
17	1150	950	2100	1.50
TOTAL	74749	70600	145349	100.0

*(Source: Statistical Report of Tripoli District of Education December 1981).

Table 2.2.2: Number of schoolchildren and their percentage in Tripoli city by Borough of Education.

Borough of Education	Number	%
Al-Andolos	59897	41.3
Tripoli-Centre	31352	21.6
Abu-Salem	54100	37.1
TOTAL	145349	100.0

Table 2.2.3: Name of schools sampled in each area by level of education and type.

Area Name	School Name and Code	Education Level	Type
AL-ANDOLOS	1- MAGD AL-ARAB	PRIMARY	MIXED
	2- MAGD AL-ARAB	PREPARATORY	GIRLS
	3- KHORTOPA	SECONDARY	GIRLS
	4- ANNISAA-ALKHLIDAT	PREPARATORY	MIXED
	5- TARIK BEN-ZIAD	PREPARATORY	BOYS
	6- TARIK BEN-ZIAD	PRIMARY	MIXED
	7- GHARNATA	PRIMARY	MIXED
	8- AL-ANDOLOS	SECONDARY	BOYS
TRIPOLI-CENTER	1- AL-IJLA	PRIMARY	MIXED
	2- ALJAMAHIRIA	PRIMARY	MIXED
	3- A-BEN SHATWAN	PREPARATORY	GIRLS
	4- AL-IJLA	PREPARATORY	GIRLS
	5- ALJAMAHIRIA	PRIM-PREPARATORY	BOYS
	6- ESSABEA MIN APRIL	SECONDARY	GIRLS
	7- AL HADI ARAFAH	PREPARATORY	BOYS
	8- IMEATIGAH	SECONDARY	GIRLS
	9- TRIPOLI	SECONDARY	BOYS
ABU-SALEM	1- FATIMA AZZAHRA	PRIMARY	MIXED
	2- AL-FATEH	SECONDARY	GIRLS
	3- AL-FATEH	PREPARATORY	GIRLS
	4- ASHAAB	PRIM-PREPARATORY	BOYS
	5- ALHADABA	PREP-SECONDARY	BOYS

Figure 2.2.2.A

بسم الله الرحمن الرحيم

الجماهيرية العربية الليبية الشعبية الاشتراكية
أمانة التعليم
الادارة العامة للعلاقات الثقافيـــة

لا ديمقراطية بدون
مؤتمرات شعبيـة

التاريخ ٤ / ٢ / ١٣٩٢ و.ر
الموافق ١١ / ٩ / ٨٢ م

الى من يهمه الامـــر

بعد التحيـــة ....

تشهد الادارة العامة للعلاقات الثقافية بأمانة التعليم بأن الطالب / الصادق مفتاح أبو نعجـة عضو هيئة التدريس بكلية الطب البشري بجامعـة الفاتح هو أحـد أعضاء بعثـة هذه الامانة للدراسة العليا ببريطانيـا لتحضير درجة الدكتوراه في مجال الاحصاء الطبي ويقـوم الان بدراسـة حقليـة بالجماهيرية تتعلق بموضوع بحثـه لنيل درجـة الدكتوراه في المجال المشار اليـه أعلاه .

عليـه يرجى تقديم كافـة التسهيلات القانونيـة الممكنـة في المواضيع ذات العلاقة بدراستـه الميدانيـة .

اشكركم على حسن تعاونكـم .

" والسلام عليكم ورحمة الله وبركاته "

(د / ابراهيم التريكي الشريف)
(مدير عام ادارة العلاقات الثقافيـة)

نسخة الى :ـ
الملف الــدوري العـــام .

م / ع / ٢٠ / ٤/٣/ع / ١٠ ......

Figure 2.2.2.B

الأخوة رؤساء مكاتب التعليم
يرجى مساعدة الصادق مفتاح أبونعجه
في مواصلة بحثه تقديراً للمصلحة العامة
وشكراً
المدير ...
١٠ / ٩ / ١٩٨٢م

Figure 2.2.2.C

السيد مدير مدرسة ...
الثانوية ...
للعدالة
يرجى قبلكم التعاون مع الطالب الصادق مفتاح أبونعجه
مع تقديم كل التسهيلات اللازمة ...
وتقبلوا فائق ...

١٩٨٢/٩/...م

Translations

Figure 2.2.2.A

Socialist People's Libyan Arab Jamahiria
Amanat (Ministry) of Education
General Cultural Department.

11-9-1983

To whom it may concern.

After greeting:

The General Cultural Department in the Amanat of Education Certifies that Sadik Abounaja, who is a teaching staff member in the Faculty of Medicine Alfateh University, and is a postgraduate student in U.K., doing a PH.D. in Medical Statistics is now going to do a field study in Libya related to his Ph.D. topic. Please provide all your assistance in this project.

Thank you for your cooperation.

Yours sincerely,

Dr. Ibrahiem Z. Sharief
General Director of Cultural Department

Figure 2.2.2.B

Comment on the above letter.

All brothers/head of Educational Bureaus in Tripoli are required to provide help to brother Sadik Abounaja in his field study.

Thank you for your cooperation.

Sincerely,

c/o Director-General Education Committee-Tripoli.

Figure 2.2.2.C

Socialist People's Libyan Arab Jamahiria

The People's General Committee-Tripoli Municipality.

The People's Committee of Education-Tripoli Municipality.

12.9.1983

Al-Andolos Education Bureau,

Brother/Sister: Headmaster of School.

Brother Sadik Abounaja, teaching staff member of Medical Faculty - Alfateh University is doing his Ph.D. in Medical Statistics, and he needs in his field study to collect some information from your school-children. Please provide all possible help and all the information he needs for his study.

Your cooperation is appreciated.

Yours sincerely,

Mahmoud M. Almajdoub

Head of Alandolos Education Bureau.

social workers was very cooperative and helpful and no objection was raised about this survey except in one preparatory girls' school (Magd-Al-Arab) where some parents objected to the undressing of their daughters, because they misunderstood how the girls were measured. However, Mr. Elglawi Salah the headmaster of that school explained to them the importance of this study and reassured them that their daughters would be measured by a female nurse in private, behind curtains, and they allowed their daughters to be measured.

The final sample of 8566 schoolchildren comprises about 6% of the total population of schoolchildren in Tripoli city. Table 2.2.4 gives the percentage distribution of the total sample by age and sex. The actual percentages of the sample within each age group are slightly different from the target stated in Table 2.1, but the discrepancies are not large except in the 6 and 17 age groups where considerably fewer children were measured than had been hoped. The reason for these discrepancies may be that the sampling unit was a class of children, and the exact ages of the children were not known in advance. Thus children from one class could contribute to the number in the sample in 2 or maybe 3 different age-groups causing some imbalance. For the 17 age group, a large enough sample of children was not always available in the schools selected resulting in small sample size for this age group. Table 2.2.5 gives the distribution of the sample by age, sex and borough of education. Table 2.2.6 shows the percentage distribution of the sample by borough of education for each age-sex group. It is clear from the table that the percentage distribution by area of the whole sample for boys and girls as shown in the bottom of the table is very close to that for the whole population of Tripoli schoolchildren as shown in Table 2.2.2, and the

Table 2.2.4: Percentage distribution of total sample by Age and Sex.

Age Group	Boys %	Girls %
6	3.7	4.6
7	6.3	6.9
8	7.5	6.7
9	7.9	7.0
10	8.1	8.4
11	9.1	9.7
12	9.3	10.1
13	8.1	10.4
14	10.2	11.6
15	10.5	10.3
16	12.1	9.9
17	7.3	4.4
TOTAL %	100.0	100.0
TOTAL No.	4342	4169

Table 2.2.5: Distribution of the sample by Age, Sex and Borough of Education.

Age Group	AL-ANDOLOS M	AL-ANDOLOS F	TRIPOLI M	TRIPOLI F	ABU-SALEM M	ABU-SALEM F	SUB-TOTAL M	SUB-TOTAL F	WHOLE * SAMPLE
6	71	89	53	50	38	51	162	190	352
7	124	137	55	56	93	95	272	288	560
8	126	126	71	68	127	84	324	278	602
9	138	114	60	81	146	97	344	292	636
10	122	128	55	82	175	140	352	350	702
11	126	166	87	93	180	145	393	404	797
12	164	166	92	100	146	156	402	422	824
13	153	196	90	86	107	153	350	435	785
14	177	189	99	107	167	188	443	484	927
15	153	183	105	103	198	145	456	431	887
16	181	141	130	121	214	151	525	413	938
17	62	46	36	37	221	99	319	182	501
TOTALS	1597	1681	933	984	1812	1504	4342	4169	8511
	3278		1917		3316		8511		

*the whole sample is 8566 children. 55 children were excluded for reasons explained in Chapter Three.

Table 2.2.6: Distribution of the sample percentage by Borough of Education for each age-sex group.

Age Group	BOYS			GIRLS		
	AL-ANDOLOS	TRIPOLI	ABU-SALEM	AL-ANDOLOS	TRIPOLI	ABU-SALEM
6	43.8	32.7	23.5	46.8	26.3	26.9
7	45.6	20.2	34.2	47.6	19.5	33.0
8	38.6	21.9	39.2	45.3	24.5	30.2
9	40.1	17.4	42.5	39.0	27.7	33.3
10	34.7	15.6	49.7	36.6	23.4	40.0
11	32.0	22.1	45.8	41.0	23.0	36.0
12	40.8	22.9	36.3	39.3	23.7	40.0
13	43.7	25.7	30.6	45.0	19.8	35.2
14	40.0	22.3	37.7	39.0	22.2	38.8
15	33.5	23.0	43.4	42.5	23.9	33.6
16	34.5	24.8	40.7	34.1	29.3	36.6
17	19.4	11.3	69.3	25.3	20.3	54.4
TOTAL	36.8	21.5	41.7	40.3	23.6	36.0

overall percentages of the sample for each age group for boys and girls are close to the percentage in each area except in a few age groups. The large imbalance in the 17 age group is because sufficient children were not available in this age group in some areas. The small sample size in this age group and the imbalance between areas is not too important. For example Tanner et al. (1966) had only 1% of their sample of boys in the 17 age group because in this age group the growth slows down and eventually ceases. (Goldstein, 1979).

2.3 Data Collection Forms:

There were three types of form used in this survey in order to simplify the collection of the information:-

(a) Figure 2.3.1 shows master form F1 for recording examination date, team, area, school, class, and child numbers, child's name, and all of the variables under study for each child.

(b) Figure 2.3.2 shows the letter to parents, form F2, which was written in Arabic and distributed to every child to take home for completion, and return to the school next day. The information on name, date of birth, birth order, number of family members, number of alive and dead children was recorded on this form.

All this information is available in what is known in Libya as the Family Book. Within the last fifteen years, the Office of Civilian Registration (Mactib-Asigel Almadanī) in the Ministry of Municipalities (Amanat Al Baladiat), issued to every Libyan family a book with a serial number which is used to record vital events (births, deaths, marriage and divorce) that happened to the family. In this study we emphasised to school children and their parents to make use of this book for correct information.

Also recorded on this form were:-

(i) for parents: their level of education, occupation, and grade of pay for working parents;

(ii) type of dwelling, and number of rooms in dwelling used only as bedrooms.

(c) Form F3 illustrated in Figure 2.3.3 contains information about every child in the class such as name, date of birth, height and weight. Form F3 was distributed in advance to the responsible teacher in every class, to enter name and date of birth.

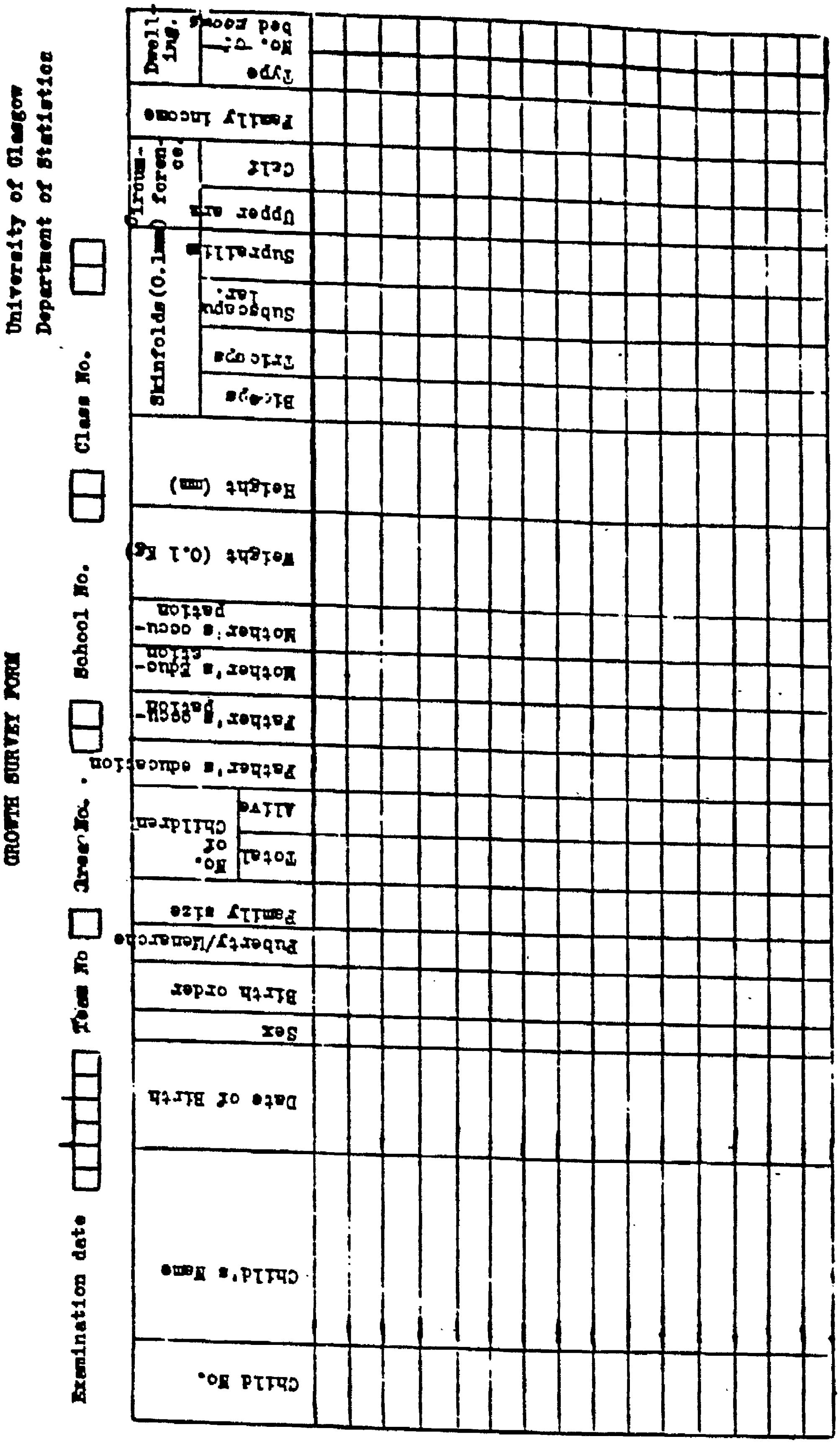


Figure 2.3.1: The master form F1 used in recording data.

Figure 2.3.2: Form 2, the letter to parents.

Form -F2-

Class .... الفصل .... اســم المدرسة School name

Child's name
.... اسـم التلميـذ / الطالـب

Dear Parents, الاخ ولــــي أسر الطالب

After Greeting, بعـد التحية،

Please complete this form and send it back with your son/daughter to school tomorrow
يرجى استكمال هذا الاستبيان وارساله مع ابنكم الى المدرسة غدا •

First: Information to be filled from Family Book: اولا : بيانات تعبأ من كتيب العائلة :

1) Birthday of Child
Day Month Year
١) تاريخ ميلاد التلميذ يوم ( ) شهر ( ) سنة ( )

2) Birth order
٢) ترتيب التلميذ / الطالب في الميلاد الاول او الثاني او ( )

3) No. of family members
٣) عدد أفراد العائلة الآن بما فيهما الوالدين ( )

4) no. of children ٤) عدد الابناء

Female إناث	Male ذكور	البيان
		alive أحياء
		dead أموات

Second: Information about parents ثانيا : معلومات عن الوالدين :

Mother الوالدة	Father الوالد	البيان
		Education Level المستوى الدراسي
		Occupation الوظيفة (المهنة)
		Grade الدرجة الحالية

Third: Dwelling ثالثا : معلومات عن السكن :

1) Type of dwelling ١) نوع السكن

a) Villa ( ) ١) فيلا
b) Appartment ( ) ٢) شقة
c) Separate House ( ) ٣) منزل شعبي

No. of bedrooms ٢) عدد الحجرات المستعملة للنوم فقط ( )

.... تاريخ ملأ الاستمارة
Date of filling the form

Note: this information is very secret. ملاحظة : —

هذه المعلومات سرية جدا ولا يجوز الاطلاع عليها لغير الجهة المسئولة•

Thank you for co-operation شكرا على حسن تعاونكم معنا

Figure 2.3.3: F3 for height and weight records, as well as name and date of birth.

Form -F3-

Class الفصـــل :

School Name اســـم المدرســة:

(يوم/شهر/سنه)

Weight الـــوزن	Height الطـــول	Date of birth تاريخ الميلاد	Child's name اسم التلميــــذ

The purpose of using this form was:-

(i) to know in advance in each chosen class, the number of children by age and sex (since this information is not available at the school administration before the survey).
This lets us know how many children in each age group we can examine in that school.

(ii) to record the readings of height and weight, since the master form F1 was being used by the other members of the team to record the skinfolds and circumferences in another part of the room.

(iii) to compare with the school records; i.e. to see if the child's file is complete or not. In fact many schools we visited in this survey have a poor record keeping system, although they have no personnell problem. In some of them you may find more than one file for one school child, no birth certificate in the file, or the file has disappeared.

(iv) to help the writer to check-up if the child's date of birth in form F2 (filled at home) is the same as in form F3 (filled in school). If we found a difference we checked the file in school to see if there was a copy of the birth certificate in it. If so we corrected the date of birth in form F2; if not, we asked the child to bring a copy of his birth certificate from home.

The examination time of the team was from 8.30 a.m. up to 2.00 p.m. every day except Fridays or formal holidays. The writer collected all forms F1, F2 and F3 each day and took them home where, in the afternoon, he completed the master form F1 from both F2 and F3. This was done every day because if there were any mistakes or missing information it would still be possible to correct these on the following day. It was a very difficult and time consuming job that took from the writer 18 hours per day for six months continuously.

2.4 Equipment:

The instruments available to the team were two Harpenden portable stadiometers whose rule scale is in mm for measuring height, two weighing machines (Model MPS 120:-120 Kg x 100g) for measuring weight to the nearest 0.1 kg, three Harpenden skinfold calipers which allow accurate measurement of skinfolds to 0.2 mm and give a constant pressure of 10 gm/mm^2 of jaw face area at all openings, and three self-retracing steel tapes, graduated in mm., for measuring the arm and calf circumferences. In addition there were two stands of curtains used to ensure privacy for children when they were dressed in under clothes, which is especially important for older girls in an Islamic country. In each school we visited, a large room was given to the team. Two kerosene heaters were required to heat the survey room in winter. The room was prepared in such a way that the equipment for height and weight measurement was in one corner isolated by the curtains, with chairs and tables for the measurement of skinfolds and circumferences on the other side of the room. Tables were large enough to write on, and for children to sit on to have their calf circumferences measured.

2.5 Staff:

The survey team consisted of four people; one doctor, the writer, one female social worker - nurse from the Community Medicine Department, Faculty of Medicine, Alfateh University, and one female nurse from the Ministry of Health. Most schools have a nurse and social worker, or both, depending on the size of school and age of children. They were very helpful. Their role in this survey was:-

(i) to bring children from their classes on the day of measurement and stand them in an orderly queue outside the measuring room;

(ii) to help young children in taking off and putting on their clothes before and after measurement;

(iii) to distribute form F2 (social information) to children, in advance, to fill in at home and collect and check them on the day of examination. If any information was not clear, or missed out in form F2 they returned the form to the child with further instructions for completion.

(iv) to identify children who were absent on the day they were due to be measured, and bring them along to be measured on a later day before the measuring team moved to another school. Thus, only a very small number of children were excluded from the survey because of absence from school.

2.6 Description of Variables:

(i) Anthropometric Variables:

Eight anthropometric variables - height, weight, triceps skinfold, biceps skinfold, subscapular skinfold, suprailiac skinfold, upper-arm circumference and calf circumference were measured for every child, using the right side of the child throughout the study. Height is the best single measurement for recording gross linear size and rate of linear growth during school age (Stuart, 1946). Weight is the best measurement for general mass and overall rate of growth in mass. Changes in body composition can be inferred by combining the impression of the changes taking place in circumferences and skinfolds. Skinfold thickness is used as a measure of subcutaneous fat of the body. Skinfold thickness measurements are a fairly accurate approach to the measurement of subcutaneous fat at a given location and combining skinfold thickness measurements from all four sites can provide a good measure of total subcutaneous fat (Lohman, 1981). Arm and calf circumferences measure the skin, fat, muscle and bones. Upper arm circumference is used as a good criterion for identifying malnutrition, although some researchers find maximum calf circumference more useful (Jelliffe and Jelliffe, 1969; Loewenstein and Phillips, 1973; Davies et al., 1974; Anderson, 1975).

Measurement Techniques:

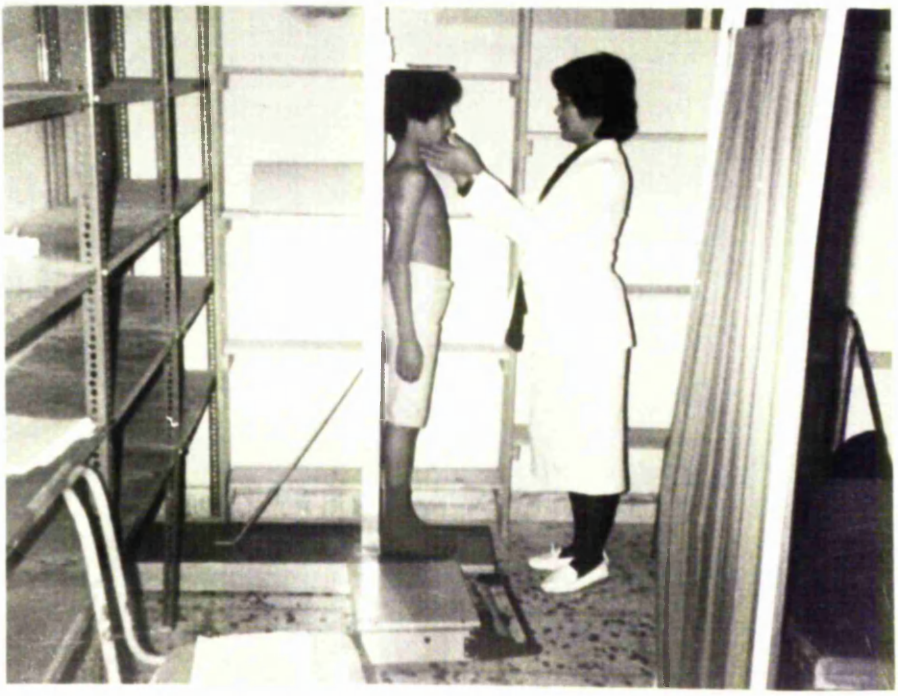
All children of one class queued outside the examination room, and were admitted in groups of five. They were asked to take-off their clothes (Figure 2.6.1) and they were measured as follows:-

Height:

The child was in under clothes and was bare-foot. The measurer

Figure 2.6.1: Libyan children from ASHAAB school undressed and ready to have skinfolds and circumferences measured.

Figure 2.6.2: A child from ASHAAB school having his height measured.



asked the child to stand straight with his heels together. The heels, buttocks and shoulders were in contact with the rule of the stadiometer. The shoulders were relaxed in a natural position. The hand and arm were loose, and relaxed with the palm facing the thigh. The head was kept in the frankfort plane, then the head block of the stadiometer was slid down on the child's head. The child's heels were on the ground and did not leave it. The measurer held the child's head and applied a gentle upward pressure on the mastoid processes, and encouraged the child to "stand tall, take a deep breath and relax". At that moment the measurer read the maximum height of the subject in completed mm. Figure 2.6.2 shows how height was measured.

Weight:

The children were weighed in under clothes, bare-foot, except for a few older girls who were shy. These girls used a special coat weighing 0.4 kg, which was deducted from the final weight. The reading was taken to the last complete 0.1 kg. The child then put on some of his/her clothes and went to the other groups to have his/her skinfolds and arm and calf circumferences measured.

Skinfold Thickness:

The skinfolds were measured as described by Tanner and Whitehouse (1975). Pinch up a fold of skin and subcutaneous tissue between the thumb and the forefinger away from the underlying muscle. Skinfolds were measured with the caliper just under the pinch point. The hand holding the caliper relaxes its grip on the handle so that the jaw can exert the full pressure, while the other hand holds the skinfold lightly allowing the pressure of the caliper alone to be applied to the skinfold. The reading was taken to the last complete 0.2 mm within 2 to 3 seconds after the caliper was applied. To make sure of the correct reading, three separate readings were taken, each with a new skinfold, and averaged.

Triceps Skinfold:

The right arm of a child was bent at right angles and on the line joining the orcromion and olecronon at the back of the arm, the mid-point was marked. The child was then asked to let his arm hang freely at his side. A skinfold was picked up just above the mark, and the caliper was applied. The reading was taken to the last complete 0.2 mm. Figure 2.6.3 shows how the triceps skinfold was measured.

Biceps Skinfold:

The child was asked to keep his arm at his side, and a skinfold was picked up at the mid-point of the interior aspect of the upper-arm on the same level where the triceps was measured. The caliper was applied under the fold and the reading was taken to the last 0.2 mm as before.

Subscapular Skinfold:

The skinfold of subscapular was picked up just below the angle of the right scapula. The fold was in a vertical line, or slightly inclined in the natural cleaving line of the skin. The reading was taken as before.

Suprailiac Skinfold:

The skinfold was picked up at a point in the mid-axillary line at a point just below the lowest palpable rib and above the iliac crest.

Figure 2.6.3. A child from ASHAAB school having his Triceps skinfold measured.

The line of the fold was approximately 45° to the mid-axillary line. The caliper was applied and the reading was taken as before.

Upper-Arm Circumference:

The child was asked to hang his arm freely at his side. At the marked point in the mid-arm (as in triceps skinfold measurement), the circumference of the arm was measured with a flexible self-retracting steel tape. The tape was placed gently, but firmly, round the limb, avoiding compression of the tissue. The measurer took the reading to the last complete 0.1 cm.

Maximum Calf Circumference:

The child was asked to sit on the table with his right leg hanging freely and relaxed with nothing supporting the foot. The measurer took the maximum calf circumference by moving the flexible steel tape up and down the leg until he obtained the maximum reading. The tape was not very tight to the leg avoiding compression of the tissue. The reading was taken to the last 0.1 cm.

(ii) Developmental and Social Variables:

Menarche: In this study there was one developmental variable - the age at menarche. The girl was asked if she had menstruated or not. If "yes" it was recorded as 1 if "not" it was recorded as zero.

Also there were eleven socio-economic variables included to allow investigation of their effect, if any, on growth. These variables were:-

Birth order: the child's position within the family was recorded (first child, second child etc.).

Family Size: Family size, total number of children in the family and number of live children in the family, were recorded.

Education:- Father's and mother's education were recorded as in Table 2.6.1.

Occupation: Father's and mother's occupation were difficult to record due to the changes in the administration of the country. Most of the existing occupation names were changed, new ones were created and others no longer existed. Thus the occupation classification which was applied in the Census in 1973 was out of use by the time of the survey. The writer visited the Census Department (the responsible department for preparing occupation classification) before starting the survey, to get a copy of an occupation classification that could be used in comparing occupations in the future. They were engaged in preparation for the new census, which will be carried out in the near future and the new occupation classification was in preparation. Because the time for the survey was limited, the writer could not wait for that, so the occupation classification used here is not a detailed one. The category of parents' occupation which was used is shown in Table 2.6.1.

Income: For family income, to avoid a direct question which could cause offence, the parents were asked "what is your grade?" To estimate the family income, for employed people, the monthly salary table by grade (constructed according to Law 15, 1981, which became law on 1st January 1982) was used. Although the allowance for occupation was not included, because some of them were unknown, it gives a reasonable estimation of the family income. It was difficult for the writer to estimate the income of self employed people such as farmers,

Table 2.6.1: Classification of Parent's occupation used in this study.

CODE	OCCUPATION	CODE	OCCUPATION
01	Housewife	19	Police & Customs officer
02	Medical Doctor & Pharmacist	20	Army
03	Science & Engineering Employee	21	Agricultural Engineer
04	Teacher	22	Tailor
05	Accountant	23	Private Business Man
06	Lawyer	24	Civil Pilot & Engineer
07	Religious Person	25	Jeweller
08	Media employee	26	Diplomat
09	Nurse	27	Farmer
10	Administrator	28	Driver (Government & Private)
11	Printing employee		
12	Cashier & Book-keeper	29	Retired
13	Transport Technician	30	Artist
14	Telecommunications employee	31	Disabled or Handicapped
15	Super Market employee	32	Student
16	Hotel & Restaurant employee	33	Petroleum Employee
17	Barber & Beauty Salon employee	34	Computing Employee
18	Electrician & Mechanic & Maintenance	88	Dead
		99	Unknown

Code for Parent's Education

Code	Education Level	Code	Education Level
0	Illiterate	3	Secondary
1	Primary	4	University
2	Preparatory	5	Higher

business men, skilled and non-skilled professionals. Table 2.6.2 shows the approximate net monthly income for employed people.

Dwelling: There were three types of housing:

(a) Villa with a backyard or duplex.

(Villa of two floors but only one door) inhabited by the high class families. Most of this type was available in area one, and recorded as 1.

(b) The middle class families live in apartments in buildings or adjacent houses on paved roads. Most of this type was available in area two, and recorded as 2.

(c) The low class families live in the third area, characterised by small apartments, small houses related to family size in a dusty area with unpaved roads and recorded as 3.

For each type, the number of rooms used only as bedrooms was recorded.

(iii) Other Variables:

The other variables included in the study in addition to the anthropometric and developmental and social variables were:-

Area: As was mentioned in the previous chapter, the study covered three areas of Tripoli city. They were coded according to their standard of living from high to low, i.e. 1, 2, and 3.

School and Class: After the sample of schools was selected, every school was given a number within the borough of education as shown in Table 2.2.3. Classes in school were coded according to the grade.

Reference Number: Every child was given a unique four digit reference number for identification purposes.

Table 2.6.2: Approximation of monthly salary for Libyan Employees calculated on the basis of mid-interval of grade, without occupation allowance, according to the Law No.15 for 1981 (Act on January 1982).

Grade	(1) Net salary per month L.D.	(2) Month salary in sterling £
16	583	1370
15	533	1252
14	483	1135
13	445	1046
12	400	940
11	371	872
10	333	783
09	293	689
08	260	611
07	234	550
06	210	493
05	192	451
04	172	404
03	155	364
02	138	324
01	124	291

Note (1) It is not possible to obtain information on the income of farmers and unemployed people.

(2) Calculation based on exchange rate in January 1984 one L.D. = £2.35.

Race: Although no provision was made on form F1 for recording a child's race, this was recorded immediately after the reference number and coded as 2 for black children and 1 for all other.

Date of Birth: The date of birth was registered on forms F2, F3 in the familiar form day/month/year. Then the writer himself converted it to decimal year form, using the Table mentioned in Practical Human Biology (Weiner and Lourie, 1981).

Sex: The sex was recorded in this study as 1 for boy and 2 for girl.

2.7 Training of Measurers and Quality Control (distance survey):

The provision of a training programme for measurers and the assessment of inter- and intra-observer variation is an essential prerequisite of any large scale survey.

For this survey the writer had his training with Professor J.V.G.A. Durnin and his staff in the Physiology Department at Glasgow University, and with Doctor Noel Cameron of the Institute of Child Health, University of London.

The other members of the team were trained by the writer in Tripoli. A pilot study was conducted in the Central School Health Centre in Tripoli, where students from different age groups visit for treatment and checkups.

The aim of the pilot study was to estimate inter- and intra-observer variation in the measurement of height, weight, skinfolds and circumferences.

Height and Weight:

In order to avoid inter-observer variation in height and weight measurements, one measurer was assigned to these throughout the whole survey and checked from time to time by the writer. 51 children were measured twice by this measurer, to estimate the intra-observer error for height and weight. Because of pressure of time only nine children had their height and weight measured once by the height and weight measurer and once by the writer, to estimate the inter-observer error for height and weight.

Skinfolds and Circumferences:

For skinfold thickness, arm circumference and calf circumference measurements, 93 children were measured by each measurer to estimate the inter-observer error for the two measurers, and then 9 children had their skinfold thickness and arm and calf circumferences measured twice by each measurer to estimate intra-observer error for each of the two teams of measurers. Once again the sample size is small in this part of the study because of pressure of time.

Table 2.8.1: Intra-observer variation of height and weight.

Measurement	Number of cases	Difference between readings	
		Mean	S.D.
Height (cm)	51	-0.02	0.22
Weight (kg)	51	-0.05	0.25

Table 2.8.2: Frequency distribution of intra-observer variation of height (cm)

Difference between readings	Frequency
-0.4	2
-0.3	7
-0.2	10
-0.1	6
0.0	7
0.1	5
0.2	7
0.3	5
0.4	2
TOTAL	51

Table 2.8.3: Inter-observer variation of height and weight

Measurement	Number of cases	Difference between Measurers	
		Mean	S.D.
Height (cm)	9	0.10	0.34
Weight (kg)	9	0.08	0.26

2.8 Results of Quality Control (distance):

Height and Weight:

The mean and the standard deviation of the difference between the readings for height and weight by the same observer are presented in Table 2.8.1. It is clear from the table that the mean difference is very close to zero for both height and weight. The standard deviation of the difference in height is 0.22 cm. For weight the standard deviation of the difference is 0.25 kg. Table 2.8.2 shows the frequency distribution of the difference between the height measurements. For 69% of the children measured, the absolute difference in measurements was less than or equal to 0.2 cm. In no case was the absolute difference greater than 0.4 cm.

Table 2.8.3 presents the mean and standard deviation of the difference between measurers for height and weight. Although the number of children measured was small, the standard deviation of the difference between measurers for both height and weight is very close to what Jordan et al. (1975) and Rona and Altman (1977) found. For height, Jordan's S.D. was 0.2 cm and Rona's S.D. was 0.4 cm. For weight, Rona found the S.D. of the difference to be 0.3 kg.

Skinfolds and Circumferences:

The mean and standard deviation of the difference between measurers (in measurement teams 1, 2) for skinfold thickness and arm and calf circumferences are shown in Table 2.8.4. Great care must be taken when training skinfold thickness measurers, because the reliability of skinfold measurements depends on the actual thickness of the fold and also on the exact position of the fold (Rona and Altman, 1977). In Table 2.8.4 the mean of the differences is negative for all four skinfold measurements, indicating that there may be a small systematic error between the two measurement teams. However, a systematic error of this magnitude is unlikely to be of any practical importance. The standard deviation of the difference between measurers for the various skinfold thicknesses varies from 0.2 to 0.4 mm which is similar to the value of 0.39 mm quoted by Rona and Altman (1977).

Table 2.8.4: Inter-observer variation of skinfolds and arm and calf circumferences

Measurement	Number of Cases	Difference between Team 1 and Team 2	
		Mean	S.D.
Biceps skinfold (mm)	93	-0.12	0.21
Triceps " (mm)	93	-0.11	0.30
Subscapular " (mm)	93	-0.10	0.32
Suprailiac " (mm)	93	-0.14	0.43
Arm circumference (cm)	93	0.14	0.18
Calf " (cm)	93	0.18	0.19

In the Cuban Survey (Jordan et al. 1975) the S.D. of the difference between measurers for arm circumference was about 0.14 cm. Our S.D. is similar, but a little higher, at 0.18 cm as is shown in Table 2.8.4.

Table 2.8.5 shows the frequency distribution of biceps skinfold difference for 93 children. 67% of the absolute differences are less than or equal to 0.2 mm and in no case was the absolute difference greater than 0.8 mm.

Table 2.8.6 presents the intra-observer variation for the skinfold thickness and arm and calf circumferences for measurement Team 1 and

Team 2 separately. The discrepancy between the two teams for each variable is very small. The intra-observer variability of skinfold and circumference measurements in Table 2.8.6 is a little higher than the inter-observer variability shown in Table 2.8.4. However, the estimates of intra-observer variability are based on a small measured number of children. Edwards et al (1955) showed that the S.D. of the difference between measurements by the same observer of triceps, subscapular and suprailiac skinfold was 0.3 - 0.6 mm which does not differ much from what we found.

The results from the quality control studies for the anthropometric measurements show that both inter- and intra-observer variation are within the range found by other workers, which suggests that the measurement of all anthropometric variables in the distance survey was carried out in a satisfactory way.

Table 2.8.5 Frequency distribution of inter-observer variation of triceps skinfold (mm)

Difference between measurements	frequency
-0.8	2
-0.6	2
-0.4	19
-0.2	27
0.0	19
0.2	16
0.4	6
0.6	1
0.8	1
Total	93

Table 2.8.6: Intra-observer error for skinfolds and arm and calf circumferences.

Measurement	Number of cases	Difference between measurements			
		Team 1		Team 2	
		Mean	S.D.	Mean	S.D.
Biceps skinfolds (mm)	9	0.12	0.36	0.12	0.33
Triceps skinfolds (mm)	9	0.11	0.37	0.12	0.35
Subscapular skinfold (mm)	9	0.03	0.43	0.04	0.45
Suprailiac skinfold (mm)	9	0.13	0.48	0.15	0.50
Arm circumference (cm)	9	0.22	0.16	0.11	0.15
Calf circumference (cm)	9	0.30	0.19	0.22	0.17

B - Follow up Survey October 1984 - January 1985:

2.9 Introduction:

The existence of velocity growth standards in addition to distance standards is essential for monitoring the growth rate of abnormal cases in the population. To find velocity growth standards, individuals should be measured twice with an interval of time in between. The interval of time could be three months, six months, or one year. However in order to avoid seasonal variation in growth rate, it is best to have a one year interval between the first and second measurements (Eveleth and Tanner, 1976). The 1984 follow up survey was the first survey carried out in Libya for growth velocity. It started in Tripoli City in the first week of October 1984 and finished at the beginning of January 1985.

The total sample size in the first survey was 8511. 57% of those in the first survey were remeasured in the follow-up survey. Table 2.9.1 shows the percentage distribution of the first sample who were remeasured in the follow-up survey, by age and sex.

Table 2.9.2 gives the distribution of the follow-up sample by age, sex and borough of education. From the table it is clear that the percentage distribution by area of the whole sample as given at the bottom of the table is very close to that for the whole population of Tripoli school-children as given in Table 2.2.2.

Table 2.9.1: Percentage of the first sample who were remeasured in the follow-up survey.

Age Group (in first survey)	Boys %	Girls %
6	55.5	67.3
7	54.8	60.4
8	42.6	65.4
9	45.9	72.6
10	39.8	69.4
11	50.6	69.5
12	61.9	71.8
13	58.8	64.8
14	45.1	57.6
15	45.1	55.0
16	53.9	48.2
17	53.9	46.7

Table 2.9.2: Distribution of follow-up sample by age, sex and Borough of Education.

Age Group	Al-Andolos		Tripoli		Abu-Salem		Sub-Total		Whole * Sample
	B	G	B	G	B	G	B	G	
6	13	21	4	3	3	6	20	30	50
7	57	92	31	32	69	66	157	190	347
8	57	75	34	44	29	61	120	180	300
9	58	85	48	46	55	57	161	188	349
10	53	68	34	60	53	94	140	222	362
11	49	90	55	64	64	96	168	250	418
12	103	133	68	62	61	110	232	305	537
13	99	146	50	75	67	87	216	308	524
14	99	131	58	46	70	92	227	269	496
15	79	118	38	67	76	84	193	269	462
16	75	100	60	44	108	68	243	212	455
17	79	67	57	27	177	88	313	182	495
Totals	821	1126	537	570	832	909	2190	2605	4795
	1947		1107		1741		4795		
%	40.6		23.0		36.3		100.0		

* the whole sample is 4848 children; 53 were excluded for reasons explained later in Chapter 3.

2.10 Follow-up Data Collection Forms:

For the follow-up survey there were two forms used for data collection.

(a) Form F3,Figure 2.3.3 which was used in the first survey to record the height and weight measurements was used in the follow-up survey in the same way.

(b) Form F4. Figure 2.10.1 was the master form in the follow-up survey. It was used for recording examination date, team, area, school and child's number, child's name, sex, date of birth and the eight anthropometric variables under study for each child.

Figure 2.10.1: The Master form F4 used in data collection Follow-up.

VELOCITY GROWTH SURVEY FORM

Examination Date [ ] TEAM NO [ ] AREA NO [ ] SCHOOL NO. [ ]

CHILD'S NUMBER	CHILD'S NAME	SEX	DATE OF BIRTH	WEIGHT (0.1 KG)	HEIGHT (mm)	Skinfolds (0.1mm)				Circum-ference (mm)	
						BICEPS	TRICEPS	SUBSCAPULAR	SUPRAILIAC	UPPER-ARM	CALF

2.11 Equipment and Measurement Techniques:

The same instruments and techniques of measurement used in first survey were used in the follow-up. (See Section 2.4).

2.12 How the follow-up sample was chosen:

The same areas and schools selected for the first survey were visited in the follow-up survey. In addition two other schools (Sogor-Alfida boys secondary school in area 1 and Dahra girls preparatory school in area 2) were visited in order to follow-up children who had transferred to these schools when going from primary to preparatory stage or from preparatory to secondary stage. In the beginning it was decided to select a random sample of children who had been measured in the first survey from each age group in each school by using the reference number, but in practice this was very difficult, because the children are redistributed every year so that a child who was in, say, class 3 - group A last year was not necessarily in class 4 - group A this year. To call out a few children from a class and leave the others in would have caused too much disturbance and confusion in the classes. The alternative method was to select classes at random from each school and to examine all the healthy children in these classes who had been measured in the first survey. Children were asked if they had been measured last year or not.

This sampling method was not ideal, but it was the only method which could be used in practice. This probably explains the variation in the proportions remeasured in each age - sex subgroup (Table 2.9.1).

The same administrative procedure as used in the first survey (Figures 2.2.2A-C) was followed for the follow-up survey. Everything went much more smoothly than in the first survey, especially the cooperation of the children themselves and their parents.

2.13 Staff:

For the follow-up survey there were two teams of measurers. One team took all of the measurements of girls whose ages were twelve years and over. This team consisted of two female nurses (one nurse for measuring heights and weights, the other one for measuring the skinfold thickness and arm and calf circumferences) who were helped by the social workers in each school. The second team was responsible for taking the anthropometric measurements from all of the boys included in the sample and from girls under twelve years old. This team consisted of three people; one doctor, the writer and one or two interns. (An intern is a medical student who has finished his medical study and is doing his final year of training).

2.14 Training of Measurers and Quality Control (follow-up survey):

For training of measurers and quality control in the follow-up survey the two teams of measurers were trained by the writer in the same Centre where the first training took place, and a similar pilot study was conducted.

Height and Weight:

Because there were two teams for measuring height and weight in this survey, the estimation of inter-observer variation is essential. There were 149 children whose height and weight were measured by two measurers from different teams to estimate the inter-observer variation for height and weight. Unfortunately intra-observer variation was not estimated because time was very short.

Skinfolds and Arm and Calf Circumferences:

There were 111 children whose skinfolds and arm and calf circumferences were measured by two measurers from different teams to estimate the inter-observer variation. Another 30 children had their skinfolds and arm and calf circumferences measured twice by each of the two measurers to estimate the intra-observer variation .

2.15 Results of Quality Control (follow-up survey):

Height and Weight:

The mean and S.D. of the difference between the readings for height and weight by the two measurers are presented in Table 2.15.1. It is clear from Tables 2.8.3 and 2.15.1 that there is very little difference between the S.D. of the differences for height and weight in both surveys. Table 2.15.2 shows the frequency distribution of the difference between the height measurements by the two measurers. For 50% of the children, the absolute difference in measurements is less than or equal to 0.2 cm, and in no case was it greater than 0.6 cm.

Skinfolds and Arm and Calf Circumferences:

Table 2.15.3 presents the mean and the S.D. of the difference between measurers for skinfold thicknesses and arm and calf circumferences. It is clear from the table that the S.D. for biceps, suprailiac skinfold, arm and calf circumferences are a little higher than those in Table 2.8.4, but they are still in the range found by other workers.

Table 2.15.4 shows the intra-observer variation for skinfold thickness, arm and calf circumferences for measurement Team 1 and Team 2 separately. The intra-observer variation for each of the two teams is similar to that observed in the first survey. Table 2.15.5, 2.15.6 show the frequency distribution of inter and intra-observer variations for triceps skinfold differences. For inter-observer variation, the absolute difference in measurements between the measurers was less than or equal to 0.2 mm for 70% of the children, and in no case was it greater than 0.8 mm. For intra-observer variations, the absolute difference in measurements was less than or equal to 0.2mm for 60% of the children, and in no case was it greater than 0.6 mm.

Table 2.15.1: Inter-observer variation for height and weight in the follow-up survey

Measurement	Number of cases	Difference between measurers	
		Mean	S.D.
Height (cm)	149	0.03	0.31
Weight (kg)	149	-0.02	0.21

Table 2.15.2: Frequency distribution of inter-observer variation of height (cm)

Difference between Measurements	Frequency
-0.5	8
-0.4	12
-0.3	15
-0.2	14
-0.1	15
0.0	15
0.1	12
0.2	17
0.3	12
0.4	15
0.5	8
0.6	6
TOTAL	149

Table 2.15.3: Inter-observer variation for skinfolds and arm and calf circumferences (follow-up survey)

Measurement	Number of cases	Difference between Team 1 and Team 2	
		Mean	S.D.
Biceps skinfold (mm)	111	0.04	0.34
Triceps skinfold (mm)	111	-0.03	0.30
Subscapular skinfold (mm)	111	0.04	0.32
Suprailiac skinfold (mm)	111	0.02	0.53
Arm circumference (cm)	111	0.01	0.20
Calf circumference (cm)	111	0.02	0.24

Table 2.15.4: Intra-observer variation for skinfolds, arm and calf circumferences (follow-up survey).

Measurement	Number of cases	Difference between measurements			
		Team 1		Team 2	
		Mean	S.D.	Mean	S.D.
Biceps skinfold (mm)	30	0.04	0.30	-0.01	0.27
Triceps skinfold (mm)	30	0.04	0.32	0.02	0.30
Subscapular skinfold (mm)	30	0.01	0.35	0.03	0.37
Suprailiac skinfold (mm)	30	0.02	0.47	0.02	0.45
Arm circumference (cm)	30	0.02	0.18	0.01	0.17
Calf circumference (cm)	30	-0.03	0.22	-0.03	0.20

Table 2.15.5: Frequency distribution of inter-observer variation for triceps skinfold (mm)

Difference between measurements	Frequency
-0.6	1
-0.4	14
-0.2	25
0.0	28
0.2	25
0.4	9
0.6	8
0.8	1
TOTAL	111

Table 2.15.6: Frequency distribution of intra-observer variation for triceps skinfold (mm)

Difference between measurements	Frequencies	
	Team 1	Team 2
-0.4	4	3
-0.2	5	7
0.0	7	9
0.2	6	5
0.4	5	3
0.6	3	3
TOTAL	30	30

The results of the quality control studies for the anthropometric measurements show that both inter- and intra-observer variation are within the range found by other workers, which suggests that the measurement of all anthropometric variables in the follow-up survey was carried out in a satisfactory way.

CHAPTER THREE

DATA HANDLING

A. Cross-Sectional Survey:

3.1 Introduction:

This survey was conducted in Tripoli city at the start of the educational year 1983-84. It began on the first week of September 1983 and finished in the middle of February 1984. A sample of this size (8566) obviously requires the use of a computer for editing and analysis of data.

The first step in dealing with the computer was to transfer the data on the master form F1 to a disk file on the ICL 2988 Computer. The data were keyed directly on to disk by Glasgow University Data Preparation Service. The writer is thankful for their help.

3.2 Data Editing:

It is not possible for a survey of this size to be free from human errors, no matter how well trained the measurers and data recorders are. It is therefore essential to check the data carefully for possible measurement errors, recording errors and transcription errors. Data editing proceeded as follows:-

To protect the original data file from accidental destruction, a copy was made and stored under the writer's adviser's Computer number. Next, a FORTRAN program was written to re-format the data with the information on examination date, team number, area number, school number and class number from the top line of each data collection form added to the end of each individual child's data. This meant that each child's data was contained in one line of seventy digits within the data file.

A line printer listing of this data file was made for checking the data. In this printout the reference numbers were checked. There was a gap in numbering between 4354 and 5000 but since the reference number is only used to identify cases with possible errors in their data, this gap in numbering is of no importance. The reference number must, however, be unique and several duplicate reference numbers were found and corrected. Cases in which most, or all, of the anthropometric measurements were missing, were discarded. There were 24 such cases, 13 boys and 11 girls. Due to repetition of measurement 7 cases were discarded, 4 boys and 3 girls. The repetition happened because the children were young, and after their measurements were taken by one measurer, they went to the other measurer and were measured again!

A further 24 cases were discarded, 11 boys and 13 girls, because their age was unknown and their social information was not recorded. This group of children did not fill in form F2, because their mothers were illiterate and their fathers were working away from home, and there were no birth certificates in their files in school. Table 3.2.1 shows a summary of the cases which were excluded.

Table 3.2.1: Summary of excluded cases.

Sex	Due to age and social variables	Due to anthropometric measurements	Due to repeated measurements	TOTAL
Boys	11	13	4	28
Girls	13	11	3	27
TOTAL	24	24	7	55

This leaves a total of 8511 cases for analysis.
The remainder of the data editing was done using the two statistical packages BMDP and SPSS.
BMDP or biomedical programs are a set of programs designed to aid data analysis by providing facilities for simple data description as well as advanced statistical analysis. The data can be examined for unreasonable values graphically and numerically. If unreasonable values are found they are checked, and, if possible corrected before analysis.

In the beginning BMDP program P1D was used to detect missing, improbably small and improbably large values. The maximum and minimum limits were set far apart at this stage with the object being to detect any obvious recording and transcription errors. These were checked on the original data forms. Most of the mistakes found at this stage were due to unrecorded leading zeros for some of the anthropometric variables. For example, if a child's triceps reading was 5.4 mm, it should be recorded as 054 on form F1, but occasionally it was recorded as 54 only so that it appeared as 540 in the data file. Mistakes of this type were easy to detect and correct. Other mistakes were due to coding of the parents' income grade. For example, instead of recording the sixth grade as 06 it was sometimes recorded as 60. Other mistakes were due to misreading numbers such as 2 and 7, 4 and 9. All these mistakes were corrected in the data file using ECCE which is a line editing package available on the ICL 2988 Computer.

This method was useful for detecting gross errors in the data, but all of the anthropometric variables are dependent on age, so that different minimum and maximum values would be appropriate for each age group for each sex. This was awkward to do on BMDP without running separate editing programs for each age-sex group, and so the SPSS package was used instead.

Statistical Package for the Social Sciences (SPSS) is an integrated system of computer programs designed for the analysis of data. It provides the user with a comprehensive set of procedures for data transformation and file manipulation, and it offers a large range of statistical routines.

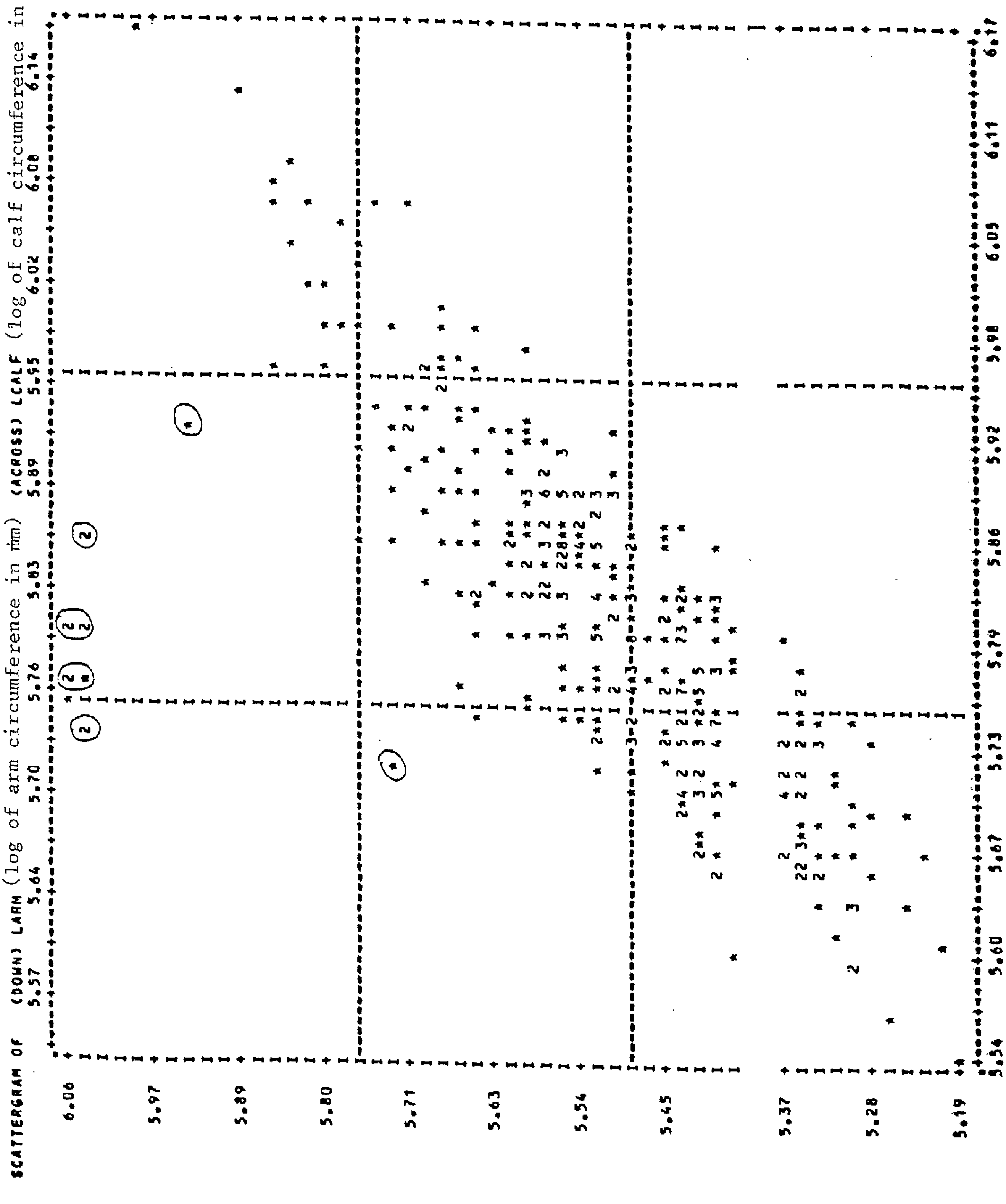
The SPSS programs are more efficient for editing this type of data because of the easy availability of commands to allow different subgroups of the data to be examined within one program run.

Age grouping was done in one-year intervals, from 5.500 to 6.499, 6.500 to 7.499 and so on until 16.500 to 17.499. Using SPSS, frequency distributions of all variables were produced within each age-sex subgroup and all abnormally high or low values were listed, along with the reference number. These were checked against the original data forms.

Scatter diagrams of height against weight, log biceps skinfold against log triceps skinfold, log subscapular skinfold against log suprailiac skinfold and log arm circumference against log calf circumference were produced for each age-sex subgroup. Logarithmic transformation was used because the distributions of these variables were positively skewed. This resulted in the detection of a few more outliers which had not been identified by univariate frequency histograms. In particular, several cases were detected when the arm and calf circumferences had been recorded in reverse order as shown in Figure 3.2.1.

After these data editing procedures had been carried out the data was felt to be 'clean' enough for analysis. Distance growth standards based on these data are presented in Chapter 4.

Figure 3.2.1: Outlying cases of arm and calf circumference detected on a scatter plot. (Girls aged 10 years).



B. Follow-up Survey:

3.3 Data Preparation and Data Editing:

The follow-up survey data which were recorded on form F4 (Figure 2.9.1) were transferred to a disk file on the ICL 2988 Computer by Glasgow University Data Preparation Service.

The survey covered 4890 children. The data editing of the follow-up survey data passed through the following steps:-

(i) A FORTRAN program was written to re-format the data with information on examination date, team number, area number and school number from the top line of each data collection form added to the end of each individual child's data. Since the children were not re-measured in the same order in both surveys, the reference numbers of children in the second survey were not in ascending order on the data sheet (Form F4). To facilitate data checking, a second reference number (a serial number) was added to each child's record in the follow-up survey in serial order from 1 to 4890. This made checking of data from the second survey on form F4 easier after the merging of the data files from the two surveys.

There were 53 digits in one line for every child in this survey.

(ii) A line printer listing of the data file was made for checking the data. In this printout 15 cases were found where the sex of the children had not been recorded. Using the master form F4 the sex of these cases was determined from the child's name and added to the data file.

(iii) The cases in the data file were sorted in ascending order of reference number and then split into two separate files - one for boys and one for girls.

(iv) The male files in both surveys were merged using a FORTRAN program to match-up the reference numbers so that every boy had two lines of data in the merged file - one from the first survey and one from the follow-up survey. The same procedure was carried out for the female files.

(v) The FORTRAN merging program printed out the number of children who were in the first survey only, second survey only, or in both surveys as shown in Table 3.3.1. From the Table it is clear that there were 42 children in the second survey who had not been measured in the first survey and they were excluded. The total number of children in both surveys was 4848; 2211 boys and 2637 girls.

(vi) The Statistical Package for the Social Sciences (SPSS) was used throughout the editing and analysis of the merged data.
The first SPSS run was to double-check the matching of records from the two surveys by comparing the two recordings of date of birth. There were 10 girls and 14 boys whose date of birth did not match. Of these, 4 girls and 5 boys had mistakes in recording date of birth in the second survey, while the records of 6 girls and 9 boys were mismatched due to errors in reference numbers. As a result, 3 girls and 4 boys were excluded and the records of the remaining 7 girls and 10 boys were corrected.

(vii) The next SPSS run looked at differences in weight and height between the two surveys. For weight, from the first run, it was decided to check 2.7% of boys' weight differences, 1.9% from the lower end of the distribution and 0.8% from the upper end. There were 38 cases to be checked. Of these, 8 were identified as typing mistakes, and the remaining 30 cases were left unchanged.

Table 3.3.1: Output from FORTRAN merging program.

Children	Number of children recorded and read from:-		Number of children read in both surveys	Number of children only in	
	First Survey	Second Survey		First Survey	Second Survey
Boys	4342	2226	2211	2131	15
Girls	4169	2664	2637	1532	27
TOTAL	8511	4890	4848	3663	42

Table 3.3.2: Results of data editing

Variable	Checked			Excluded			Corrected		
	Boys	Girls	Total	Boys	Girls	Total	Boys	Girls	Total
Reference Number and Date of Birth	14	10	24	4	3	7	10	7	17
Height	66	80	146	0	8	8	9	10	19
Weight and Skinfolds	129	197	326	17	21	38	12	18	30
Arm and Calf Circum-ferences							8	12	20
TOTAL	209	287	496	21	32	53	39	47	86

For girls, 3.4% of the weights were checked; 2.4% from the lower end of the distribution and 1.0% from the upper end i.e. 90 cases were checked. 4 cases out of 90 were excluded because their weight and height had not been measured in the first survey, 7 cases were identified as typing mistakes, and the remaining 79 cases were left unchanged. For height 3%, or 66 boys' height were checked. 9 cases were identified as due typing mistakes and 57 cases were left unchanged. For girls 3%, or 80, heights were checked. 8 cases were excluded because their height and weight had not been measured in the first survey, 10 cases were identified as due to typing mistakes and 62 cases were left unchanged.

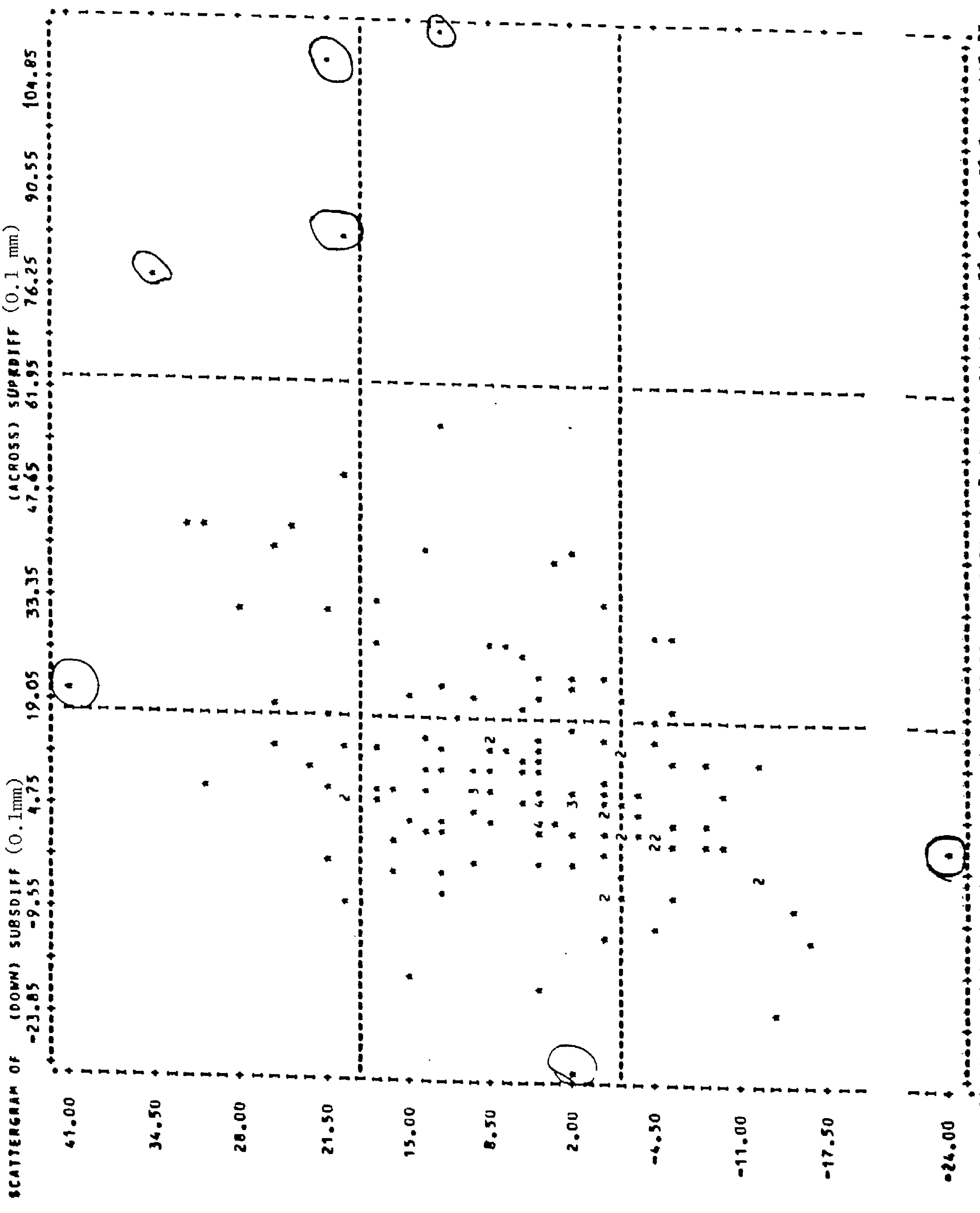
The typing mistakes were mostly due to unclear recording on the data sheet, or transposition of digits by the typist. The illustration below shows how some boys' weights were recorded and typed.

Recorded	371	298	270	393	281	327	261
Typed	311	898	230	303	218	237	216

(viii) The next step was to produce scatter diagrams of height differences (second-first) against weight difference, biceps skinfold difference against triceps skinfold difference, subscapular skinfold difference against suprailiac skinfold difference and arm circumference difference against calf circumference difference. Also, scatter diagrams for data from the follow-up survey only such as height against weight, log biceps skinfold against log triceps skinfold, log subscapular skinfold against log suprailiac skinfold and log arm circumference against log calf circumference were produced for each age-sex subgroup to detect outliers which might not have been evident from univariate presentations. The scattergrams identified 91 boys and 107 girls as outliers. These data were listed according to reference number. After checking, 17 boys and 21 girls were excluded. 12 cases of skinfold thickness and 8 cases of arm and calf circumferences were corrected for boys, while 18 cases of skinfold thickness and 12 arm and calf circumferences were corrected for girls. The remaining cases were left unchanged.

The excluded cases were mainly very obese children whose weight and skinfolds were very large. In some cases skinfolds were so large that they were unmeasurable. Table 3.3.2 shows a summary of the results of data editing and Figure 3.3.1 shows an example of outliers detected by scattergram for boys of age group 2 (7 years). After these data editing procedures had been carried out, the data were felt to be 'clean' enough for analysis. Velocity standards based on these data are presented in Chapter 5.

Figure 3.3.1: Detection of outliers using a scattergram of differences - suprailiac difference vs subscapular difference.



CHAPTER FOUR

CROSS SECTIONAL GROWTH STANDARDS

A. CROSS-SECTIONAL RESULTS (DISTANCE).

The results of the cross-sectional growth study based on data analysis for 8511 schoolchildren measured in the 1983 survey are presented in the first part of this chapter as follows:

4.1 Height:

Height is assumed to follow a Gaussian (Normal) distribution within each age - sex subgroup. Figures 4.1.1, 4.1.2 show a histogram and a probability plot produced by MINITAB for boys' and girls' height in age group 3 (8 years) as an example.

Percentiles are calculated by using the equation in Section 2.1, where the 3rd and 97th percentiles are given by $\bar{x} \pm 1.88$ S, 10th and 90th percentiles are given by $\bar{x} \pm 1.28$S, 25th and 75th percentiles are given by $\bar{x} \pm 0.675$ S and the 50th percentile is given by $\bar{x}$, where $\bar{x}$ is the sample mean height and S is the standard deviation adjusted by Healy's Method (Healy, 1962). This adjustment is required to allow for the fact that the children in, for example, the 8 years old group have ages which range from 7½ to 8½ years resulting in a larger spread of heights than if all children were measured at exactly 8 years of age. This method of estimating percentiles is more precise than simply using the actual percentiles observed from the sample (Healy, 1974). Figures 4.1.3, 4.1.4 present the data of Table A1 (Appendix) with the percentiles of different age-groups joined by smooth hand-drawn lines. Table A2 (Appendix) shows the height percentiles of boys and girls by age groups obtained by the empirical method, that is, using the actual percentiles from the data. There are some differences between the empirical and the adjusted methods especially at the two extremes (3rd and 97th

<u>Figure 4.1.1</u>: (a) Height distribution of Libyan boys aged 8 years.

(b) Height probability plot for the same age group.

(a)

```
HT
 EACH * REPRESENTS   2 OBSERVATIONS

 MIDDLE OF   NUMBER OF
 INTERVAL    OBSERVATIONS
    104.         0
    108.         3    **
    112.        13    *******
    116.        37    *******************
    120.        77    ***************************************
    124.        82    *****************************************
    128.        58    *****************************
    132.        38    *******************
    136.        11    ******
    140.         5    ***
```

(b)

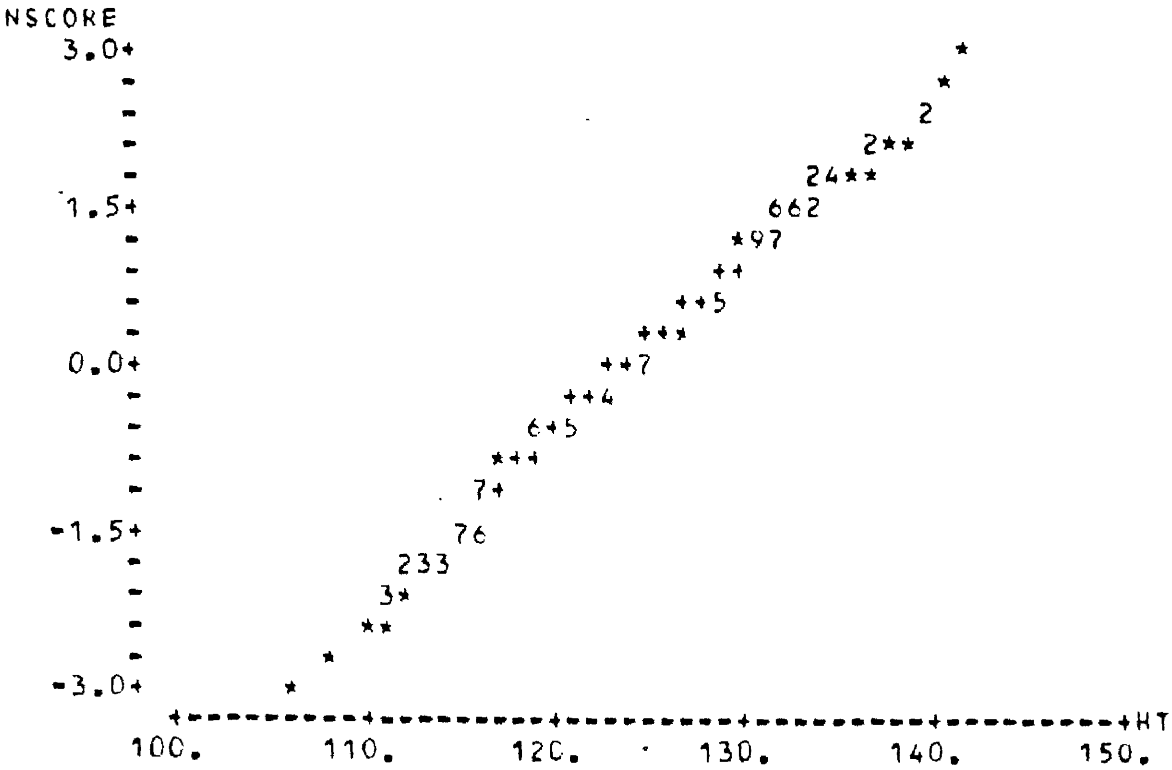


Figure 4.1.2: (a) Height Distribution for Libyan girls aged 8 years

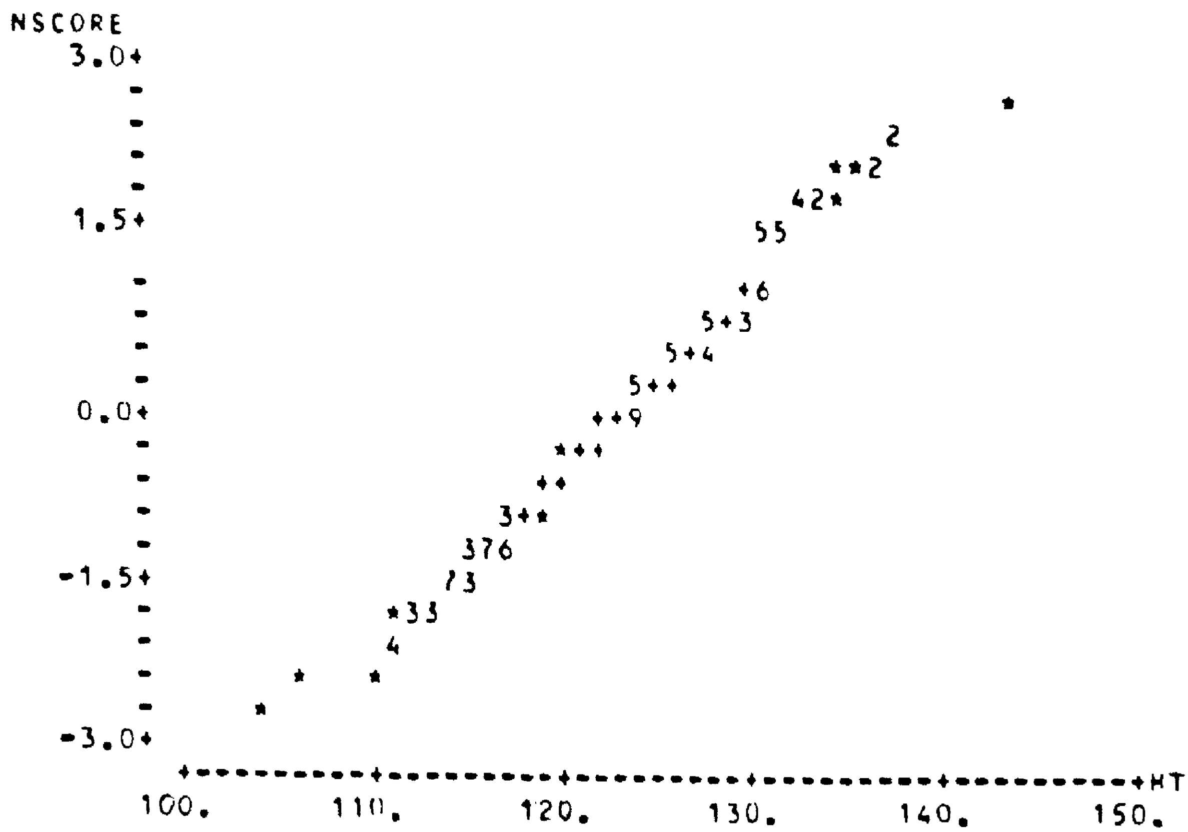
(b) Height Probability plot for the same age group.

(a)

```
HT
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
  105.          2     *
  110.          9     *****
  115.         32     ****************
  120.         90     *********************************************
  125.         78     ***************************************
  130.         52     **************************
  135.         11     ******
  140.          2     *
  145.          1     *
```

(b)



percentiles), where the precision of the empirical estimates is less (Healy, 1974). Also presented in Figures 4.1.3 and 4.1.4 for comparison are the 3rd, 50th and 97th percentiles for English schoolchildren (Tanner et al., 1966). These will be discussed in detail later in this Chapter.

Figure 4.1.3: Percentiles of Height of Libyan and English Boys aged 6 to 17 years.

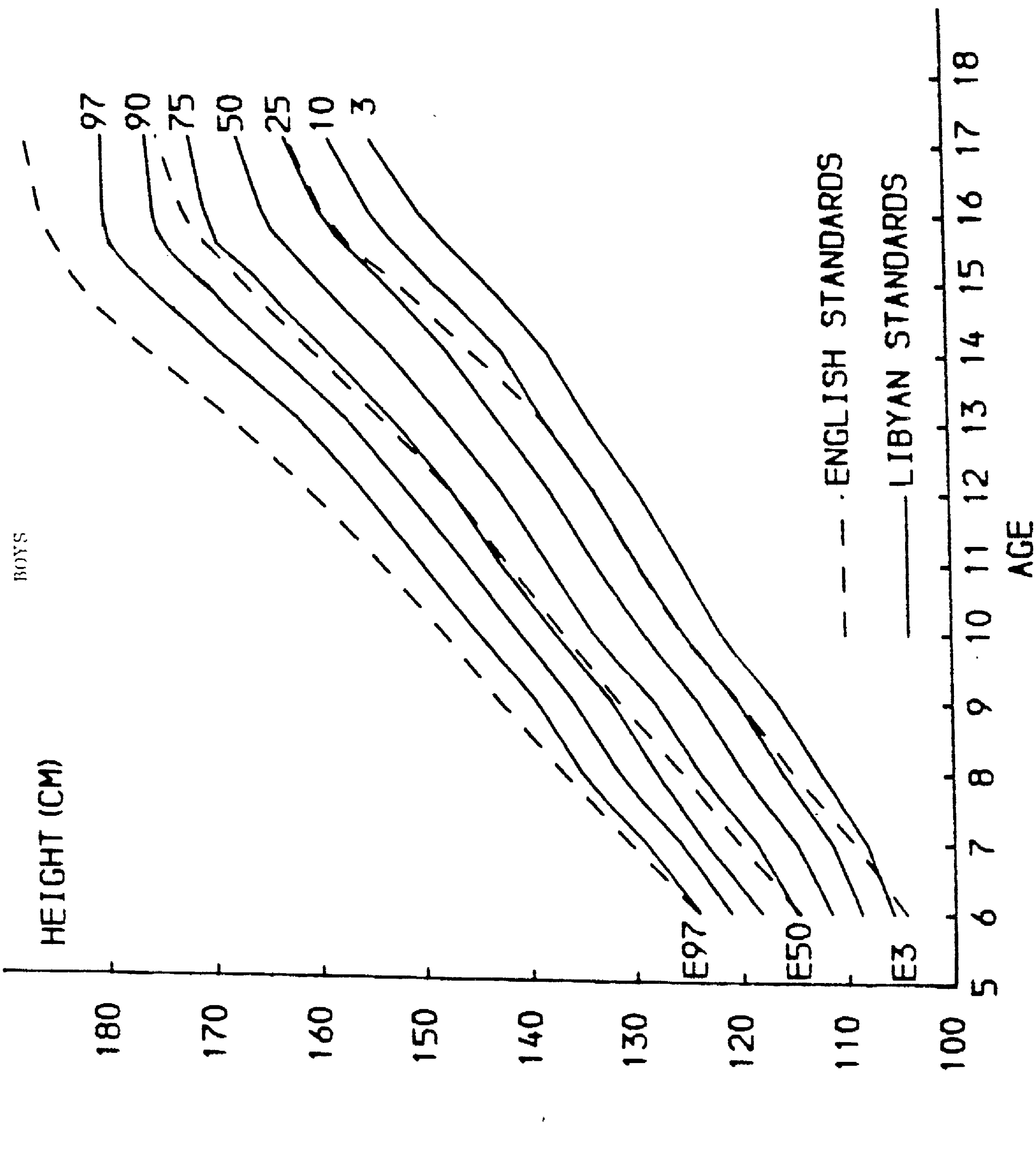
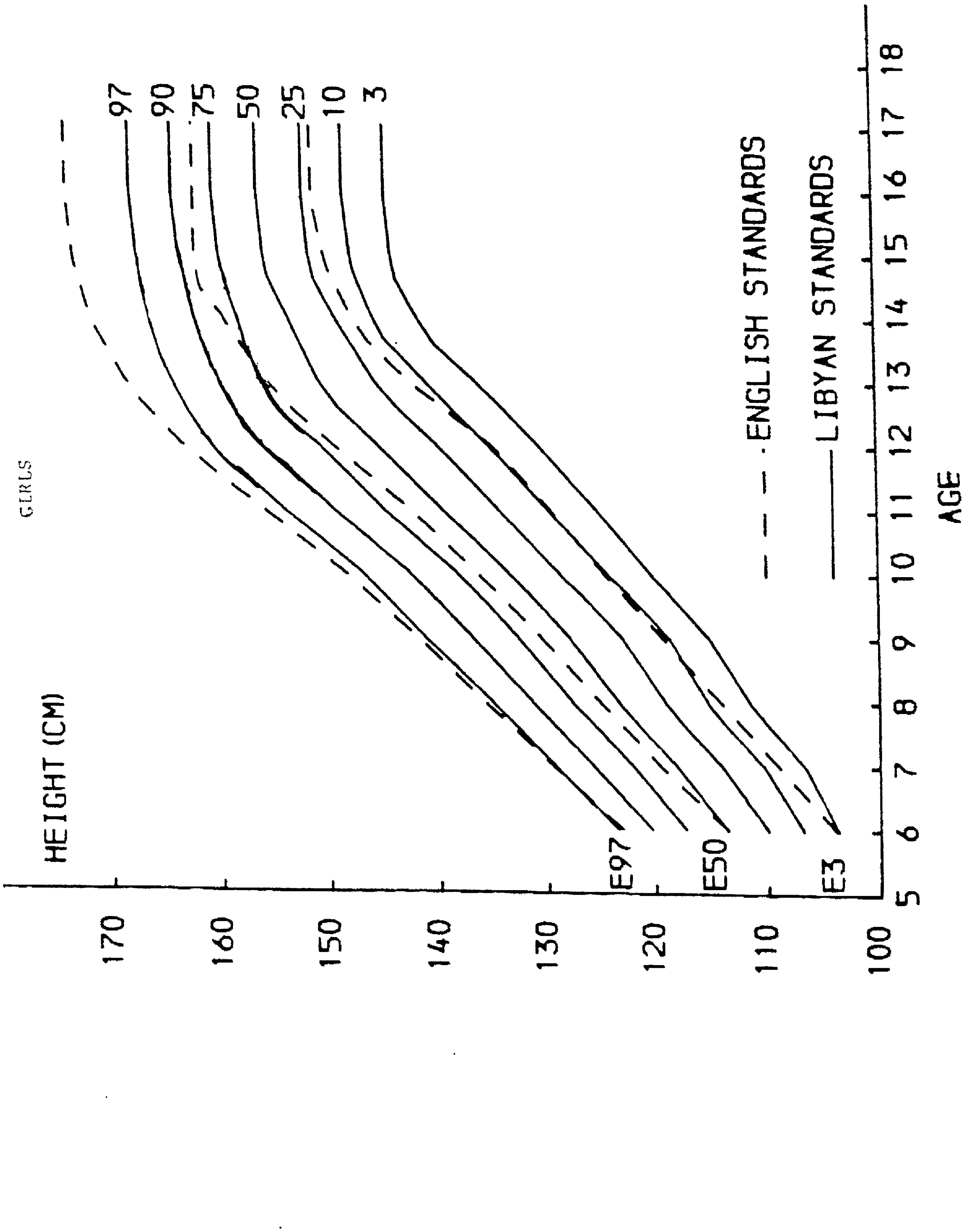


Figure 4.1.4: Percentiles of Height of Libyan and English Girls aged 6 to 17 years.



4.2 Weight:

Weight distribution is not Gaussian like height. It is positively skewed as shown in Figures 4.2.1(a), 4.2.2(a). In order to normalise the distribution of weight, log-transformation was suggested (Rona et al. 1977) by using log (wt - Constant). The value of the Constant in the transformation in this study to produce approximately a Gaussian distribution for both boys and girls in each age-group was estimated as 13 kg. The method of estimation of this Constant will be presented in Chapter 6.

Figures 4.2.1(b,c), 4.2.2 (b,c) show the weight distribution after transformation along with probability plots. Percentiles of transformed weight were derived in exactly the same way as for height. Percentiles of weight itself were obtained by inverse transformation. Figures 4.2.3,4 present the data of Table A3 (Appendix) with the percentiles for different age-groups joined by smooth, hand-drawn lines. The weight percentiles obtained by the empirical method using the actual data for boys and girls by age group are given in Table A4 (Appendix). There is some difference between weight percentiles obtained by the empirical method and those obtained by the adjusted method after transformation, especially at the two extremes, for the reason mentioned in Section 4.1. Also presented in Figures 4.2.3 and 4.2.4 for comparison are the 3rd, 50th and 97th percentiles for English school children.(Tanner et al.,1966) which will be discussed in detail later in this Chapter.

Figure 4.2.1: (a) Weight distribution of Libyan boys aged 8 years before transformation.
(b) Weight distribution after log transformation.
(c) Probability plot for log transformed weight.

(a)

```
WT
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    16.          1     *
    18.          8     ****
    20.         53     ***************************
    22.         67     **********************************
    24.         66     *********************************
    26.         53     ***************************
    28.         31     ****************
    30.         14     *******
    32.         10     *****
    34.          7     ****
    36.          6     ***
    38.          5     ***
    40.          0
    42.          1     *
    44.          1     *
    46.          0
    48.          1     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    0.6          3     **
    0.7          3     **
    0.8         26     *************
    0.9         60     ******************************
    1.0         81     *****************************************
    1.1         81     *****************************************
    1.2         38     *******************
    1.3         18     *********
    1.4         12     ******
    1.5          2     *
```

(c)

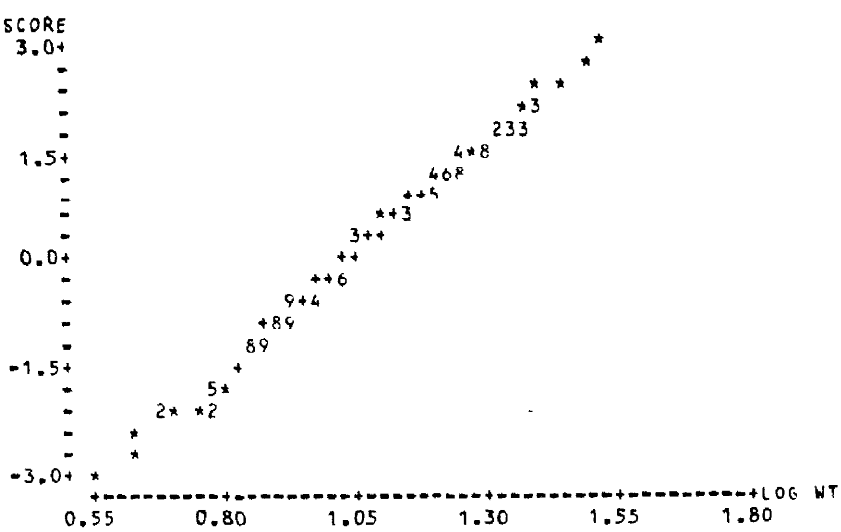


Figure 4.2.2: (a) Weight distribution of Libyan girls aged 8 years before transformation.
(b) Weight distribution after log transformation.
(c) Probability plot for log transformed weight.

(a)

```
WT
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
    16.        4      *
    20.       81      *****************
    24.      113      ***********************
    28.       47      **********
    32.       26      ******
    36.        2      *
    40.        1      *
    44.        1      *
    48.        1      *
    52.        1      *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
    0.5        1      *
    0.6        2      *
    0.7        6      ***
    0.8       23      ************
    0.9       53      ***************************
    1.0       65      *********************************
    1.1       65      *********************************
    1.2       39      ********************
    1.3       17      *********
    1.4        3      **
    1.5        2      *
    1.6        1      *
```

(c)

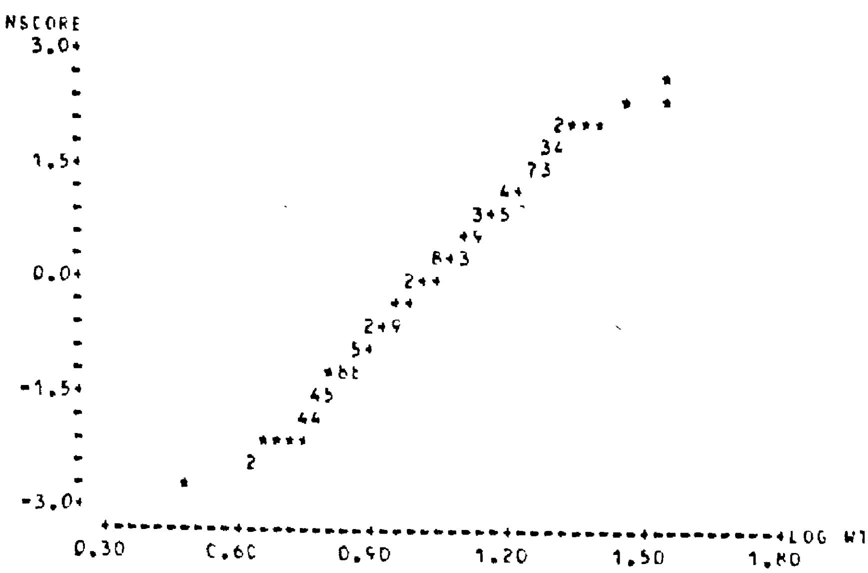


Figure 4.2.3: Percentiles of Weight of Libyan and English boys aged 6-17 years.

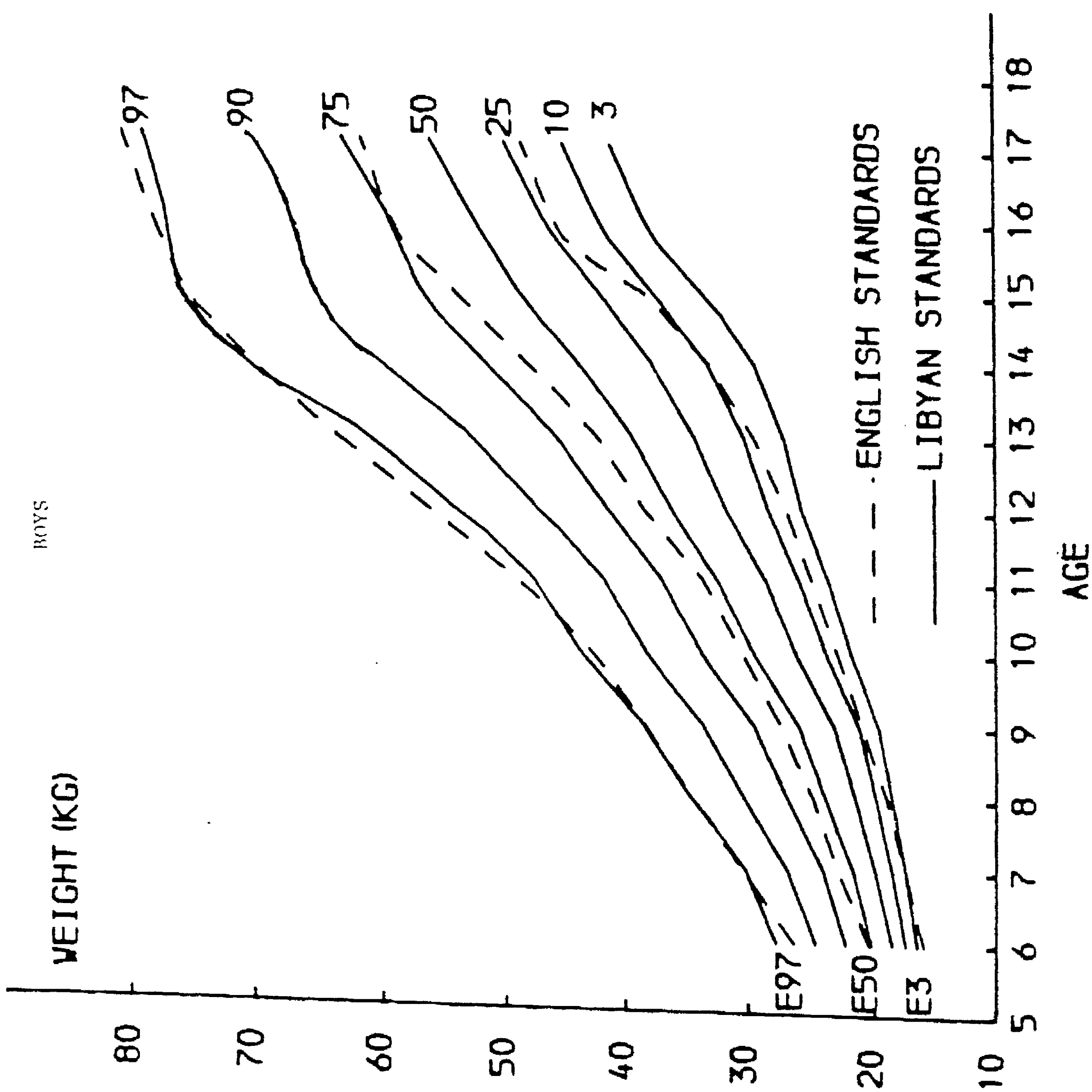
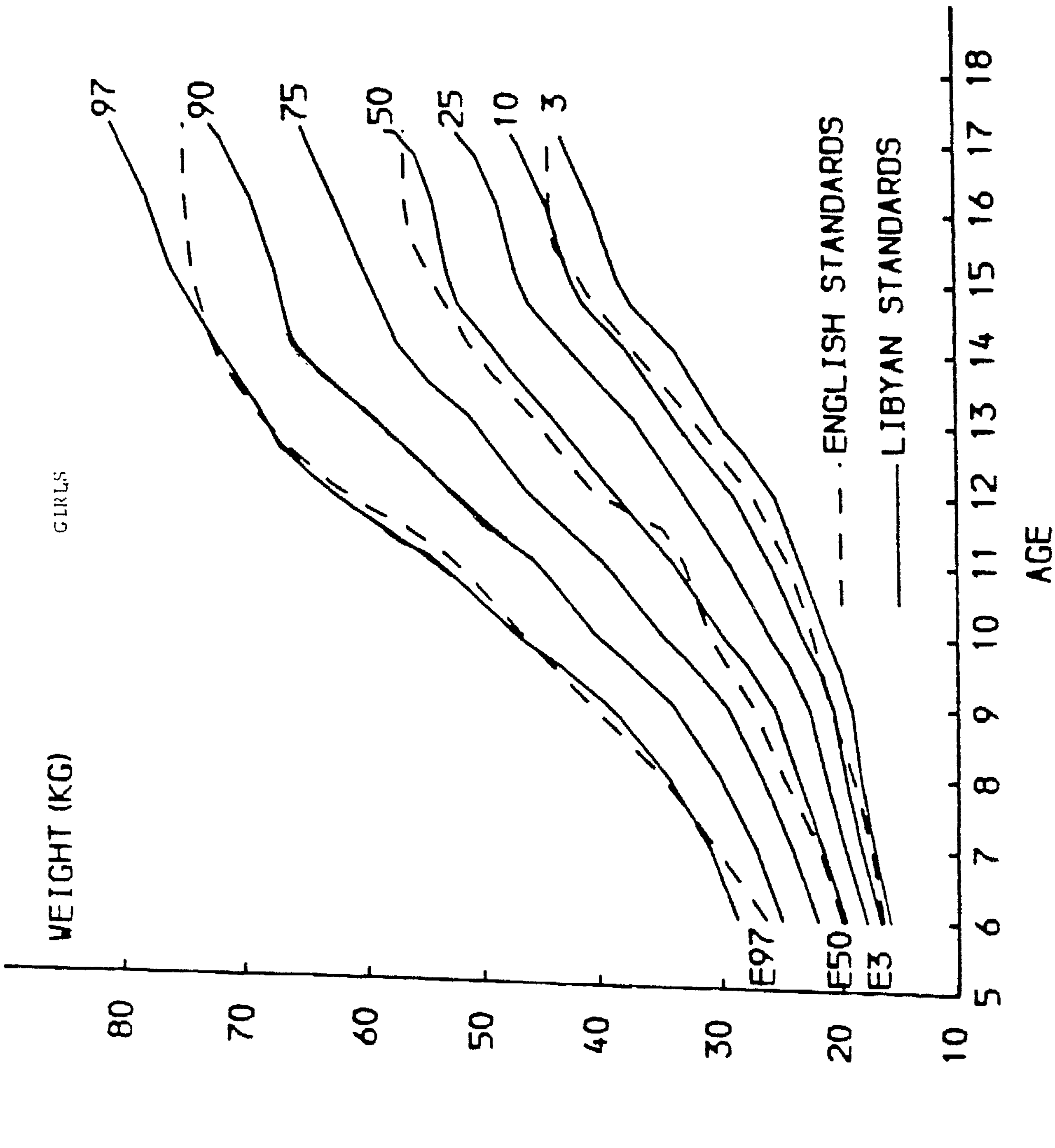


Figure 4.2.4: Percentiles of Weight of Libyan and English girls aged 6 - 17 years.



4.3 Skinfold Thickness:

The distribution of the skinfold thickness of biceps, triceps, subscapular and suprailiac is well known to be positively skewed. Many workers in this field have found this (Edwards et al.,1955; Durnin and Rahaman, 1967; Durnin and Womersley, 1974; Tanner and Whitehouse, 1962; Venrooij et al.,1978; and Cameron, 1977). Log transformations are needed to achieve normal or approximately normal distributions for all skinfold thicknesses. The formula of Edwards et al. (1955) was used:

$$\text{Skinfold transformation} = \log_{10}\text{ (Skinfold reading in 0.1mm - constant)}$$

Figures 4.3.1 to 4.3.8 show the distribution of biceps, triceps, subscapular and suprailiac skinfold thickness of age group 3 (8 years) as an example before and after log-transformation, with probability plots for boys and girls respectively. The constant values used in log-transformation for biceps, triceps and suprailiac skinfold thickness were different for boys and girls, however the same value was used for subscapular skinfold for both boys and girls (Table 4.3.1). In the probability plots (except for the boys biceps skinfold thickness where there is one outlying value at the bottom of the plot which has been checked and found to be a correct value) all the skinfold thicknesses of boys and girls gave reasonably straight lines. Percentiles of transformed skinfold thickness were derived in the same way as for height and weight and percentiles of skinfolds obtained by inverse transformation. Figures 4.3.9 to 4.3.16 present the data of Tables A5 to A8 (Appendix) for the biceps, triceps, subscapular and suprailiac skinfold thickness. In each case the percentiles for different age groups are joined by smooth, hand-drawn lines.

For comparison, the 3rd, 50th and 97th percentiles of triceps and subscapular skinfold thickness for English school children (Cameron, 1977); are presented. No such data were readily available for biceps and suprailiac skinfolds for English school children.

Table 4.3.1: Value of Constants used in skinfold log-transformation by sex

Skinfold Variable	Boys	Girls
Biceps	21	22
Triceps	30	32
Subscapular	27	27
Suprailiac	25	28

The derivation of these Constants will be shown in Chapter 6.

Figure 4.3.1: (a) Biceps skinfold distribution for Libyan boys aged 8 years.
(b) Biceps skinfold distribution after log-transformation.
(c) Probability plot for log transformed biceps skinfold.

(a)

```
BIC
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   20.          1      *
   40.        106      **********************
   60.        108      **********************
   80.         41      *********
  100.         11      ***
  120.          5      *
  140.          2      *
  160.          2      *
  180.          0
  200.          1      *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   0.4          1      *
   0.6          0
   0.8          0
   1.0         15      ********
   1.2         38      *******************
   1.4         93      ***********************************************
   1.6         82      *****************************************
   1.8         37      *******************
   2.0          8      ****
   2.2          3      **
```

(c)

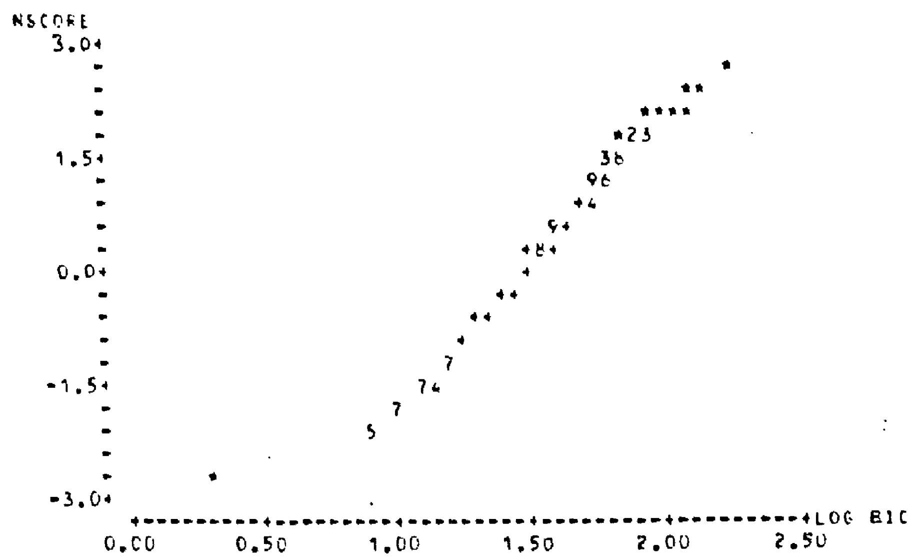


Figure 4.3.2: (a) Biceps skinfold distribution for Libyan girls aged 8 years.
(b) Biceps skinfold distribution after log transformation.
(c) Probability plot for log transformed biceps skinfold.

(a)

```
BIC
 EACH * REPRESENTS   5 OBSERVATIONS
  3 MISSING OBSERVATIONS

 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
     30.        47      **********
     40.       116      ************************
     50.        70      **************
     60.        36      ********
     70.        22      *****
     80.        12      ***
     90.         6      **
    100.         3      *
    110.         1      *
    120.         3      *
    130.         2      *
    140.         2      *
    150.         1      *
```

(b)

```
 EACH * REPRESENTS   2 OBSERVATIONS
  3 MISSING OBSERVATIONS

 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
     0.8         3      **
     0.9        13      *******
     1.0        24      ************
     1.1        23      ************
     1.2        19      **********
     1.3        81      *****************************************
     1.4        52      **************************
     1.5        23      ************
     1.6        37      *******************
     1.7        21      ***********
     1.8        13      *******
     1.9         4      **
     2.0         5      ***
     2.1         3      **
```

(c)

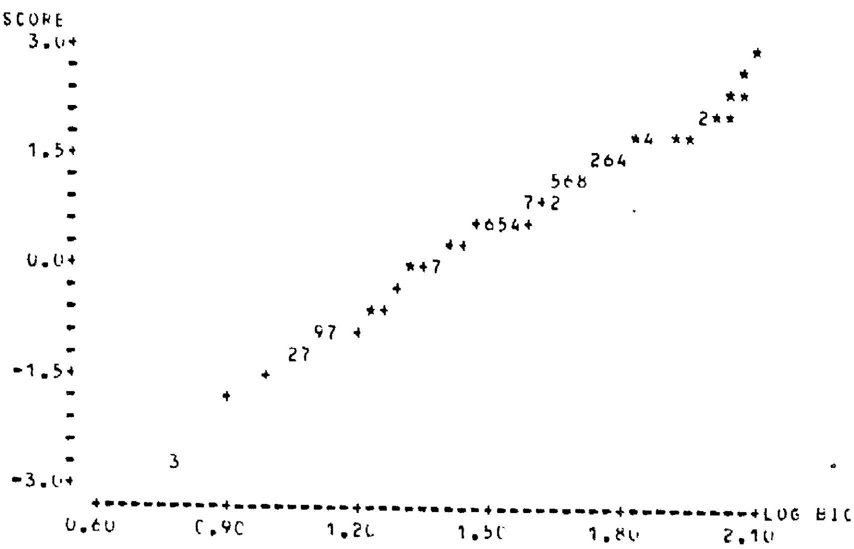


Figure 4.3.3: (a) Triceps skinfold distribution of Libyan boys aged 8 years before transformation.
(b) Triceps skinfold distribution after log transformation.
(c) Probability plot for log transformed triceps skinfold.

(a)

```
TRIC
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   40.          11     ***
   60.         102     *********************
   80.         102     *********************
  100.          59     ************
  120.          24     *****
  140.           7     **
  160.           7     **
  180.           1     *
  200.           5     *
  220.           3     *
  240.           1     *
  260.           1     *
  280.           0
  300.           1     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   0.9           3     **
   1.0           3     **
   1.1           3     **
   1.2           1     *
   1.3          17     *********
   1.4          19     **********
   1.5          57     *****************************
   1.6          53     ***************************
   1.7          59     ******************************
   1.8          44     **********************
   1.9          26     *************
   2.0          19     **********
   2.1           9     *****
   2.2           4     **
   2.3           6     ***
   2.4           1     *
```

(c)

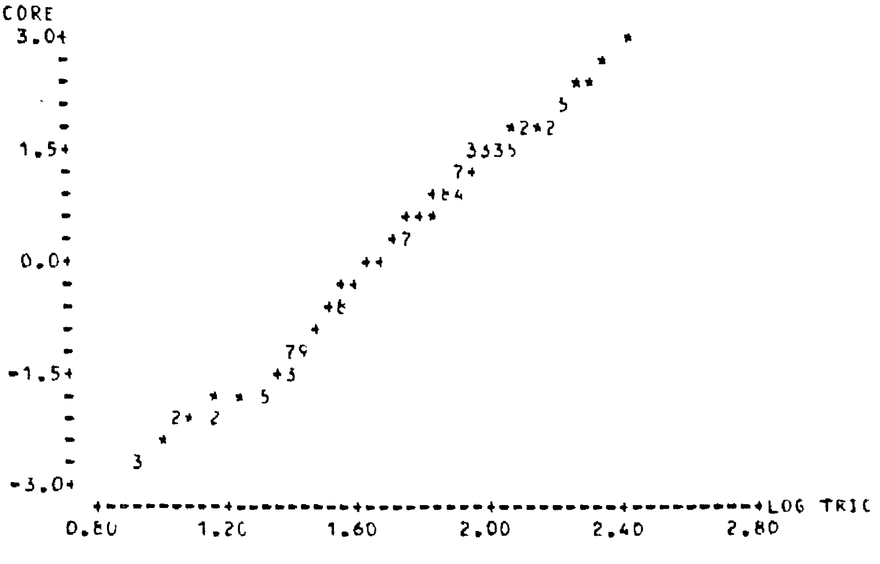


Figure 4.3.4: (a) Triceps skinfold distribution of Libyan girls aged 8 years before transformation.
(b) Triceps skinfold distribution after log transformation.
(c) Probability plot for log transformed triceps skinfold.

(a)

```
TRIC
 EACH * REPRESENTS   2 OBSERVATIONS

 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
    40.         0
    60.        46      ***********************
    80.        84      ******************************************
   100.        74      *************************************
   120.        28      **************
   140.        22      ***********
   160.         6      ***
   180.         8      ****
   200.         3      **
   220.         2      *
   240.         1      *
   260.         0
   280.         3      **
```

(b)

```
 EACH * REPRESENTS   2 OBSERVATIONS

 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVAITONS
     1.3       10     *****
     1.4       15     ********
     1.5       18     *********
     1.6       43     **********************
     1.7       44     **********************
     1.8       62     *******************************
     1.9       35     ******************
     2.0       25     *************
     2.1       11     ******
     2.2        8     ****
     2.3        3     **
     2.4        3     **
```

(c)

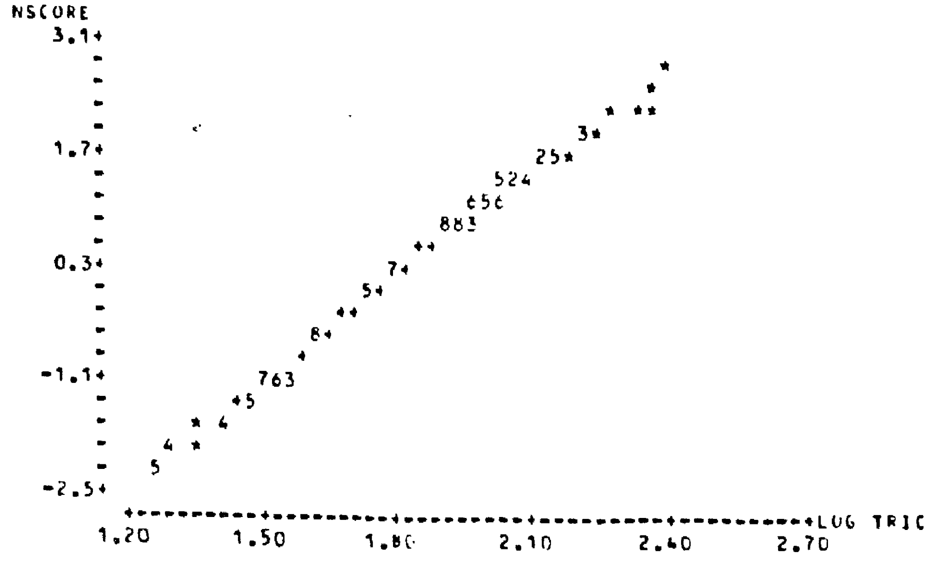


Figure 4.3.5: (a) Subscapular skinfold distribution of Libyan boys aged 8 years before transformation.
(b) Subscapular skinfold distribution after log transformation.
(c) Probability plot for log transformed subscapular skinfold.

(a)

```
SUBS
 EACH * REPRESENTS    5 OBSERVATIONS

 MIDDLE OF    NUMBER OF
 INTERVAL     OBSERVATIONS
     20.        2     *
     40.      116     ************************
     60.      141     *****************************
     80.       36     ********
    100.       10     **
    120.        1     *
    140.        7     **
    160.        2     *
    180.        3     *
    200.        1     *
    220.        2     *
    240.        3     *
```

(b)

```
EACH * REPRESENTS    5 OBSERVATIONS
 1 MISSING OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   0.0         1     *
   0.2         0
   0.4         4     *
   0.6         6     **
   0.8         1     *
   1.0        12     ***
   1.2        77     ****************
   1.4       114     ***********************
   1.6        65     *************
   1.8        23     *****
   2.0         9     **
   2.2         8     **
   2.4         3     *
```

(c)

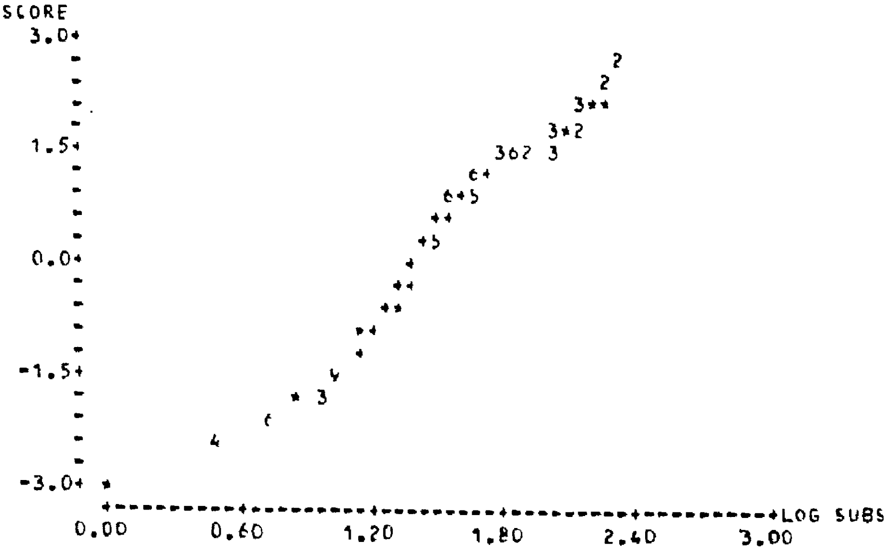


Figure 4.3.6: (a) Subscapular skinfold distribution of Libyan girls aged 8 years before transformation.
(b) Subscapular skinfold distribution after log transformation.
(c) Probability plot for log transformed subscapular skinfold.

(a)

```
SUBS
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
    40.      119    ************************
    80.      117    ************************
   120.       22    *****
   160.        9    **
   200.        6    **
   240.        1    *
   280.        2    *
   320.        0
   360.        1    *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
    0.6       2     *
    0.8       0
    1.0       5     ***
    1.2      38     *******************
    1.4      73     *************************************
    1.6      89     *********************************************
    1.8      36     ******************
    2.0      19     **********
    2.2      11     ******
    2.4       3     **
    2.6       1     *
```

(c)

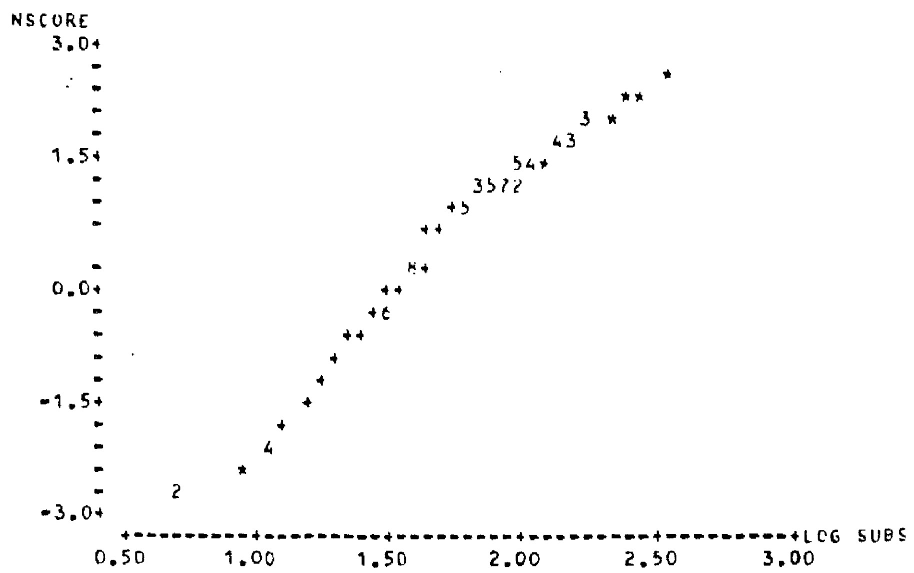


Figure 4.3.7: (a) Suprailiac skinfold distribution for Libyan boys aged 8 years.
(b) Suprailiac skinfold distribution after log transformation.
(c) Probability plot for log transformed suprailiac skinfold.

(a)

```
SUPR
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    20.        2    *
    40.      133    ***************************
    60.      124    *************************
    80.       28    ******
   100.        9    **
   120.        7    **
   140.        4    *
   160.        4    *
   180.        2    *
   200.        2    *
   220.        1    *
   240.        2    *
   260.        2    *
   280.        3    *
   300.        1    *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF

INTERVAL     OBSERVATIONS
    0.4        2    *
    0.6        3    **
    0.8        6    ***
    1.0       20    **********
    1.2       82    *****************************************
    1.4      100    **************************************************
    1.6       61    *******************************
    1.8       20    **********
    2.0       16    ********
    2.2        6    ***
    2.4        8    ****
```

(c)

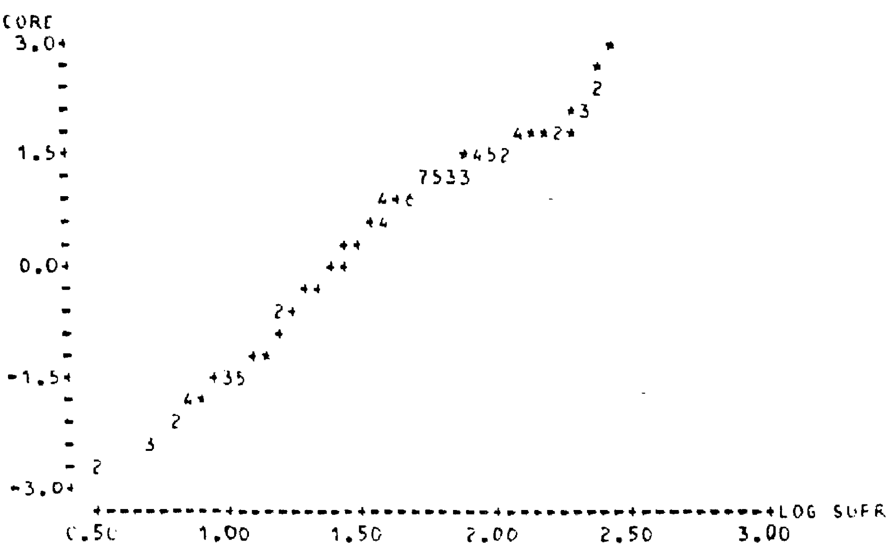


Figure 4.3.8: (a) Suprailiac skinfold distribution of Libyan girls aged 8 years before transformation.
(b) Suprailiac skinfold distribution after log transformation.
(c) Probability plot for log transformed suprailiac skinfold.

(a)

```
SUPR
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    40.      126     **************************
    80.      112     ***********************
   120.       22     *****
   160.        6     **
   200.        4     *
   240.        2     *
   280.        4     *
   320.        0
   360.        1     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    0.4        2     *
    0.6        2     *
    0.8        6     ***
    1.0       20     **********
    1.2       32     ****************
    1.4       64     ********************************
    1.6       84     ******************************************
    1.8       35     ******************
    2.0       19     **********
    2.2        6     ***
    2.4        6     ***
    2.6        1     *
```

(c)

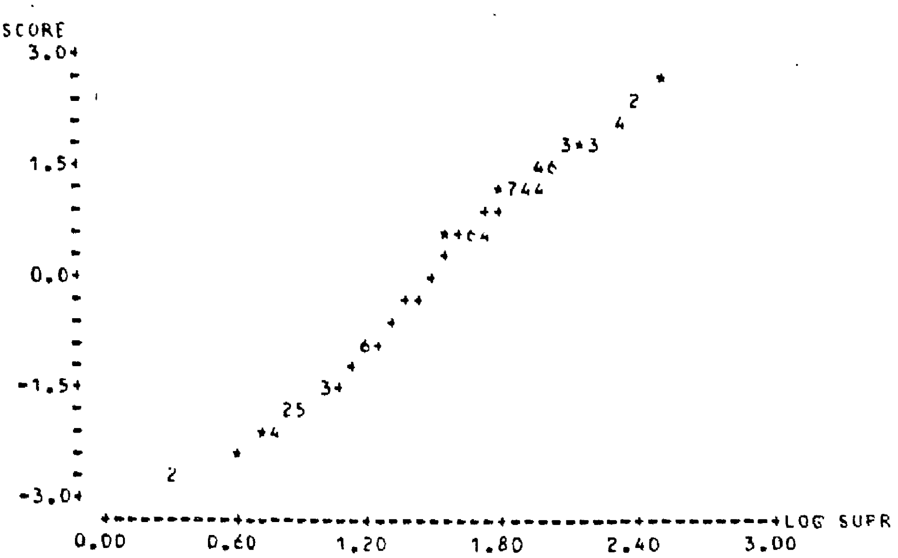


Figure 4.3.9: Percentiles of Biceps skinfold thickness of Libyan boys aged 6-17 years.

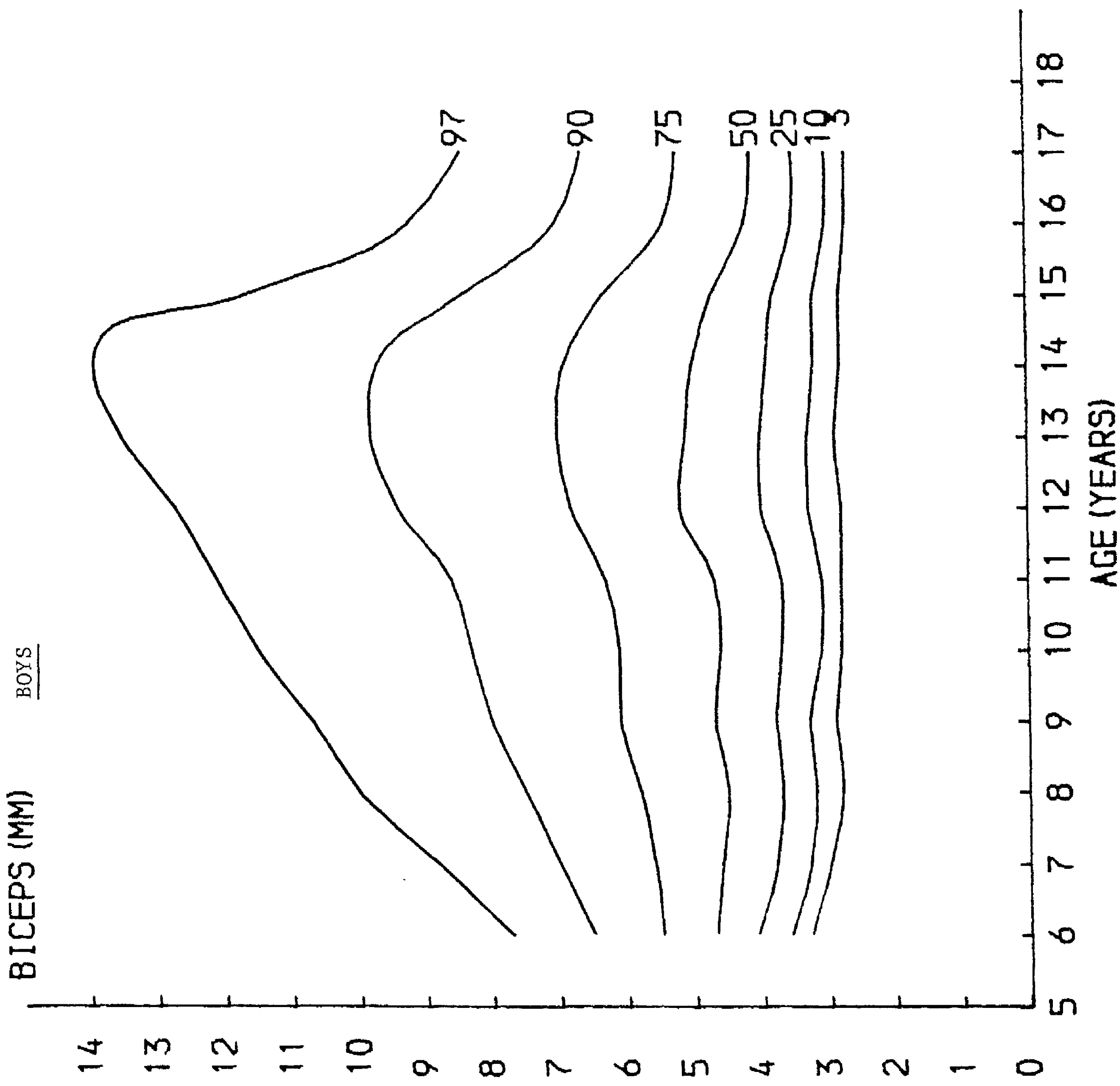


Figure 4.3.10: Percentiles of Biceps skinfold thickness of Libyan girls aged 6-17 years.

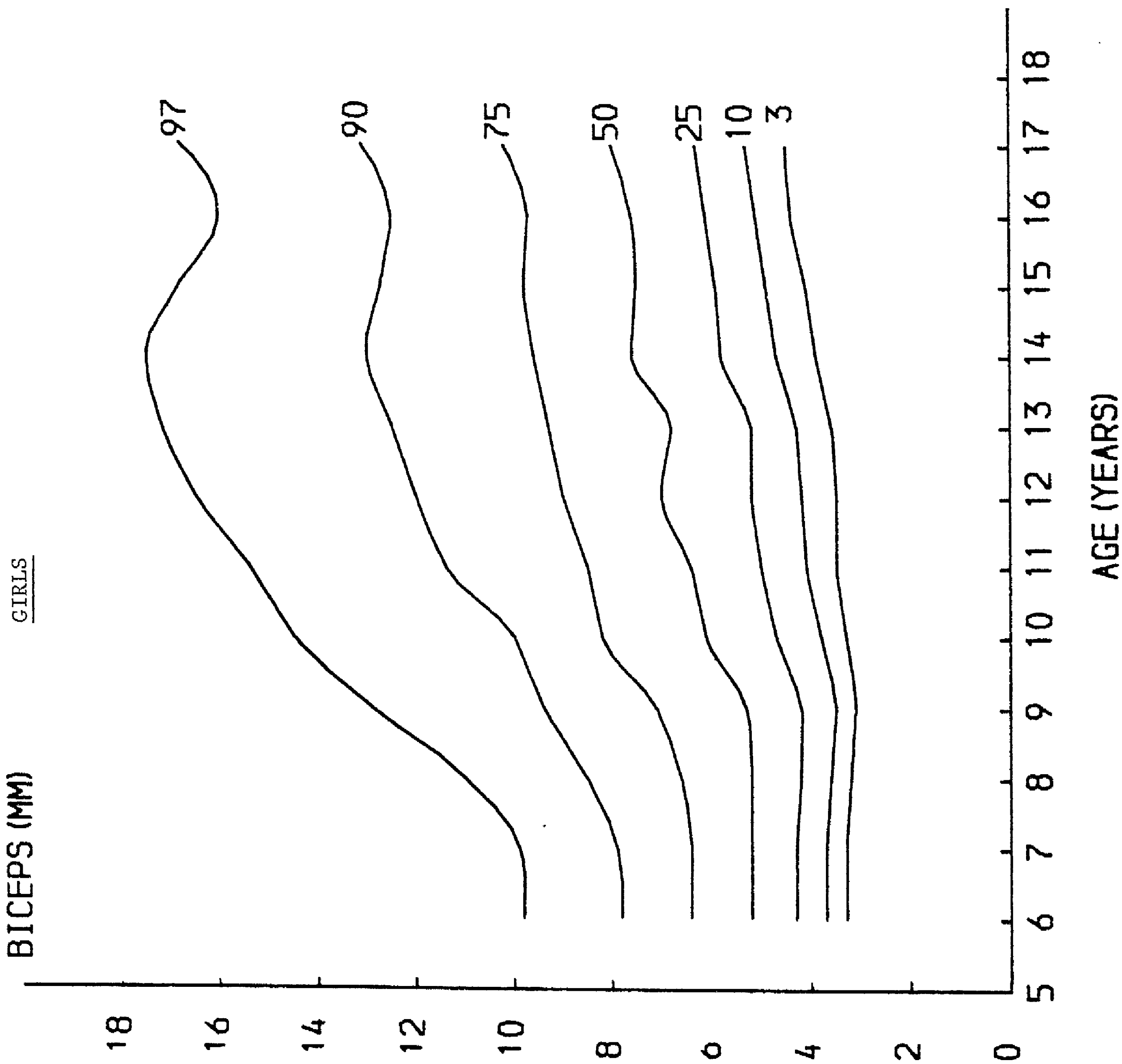


Figure 4.3.11: Percentiles of Suprailiac skinfold thickness of Libyan boys aged 6 - 17 years.

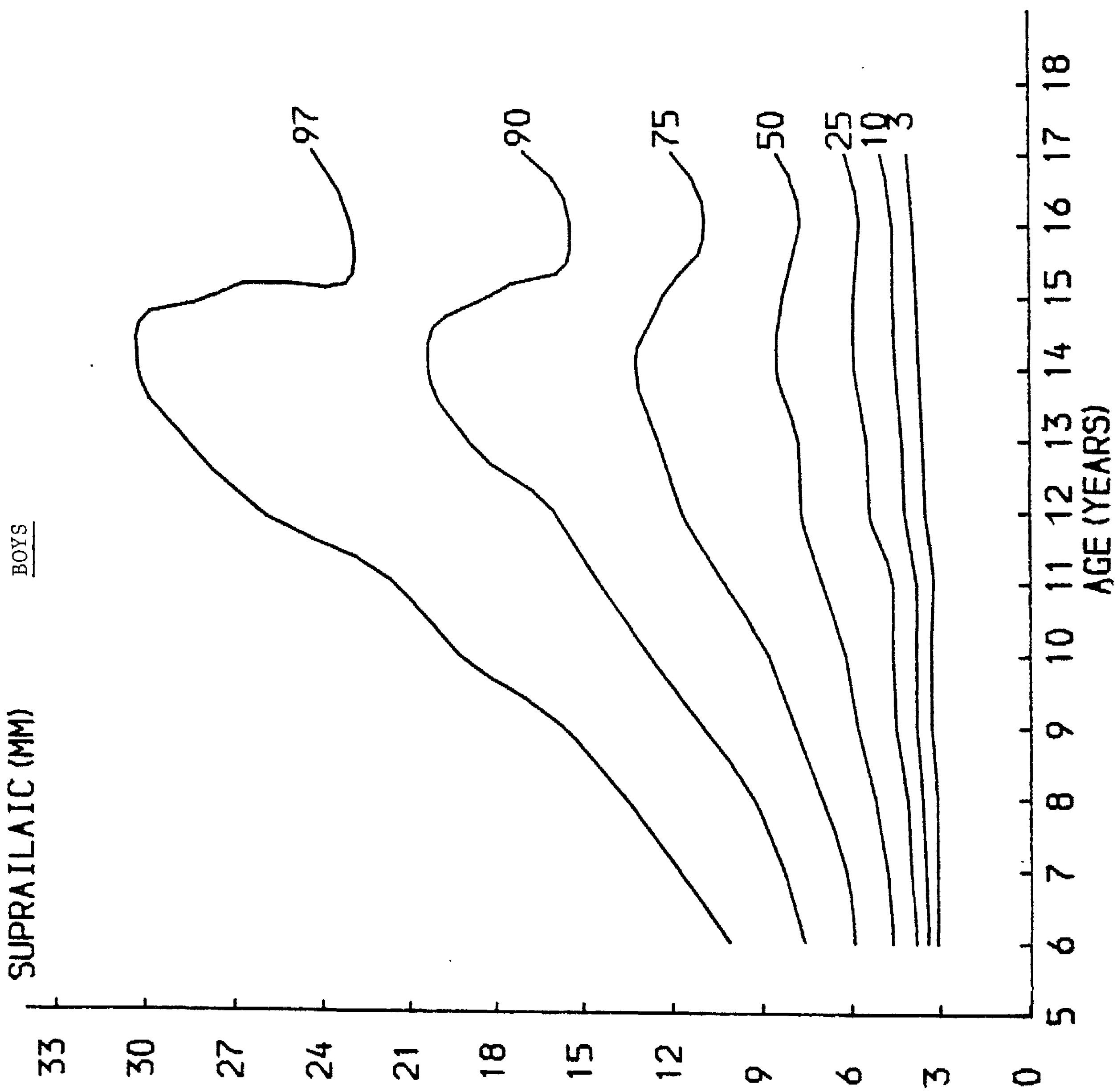


Figure 4.3.12: Percentiles of Suprailiac skinfold thickness of Libyan girls aged 6 - 17 years.

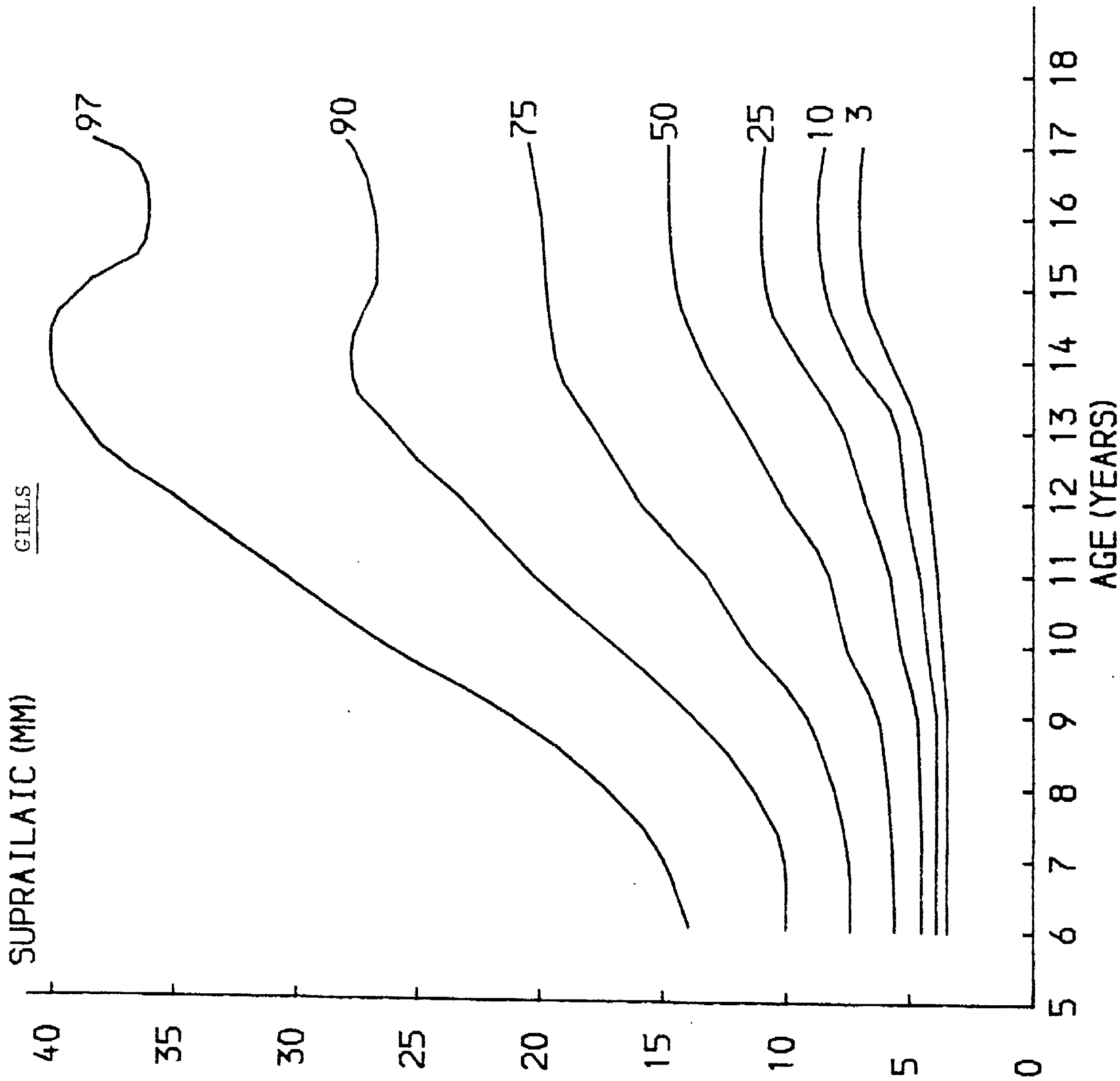


Figure 4.3.13: Percentiles of Triceps skinfold thickness of Libyan and English boys aged 6 - 17 years.

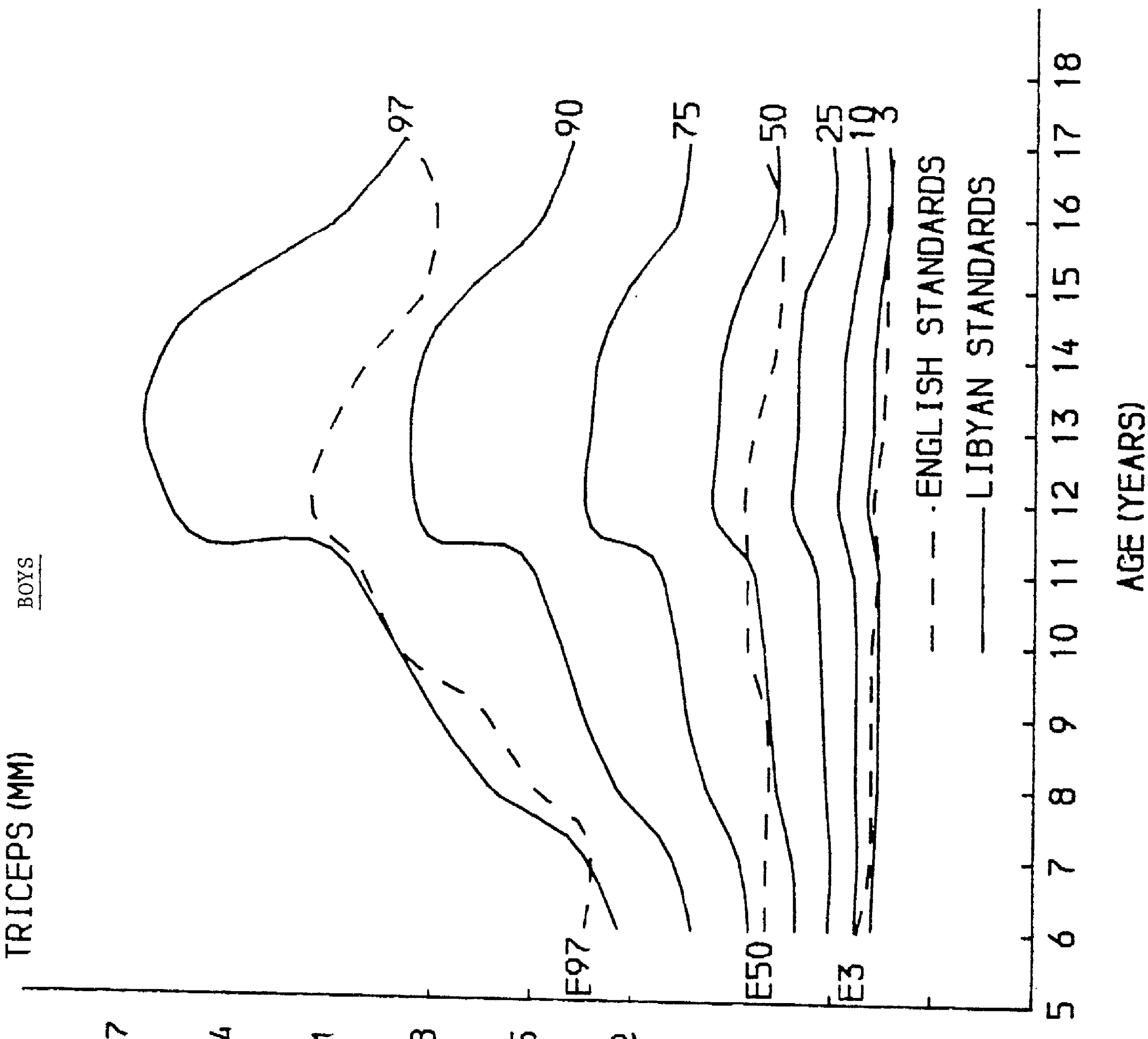


Figure 4.3.14: Percentiles of Triceps skinfold of Libyan and English girls aged 6 - 17 years.

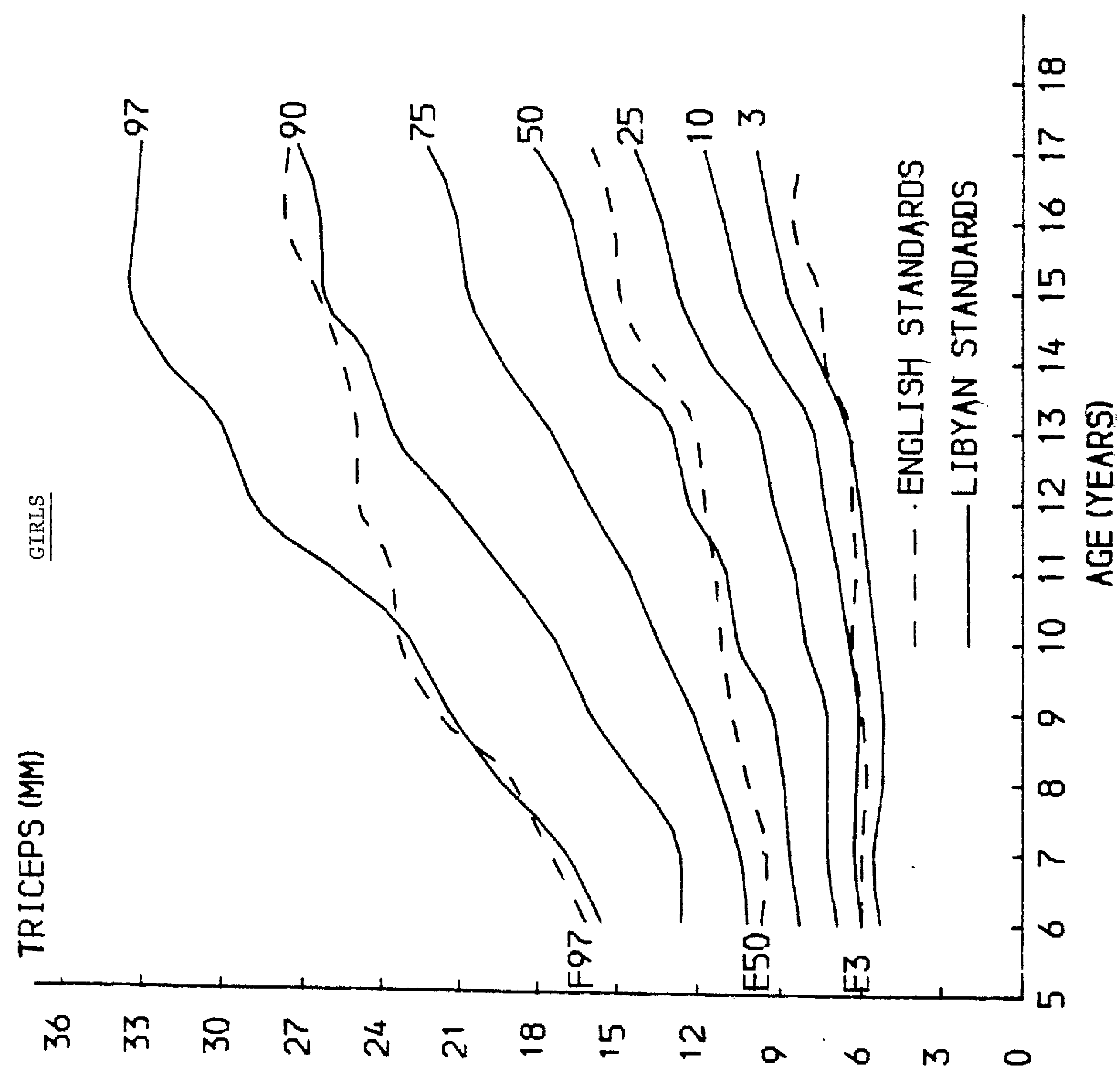


Figure 4.3.15: Percentiles of subscapular skinfold thickness of Libyan and English boys aged 6 - 17 years.

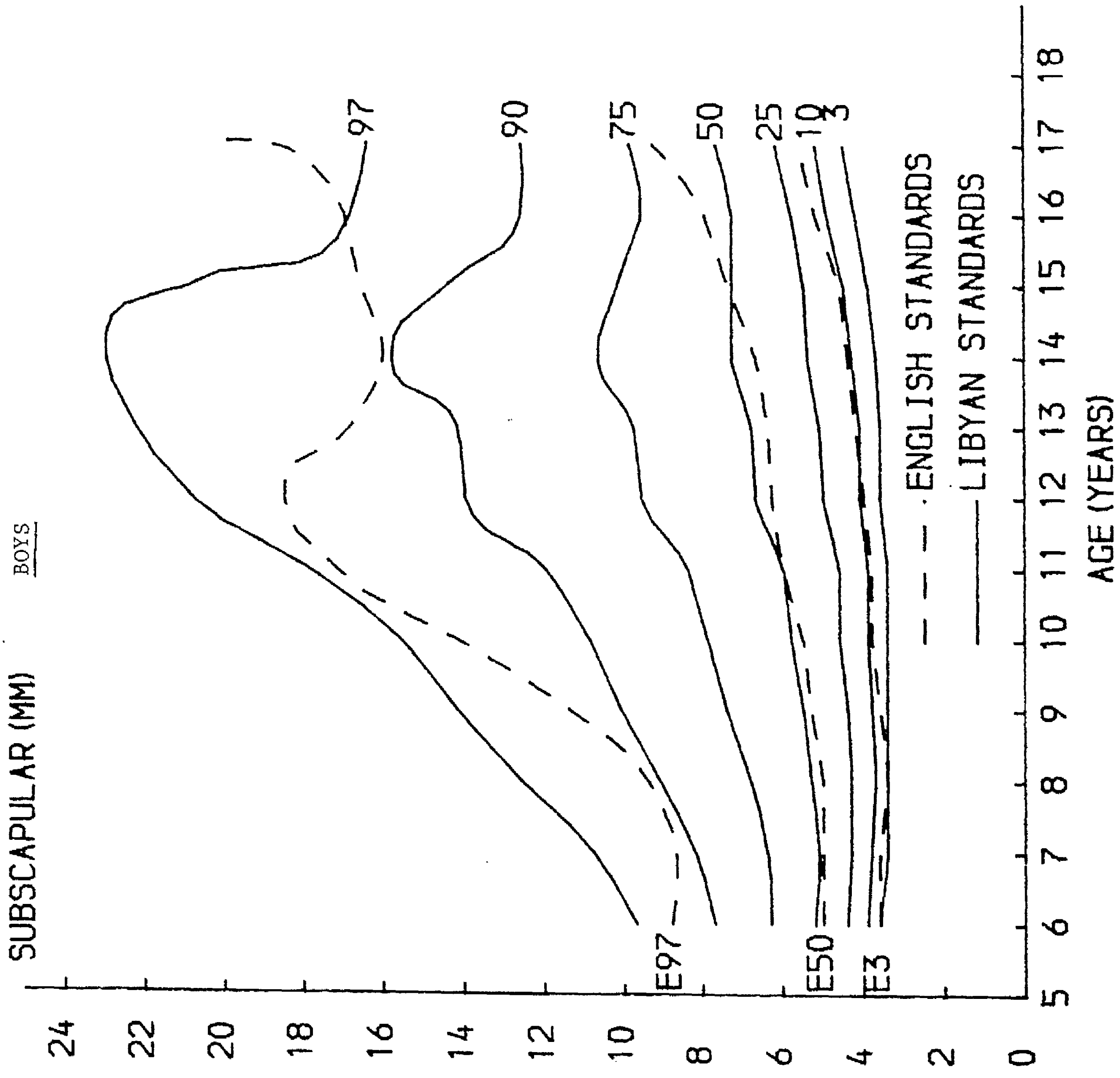
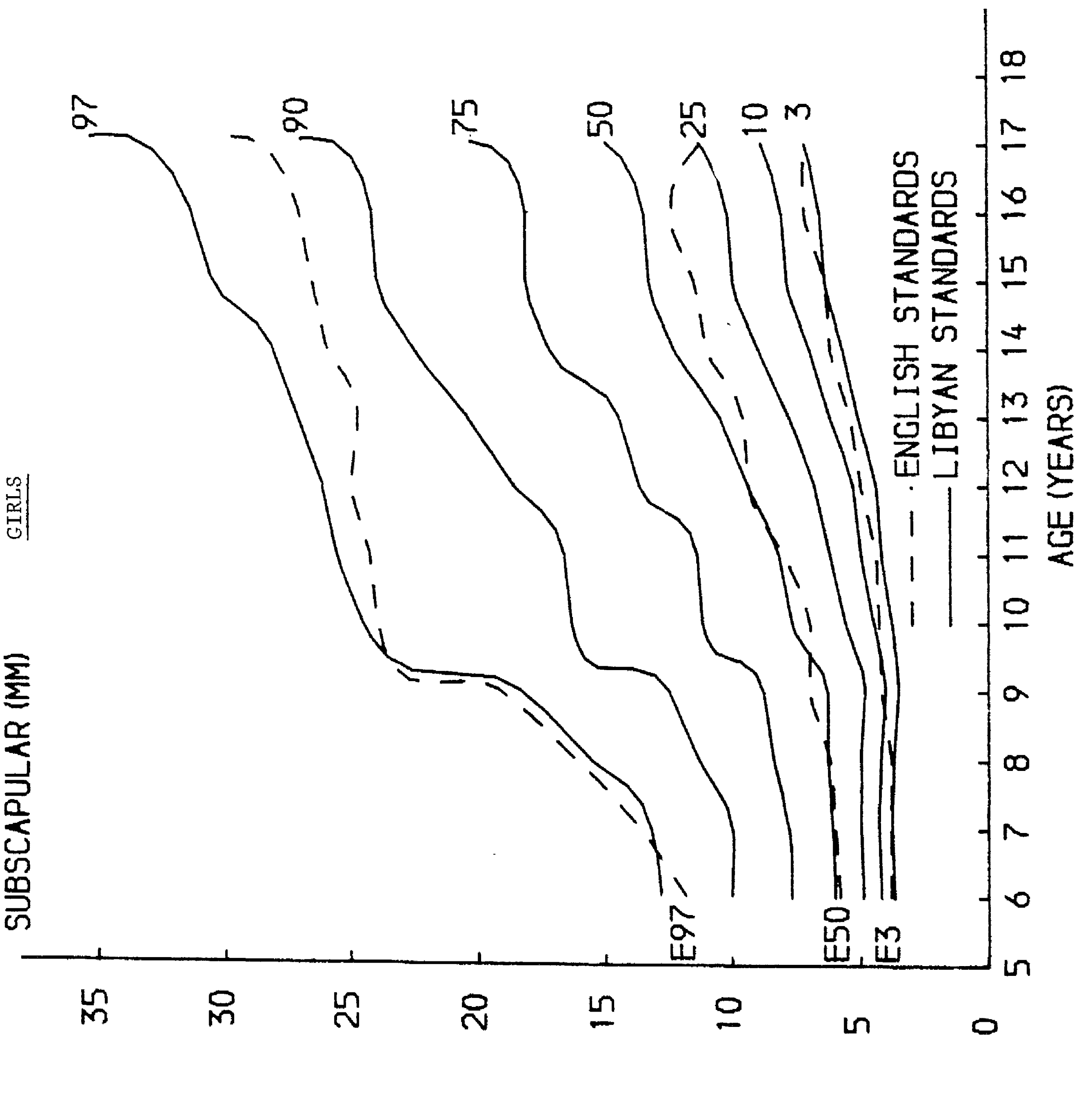


Figure 4.3.16: Percentiles of subscapular skinfold thickness of Libyan and English girls aged 6 - 17 years.



4.4 Mid Upper-Arm and Maximum Calf Circumferences:

The mid upper arm circumference and the maximum calf circumference distributions were positively skewed in most age groups, but to a lesser degree than the skinfold thicknesses. This has been observed by others (Cameron, 1977; Kemm, 1982). When log-transformation was applied to both arm and calf circumferences, their distributions become more normal. For example Figures 4.4.1 to 4.4.4 show the arm and calf circumference distributions for boys and girls of age group 3 (8 years) before and after using the log-transformation. They show also the probability plots after log-transformation. Different constant values of log-transformation were found for boys' and girls' arm and calf circumferences.

The constant values used for arm are 130, 120 mm and for calf 180, 160 mm for boys and girls respectively. The derivation of these constants will be shown in Chapter 6. Figures 4.4.5 to 4.4.8 present the percentiles of arm and calf circumferences for boys and girls by age as shown in Tables A9, A10 (Appendix). Also presented for comparison are the 3rd, 50th and 97th percentiles for English school-children (Cameron, 1979). These will be discussed later in this Chapter.

Figure 4.4.1: (a) Arm circumference distribution of Libyan boys aged 8 years before transformation.
(b) Arm circumference distribution after log transformation.
(c) Probability plot after log transformation of arm circumference.

(a)

```
ARM
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   140.        1     *
   150.       12     ******
   160.       40     ********************
   170.       90     *********************************************
   180.       93     ***********************************************
   190.       33     *****************
   200.       23     ************
   210.        9     *****
   220.        8     ****
   230.        3     **
   240.        6     ***
   250.        3     **
   260.        1     *
   270.        2     *
```

(b)

```
EACH * REPRESENTS   5 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
    1.1        1     *
    1.2        4     *
    1.3        5     *
    1.4       15     ***
    1.5       50     **********
    1.6       68     **************
    1.7      104     *********************
    1.8       44     *********
    1.9       15     ***
    2.0       12     ***
    2.1        5     *
    2.2        1     *
```

(c)

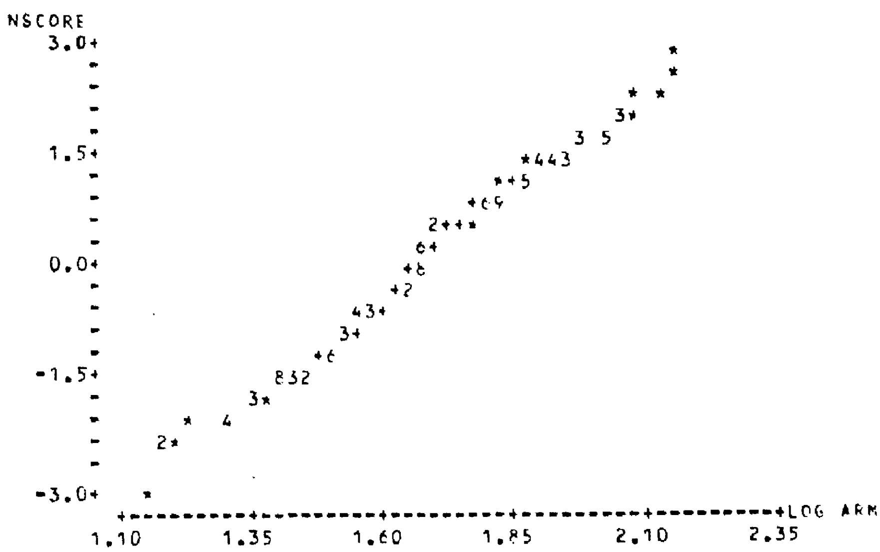


Figure 4.4.2: (a) Arm circumference distribution of Libyan girls aged 8 years before transformation.
(b) Arm circumference distribution after log transformation.
(c) Probability plot after log transformation of arm circumference.

(a)

```
ARM
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
   140.        0
   150.       10     *****
   160.       51     **************************
   170.       62     *******************************
   180.       53     ***************************
   190.       47     ************************
   200.       24     ************
   210.        9     *****
   220.       11     ******
   230.        5     ***
   240.        1     *
   250.        1     *
   260.        1     *
   270.        0
   280.        2     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF   NUMBER OF
INTERVAL    OBSERVATIONS
   1.4         1     *
   1.5        20     **********
   1.6        40     ********************
   1.7        82     *****************************************
   1.8        76     **************************************
   1.9        34     *****************
   2.0        19     **********
   2.1         3     **
   2.2         2     *
```

(c)

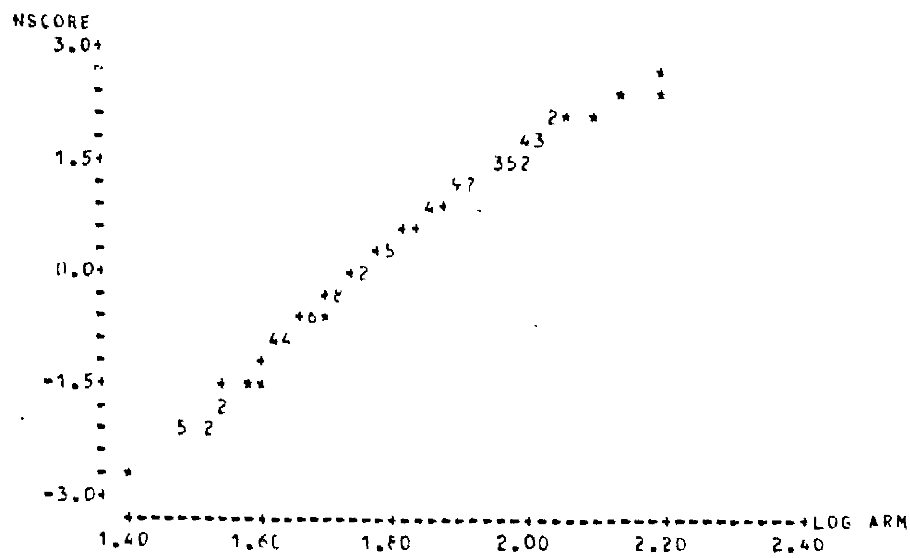


Figure 4.4.3: (a) Calf circumference distribution of Libyan boys aged 8 years before transformation.
(b) Calf circumference distribution after log transformation.
(c) Probability plot after log transformation of calf circumference.

(a)

```
CALF
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   210.          8     ****
   220.         27     **************
   230.         60     ******************************
   240.         62     *******************************
   250.         66     *********************************
   260.         44     **********************
   270.         13     *******
   280.         19     **********
   290.         11     ******
   300.          4     **
   310.          6     ***
   320.          3     **
   330.          1     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
   1.50          8     ****
   1.55          2     *
   1.60         22     ***********
   1.65         21     ***********
   1.70         39     ********************
   1.75         29     ***************
   1.80         55     ****************************
   1.85         47     ************************
   1.90         44     **********************
   1.95         13     *******
   2.00         22     ***********
   2.05         10     *****
   2.10          8     ****
   2.15          4     **
```

(c)

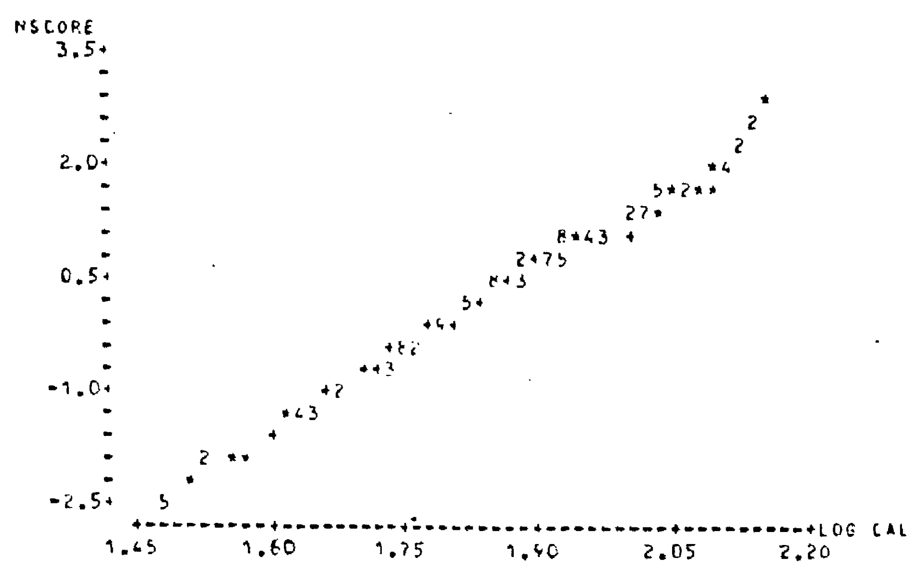


Figure 4.4.4: (a) Calf circumference distribution of Libyan girls aged 8 years before transformation.
(b) Calf circumference distribution after log transformation.
(c) Probability plot after log transformation of calf circumference.

(a)

```
CALF
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
  190.          1     *
  200.          3     **
  210.         10     *****
  220.         18     *********
  230.         52     **************************
  240.         52     **************************
  250.         45     ***********************
  260.         41     *********************
  270.         28     **************
  280.         11     ******
  290.          9     *****
  300.          4     **
  310.          1     *
  320.          0
  330.          1     *
  340.          0
  350.          1     *
```

(b)

```
EACH * REPRESENTS   2 OBSERVATIONS

MIDDLE OF    NUMBER OF
INTERVAL     OBSERVATIONS
  1.55          2     *
  1.60          2     *
  1.65          2     *
  1.70          7     ****
  1.75          4     **
  1.80         31     ****************
  1.85         36     ******************
  1.90         52     **************************
  1.95         45     ***********************
  2.00         48     ************************
  2.05         24     ************
  2.10         14     *******
  2.15          7     ****
  2.20          1     *
  2.25          2     *
```

(c)

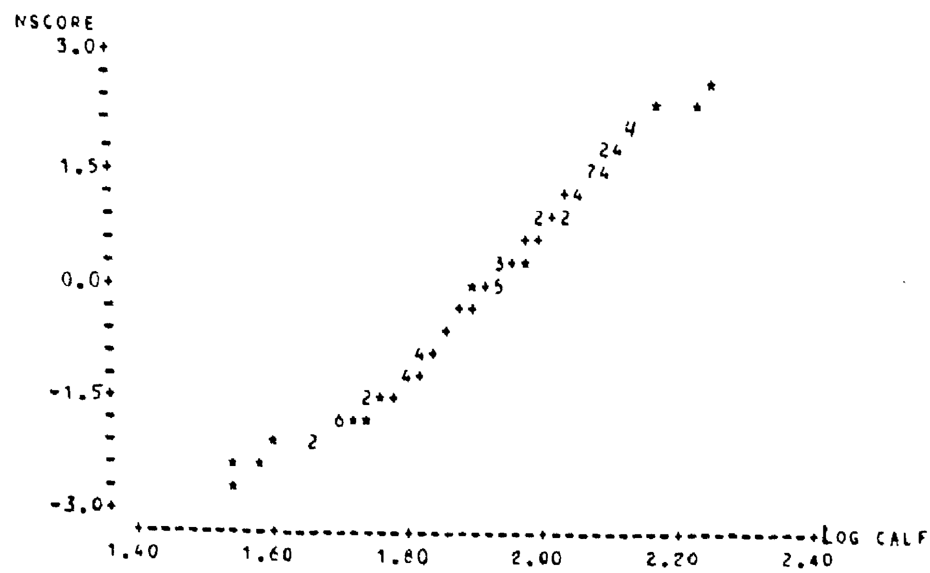


Figure 4.4.5: Percentiles of mid upper arm circumference of Libyan and English boys aged 6 to 17 years.

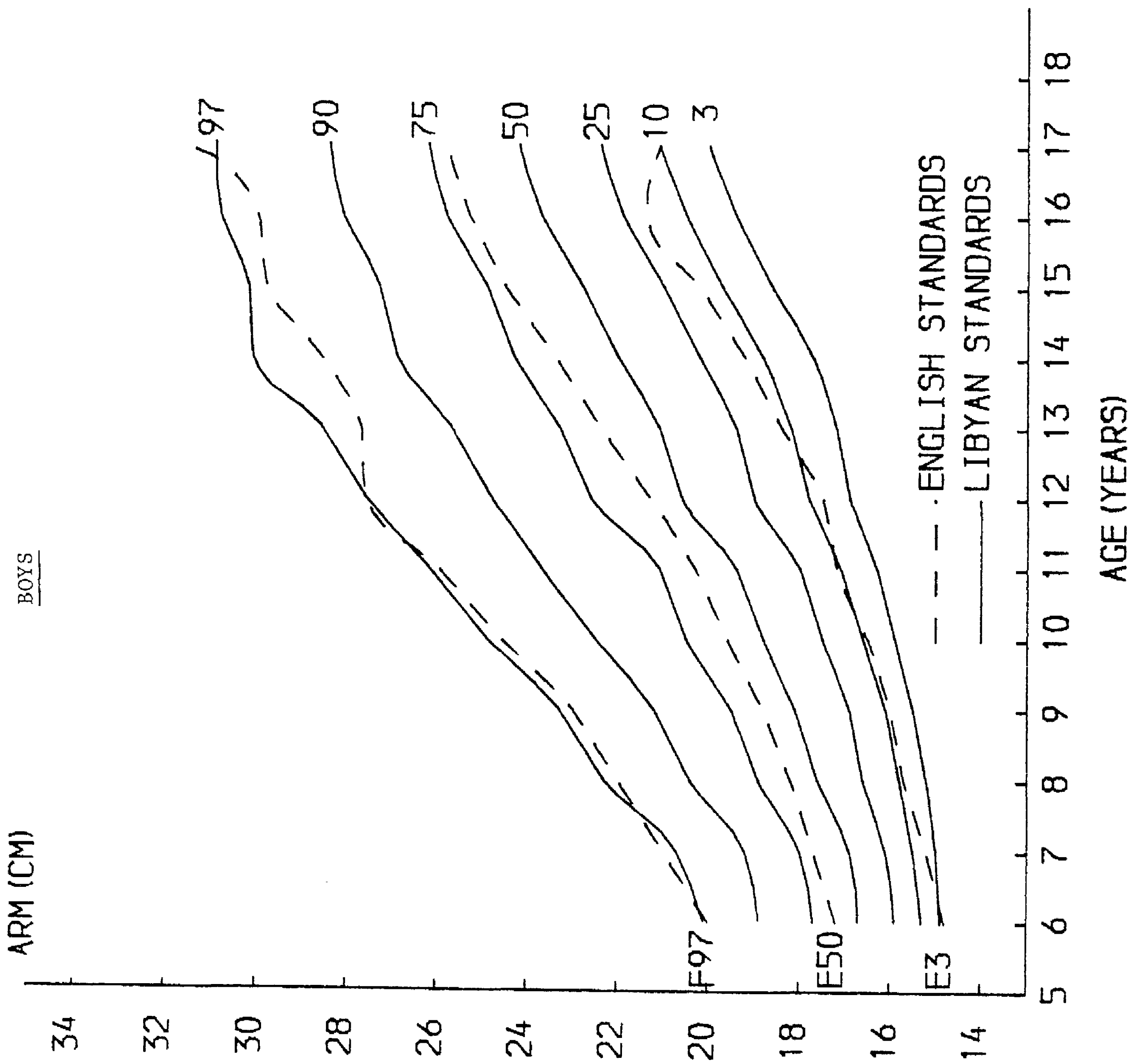


Figure 4.4.6: Percentiles of mid upper arm circumference of Libyan and English girls aged 6 to 17 years.

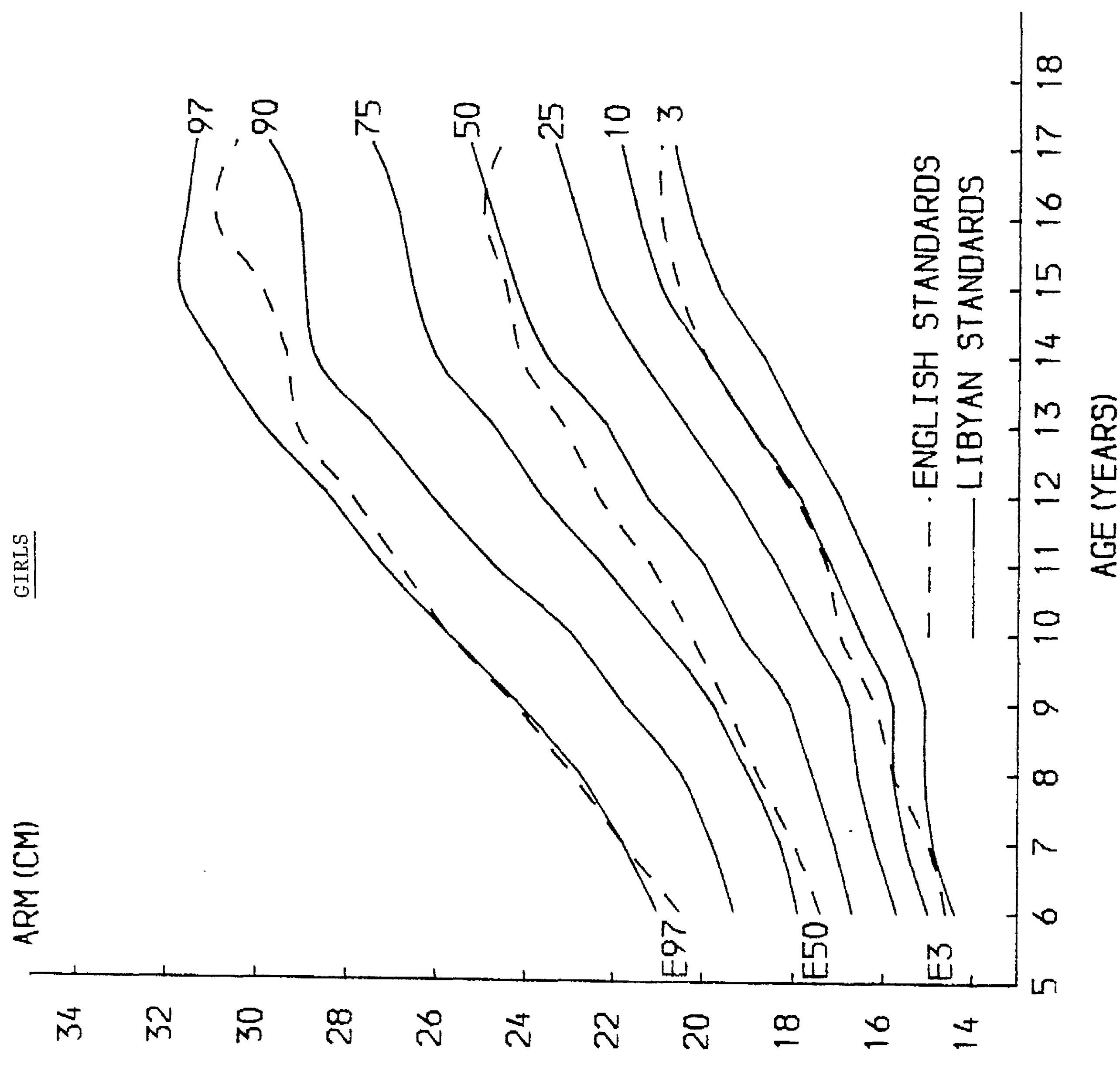


Figure 4.4.7: Percentiles of maximum calf circumference of Libyan and English boys aged 6 to 17 years.

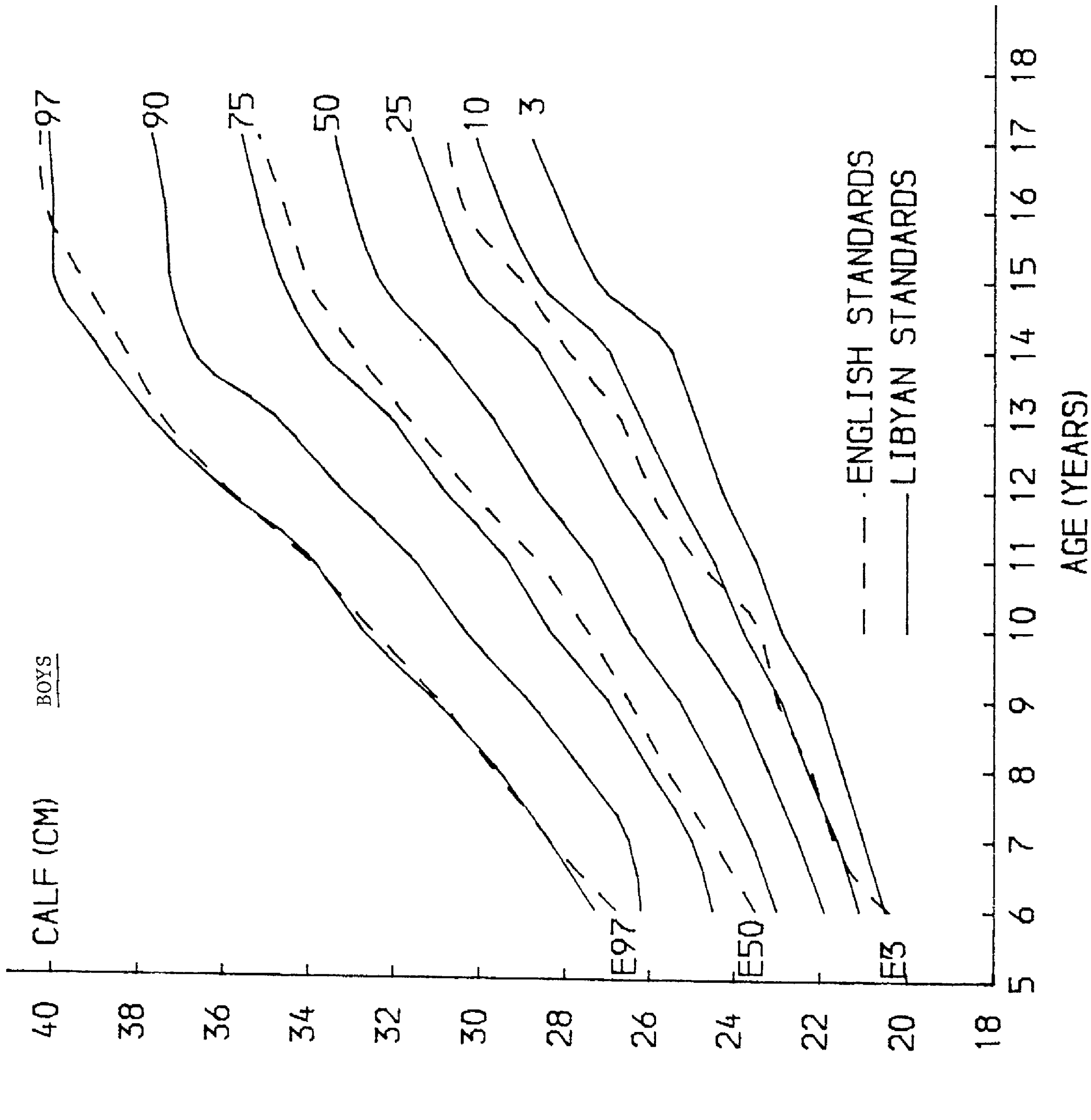
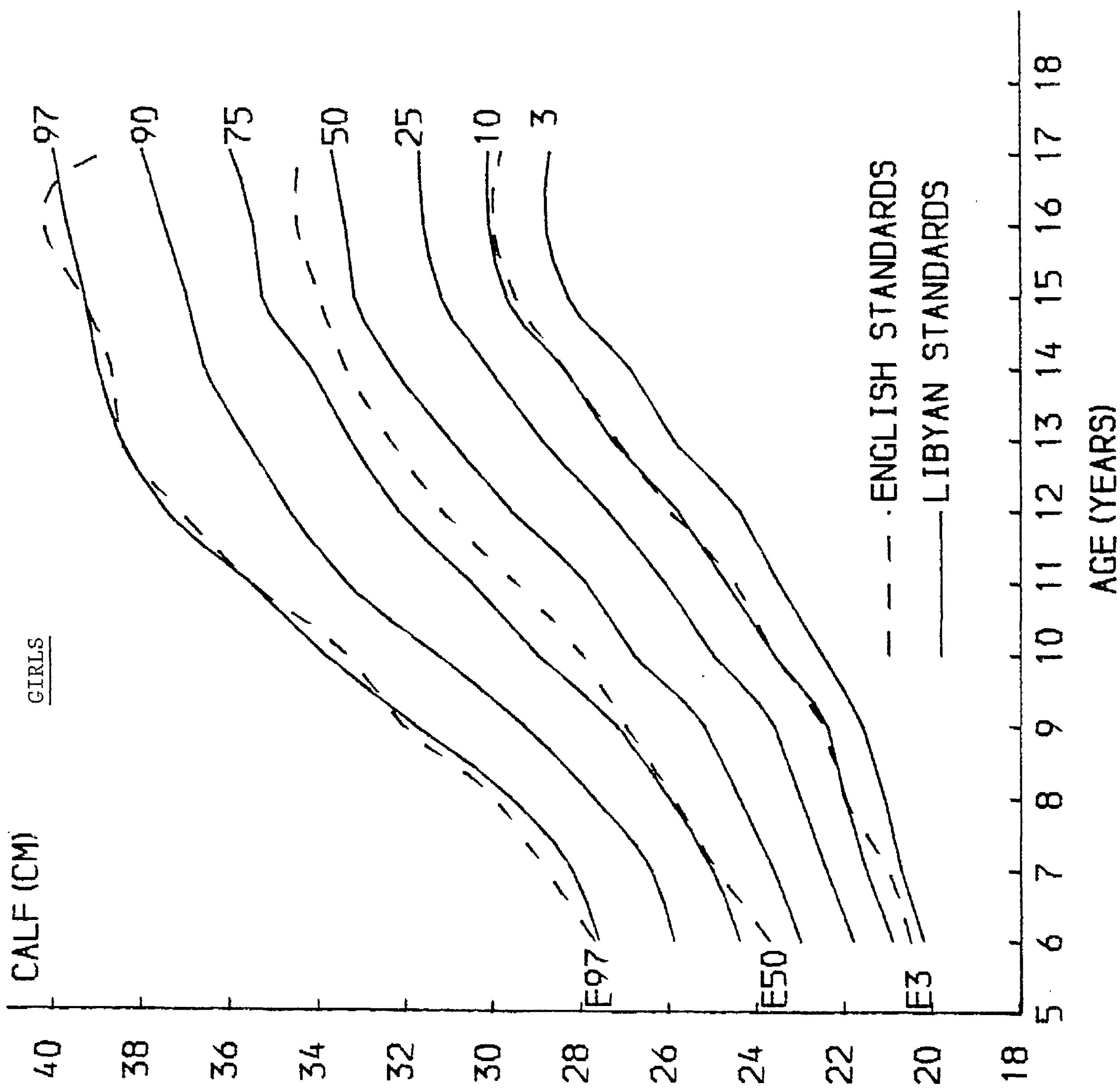


Figure 4.4.8: Percentiles of maximum calf circumference of Libyan and English girls aged 6 to 17 years.



B. Discussion:

The results of the cross-sectional study will be discussed in the remaining part of the chapter. As stated in Chapter one, the results of this study will be compared with data from three other sources. Firstly, comparison will be made with previous Libyan data to find out what changes in patterns of growth have taken place between the two studies. The only published Libyan growth data for school-age children is on skinfold thickness of Libyan boys by Ferro-Luzzi which was carried out in 1957 and published in 1962 (Ferro-Luzzi, 1962). Secondly, comparison will be made with English standards to show to what extent the English growth charts, which are currently in use in Libya, are valid for assessing Libyan children's growth. Thirdly, comparison will be made with some neighbouring Arab countries like Egypt and Tunisia to see if there is any big difference in growth between the children of adjacent countries.

4.5 Height:

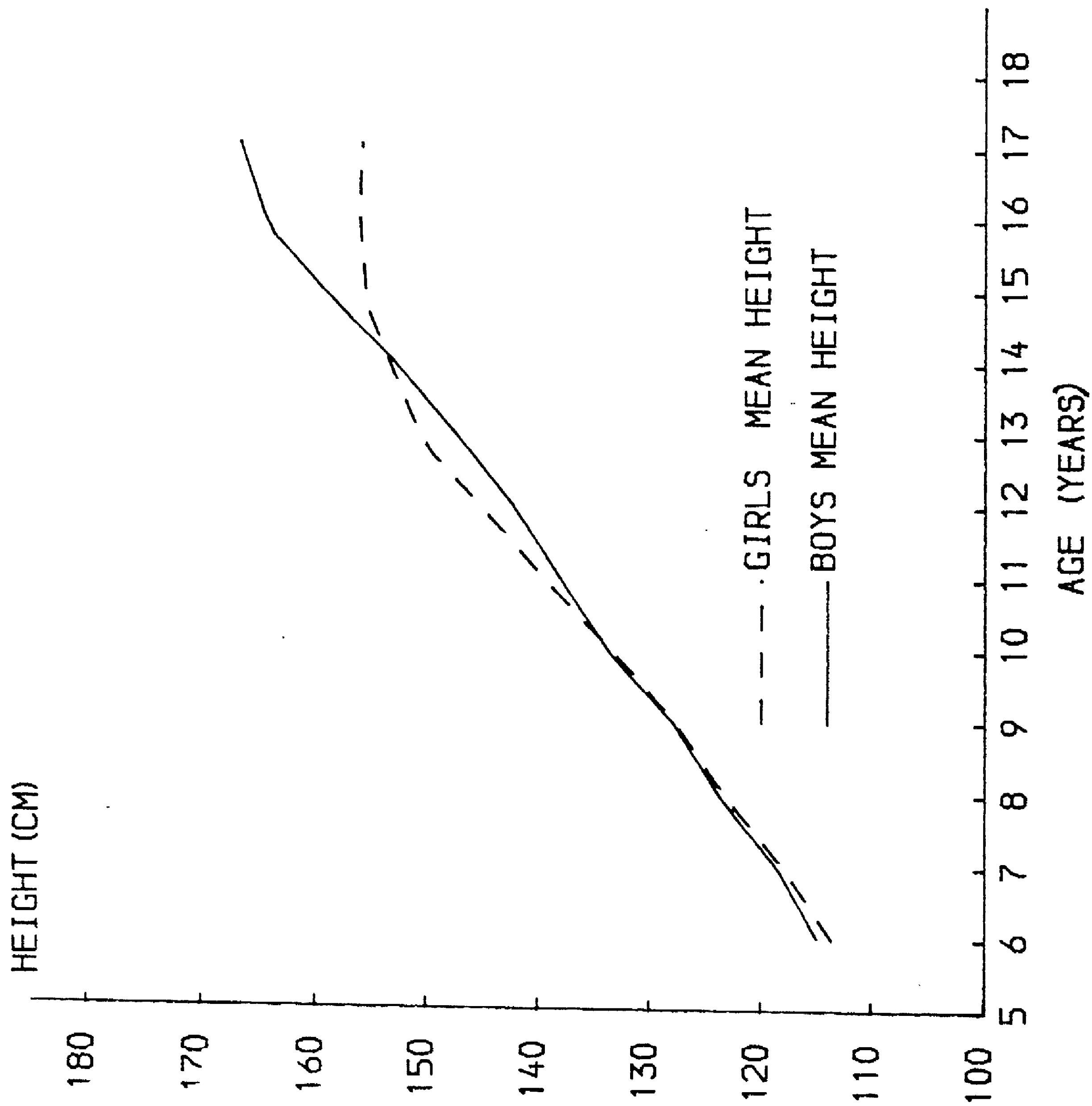
The mean height of Libyan boys is slightly taller than the girls until the girls' adolescent growth spurt begins as is shown in Figure 4.5.1. This is the height pattern in every country (Eveleth and Tanner, 1976). The Libyan girls height spurt begins at age 11 years, when the mean height of girls accelerated leaving the boys' mean height behind. This continued until the adolescent spurt of boys occurs, and the boys' mean height overtakes the girls' mean height at age 14 years, and exceeds it from then on. The sex difference becomes much larger after puberty than before it, since the boys' adolescent growth spurt is greater than the girls (Eveleth and Tanner, 1976). This is true with the Libyan children's height, resulting in a difference of 10 cm. between boys' and girls' mean height at age 17 years.

Libyan and English Height:

From Figures 4.1.3, 4.1.4, it can be seen that for boys' and girls' height, there is little difference between the Libyan and English standards at age 6 years, but with increasing age the difference increases in both sexes. For boys' height, the English 3rd percentile catches the Libyan 10th percentile at age 9 years, and they were superimposed until about age 14 years.

The English 3rd percentile reached about the Libyan 25th percentile at age 17 years. The English 50th percentile exceeded the Libyan 50th percentile after age six years moving nearer the Libyan 75th percentile up to age 12 years, when the English 50th percentile crossed the Libyan 75th percentile and moved parallel to it. By age 17 years the English 50th height percentile reached about the Libyan 90th percentile,

Figure 4.5.1: Mean height of Libyan boys and girls aged 6-17 years.



with a difference about 7.0 cm between the two height means. The English 97th percentile of height is above the Libyan 97th percentile after age 6 years and the difference increases as age increases, until at age 17 years the English boys' 97th percentile is greater than the Libyan boys' 97th percentile by about 7.0 cm.

The girls' height percentiles followed a similar pattern to boys' height percentiles except at the 97th percentile where the Libyan girls are very close to the English girls up to age 11 years; then the English girls' percentile increased faster, probably because the adolescent growth spurt occurs earlier in the English girls.

It can be seen that between age 12 and 13 years, 10% of Libyan children's heights, and at age 17 years, 25% of Libyan children's heights fell below the English 3rd percentile of height. Also it is clear from Figures 4.1.3 and 4.1.4 that none of the Libyan height percentiles are the same as those of their English peers, which shows that the English standards which are currently in use in Libya are not valid for assessing the growth of Libyan school children. Local standards constructed from data from Libyan children should be used.

Libyan, Egyptian and Tunisian Height:

It is important to compare the results of this study of Libyan school children's growth with available information on children from neighbouring Arabic countries such as Egypt and Tunisia.

Although the three countries, Egypt, Libya and Tunisia are at present three separate Arabic countries, in fact they are one people sharing the same land and Mediterranean climate, with one language, one religion, one educational system and one dwelling system. Also, they are all descended from the Arabic race and are likely to be genetically similar.

The Egyptian mean heights are based on a national study (McDowell et al., 1970) and the Tunisian mean height of well-off children (Boutourline Young, 1973) have been published (Eveleth and Tanner, 1976) and are presented in Figures 4.5.2 and 4.5.3 with the Libyan mean height of boys and girls respectively. These studies were not all carried out at the same time, but they are the only currently available data. When making this comparison it should be borne in mind that the conditions in Egypt and Tunisia have not changed dramatically between 1973 and 1983, but that Libya has developed a lot during that period.

For boys, the Libyan mean height was greater than both Tunisian and Egyptian mean heights up to age 7 years, when the Tunisian mean height accelerated leaving the Libyan mean height between the Tunisian and Egyptian means until age 11½ years. From about age 14 years to 16 years the Libyan and Egyptian mean heights were superimposed. At age 17 years the Egyptian mean height exceeded the Libyan mean height by 2 cm. The Tunisian mean height was the same as the Libyan mean height at age 16 years and age 17 years.

The Libyan girls' mean height was greater than both Tunisian and Egyptian girls' mean height until age 12½ years, when the Tunisian mean height crossed the Libyan mean and continued parallel to it. At age 14½ years the Egyptian mean height crossed the Libyan and superimposed the Tunisian mean height. At age 16 years the Libyan girls' mean height was about 2 cm less than both the Tunisian and Egyptian girls' mean height.

Overall, it can be said that there is not much difference between the mean height of Libyan, Tunisian and Egyptian children.

In general, (Eveleth and Tanner, 1976) it is true that the difference in the mean height between Arabic countries is less than the difference in mean height between European countries.

Figure 4.5.2: Mean height of Libyan, Egyptian and Tunisian boys aged 6 to 17 years.
Source: Eveleth and Tanner, 1976.

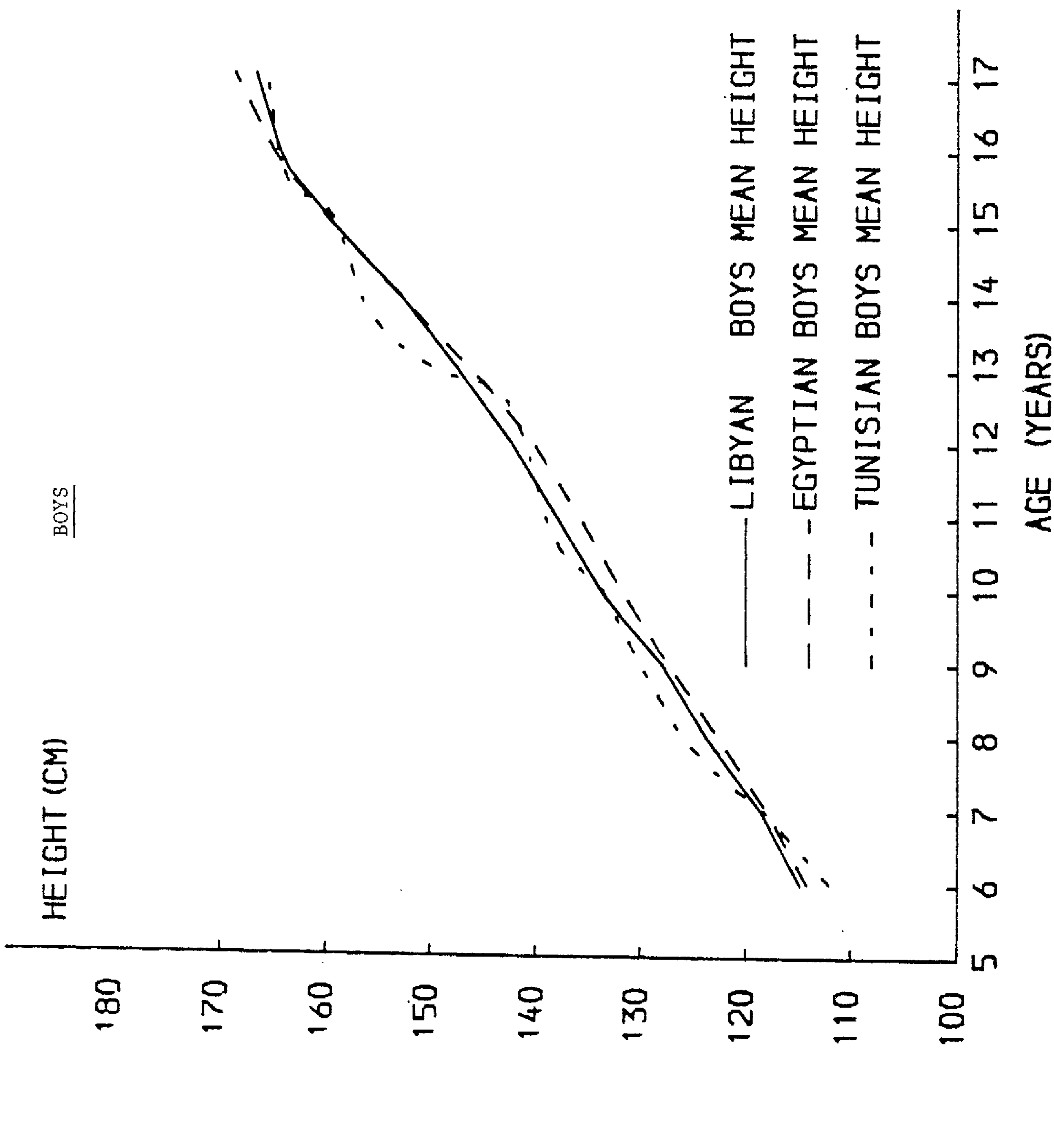
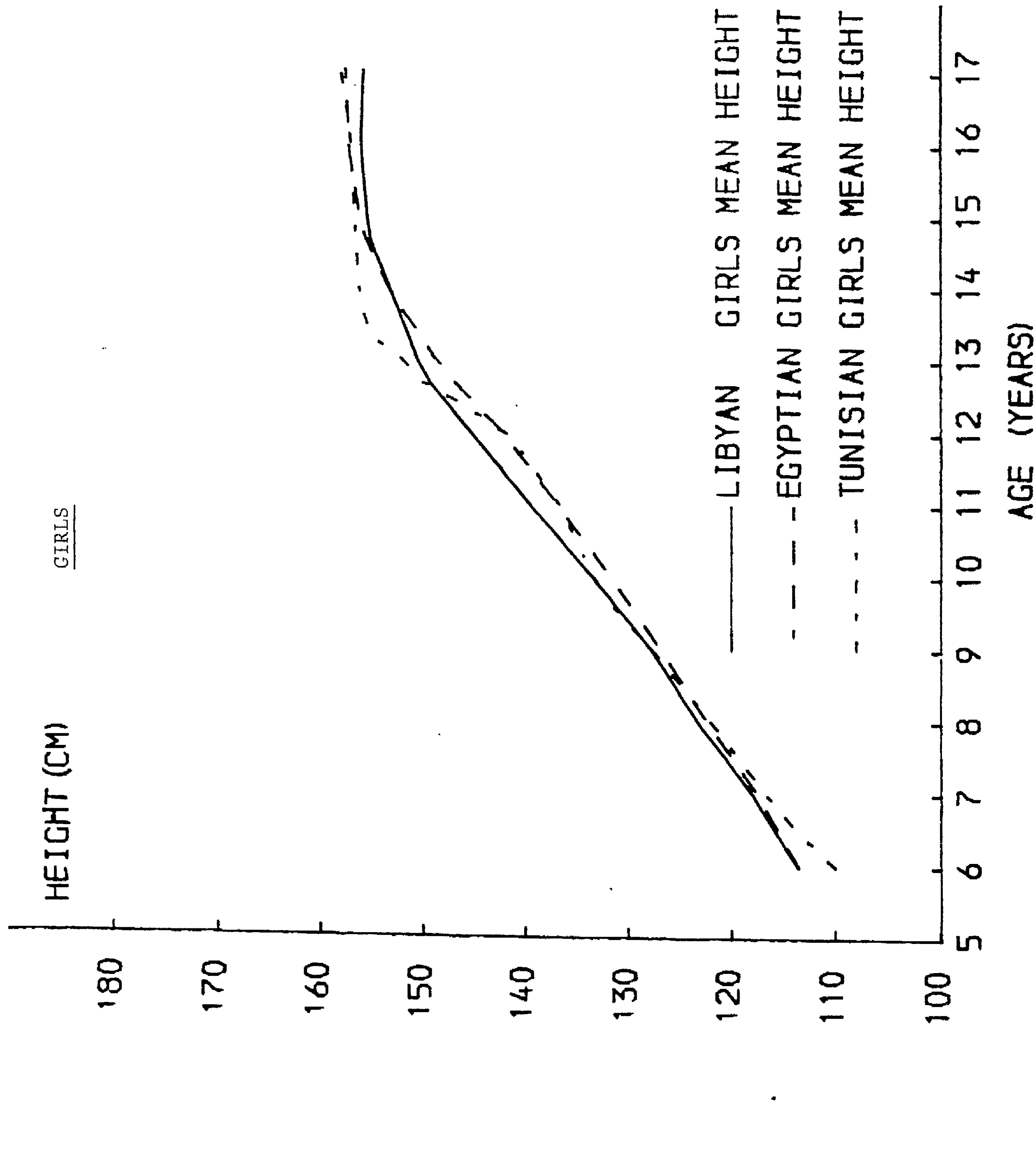


Figure 4.5.3: Mean height of Libyan, Egyptian and Tunisian girls aged 6 to 17 years.
Source: Eveleth and Tanner, 1976.



4.6 Weight:

The difference in mean weight between Libyan boys and girls up to age 10½ years is negligible (Figure 4.6.1). The difference is never more than ½ kg over this age range. From age 11 years on, girls become heavier than boys. At age 11 years the difference in mean weight is 1.5 kg; at age 14 years the difference reached its peak of 5.1 kg, and by age 17 years the difference is 2.0 kg. This difference is due to physiological factors. The adolescent growth spurt occurs earlier in girls than boys. When the adolescent growth spurt starts, it accelerates the growth of most of the body, and the gain in weight is relatively greater than the gain in height during this time, for weight is a measure which aggregates growth of several body tissues - bones, muscles, and subcutaneous tissues (Tanner, 1962). Thus the girls become heavier than boys, and when the boys' adolescent spurt started, it accelerated boys' weight and the difference between boys and girls decreased.

Figure 4.6.2 shows how Quetelet's index of obesity, $\frac{\text{weight}}{(\text{height})^2} \times 100$, varies according to age and sex. (Rao, et al., 1970; Cole, 1978; Johnston et al., 1978; Keiller et al., 1979; Cole et al., 1981). It is clear from the figure that the girls became more obese than boys especially after age 15 years when the girls' height starts decelerating while they are still putting on weight. The other reason that older girls put on more weight than boys is due to the light work they do and the fact that they do little or no exercise because of social customs compared with the boys.

Libyan and English Weight:

From Figures 4.2.3, 4.2.4, it is clear that there is a difference

<u>Figure 4.6.1</u>: Mean weight for Libyan boys and girls aged 6 to 17 years, 1983.

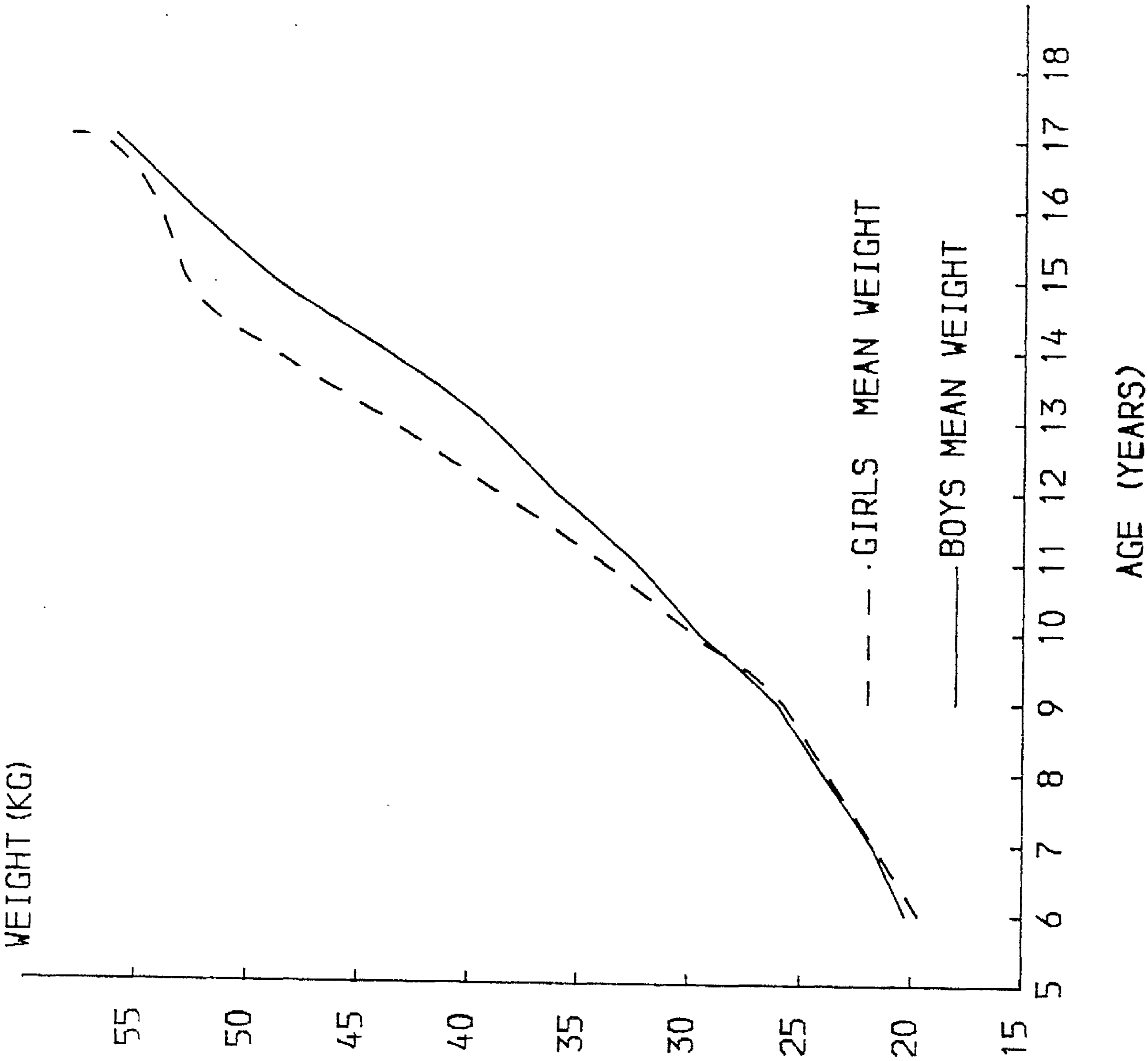
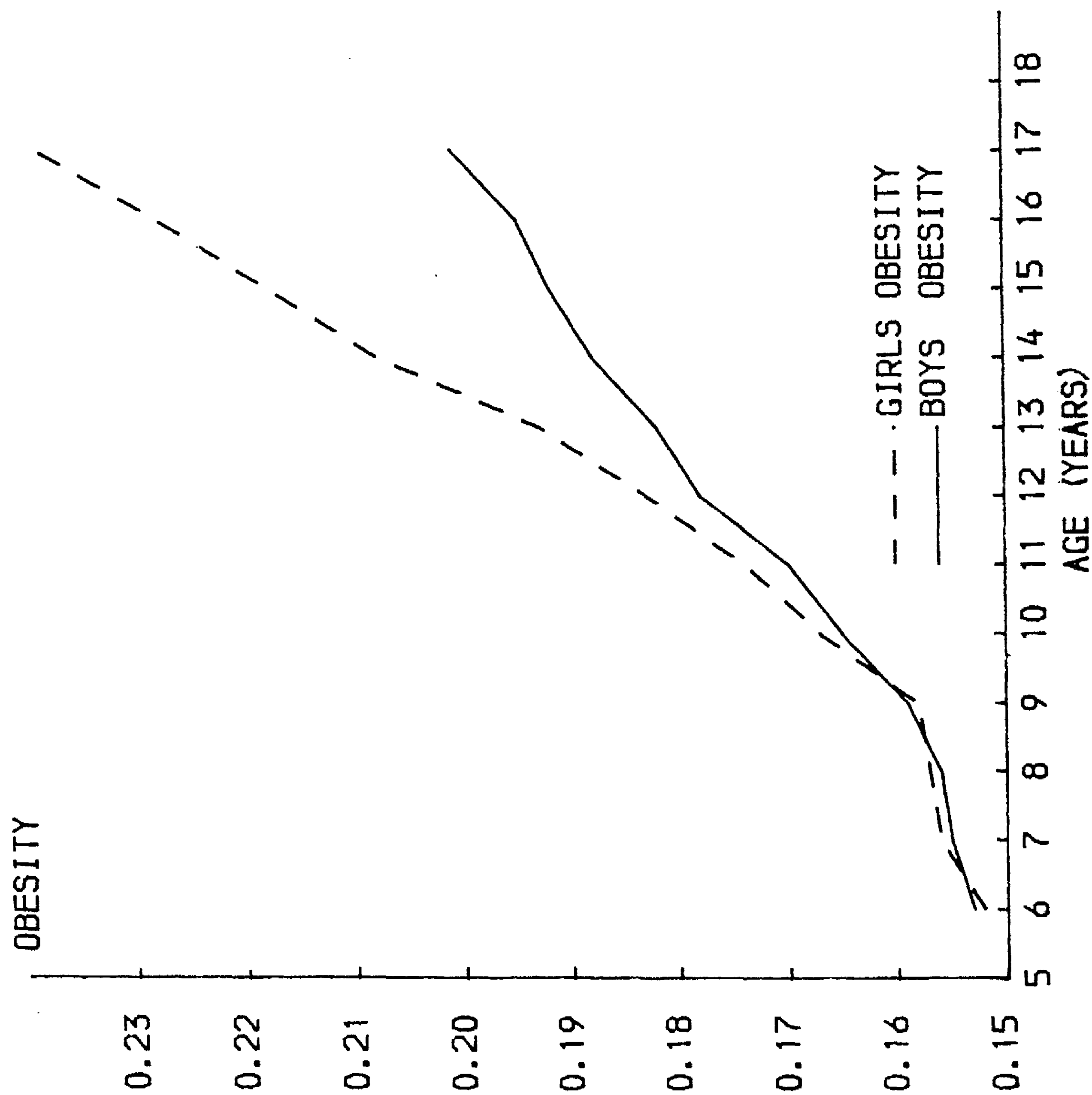


Figure 4.6.2: The mean obesity of Libyan boys and girls aged 6 to 17 years, 1983.



between the Libyan and English standards.

For boys, there is little difference between the Libyan and English standards at age 6 years, and there is little difference between the 97th percentiles throughout the whole range. However, at the 3rd and 50th percentiles the difference increases with age until at age 16 years the English 3rd and 50th percentiles are about 6 kg above the Libyan 3rd and 50th percentiles.

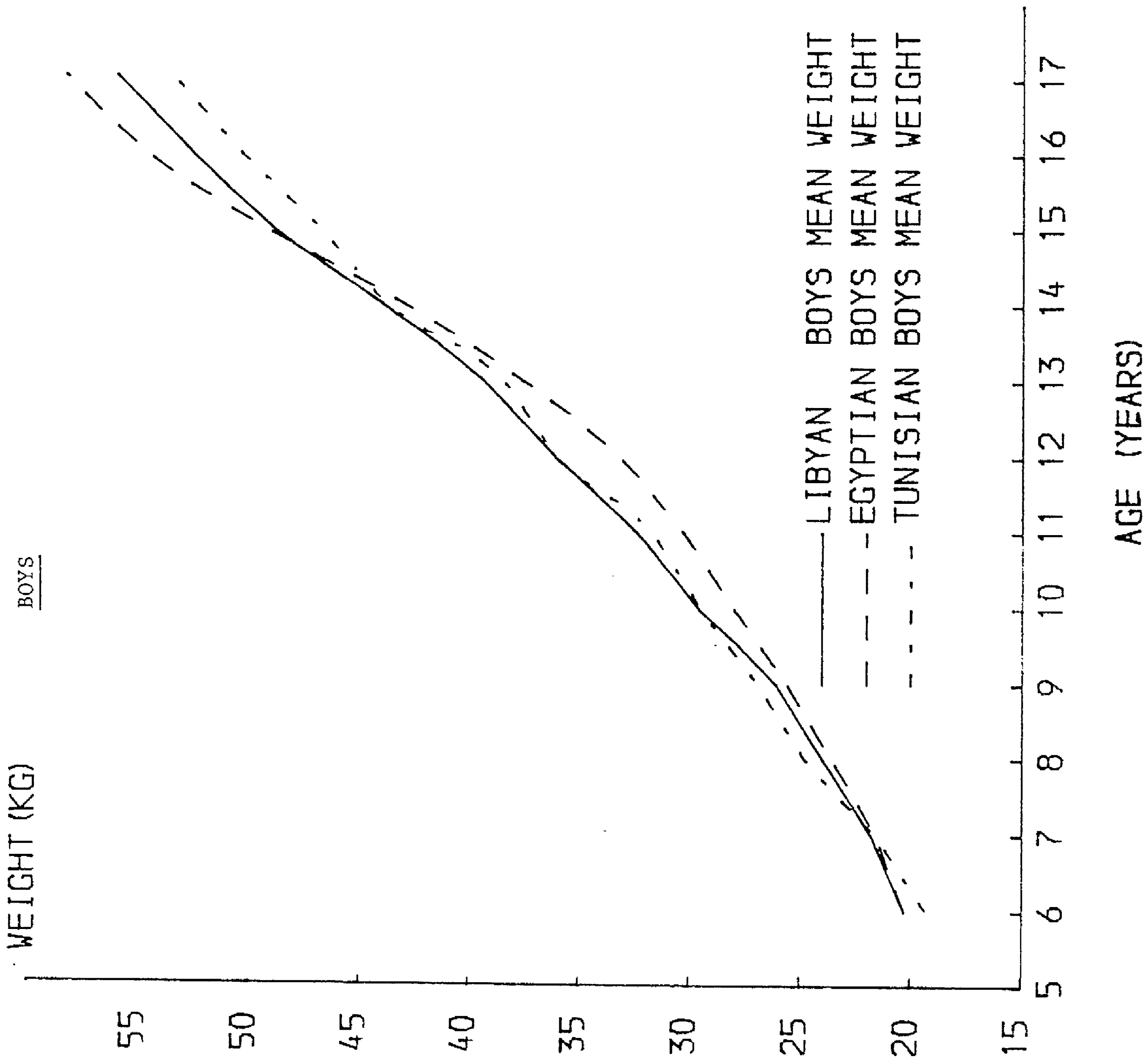
For girls, there is little difference between English and Libyan standards throughout the whole age range, although the English 3rd and 50th percentiles are slightly higher than the Libyan 3rd and 50th percentiles, while the Libyan 97th percentile is slightly higher than the English 97th percentile for girls over 13 years. The reason for this is, as mentioned above, lack of exercise and the habitual Libyan diet which is characterized by high carbohydrate and high fat intake compared with the English diet (see Section 1.7).

From the above discussion, it is clear that the English standards which are currently in use in Libya are not suitable for assessing the growth of Libyan children and that local standards should be used.

Libyan, Egyptian and Tunisian Weight:

It is not unexpected to find that the mean weights in the three countries' children are similar since the environmental conditions are similar. Figure 4.6.3 shows the mean weight of Libyan, Egyptian and Tunisian boys. It is clear from the figure that there is little difference between the three mean weights. None of them exceed the other two through all the ages. At age 17 years the Libyan boys mean weight is 2.3 kg less than the Egyptian boys and is about 3.5 kg heavier than Tunisian boys.

Figure 4.6.3: Mean weight of Libyan, Egyptian and Tunisian boys aged 6 to 17 years.
Source: (Eveleth and Tanner, 1976).



The Libyan boys are more obese then the Egyptians and Tunisian boys between ages 10 to 15 years, while the Egyptian boys become fatter from age 15 years on (Figure 4.6.4).

Figure 4.6.5 shows the girls' mean weight of the three countries. The Libyan mean weight exceeds the other two means throughout the age groups, and the difference becomes larger from age 10 to 16 years by comparison with Egyptian mean weight, and from 10 to 17 years by comparison with Tunisian mean weight, except for the age group 13 to 14 years. The Libyan girls' mean weight is 2 kg heavier than Egyptian girls' mean weight at age 17 years, and is 2 kg heavier than the Tunisian girls' mean weight at age 16 years.

Figure 4.6.6 shows the girls' obesity in the three countries by age group. It is clear that the Libyan girls are more obese than the Egyptian and Tunisian girls from age 9 years on.

Figure 4.6.4: Obesity of Libyan, Egyptian and Tunisian boys aged 6 to 17 years.

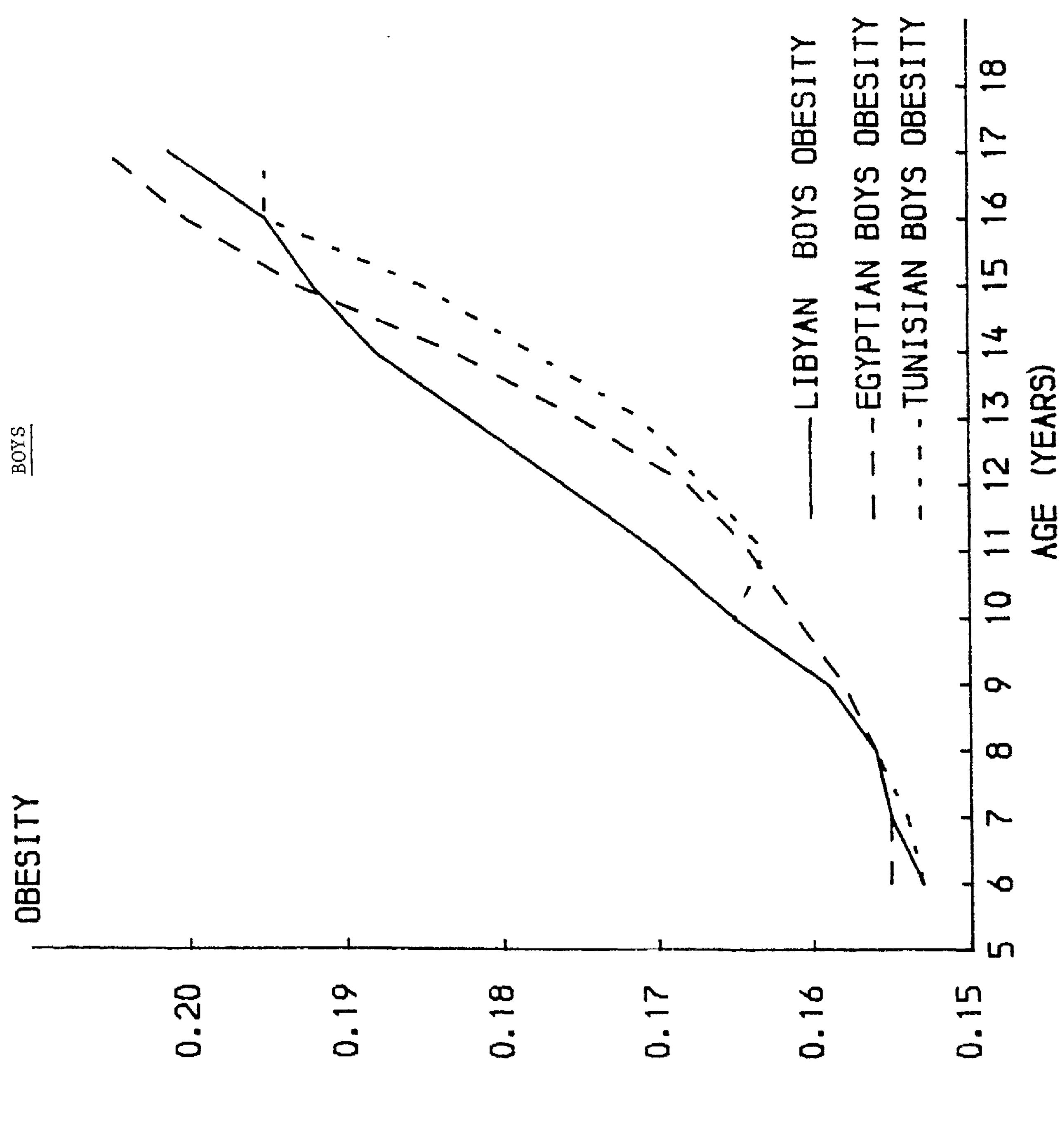


Figure 4.6.5: Mean weight of Libyan, Egyptian and Tunisian girls aged 6 to 17 years.
Source: (Eveleth and Tanner 1976).

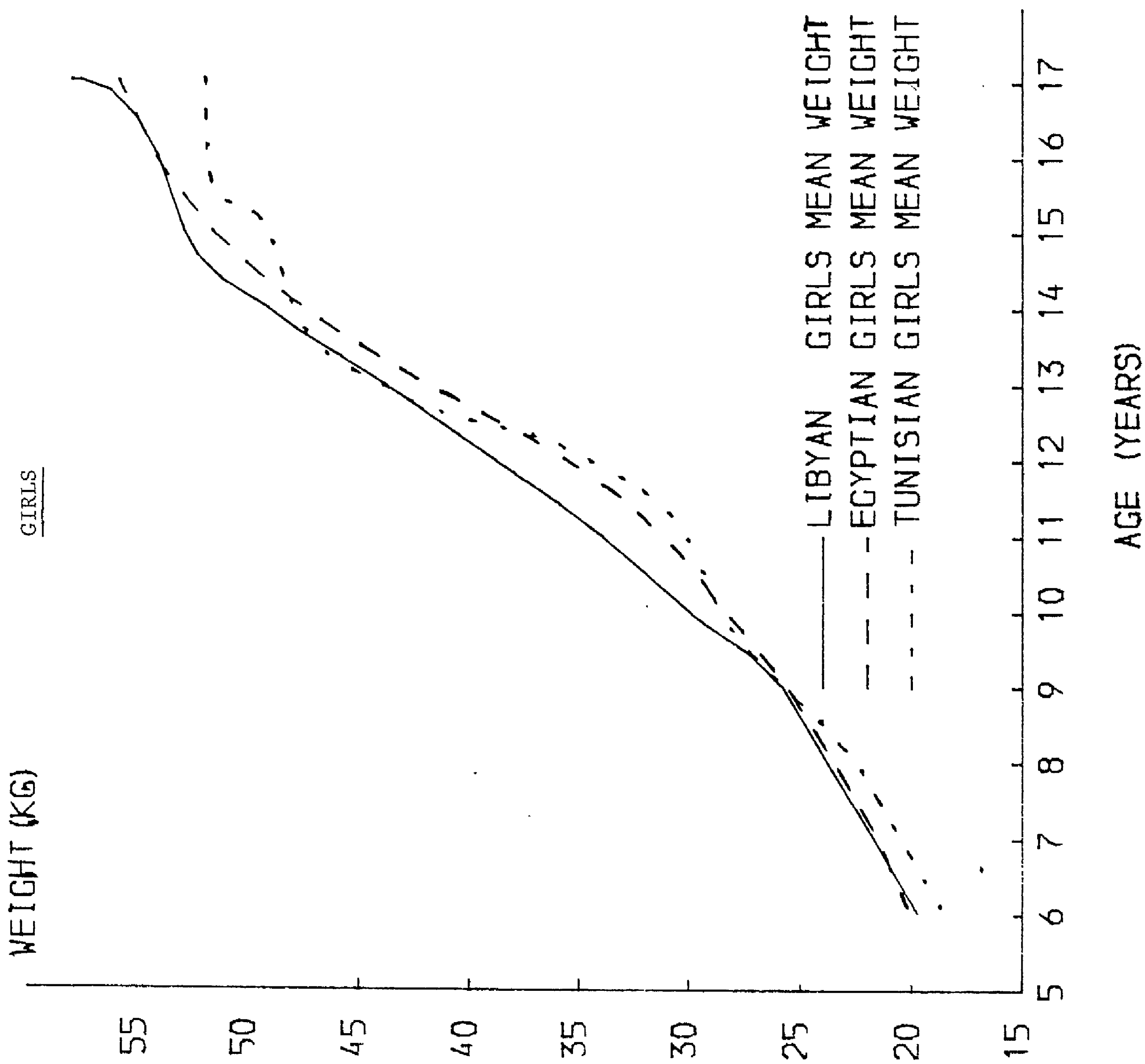
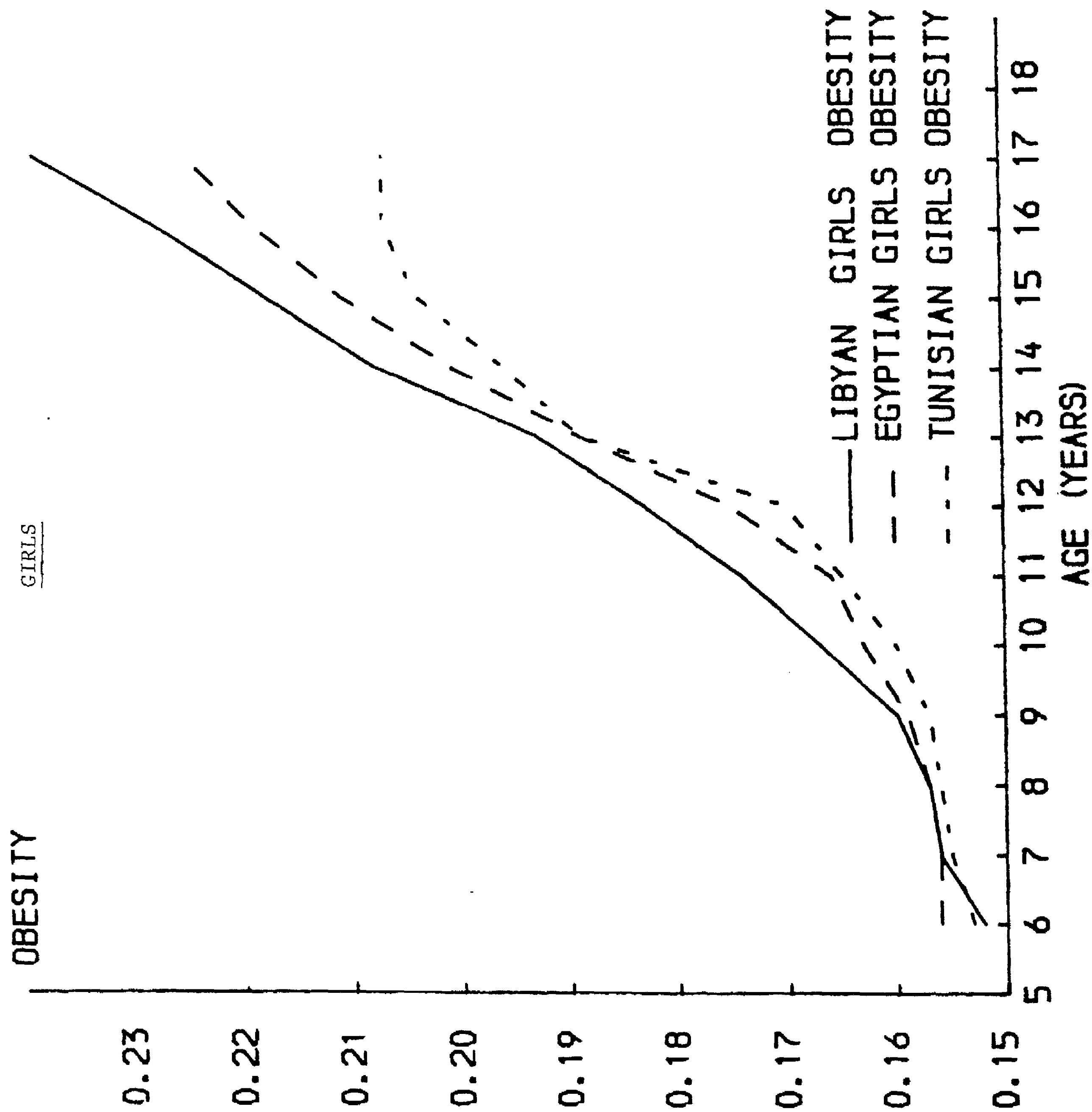


Figure 4.6.6: Obesity of Libyan, Egyptian and Tunisian girls aged 6 to 17 years.



4.7 Skinfold Thickness:

The general pattern of biceps, triceps, subscapular and suprailiac skinfold thickness percentiles is similar for boys and girls up to age 9 years, when the girls' percentiles start increasing gradually with age.

The boys' skinfold percentiles start increasing about 2 years later than girls i.e. at age 11 years, and their increment is sharper than for girls. However, the boys' skinfold percentiles decrease rapidly after puberty, contrary to girls' skinfold percentiles. This is because boys start to develop more muscles and bone during adolescence rather than putting on fat (Tanner, 1962). Also there is a sex difference throughout the biceps, triceps, subscapular and suprailiac skinfold thickness, where girls' skinfold percentiles are larger than the boys through all age groups, and this difference increases after puberty. This finding agrees with other workers in this field (Tanner and Whitehouse, 1962; Venrooij, 1978; Cameron, 1977). The suprailiac skinfolds are larger than the other skinfolds for boys and girls.

The Biceps and Suprailiac Skinfold Thickness:

Published data on biceps and suprailiac skinfold thickness are scarce for comparison because of their higher variability. They are the least reproducible skinfolds if repeated measurements are made. (Womersley and Durnin, 1975). The percentiles of biceps skinfold thickness of Libyan boys and girls follow the general pattern of Dutch biceps skinfold thickness percentiles (Venrooij, 1978).

Despite the difference between the percentile values, the girls' biceps and suprailiac skinfold percentiles have a very similar pattern throughout the age groups (Figures 4.3.10, 4.3.12), while the boys' biceps and suprailiac skinfold percentiles are very close up to age 16 years, when biceps percentiles continued decreasing, but the suprailiac percentiles start increasing (Figures 4.3.9 and 4.3.11).

The Triceps Skinfold and Subscapular Skinfold of Libyan boys 1957 and 1983:

It has been said earlier that the study of triceps and subscapular skinfold thickness of Libyan boys aged 6 to 14 years (Ferro-Luzzi,1957) is the only previous Libyan data available which can be used for comparison. It is clear from the data in Tables A11, A12 (Appendix) which are presented in Figures 4.7.1, 4.7.2, that there is a large difference between the percentiles of triceps and subscapular skinfold thickness of 1957 and 1983.

For triceps skinfold it is clear from the figure that the 3rd percentile of 1957 is far behind the 3rd percentile of 1983 through all the age groups. The 50th percentile of 1957 started with the 25th percentile of 1983, and from age 7 years to 12 years it stayed between the 25th and the 10th percentiles of 1983, and by age 14 years it reached about the 10th percentile of 1983. The difference is very large between the 97th percentiles and 1957 and 1983.

The subscapular skinfold percentiles have a similar pattern to those in triceps skinfolds. There is a large difference between the percentiles of subscapular skinfolds in the two studies. This difference between the triceps and subscapular skinfolds of Libyan boys at 1957 and 1983 can be attributed to nutritional, health, and educational factors which are controlled by national income (see Section 1.7). It is well known that income influences the physical growth of people. This comparison between the two studies of Libyan children when the national income was very low in the 1950's and nowadays when the income is improved, is supporting what others found (Ferro Luzzi, 1962; Boutourline et al., 1972; Eveleth and Tanner, 1976); that there is a relation between the economic levels of a country and the thickness of skinfolds (which are used as an index of obesity by some workers (Seltzer et al.,1965; Durnin et al.,1967; Colley 1974 and Garn et al., 1981) in the anthropometric field).

Triceps and Subscapular Skinfolds of Libyan and English Children:

The triceps and subscapular skinfold thickness of Libyan children in this study will be compared with the triceps and subscapular skinfolds of English children (Cameron, 1977). Figures 4.3.13 and 4.3.14 show the percentiles of triceps skinfold thickness for boys and girls respectively, with the 3rd, 50th and 97th percentiles of English triceps skinfold thickness standards.

For boys' triceps skinfold, the English 3rd and 50th percentiles are slightly higher than the Libyan 3rd and 50th percentiles up to age 11½ years, when the Libyan 3rd and 50th percentiles exceeded the English 3rd and 50th percentiles through the ages up to age 16 years when they become about the same.

For the girls' triceps skinfold, the 3rd and 50th percentiles are similar to the boys' percentiles except that the differences between the Libyan and the English 3rd and 50th percentiles increase with age. For the 97th percentiles there is a small difference before age 11 years, then the Libyan 97th percentile exceeds the English 97th percentile. The difference between the Libyan and the English standards after age 12 years is, as mentioned in Section 4.6, probably

Figure 4.7.1: Percentiles of Triceps skinfold thickness of Libyan boys aged 6 to 14 years at 1957 and 1983.

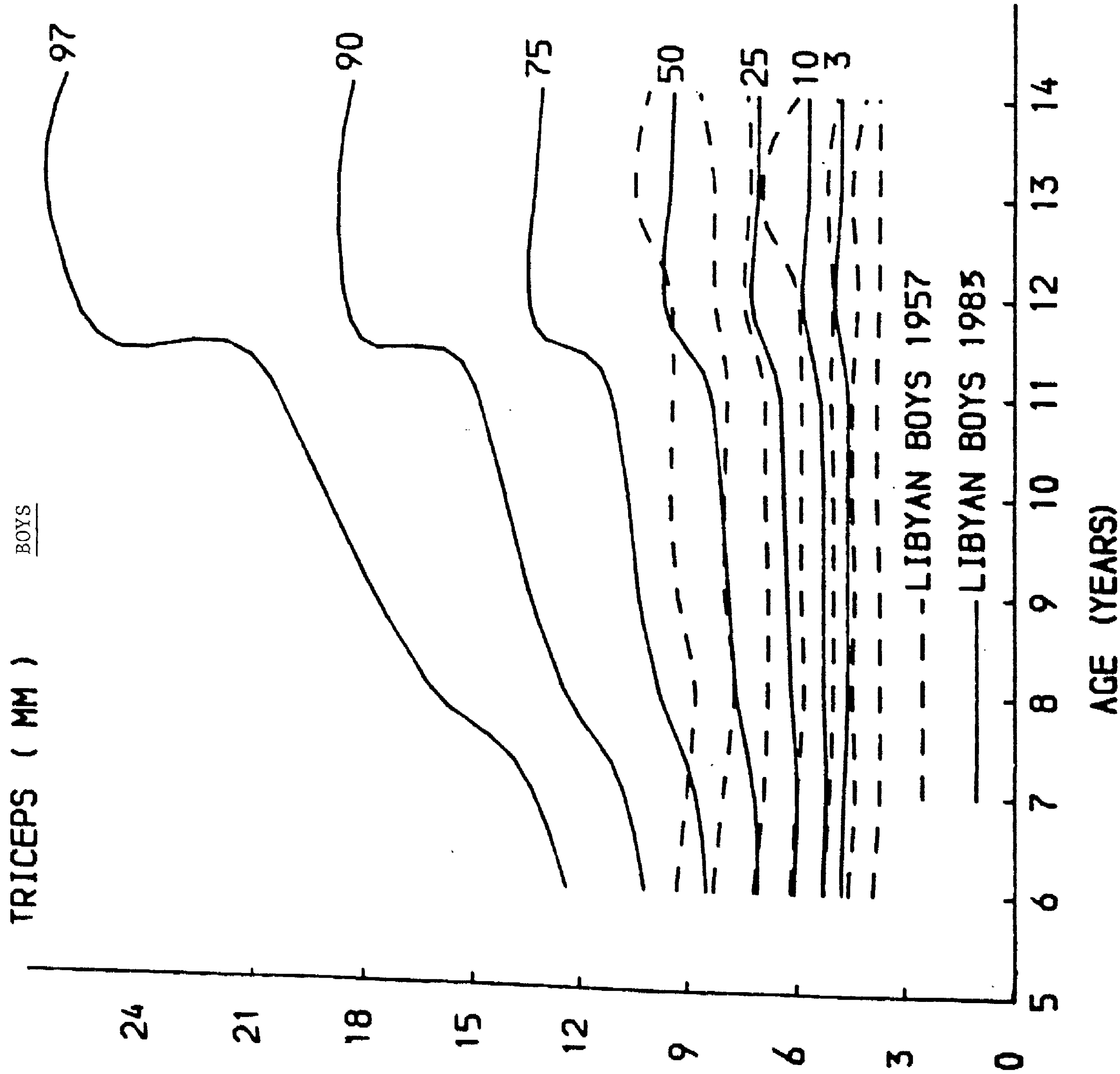
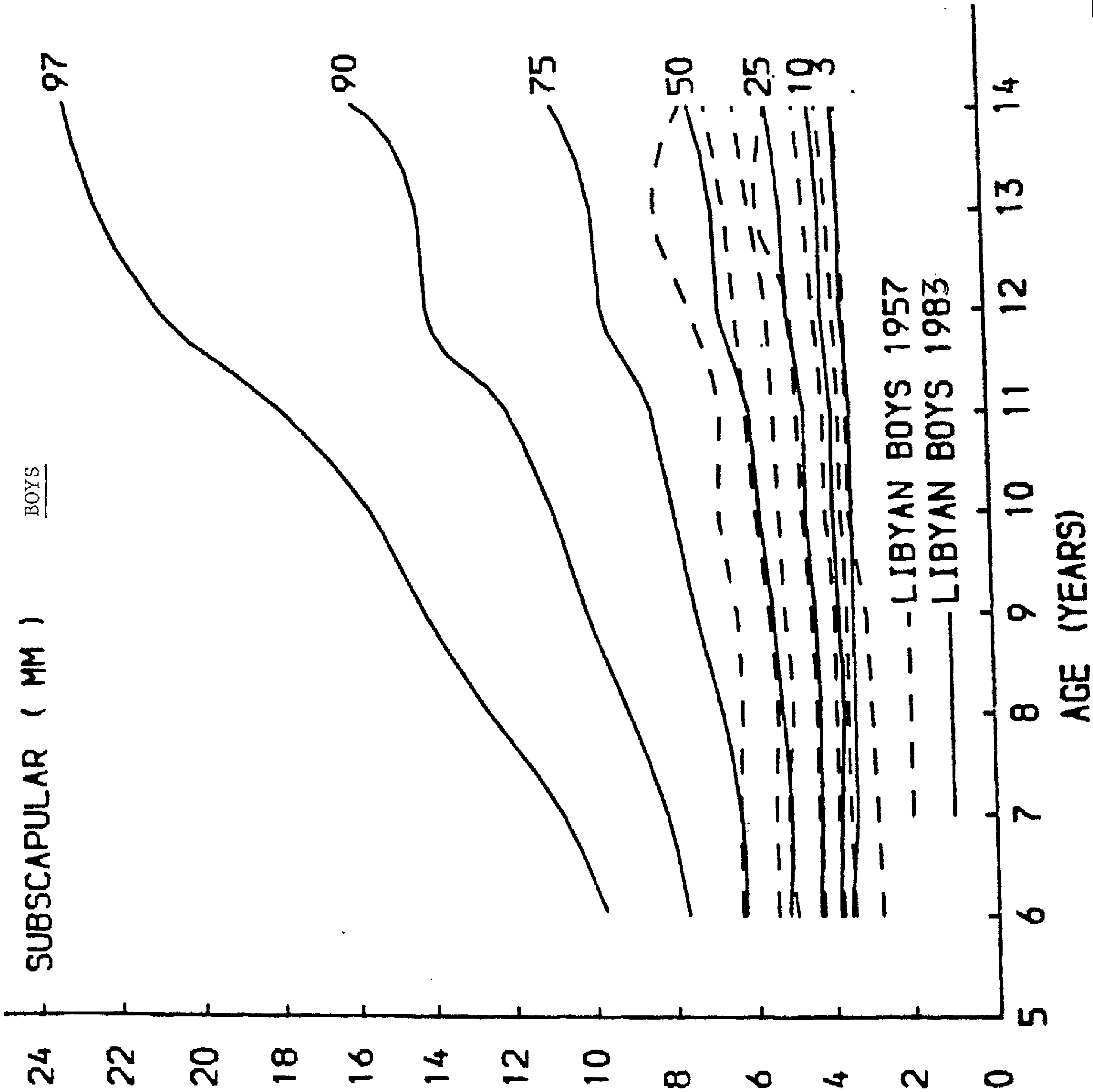


Figure 4.7.2: Percentiles of subscapular skinfold thickness of Libyan boys aged 6 to 14 years at 1957 and 1983.



due to lack of exercise for Libyan girls because of the social habits and also due to the type of food and climate for both boys and girls.

The subscapular skinfold thickness is shown in Figures 4.3.15 and 4.3.16 for boys and girls respectively with the 3rd, 50th and 97th percentiles of English subscapular skinfold thickness standards. For boys subscapular skinfold, the Libyan and English 3rd percentiles are very close up to age 9 years when the English 3rd percentile becomes closer to the Libyan 10th percentile and they are superimposed up to age 15 years. The English 3rd percentile reached about the Libyan 25th percentiles at age 17 years. The Libyan 50th percentile is slightly higher than the English 50th percentile up to age 15 years, when the English 50th percentile exceeded the Libyan 50th percentile and reached about the Libyan 75th percentile by age 17 years. The Libyan 97th percentile is higher than the English 97th percentile and by age 11 years, they become very close. At age 12 years the English 97th percentile starts decreasing up to age 14 years then starts increasing. The Libyan 97th percentile continued increasing after age 12 years up to age 15 years, then started decreasing sharply until it crossed the English 97th percentile at age 16 years. This indicates that obesity is more common in Libyan boys than in English boys.

For girls' subscapular skinfold, there is very little difference between the Libyan and English 3rd percentiles throughout the whole age range. The Libyan and English 50th percentiles are very close to each other up to age 12 years when the Libyan 50th percentile exceeds the English 50th percentile and the difference between them is increased with age. The English 97th percentile is a little higher than the Libyan 97th percentile up to age 10 years, then the Libyan

97th percentile becomes larger and the difference increases with age up to age 17 years.

The girls' subscapular skinfold thickness percentiles show a similar pattern to the triceps skinfold thickness percentiles, which is not the case with the boys's subscapular skinfold thickness.

In summary, the pattern in both boys' and girls' triceps and subscapular skinfold thicknesses agrees with the pattern observed for the heights and weights earlier, and indicates that there is more obesity among Libyan children than among English children, especially girls.

4.8 Mid-Upper-Arm and Maximum Calf Circumferences:

There is no difference between the mean arm circumference of boys and girls up to age 9 years, then the girls' mean arm exceeds the boys' mean arm through all the age groups. The maximum difference was 1.6 cm at age 14 years, decreasing gradually to 1.1 cm at age 17 years. The mean of maximum calf circumference has the same sex pattern as mid arm circumference. The maximum difference between boys and girls is 1.3 cm at age 14 years and is 0.3 cm at age 17 years.

The Libyan and English Mid-Upper Arm and Maximum Calf Circumferences:

The English mid-upper-arm circumference and the maximum calf circumference (Cameron, 1977) are used for comparison with this study.

From Figures 4.4.5 to 4.4.8, it can be seen that the relationship between the English and Libyan standards is similar for both boys' and girls' arm and calf circumferences. The English 3rd percentiles of arm and calf circumferences are near to the Libyan 10th percentiles of arm and calf circumferences throughout the whole age group. The English 50th percentiles of arm and calf are a little bit higher than the Libyan 50th percentiles of arm and calf, and the difference is increasing as age increases for boys, but for girls, the difference decreases as age increases, probably because the Libyan girls are getting fatter by this time. The Libyan and English 97th percentiles of calf circumferences are very close through all the age groups, but for arm circumference from age 12½ years on, the Libyan 97th percentiles are larger than the English 97th percentiles for both boys and girls.

It can be said that the English 3rd and 97th percentiles are close to fitting the Libyan 10th and 97th percentiles for arm and calf circumferences for both boys and girls, but the English 50th percentiles are a bit higher than the Libyan 50th percentiles of arm and calf circumferences for both boys and girls.

4.9 Summary:

From the cross-sectional growth study of Libyan school children in 1983, it is concluded that:

(1) there are differences between the English standards which are currently in use in Libya, and the results of this study for all of the anthropometric variables studied which provides strong evidence against the use of the English standards in assesing the growth of Libyan children aged 6 to 17 years. The use of local standards based on the 1983 survey is recommended as an alternative to the English standards.

(2) there is a significant difference in the distribution of Libyan boys' skinfold thickness between the 1957 and 1983 studies, which confirms the improvement in the nutrition, health, education and income levels in Libya during this period of time.

(3) the distributions of height and weight of Libyan children aged 6 to 17 years are similar to those of the neighbouring Arabic countries of Egypt and Tunisia.

CHAPTER FIVE

VELOCITY STANDARDS

5.1 Introduction:

Distance growth standards, as presented in Chapter 4, are more commonly used than velocity standards especially in applications in community medicine such as maternity and child health centres and school health centres. However, distance and velocity standards are complementary and both are required for a full understanding of the growth process and for assessing both size and rate of change.

Distance standards tell us about the size attained at a particular age, but they tell us nothing about the individual's rate of growth (velocity), although they give us an estimate of the mean rate of growth of a population. They tell us nothing about the variability of the individual's rates around the population mean.

The velocity standards differ from the distance ones in that in velocity standards a child does not have the same strong tendency to stay in the same percentile position from one age to another. There is a tendency for a child to move from a position in the outer percentiles in one year towards a more central position in the subsequent year. (Tanner et al. 1966).

In clinical applications, specialists can make use of velocity standards in addition to distance standards, because pathogenic factors will usually affect the rate of growth directly and the earliest diagnosis of abnormality will be made by reference to the velocity standards (Tanner, 1951; Tanner, 1962; Eveleth et al. 1976).

For these reasons one of the objectives of this study, as mentioned in Section 1.5, was to establish growth velocity standards for Libyan school children, and the 1984 follow-up survey was carried out for this purpose.

In this follow-up survey there were 4795 Libyan school children, 2190 (46%) boys and 2605 (54%) girls, whose growth velocities will be presented and discussed in this chapter. The Libyan growth velocity results will then be compared with:

(1) English Height and Weight Velocity Standards (Tanner et al., 1966).

(2) Dutch skinfold thickness velocity (Venrooij, 1978).

(3) Dutch arm and calf velocity (Venrooij, 1978).

5.2 Choice of Standards from Other Countries for Comparison:

The 1984 survey was the first follow-up growth survey in Libya, and therefore it contains the only growth velocity data available for Libyan school children. Among Arabic countries, the Sudanese growth velocity data (Sukkar et al., 1980; Kemm, 1982) are the only growth velocity data available. Even these studies gave only a graphical representation of growth velocity. Numerical values were only published for arm circumference velocity.

The English velocity standards given by Tanner et al. (1966) were only for height and weight. Cameron (1977) in his thesis, gave the mean and standard deviations of height, weight, arm and calf circumference and triceps and subscapular velocities. Because we used the English distance standards for comparison with Libyan distance standards in Chapter 4 (Tanner et al., 1966), it seems best to compare the Libyan height and weight velocities with the English height and weight velocity standards based on the same study.

For skinfold and arm and calf circumference velocities Cameron (1977) gave only the mean values of triceps and subscapular skinfold and arm and calf circumference velocities and did not give the median. In our study skinfolds and arm and calf circumference velocities are not normally distributed, but are positively skewed in many age groups (Tables D9-D12, Appendix) and so it was thought appropriate to quote percentiles rather than mean and standard deviation. Hence the percentiles of Libyan biceps, triceps and subscapular skinfold and arm and calf circumference velocities (Figures 5.3-14) are compared with the 50th percentiles of Dutch skinfolds and arm and calf circumference velocities published by Venrooij (1978).

5.3 Distance Standards: Comparison between the 1983 and 1984 Surveys:

The distance medians of the anthropometric variables for both the first and the follow-up surveys for boys and girls are shown in Tables 5.3.1, 5.3.2, to check whether the distance results from the follow-up survey are compatible with the distance results from the first survey. The age-grouping used in the tables refers to the age of the children at the time of the first survey. Thus for comparison of distance results the median value for age group 7 years in the first study should be compared with that for age group 6 years in the follow-up survey, and the median value for age group 8 years in the first survey should be compared with that for age group 7 years in the follow-up survey, and so on. The results in the two surveys are very similar for weight and arm and calf circumference, and acceptable, but more variable for skinfold thicknesses which are known to be subject to greater measurement error. However for height there is a large difference between the medians in the two surveys for the same age group. This suggests that there may be an error in the measurement of height, and possible sources of error will be discussed in Section 5.5.

Table 5.3.1: Comparison of the Median Values of Anthropometric Variables in the First and Follow-up Surveys

BOYS

Age Group	Height (cm)		Weight (Kg)		Biceps (mm)		Triceps (mm)		Subscapular (mm)		Suprailiac (mm)		Arm (cm) Circumference		Calf (cm) Circumference	
	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up
6	115.2	124.0	20.2	22.5	4.8	4.3	7.1	7.0	5.3	5.6	4.8	5.5	17.0	17.4	23.4	24.0
7	118.2	126.1	22.0	24.3	4.7	4.5	7.2	7.6	5.2	5.5	4.8	5.8	17.0	17.5	23.5	24.8
8	123.6	133.1	23.8	27.3	4.4	4.4	7.5	7.8	5.3	5.6	5.2	6.0	17.5	18.3	24.5	26.0
9	128.0	135.7	26.1	28.8	4.7	4.8	8.0	8.2	5.4	6.2	5.8	6.4	18.1	18.7	25.4	26.5
10	133.7	141.8	29.3	31.7	4.5	4.6	8.0	8.0	5.8	6.0	6.2	6.4	18.6	19.5	26.2	27.3
11	137.8	146.3	31.8	35.7	4.6	4.6	8.2	8.8	6.0	6.4	6.3	6.7	19.3	20.2	27.5	28.7
12	142.1	151.5	35.3	39.4	5.0	5.0	9.2	9.4	6.2	7.2	7.0	7.6	20.2	21.2	28.7	29.8
13	147.0	157.0	38.5	43.3	5.0	4.8	9.2	9.2	6.8	7.2	7.2	7.8	21.0	22.0	30.0	31.0
14	152.5	162.7	43.6	47.2	4.8	4.2	9.0	8.6	6.8	7.0	7.8	7.8	22.0	22.5	31.0	31.8
15	160.0	169.0	48.3	53.1	4.4	4.2	8.2	8.0	7.0	7.6	7.5	7.8	22.5	23.6	32.2	33.2
16	165.1	171.9	53.1	55.2	4.0	4.0	7.6	7.8	7.3	7.4	7.7	7.8	23.6	24.2	33.0	33.4
17	166.8	173.0	55.3	57.5	4.0	4.0	7.5	7.8	7.5	8.0	7.8	8.0	24.0	25.0	33.2	34.4

Table 5.3.2: Comparison of the Median Values of Anthropometric Variables in the First and Follow-up Surveys

GIRLS

Age Group	Height (cm)		Weight (Kg)		Biceps (mm)		Triceps (mm)		Subscapular (mm)		Suprailiac (mm)		Arm (cm) Circumference		Calf (cm) Circumference	
	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up	First Survey	Follow up
6	113.5	122.2	19.6	22.2	5.2	4.9	8.0	8.5	5.8	6.0	5.4	6.5	16.5	17.4	22.9	24.0
7	117.7	126.1	21.8	24.0	5.2	5.0	8.6	9.2	6.0	6.5	5.6	6.6	17.3	18.0	23.6	25.0
8	122.8	131.0	23.6	26.0	5.2	5.5	9.0	9.3	6.0	7.0	6.0	7.4	17.5	18.5	24.4	25.4
9	127.4	135.9	25.4	28.5	5.2	5.8	9.0	10.0	6.0	7.0	6.0	7.6	18.0	19.0	25.0	26.5
10	133.3	141.3	29.5	33.3	6.1	6.4	10.8	11.7	7.4	8.3	7.1	9.0	19.0	20.0	27.0	28.2
11	139,4	148.8	33.6	39.0	6.2	7.2	10.5	12.8	7.5	9.7	8.0	10.2	20.0	21.4	27.6	29.5
12	145.5	154.5	38.5	44.5	7.0	8.0	12.1	14.0	8.9	10.4	10.0	11.9	21.0	22.5	29.5	31.2
13	151.0	158.0	44.0	49.0	6.5	8.0	13.0	15.0	10.0	11.9	11.1	12.8	22.0	23.5	31.0	32.4
14	153.7	158.4	49.3	52.3	7.4	8.6	15.0	16.2	12.0	13.6	13.2	14.8	23.5	24.5	32.0	33.3
15	155.5	159.6	51.7	54.3	7.4	9.2	16.4	17.6	12.9	14.2	14.0	15.6	24.0	25.1	33.0	34.1
16	156.0	159.7	53.5	55.5	7.9	9.5	17.4	19.0	13.0	15.8	14.1	17.0	24.9	26.0	33.2	35.0
17	155.6	160.0	55.2	55.0	8.0	9.4	18.0	19.4	14.8	15.2	16.0	16.4	25.4	26.1	33.5	34.6

5.4 Age Grouping and the Calculation of Growth Velocity.

For the purpose of producing growth velocity standards the age of each individual was calculated as the average of his ages at the first and follow-up surveys. This age is called the age-centre for the individual. The age-centres were grouped in one year intervals from 6.00 to 6.99, 7.00 to 7.99 and so on. This grouping was chosen because, with the exception of a few children who are very close to the borderline between two age groups, children whose age at the first survey was between 5.50 and 6.49 years will have an age-centre between 6.00 and 6.99 years and so on. These age-centre groups will be denoted by 6.5, 7.5 and so on.

Table 5.4.1 shows the mean age-centre within each of the groups along with the mean and the range of the time interval between the two surveys for boys and girls. Overall the mean interval between the first and the follow-up survey is 1.00 years with a range from 0.86 to 1.08 years. Johnston et al. (1973) and Cameron (1977) reported ranges of 0.9 to 1.10 and 0.85 to 1.15 years respectively for their velocity standards.

For each anthropometric variable the growth velocity for each individual was calculated by dividing the difference between the measurement at the first and follow-up surveys by the time interval between the two surveys for that individual. This adjustment is required since the time interval is not exactly one year for every individual.

Table 5.4.1: Mean Age-centres and Minimum, Mean and Maximum Time Interval between the Two Surveys

Age Group	Mean Age-centre		BOYS			GIRLS		
	Boys	Girls	Minimum	Mean	Maximum	Minimum	Mean	Maximum
6.5	6.62	6.65	0.93	1.01	1.08	0.99	1.04	1.08
7.5	7.45	7.48	0.93	1.00	1.08	0.98	1.03	1.08
8.5	8.54	8.49	0.86	1.02	1.08	0.88	1.03	1.08
9.5	9.50	9.50	0.86	0.98	1.08	0.88	1.03	1.08
10.5	10.50	10.49	0.86	0.99	1.07	0.88	1.03	1.07
11.5	11.53	11.52	0.86	0.99	1.07	0.98	1.03	1.08
12.5	12.50	12.50	0.86	0.97	1.07	0.96	1.02	1.08
13.5	13.51	13.48	0.86	0.97	1.07	0.96	1.02	1.07
14.5	14.49	14.49	0.88	0.96	1.07	0.95	1.02	1.07
15.5	15.50	15.49	0.88	0.96	1.07	0.95	1.01	1.07
16.5	16.51	16.50	0.88	0.96	1.05	0.95	1.00	1.07
17.5	17.43	17.46	0.88	0.93	1.04	0.95	0.99	1.07

5.5 The Follow-Up Survey Results:

1) Height Velocity:

Table 5.5.1 gives the median height velocity for Libyan and English children. The Libyan median height velocity is higher than the English median height velocity (Tanner et al., 1966; Cameron, 1977) in every age group for boys and girls. The differences range from 2.6 to 5.0 cm/year for boys and 1.6 to 4.5 cm/year for girls. This pattern is not consistent with the distance standards for height presented in Chapter 4 (Figures 4.1.3, 4.1.4) which give no indication of a dramatically different growth rate in Libyan and English children. When taken in conjunction with the discrepancy between the median heights of Libyan children in corresponding age groups in the first and follow-up surveys, this indicates that there is a serious error in the measurement of height in one, or both, of the surveys carried out in Libya.

Possible Sources of Error:

The error in height measurement may be in the first survey, the second survey, or both, and could be due to:

i) a systematic error resulting from a fault in one or both stadiometers.

ii) a systematic error by one or more measurers.

The first survey is thought to be free from measurement errors for the following reasons:

a) the stadiometers which were used in the first survey were new and their counters were checked before use.

b) throughout the first survey there was only one measurer for height and weight. The quality control data from the first survey (Table 2.8.1) give no indication of the presence of any systematic measurer error.

Table 5.5.1: The 50th Percentiles of Height Velocity (cm/yr) for Libyan and English Children by Age and Sex

Age-centre Group	BOYS			GIRLS		
	Libyan	English	Difference	Libyan	English	Difference
6.5	9.0	5.9	3.1	8.6	5.9	2.7
7.5	8.5	5.7	2.8	8.7	5.6	3.1
8.5	8.1	5.5	2.6	8.4	5.4	3.0
9.5	8.2	5.2	3.0	8.4	5.4	3.0
10.5	7.6	5.0	2.6	8.8	5.8	3.0
11.5	8.1	4.9	3.2	8.7	6.3	2.4
12.5	9.1	5.5	3.6	8.2	6.1	2.1
13.5	10.3	7.0	3.3	6.2	4.6	1.6
14.5	10.9	6.8	4.1	4.6	2.1	2.5
15.5	9.0	4.8	4.2	4.4	0.6	3.8
16.5	7.0	2.8	4.2	4.5	0.0	4.5
17.5	6.2	1.2	5.0	4.4	0.0	4.4

Also, if there was any systematic measurer error, it might be expected to appear in weight difference also since the same measurer measured both height and weight. However, this did not happen.

c) Comparison of the results of the first survey with the other distance standards for height as shown in Chapter 4 (Figures 4.5.2, 4.5.3) suggests that the results from the first survey are reasonable.

Hence it was suspected that the error lay in the follow-up survey. The quality control data from the follow-up survey, where two measuring teams were used for height and weight (Table 2.15.1) suggests that there was no systematic error of measurement between the two teams. The height data from the follow-up survey were also analysed separately for the two teams using the "team code" at the top of the data collection sheet (Figure 2.10.1) and the error was found to be present for both teams.

Before the start of the follow-up survey, the digital counters giving the read-out of height had been replaced on both stadiometers and this now seemed to be the most likely source of error. To confirm this suspicion a colleague was asked to check both the stadiometers in Tripoli and there was a systematic error of about 2.0 cm. in each counter. A further computer program was written to subtract 2.0 cm. from every individual's height in the follow-up survey, but the result was unsatisfactory because there were some children (185 in total) whose height velocity was zero or negative, which is unlikely to be true, and indicates the error may not have been of the same magnitude throughout the second survey.

For the above reasons, we believe that there was an error in height measurement in the follow-up survey due to the digital counters on the stadiometers being incorrectly calibrated after replacement and the height velocity results cannot be used.

More work needs to be done in order to construct height velocity standards for Libyan children.

2) Weight Velocity:

The weight velocity distribution is positively skewed in most, but not all, age groups (Table D8, Appendix). This has been found by others (Tanner et al., 1966; Sukker et al. 1980; Kemm, 1982). The weight velocity percentiles were calculated directly by the empirical method without attempting to transform to Normality as was done in Chapters 4 and 6 for the distance standards. The main reason for doing this was that, in contrast with the distance results, the velocity distribution was not positively skewed in all age groups, so that the same transformation could not be applied in all age groups.

The weight velocity percentiles for Libyan boys and girls by age group are given in Table D1 (Appendix) and presented in Figures 5.5.1,2 with the 3rd, 50th and 97th percentiles of English standards for comparison (Tanner et al. 1966). The percentile points were joined by smooth hand drawn lines.

In comparing these weight velocity percentiles with the English weight velocity standards which are in current use in Libya (Tanner et al. 1966) both the studies have the same weight velocity pattern for the pre-adolescent ages (before 10½ years for girls and before 12 years for boys) except for the 97th percentile where the English boys have larger weight velocity than the Libyan boys, while the Libyan girls 97th percentile is larger than that of the English girls of the same age group. Also it is clear from the graphs that after adolescence the

Figure 5.5.1: Percentiles of weight velocity (Kg/year) of Libyan and English boys aged 6-17 years.

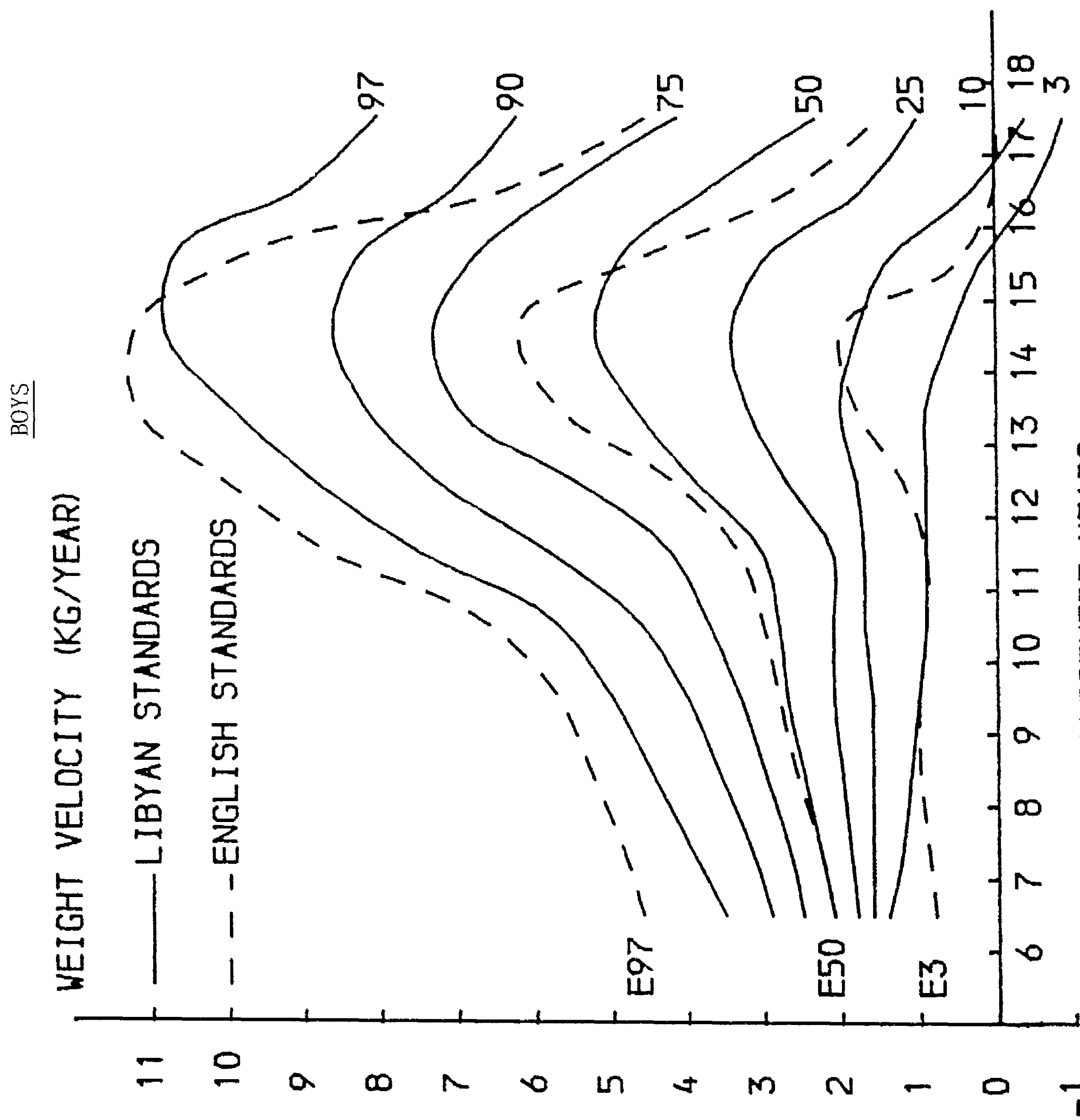
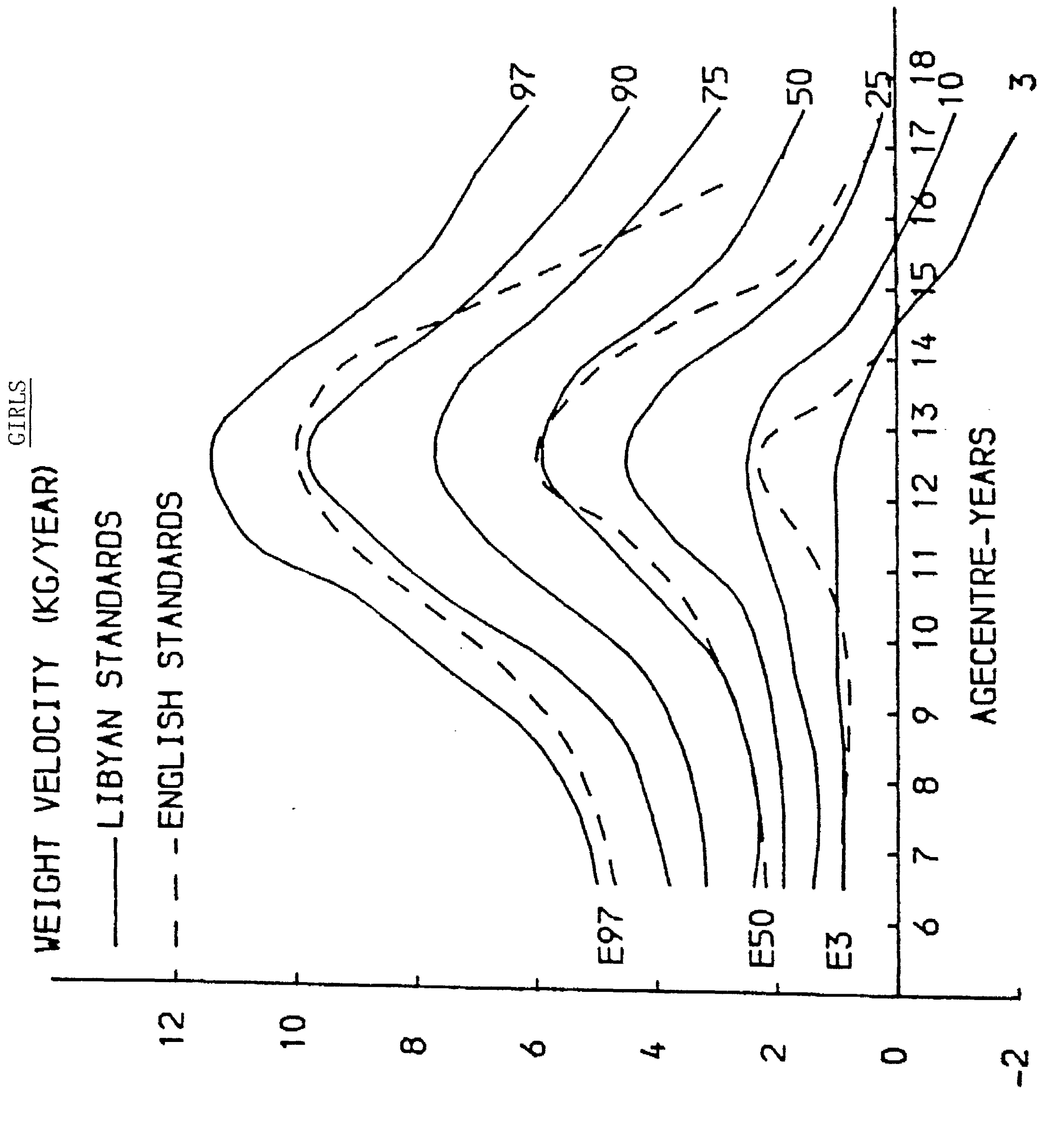


Figure 5.5.2: Percentiles of weight velocity (kg/year) of Libyan and English girls aged 6-17 years.



weight velocity decreases earlier in English girls whose median weight velocity is close to zero after age sixteen years.

3) Skinfold Velocity:

The girls biceps and triceps skinfold velocity distributions were positively skewed in most age groups, while the boys are negatively skewed in some age groups, positively skewed in some age groups and almost symmetrical in others (Tables D9,10, Appendix). The subscapular and suprailiac skinfold velocities for boys and girls are positively skewed in almost all age groups (Tables D11, 12, Appendix).
The empirical percentiles of biceps, triceps, subscapular and suprailiac skinfold velocity of boys and girls are given by age group in Tables D2-5, (Appendix) and presented in Figures 5.5.3-5.5.10 with the Dutch 50th percentiles of biceps, triceps and subscapular skinfold velocity (Venrooij, 1978). No standards were available for comparison with suprailiac velocity percentiles. In all figures the percentile points were joined by smooth hand drawn lines.

It is clear from the graphs that the girls velocity percentiles show larger amounts of fat accumulated by time than boys. This indicates that the girls are less active than boys, especially at adolescence. The boys biceps and triceps skinfold velocities are less than those of the girls during the adolescent period and after, because some of the fat is converted to muscle at this age (Brozek and Keys, 1951; Venrooij, 1978). The Libyan 50th percentiles for biceps, triceps and subscapular skinfold velocity are larger than the Dutch 50th percentiles of the biceps, triceps and subscapular skinfolds velocity for both boys and girls. The reason for this is unknown, but is most likely due to nutritional and environmental factors.

Figure 5.5.3: Percentiles of Biceps Skinfold velocity (0.1mm/yr) of Libyan and Dutch Boys.

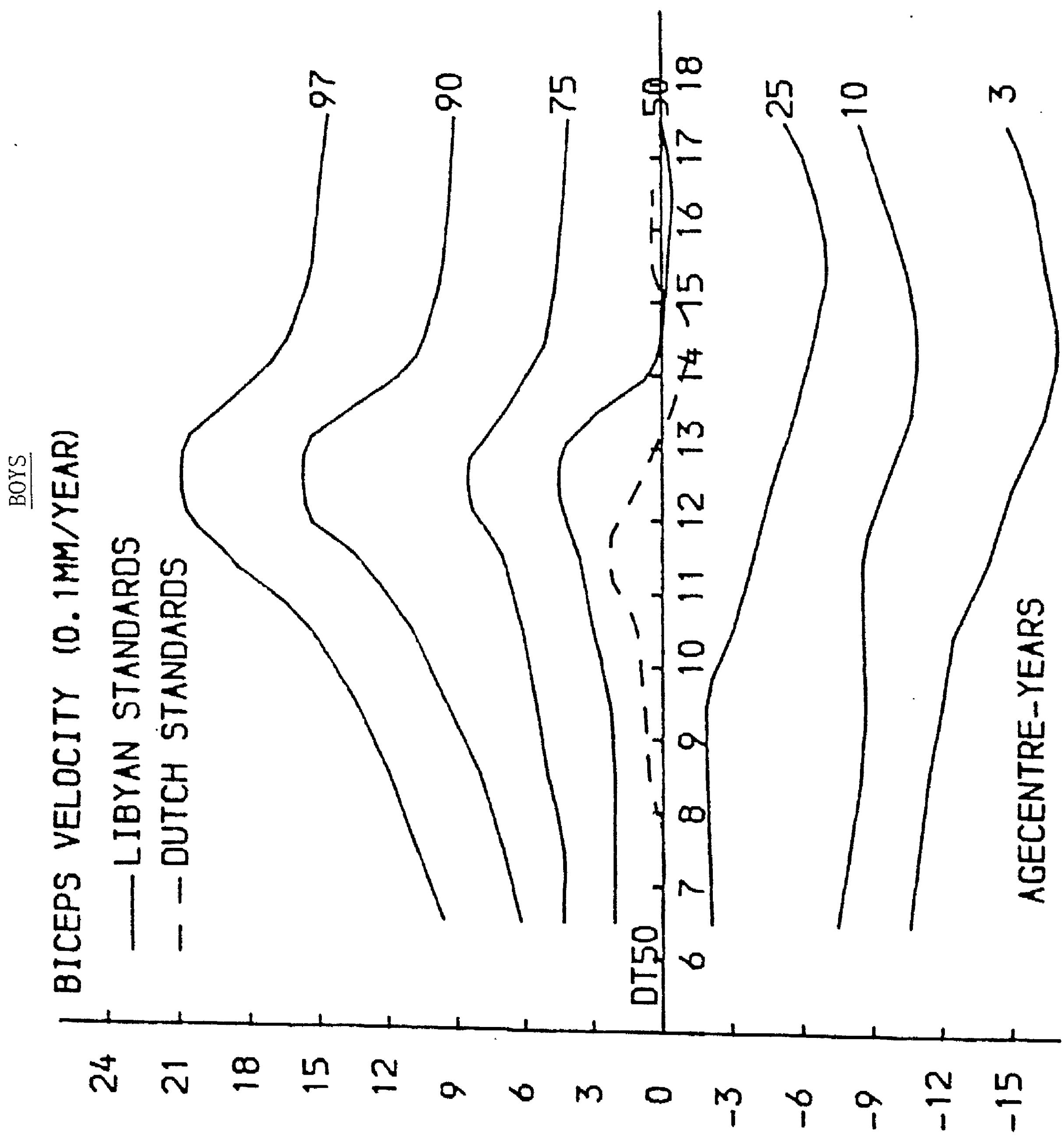


Figure 5.5.4: Percentiles of Biceps Skinfold velocity (0.1mm/y) for Libyan and Dutch Girls.

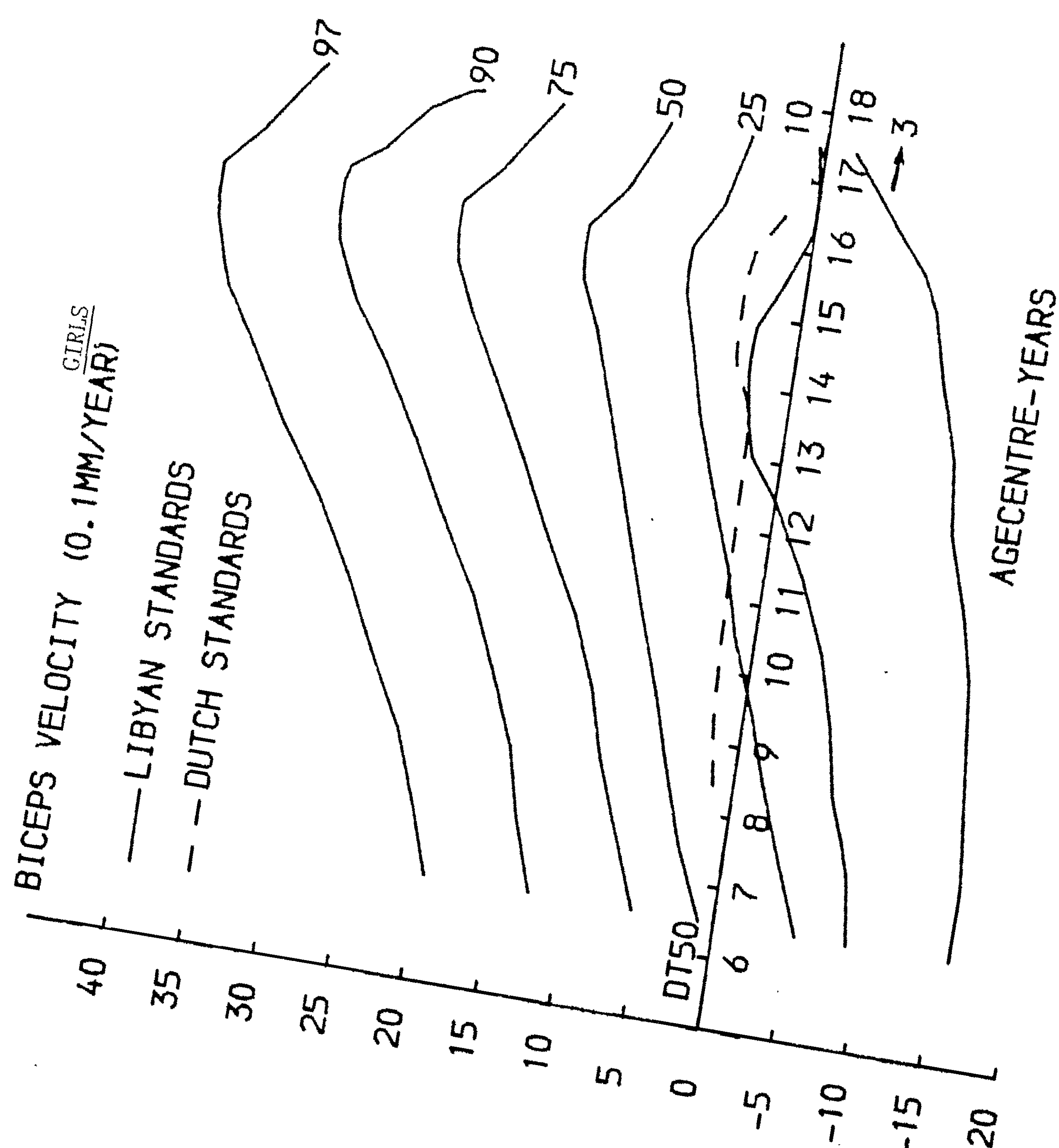


Figure 5.5.5: Percentiles of Triceps Skinfold velocity (0.1mm/y) of Libyan and Dutch Boys.

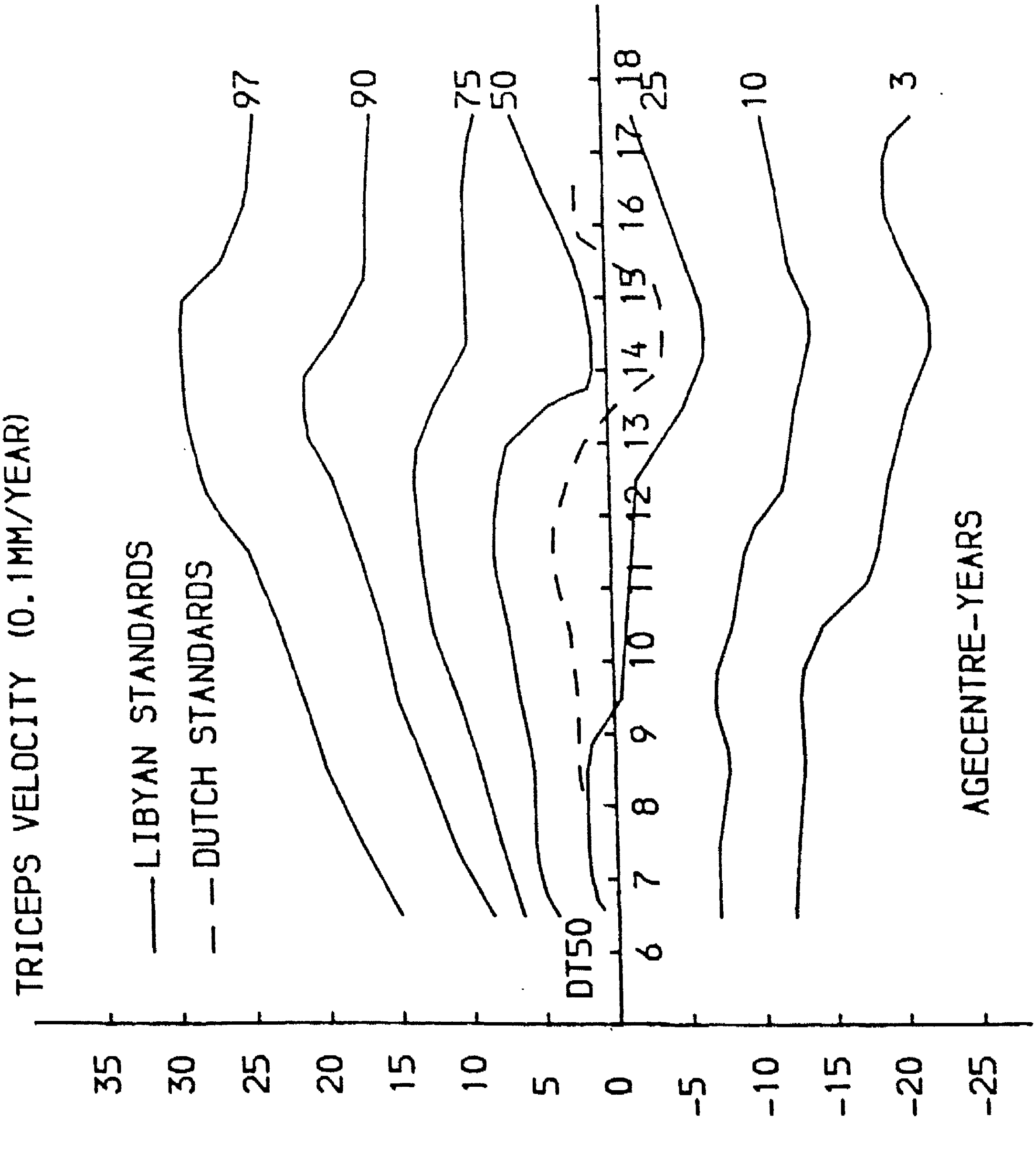


Figure 5.5.6: Percentiles of Triceps Skinfold Velocity (0.1mm/y) of Libyan and Dutch Girls.

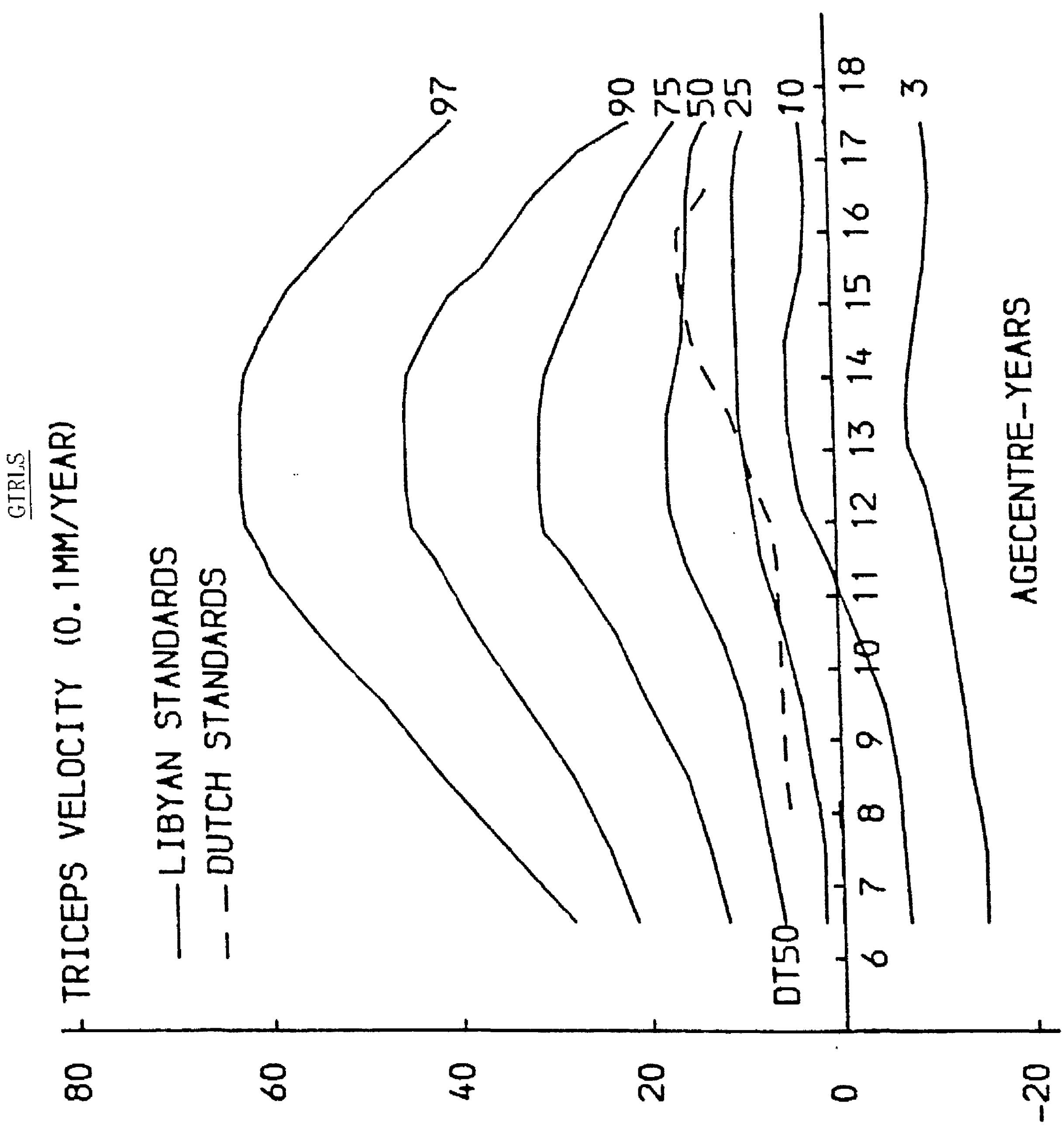


Figure 5.5.7: Percentiles of Subscapular Skinfold Velocity (0.1mm/y) of Libyan and Dutch Boys.

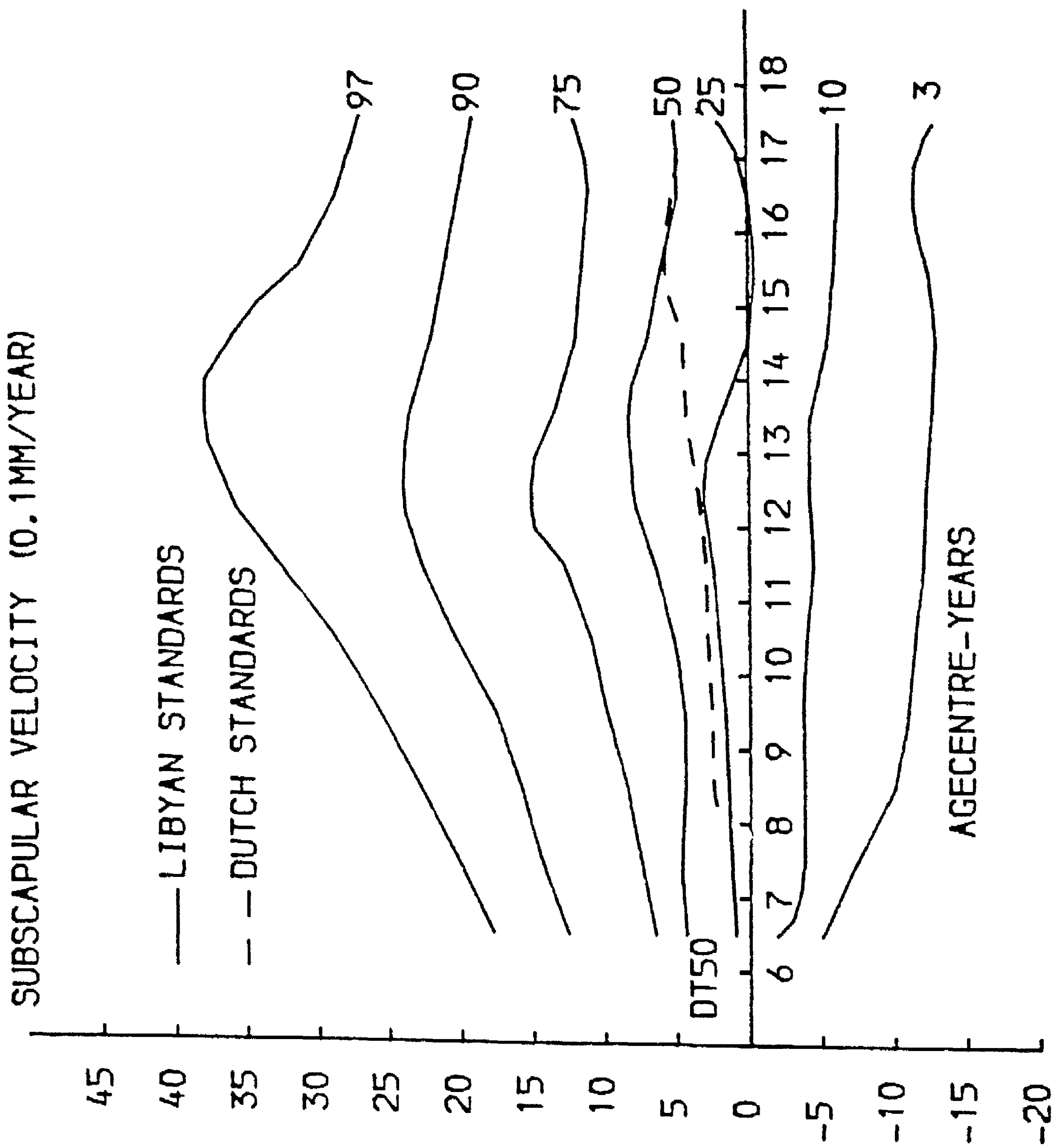


Figure 5.5.8: Percentiles of Subscapular Skinfold Velocity (0.1mm/y) of Libyan and Dutch Girls.

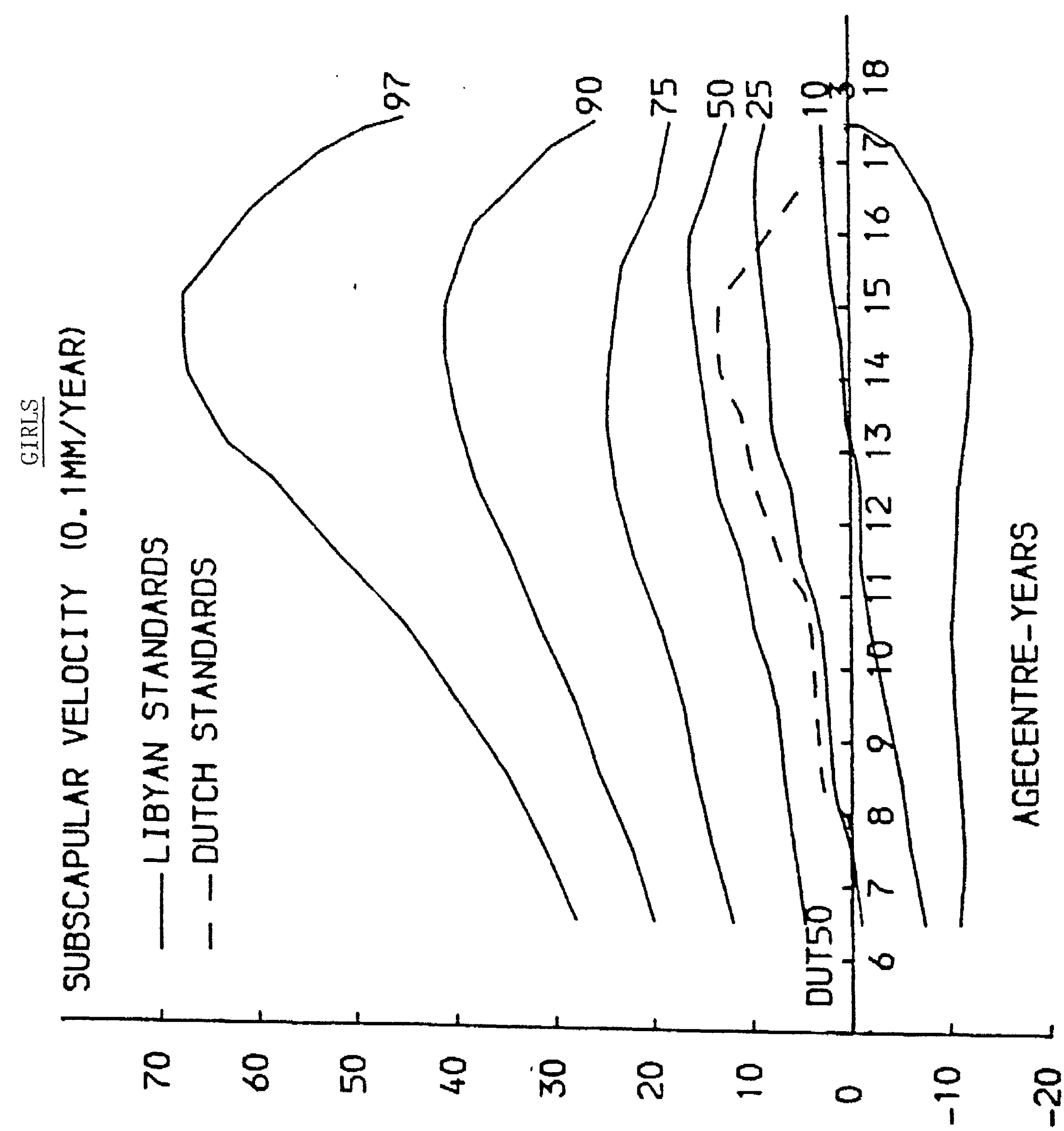


Figure 5.5.9: Percentiles of Suprailiac Skinfold Velocity (0.1mm/y) of Libyan Boys.

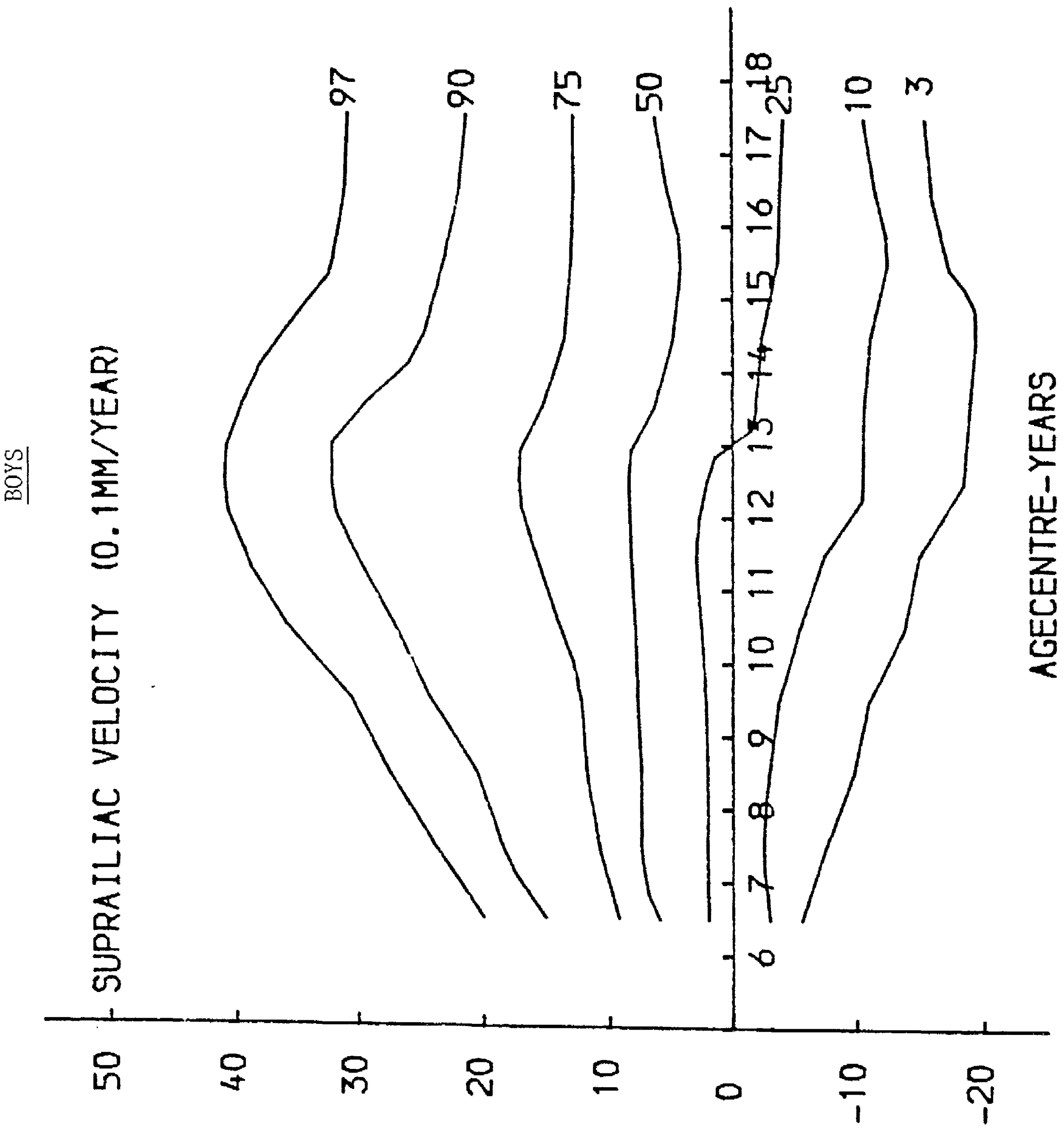
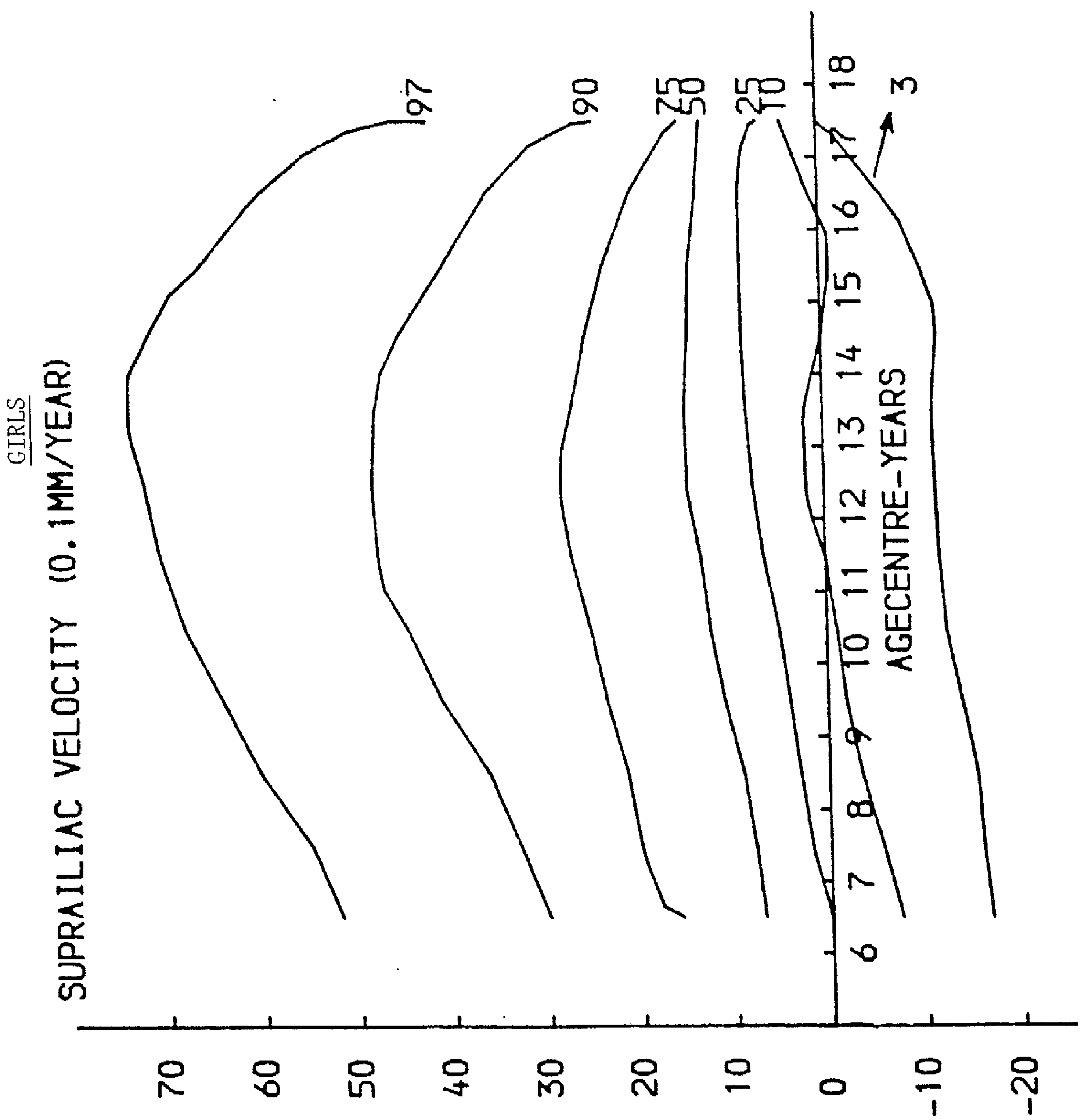


Figure 5.5.10: Percentiles of Suprailiac Skinfold Velocity (0.1mm/y) of Libyan Girls



It is worth noting that all of the skinfold velocities show substantial variation, with large reductions being not uncommon in all age groups for both boys and girls.

4) <u>Arm and Calf Circumference Velocities</u>:

The distributions of arm and calf circumference velocities are positively skewed (Tables D13,14, Appendix). The empirical percentiles of arm and calf circumference velocity are given by age group in Tables D6,7 (Appendix) and are presented in Figures 5.5.11-5.5.14. Also presented for comparison are the 50th percentiles for Dutch children (Venrooij, 1978). From the graphs it is clear that there is a sex difference for both arm and calf velocities, and the girls' peak velocity occurs about one year before the boys.

The Dutch 50th percentiles of arm and calf velocities are less than the Libyan 50th percentiles except for boys' arm velocity where both the 50th percentiles are very close. Thus, as for the skinfold velocities, the Libyan and the Dutch arm and calf circumference velocity standards are different.

Figure 5.5.11: Percentiles of Arm Circumference Velocity (mm/y) of Libyan and Dutch Boys.

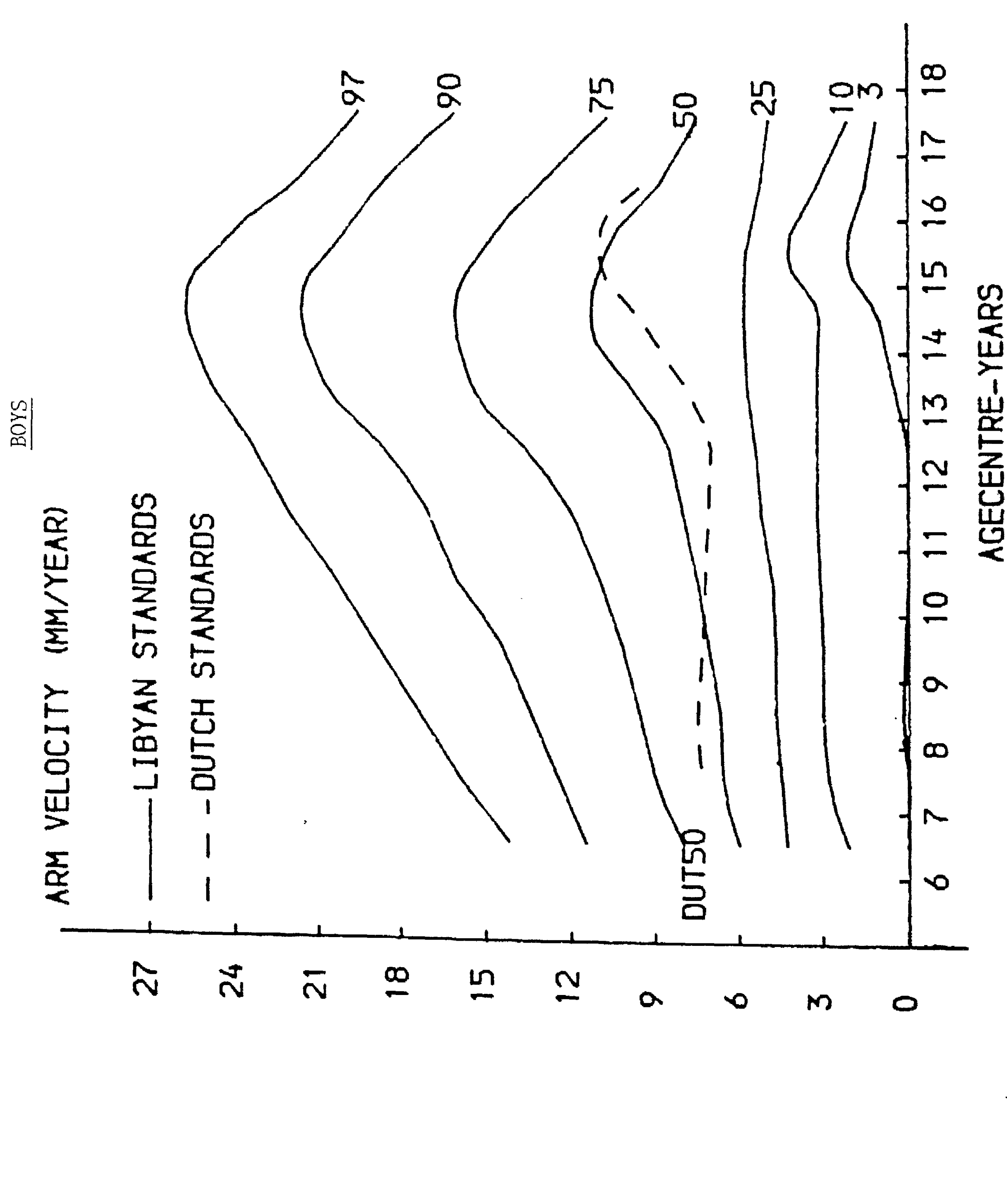


Figure 5.5.12: Percentiles of Arm Circumference Velocity (mm/y) of Libyan and Dutch Girls.

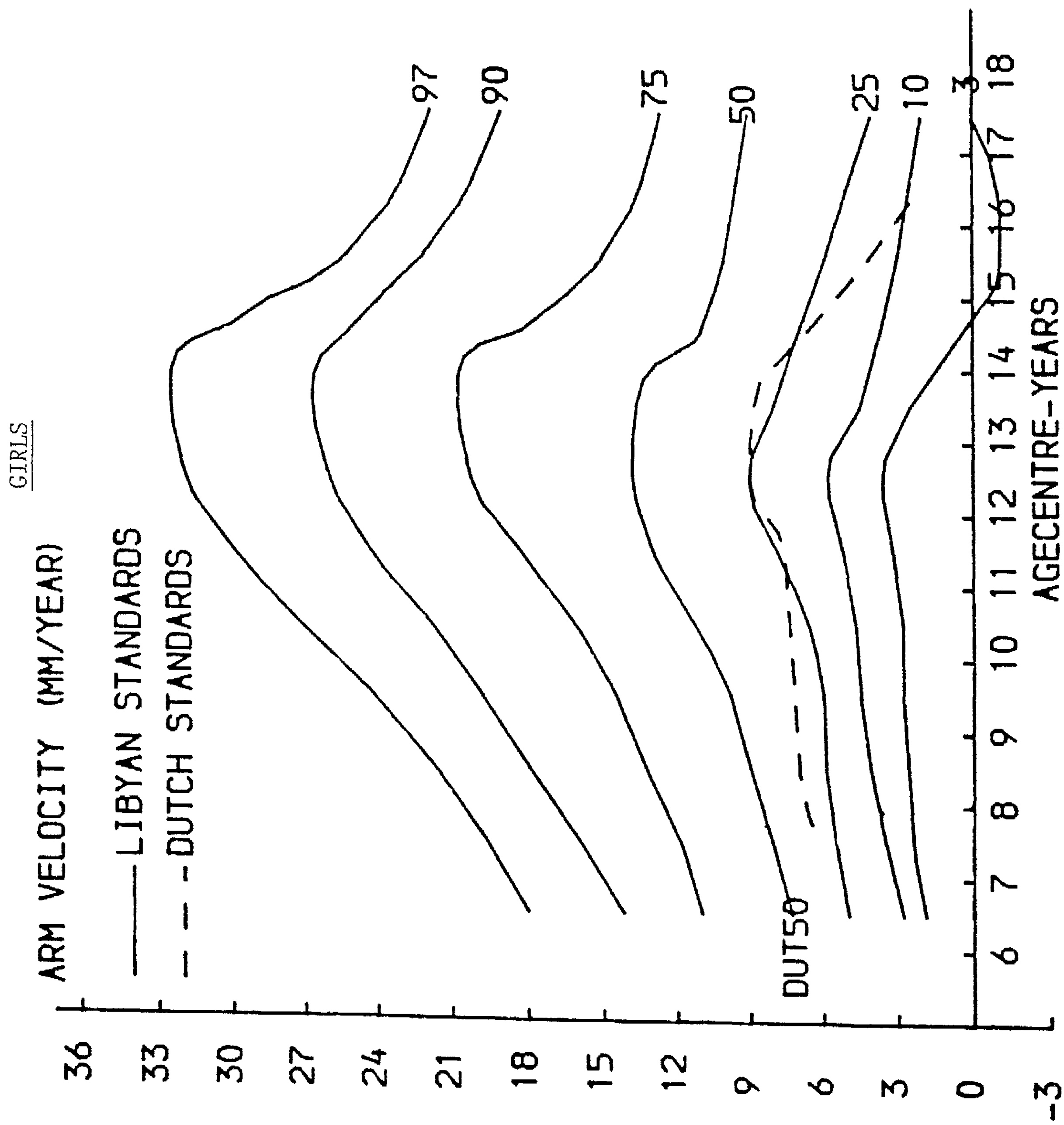


Figure 5.5.13: Percentiles of Calf Circumference Velocity (mm/y) of Libyan and Dutch Boys.

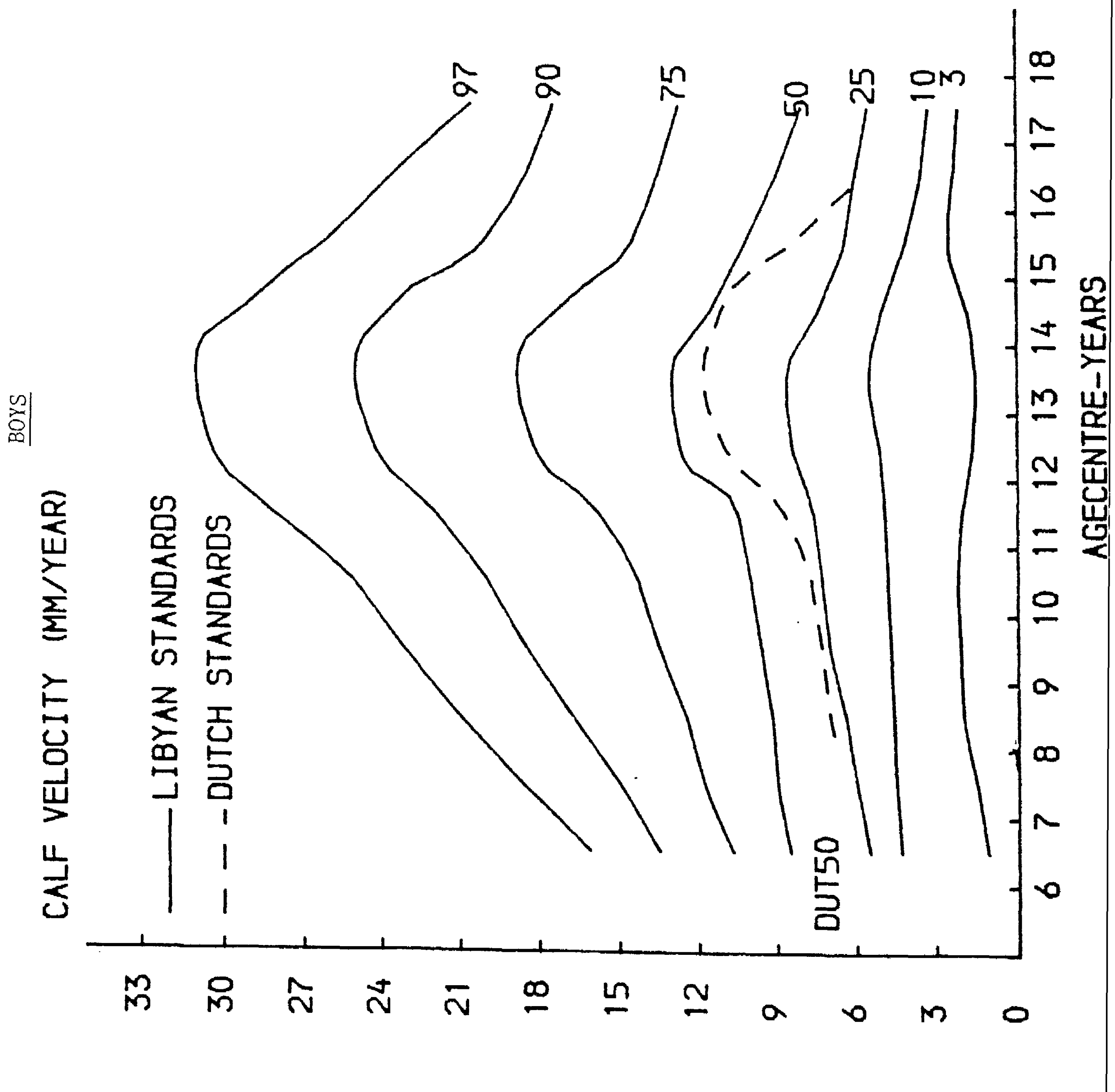
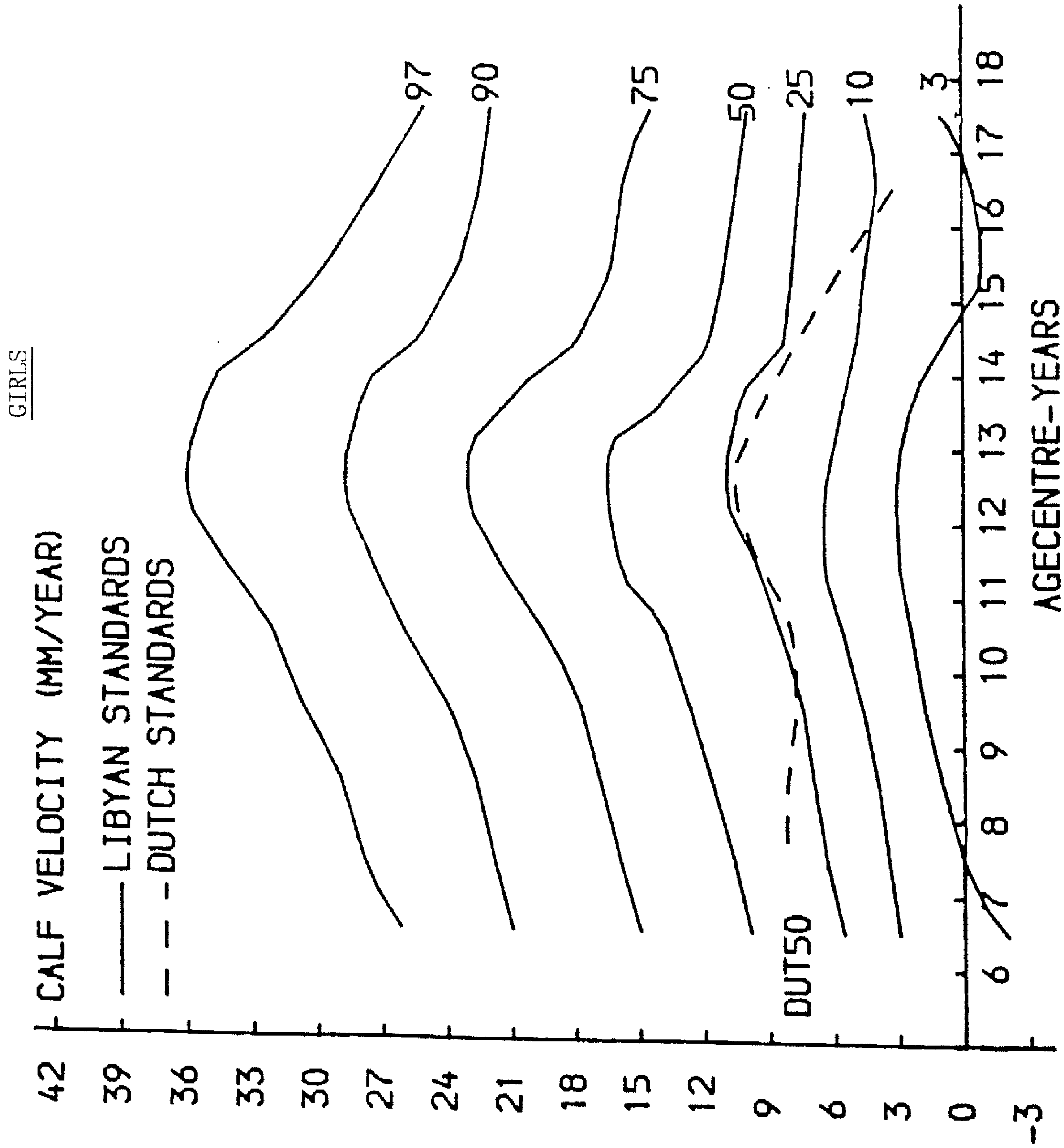


Figure 5.5.14: Percentiles of Calf Circumference Velocity (mm/y) of Libyan and Dutch Girls.



5.6 Summary:

The establishment of local velocity standards is no less important than the establishment of local distance standards, for they are complementary in the assessment of growth and development.

For this reason the 1984 follow-up survey was carried out to provide local growth velocity standards for the people working in the health field in Libya. Unfortunately, the results for height velocity could not be used because of an error in calibration of the stadiometer counters at the start of the follow-up survey, but growth velocity standards have been established for all the other anthropometric variables measured. More work is needed to establish height velocity standards. Comparison between the Libyan and English weight velocity standards showed that although there is little difference between the weight velocity at the pre-adolescent stage, there are quite substantial differences at adolescence and after.

The comparison between Libyan and Dutch velocity of biceps, triceps, subscapular skinfolds and arm and calf circumferences showed that there is a difference between the two studies which is most likely due to nutritional and environmental factors.

These differences demonstrate the need for local velocity standards in addition to local distance standards to replace the English standards in current use in Libya.

CHAPTER SIX

ESTIMATION OF CONSTANTS

6.1 Introduction:

It has been mentioned in Chapter Four that for those anthropometric variables which did not show a Gaussian distribution, a logarithmic transformation was applied to produce as close an approximation as possible to a Gaussian distribution. The logarithmic transformation used was of the form log $(x - c)$ where c is a positive constant. In this chapter, all logarithms will be assumed to be to the base e unless otherwise stated. There does not seem to be any biological explanation for the need for a constant term in the transformation for weight, nor for arm and calf circumferences, but for skinfolds, it can be interpreted as the thickness of the two layers of skin included in the fold (Edwards et al. 1955, Durnin 1984, personal communication).

Weight data has been analysed by some workers without transformation even though it is positively skewed (Stuart and Meredith, 1946; Tanner et al. 1966; Van Venrooij, 1978; Cameron, 1977). Rona and Altman (1977) tried the simple transformation log (weight), but they found it unsuitable, and by using a transformation of the form log (weight - constant), they could significantly improve the fit of a Gaussian distribution to the data. They used different constant values for different age groups for boys and girls separately.

Because of the gross departure of the skinfold thickness distribution from normality, all the workers in the growth field are agreed that a transformation of the form log (skinfold in mm - constant) should be applied. Different values of the constant for skinfold thickness have been suggested. Edwards et al (1955) recommended the use of the value 18 as the constant for all age groups since this could be interpreted as the thickness of two layers of skin, while Rona and Altman (1977) found 15 and 30 were the best constant values for girls and boys respectively aged 5 to 11 years. Kemm (1982) found no single transformation could normalise the distribution of all age-sex subgroups, so he used different constant values for different age-sex subgroups. Durnin (1984, personal communication) suggested 15 as the constant value for both boys and girls skinfolds.

The arm and calf circumference data usually do not show such a large deviation from normality as skinfold thickness. Many workers (Van Venrooij 1978, Cameron 1977, Kemm, 1982) have estimated the arm and calf circumference percentiles without transformation even though the distributions were significantly positively skewed. Both Rona and Altman (1977) and Kemm (1982) used the coefficients of skewness and kurtosis for testing the normality of the distribution of the variables.

For the purposes of deriving the anthropometric standards for each variable presented in Chapter Four, it was decided to use for each variable and for each sex the best <u>single</u> constant value for all age groups. This was done for simplicity and also because of pressure of time, since the author had to return to Tripoli to organise the data collection for the follow-up survey and wished to have some results from the first survey to show to the authorities in Libya.

This chapter presents the method of estimation of the single best constant for each variable, and also assesses whether it was reasonable to use only one overall constant rather than use the best constant for each individual age group.

Firstly, there will be a brief explanation of the theory behind a method of estimation of the constant which has not, as far as we know, been applied by any other workers in this field. The method, using profile likelihood (Kalbfleish, 1979), will be illustrated on the data for some of the variables involved.

6.2 Theory:

If we have n measurements with values $x_1, x_2, \dots x_n$ which come from a normal population with mean μ and standard deviation σ, then the likelihood of the data is

$$Lik(\underset{\sim}{x}/\mu,\sigma) = \prod_{i=1}^{n} \frac{1}{\sqrt{2\pi\ \sigma^2}} \exp\left(-\frac{1}{2}\left\{\frac{x_i-\mu}{\sigma}\right\}^2\right)$$

$$= (2\pi\sigma^2)^{-\frac{n}{2}} \exp\left(-\frac{i}{2}\sum_{i=1}^{n}\left\{\frac{x_i-\mu}{\sigma}\right\}^2\right)$$

The maximum liklihood estimates (M.L.E's) of μ,σ^2 are

$$\hat{\mu} = \bar{x} \qquad , \qquad \hat{\sigma}^2 = s^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

On the other hand if the data require a transformation to Normality of the form $\log(x_i - c)$ then if y_i denotes the observed value for the i^{th} individual the likelihood of the data will be

$$Lik\ (\underset{\sim}{y}/\mu,\sigma,\ c) = (2\pi\sigma^2)^{-\frac{n}{2}} \prod_{i=1}^{n} (y_i - c)^{-1} \exp\left(-\frac{1}{2}\left[\frac{\log(y_i-c)-\mu}{\sigma}\right]^2\right)$$

provided that $\min y_i > c$.

The simplest approach to maximising $Lik(\underset{\sim}{y}/\mu,\sigma,c)$ with respect to μ,σ,c is to treat c as a constant, find the maximised value for the likelihood conditional on this value of c, do this for various values of c and plot the maximised likelihood against c, looking for a local maximum. However, it is easier to work with log-likelihood rather than likelihood itself, and the value of the maximised log-likelihood, conditional on c is proportional to

$$-\ n \log \hat{\sigma}(c) - \sum_{i=1}^{n} \log\ (y_i - c)$$

where

$$\hat{\sigma}(c)^2 = \frac{1}{n} \sum_{i=1}^{n} \{ \log(y_i - c) - \overline{\log(y - c)} \}^2$$

and $$\overline{\log(y - c)} = \frac{1}{n} \sum_{i=1}^{n} \log (y_i - c)$$

Thus it is easiest to plot

$$n \log \hat{\sigma}(c) + \sum_{i=1}^{n} \log (y_i - c)$$

against c and look for a local minimum.

The following steps were used to estimate the value of the constant for each variable for each sex:-

(1) For the j^{th} age group ($j = 1,\ldots,12$) let the constant be c_j, let n_j be the number of individuals, y_{ij} be the observed value for the i^{th} individual ($i=1,\ldots,n_j$) and let

$$L_{min}^{(j)}(c_j) = n_j \log \hat{\sigma}(c_j) + \sum_{i=1}^{n_j} \log (y_{ij} - c_j)$$

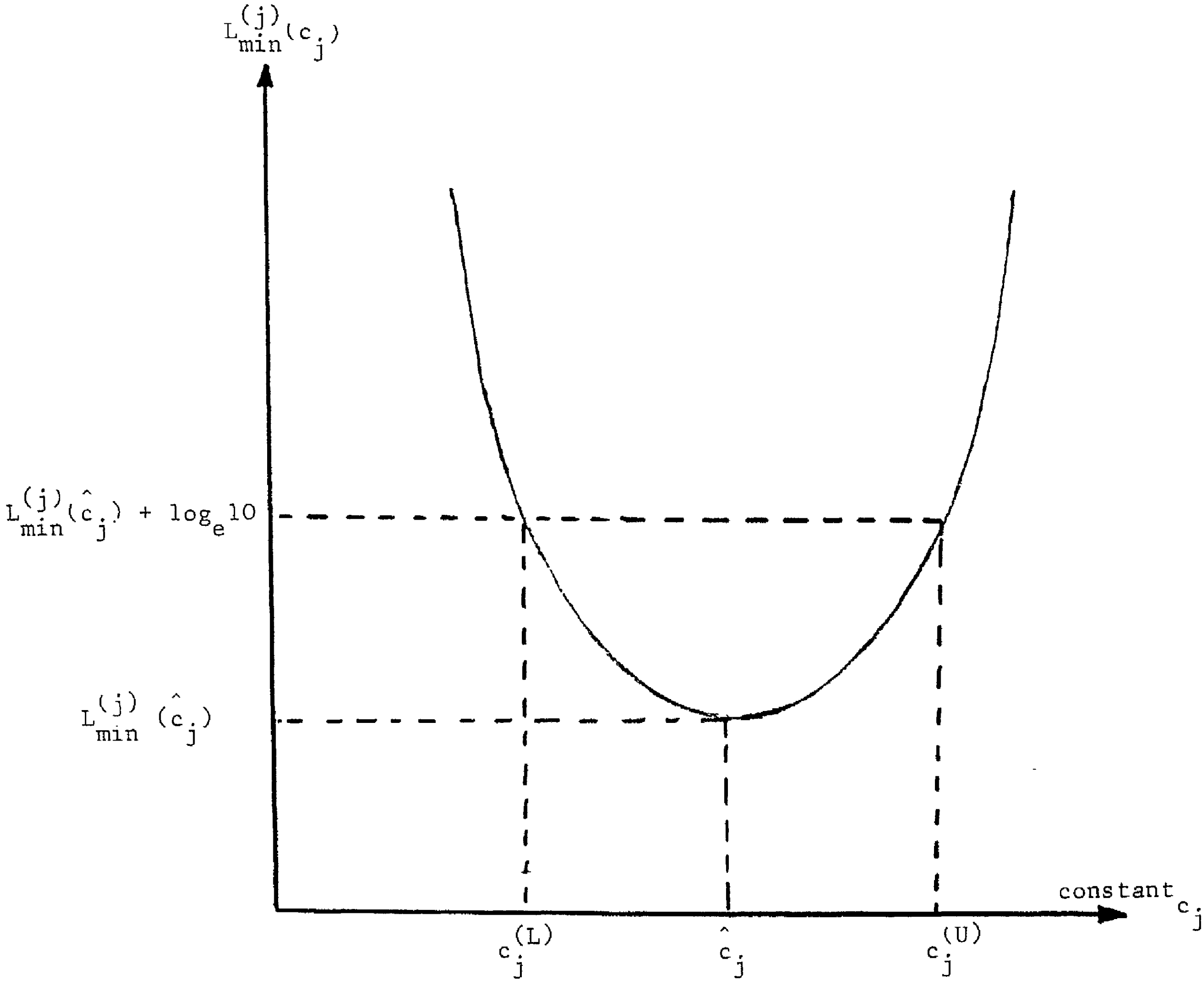
$L_{min}^{(j)}(c_j)$ was plotted against c_j using the MINITAB program shown in Figure C1(Appendix). Figure 6.2.1 presents a sketch of $L_{min}^{(j)}(c_j)$ against c_j.

(2) $\hat{c}_j$ is the best estimate of the constant, and the value of minus the log likelihood at this point is $L_{min}^{(j)}(\hat{c}_j)$.

(3) To find an interval estimate for the constant, $\log_e 10$ is added to $L_{min}^{(j)}(\hat{c}_j)$ (Kalbfleish, 1979) giving $c_j^{(L)}$ and $c_j^{(U)}$ as the lower and upper end points of the interval.

The justification for this is that such an interval will contain all values of the constant for which the likelihood is greater than $\frac{1}{10}$ of its maximum value attained at $\hat{c}_j$. Kalbfleish refers to this interval as a 10% likelihood interval, which provides us with a range

Figure 6.2.1: How the endpoints of the 10% likelihood interval for the constant are calculated graphically.



of plausible values of the constant. This can be thought of as being analogous to an approximate 95% confidence interval for the constant in the log transformation (Kalbfleish p.202).

(4) Compare the interval estimates for the constant for each age group to find the values of the constant, if any, which are common to the intervals for all age groups.

(5) To decide which single value of the constant is best for all age groups, let $L^{(j)}_{min}(c)$ be the value of minus the log likelihood if the value c is used as the constant for the j^{th} age group. Then the best common value of the constant to use for all twelve age groups will be the value $\hat{c}$ which minimises

$$\sum_{j=1}^{12} L^{(j)}_{min}(c) \; .$$

To see if using $\hat{c}$, the best overall value of the constant, provides a significantly worse fit than using $\hat{c}_j$, the best individual estimates from the twelve age groups, use the result that

$$2 \sum_{j=1}^{12} \{L^{(j)}_{min}(\hat{c}) - L^{(j)}_{min}(\hat{c}_j)\} \sim \chi^2(11)$$

6.3 An Illustration and Results:

It is helpful to use an example from the actual data to illustrate how the constant values were estimated.

In the following example the boys' weight for age group 4 (9 years) will be used:-

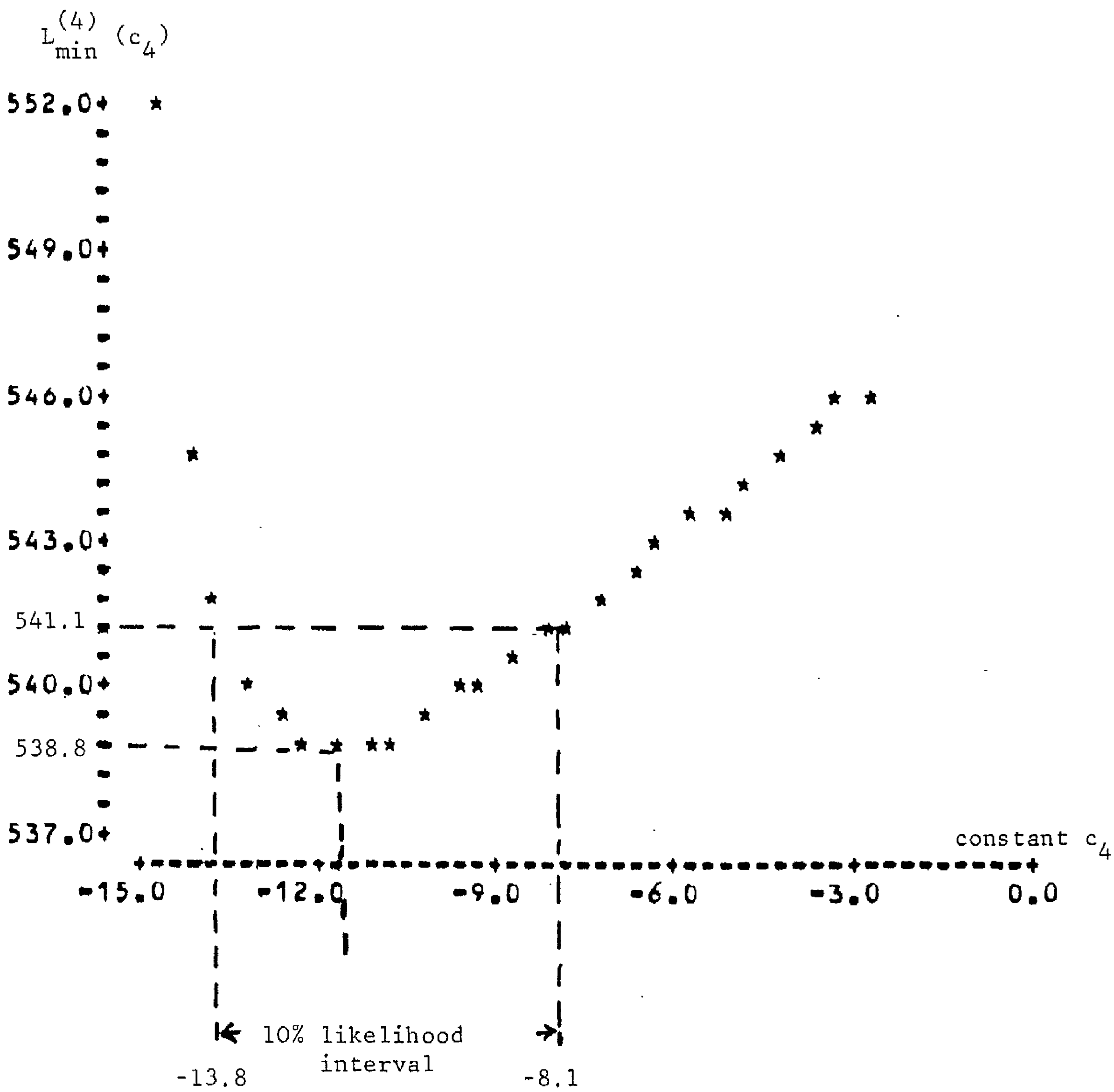
A MINITAB program was used to calculate and plot the values of $L_{min}^{(4)}(c_4)$ against the constant c_4 (Figure 6.3.1). From Figure 6.3.1 it is clear that $L_{min}^{(4)}(\hat{c}_4)$ is 538.8 and the value of $\hat{c}_4$ is 11.7. The values of $\hat{c}_j$ for all variables for each age-sex subgroup are given in Table C2 (Appendix).

The value of $L_{min}^{(4)}(\hat{c}_4) + \log_e 10 = 538.8 + 2.3 = 541.1$, and the 10% likelihood interval for c_4 is from 8.1 to 13.8. Figure 6.3.2 shows the 10% likelihood intervals for c_j for boys' weight for all age groups. (Also in Table C3 (Appendix)). Similar results for skin-folds and arm and calf circumferences are given in Tables C4 - C9 (Appendix). The values of $L_{min}^{(j)}(c)$ for a range of values of c for each age group for weight are given in Table 6.3.1 along with values of $L_{min}^{(j)}(\hat{c}_j)$. Tables C10 - C15 (Appendix) present the same information for the other variables. Table 6.3.2 summarises the best overall constant values for each variable and sex, and also gives chi square goodness-of-fit statistics on eleven degrees of freedom along with their significance levels. For example, for boys' weight in Table 6.3.1, goodness of fit statistic for an overall constant $\hat{c}$ of 13 is

$$2 \sum_{j=1}^{12} \left\{ L_{min}^{(j)}(13) - L_{min}^{(j)}(\hat{c}_j) \right\} = 2\ \{8397.7 - 8378.8\} = 37.8$$

(as in Table 6.3.2).

Figure 6.3.1: Estimation of the constant value in the transformation for weight for boys aged 9 years (age group 4).



Note. In the MINITAB program (Appendix C1) the transformation was expressed as $\log_e$ (x + constant) rather than $\log_e$ (x- constant). Thus $\hat{c}_4$ = 11.7 and the 10% likelihood interval for c_4 is 8.1 to 13.8.

Figure 6.3.2: 10% likelihood intervals for boys' weight by age group.

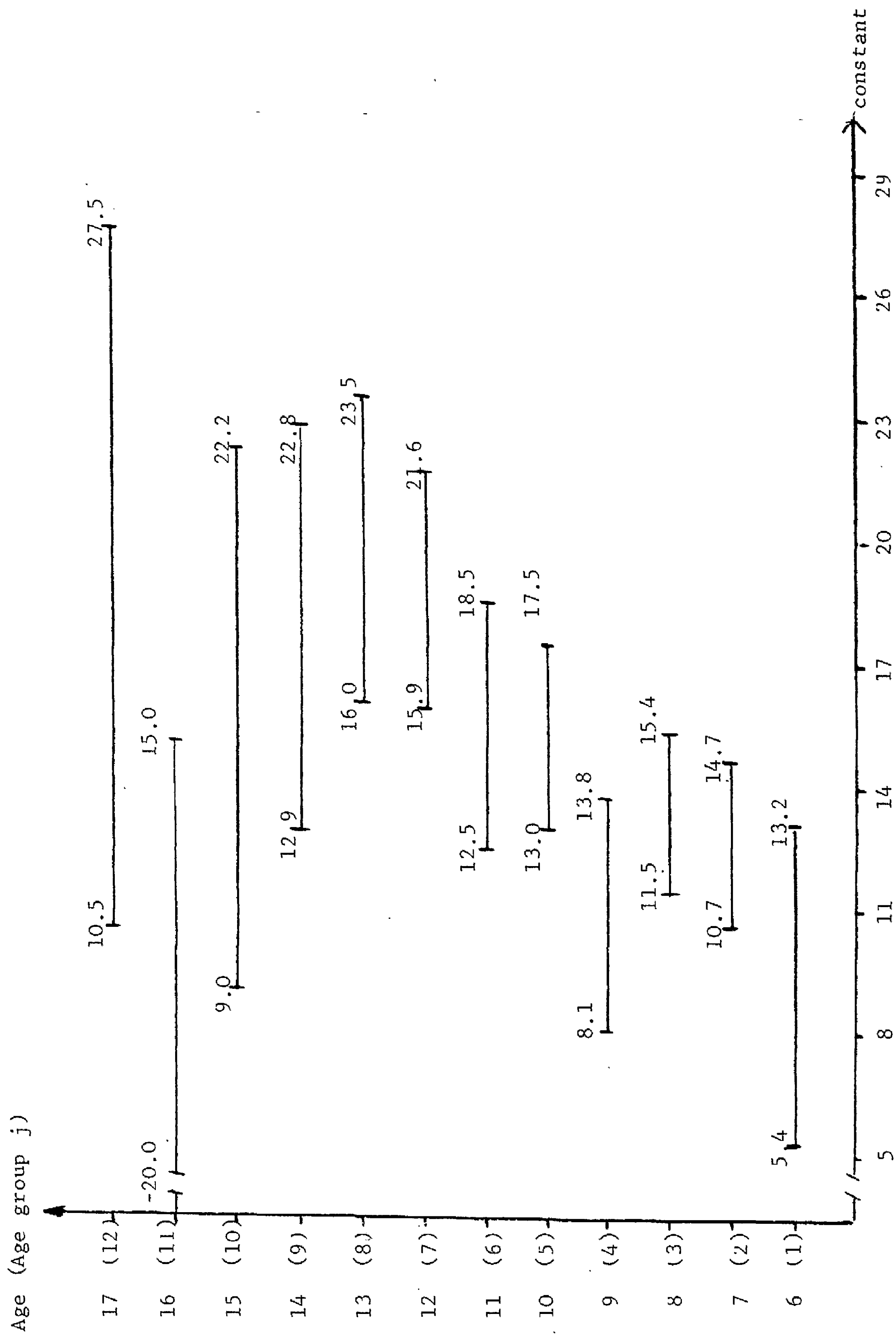


Table 6.3.1: Values of $\hat{c}_j$, $L^{(j)}_{min}(\hat{c}_j)$, $\hat{c}$ and $L^{(j)}_{min}(\hat{c})$ for weight by sex.

Age (age group) j	$\hat{c}_j$	$L^{(j)}_{min}(\hat{c}_j)$	Value of Overall Constant						
			18	17	16	15	14	13	12
BOYS									
6(1)	10.8	162.8	-	-	-	-	167.0	164.6	163.0
7(2)	13.4	319.0	-	-	392.0	323.5	319.0	319.0	320.0
8(3)	13.8	446.0	-	-	453.0	447.0	446.0	446.7	448.1
9(4)	11.7	538.8	-	-	-	-	542.8	539.8	538.8
10(5)	16.0	598.8	603.6	599.4	598.8	599.4	600.0	601.2	602.4
11(6)	16.3	717.6	718.2	717.6	717.6	717.6	718.8	719.4	720.0
12(7)	20.0	799.5	796.0	797.0	797.8	799.0	800.5	801.3	802.5
13(8)	20.6	755.2	755.4	756.0	756.5	757.8	758.4	759.6	760.2
14(9)	19.5	1041.0	1041.2	1041.4	1041.8	1042.2	1042.8	1043.3	1044.0
15(10)	17.7	1082.0	1082.0	1082.0	1082.4	1082.4	1082.6	1082.8	1083.2
16(11)	3.9	1187.8	1191.0	1190.1	1189.6	1189.0	1188.5	1188.2	1187.9
17(12)	21.2	730.3	730.6	730.6	730.9	731.3	731.5	731.8	732.1
TOTAL		8378.8					8397.9	8397.7	8402.2
								$\hat{c}=13$	
GIRLS									
6(1)	11.3	216.0	-	-	-	-	226.8	217.8	216.6
7(2)	11.0	348.6	-	-	-	-	353.4	350.4	349.2
8(3)	13.2	382.2	-	-	397.2	384.5	382.2	382.2	382.5
9(4)	15.3	468.0	-	-	468.4	468.0	468.4	470.3	471.4
10(5)	15.5	654.6	661.2	655.8	654.6	654.6	655.2	655.8	657.0
11(6)	14.5	825.0	-	827.5	827.0	826.0	826.0	826.5	827.0
12(7)	13.2	966.4	970.0	968.4	967.6	966.8	966.4	966.4	966.4
13(8)	15.4	993.2	993.6	993.3	993.2	993.2	993.2	993.5	993.7
14(9)	4.5	1146.9	-	-	-	-	1149.1	1148.8	1148.1
15(10)	18.7	977.6	977.6	977.6	977.6	977.6	978.4	978.8	979.2
16(11)	23.6	903.2	904.0	904.4	904.5	904.9	905.0	905.5	905.8
17(12)	28.4	406.8	408.3	408.5	408.8	408.9	409.1	409.2	409.5
TOTAL		8288.5					8313.2	8305.2	8306.4
								$\hat{c}=13$	

Table 6.3.2.: The best constant values used in log-transformation with chi-square values and level of significance by variable and sex.

Variable	Best constant Boys	Best constant Girls	Value of χ^2 (11df) Boys	Value of χ^2 (11df) Girls	Significant at Boys	Significant at Girls
Weight	13	13	37.8	33.4	<0.0005	<0.0005
Biceps	21	22	40.0	25.6	<0.0005	<0.005
Triceps	30	32	36.6	36.0	<0.0005	<0.0005
Subscapular	27	27	82.6*	93.0	<0.0005	<0.0005
Suprailiac	25	28	179.2*	14.0	<0.0005	0.23
Arm Circumference	130	120	35.8	18.4	<0.0005	0.09
Calf Circumference	180	160	21.2**	9.4	<0.025	0.60

* 10 degrees of freedom

** 9 " " "

Table 6.3.3: Weight distance centiles (kg); transformed data using different constants, $\hat{c}_j$, for each age group

BOYS

Age (Age group j)	Constant $\hat{c}_j$	Centiles (kg)						
		3rd	10th	25th	50th	75th	90th	97th
6(1)	10.8	15.8	17.7	19.0	20.2	22.3	24.6	27.9
7(2)	13.4	17.0	18.5	20.2	21.9	23.9	26.2	31.0
8(3)	13.8	18.9	19.9	21.5	23.8	26.5	30.7	36.1
9(4)	11.7	20.0	21.2	23.4	26.1	29.1	33.3	40.5
10(5)	16.0	22.4	24.1	26.2	29.3	33.0	38.0	49.3
11(6)	16.3	23.7	26.0	28.8	31.8	36.4	42.6	49.7
12(7)	20.0	26.2	28.8	31.5	35.3	40.6	49.1	57.7
13(8)	20.6	27.7	30.5	33.8	38.4	45.6	54.1	65.1
14(9)	19.5	29.5	33.0	37.7	43.6	51.9	61.0	76.2
15(10)	17.7	33.7	37.8	42.8	48.3	56.3	65.5	78.6
16(11)	3.9	37.5	42.4	47.2	53.1	59.0	66.7	76.4
17(12)	21.2	41.7	45.8	50.0	55.3	61.6	68.8	79.0
GIRLS								
6(1)	11.3	15.3	16.8	18.4	19.6	22.0	25.3	29.4
7(2)	11.0	16.8	18.4	20.0	21.8	23.8	26.4	32.0
8(3)	13.2	18.5	19.8	21.4	23.6	26.4	30.0	33.5
9(4)	15.3	19.4	21.1	23.0	25.4	28.7	34.2	41.4
10(5)	15.5	21.4	23.5	26.0	29.4	34.8	42.0	51.0
11(6)	14.5	23.0	26.2	29.0	33.5	40.2	47.7	54.2
12(7)	13.2	25.2	29.2	32.8	38.5	49.0	55.3	64.2
13(8)	15.4	29.2	33.3	38.0	44.0	50.5	58.0	72.0
14(9)	4.5	32.5	37.8	43.0	49.3	55.6	67.4	77.0
15(10)	18.7	40.0	43.5	46.4	51.7	59.0	68.1	77.2
16(11)	23.6	21.1	44.6	48.0	53.5	60.6	67.5	77.2
17(12)	28.4	42.5	45.9	48.8	55.2	63.5	70.5	78.0

As can be seen from Table 6.3.2, most of the goodness-of-fit tests are significant, indicating that a better fit to a normal distribution would have been obtained by using the constants $\hat{c}_j$ in each separate age group. To see if using the $\hat{c}_j$ values rather than $\hat{c}$ would have made any practical difference to the standards obtained, two things were done.

Firstly, to investigate if the log transformation applied to the data using the values of the best overall constant $\hat{c}$ in Table 6.3.2 will give a normal or very close to normal distribution, a normal probability plot was produced for each variable for each age-sex sub-group. In most cases, a good straight line was produced as shown in Figures 4.2.1, 4.2.2, 4.3.1-8. These plots and others which have not been reproduced in Chapter 4 suggest that the constant values $\hat{c}$ of Table 6.3.2 which have been used in the log transformation when constructing the standards presented in Chapter 4, are suitable for the Libyan children's data.

Secondly, the standards for weight for boys were recomputed, using the best individual constants $\hat{c}_j$ for each age group in the log transformation, and these are presented in Table 6.3.3. By comparing these standards with those in Table A3 (Appendix) it can be seen that there are no large differences between the standards produced by the two methods except at the 97th percentile for some age groups.

From Figure 6.3.2, there is a suggestion that, with the exception of the 16 year old age group, the value of the constant increases with increasing age for boys' weight. This could be further investigated by attempting to fit the boys' weight data by a transformation of the form log(wt - b. Age group - a). Further work could be carried out on this line, but it is unlikely to make any practical difference to the standards obtained.

6.4 Discussion:

By using the method of profile likelihood it is possible to find a suitable constant value $\hat{c}_j$ for each age group for all variables which showed a deviation from normality. These values are shown in Table C2 (Appendix). For boys' calf circumference in the 6 and 17 year age groups a suitable constant value could not be determined. In both age groups the minimum of minus the log likelihood was undetermined (or, at least, $\hat{c}_j$ was not in the range from - 100 to min y_{ij}). This is likely to be because of the presence of several outliers at the lower end of the distribution. Since the constant is constrained to be less than the minimum of the observations, this may lead to a very large range of values of the constant giving almost the same value for the log likelihood. The chi-square goodness-of-fit value for boys' calf was calculated for ten age groups with nine degrees of freedom.

There were also problems with one age group for both suprailiac and subscapular skinfolds where the $\hat{c}_j$ value for that one age group was very different from that in all other age groups because of outliers at the lower end of the distribution. This age group was excluded for the purposes of calculating $\hat{c}$, and chi-square values calculated on ten degrees of freedom. When the standards of Chapter 4 were produced, the outliers in this age group were excluded before logarithmic transformation.

Rona and Altman (1977) and Kemm (1982) could not find one constant value which can be used in weight transformation for all age groups. Table 6.4.1 shows the values of the best constants $\hat{c}_j$ for weight for Libyan children by age group compared with those for English children given by Rona and Altman (1977). Rona did not give any details of the triceps skinfold constant values by age group. Kemm (1982) used different constant values which varied from 2 to 32 for boys' and girls' triceps skinfolds.

Comparison between the constant values for biceps, triceps, subscapular and suprailiac skinfolds of Libyan and Sudanese children by age and sex are given in Table C16 (Appendix).

It is clear from the table that there are some differences between the constant values of the two studies which might be attributed to differences in the actual skinfolds values and therefore to nutritional and ethnic factors. (Durnin, personal communication).

In conclusion it can be said that in the growth field, it has become common to use a logarithmic transformation when constructing growth standards for the variables which show a deviation from normality, even though the transformations may have no simple biological interpretation. The use of the method of profile likelihood is helpful in estimating the constant values for each variable by age and sex, and therefore for choosing the best constant to use in the transformation, although in practice the standards obtained are not substantially affected by moderate changes in the value of the constant.

Table 6.4.1: Weight constant values of Libyan and English children by age and sex.

AGE	LIBYAN		ENGLISH *	
	BOYS	GIRLS	BOYS	GIRLS
6	10.8	11.3	8.0	7.0
7	13.4	11.0	12.0	9.0
8	13.8	13.2	12.0	11.0
9	11.7	15.3	16.0	13.0
10	16.0	15.5	16.0	15.0
11	16.3	14.5	16.0	17.0

* Rona and Altman 1977.

CHAPTER SEVEN

SOCIO-ECONOMIC VARIABLES

7.1 Introduction

The influence of socio-economic variables on body growth has been discussed by many writers in the field of human growth (Tanner, 1962; Eveleth and Tanner, 1976; Rona et al. 1978; Rona, 1981; Bogin et al. 1981; Bielicki et al. 1981). Socio-economic variables have an effect on height and weight in highly industrial countries as well as in developing countries. High income and high educational level indicate not only better nutrition but also better child care and better social and medical services.

There are twelve socio-econonomic variables included in the 1983 Libyan study. These variables, which are listed below are described fully in Section 2.6 (ii).

Family size

Total number of children

Total number of live children

Birth order (Parity)

Father's and Mother's education

Father's and Mother's occupation

Type of housing

Number of bedrooms.

Father's and Mother's income

Tables B1-B7 (Appendix) give the distribution of each of these variables. Also from these tables it can be seen that the response rate for the socio-economic questionnaires is high for the first ten variables, varying from 95.4% for father's education to 99.7% for family size. For the last two sensitive questions about Father's and Mother's income, the response rate was poor. Only 33.3% of working mothers and 37.7% of fathers responded and for this reason the information about income will be omitted from the analysis in Sections 7.3 and 7.4. Rona et al. (1978) had a response rate of 70% for questions on family income, which although better than the present study, is still not high.

Throughout, the unit of data is the child and not the family, so that families are counted as many times as they have numbers of children in the study. Table 7.1.1 gives summary statistics for some of the socio-economic variables which are described more fully in Tables B1-B7 (Appendix). A few words should be said here about each of the socio-economic variables which may give insight into the association between growth and these variables in Libyan society at the time of the study.

Table 7.1.1 Summary Statistics for Quantitative Socio-economic Variables

Variable	No. of Cases*	Mean	Median	Standard Deviation
Family Size	8489	8.2	8.8	2.5
Total No. of Children	8487	7.7	7.4	5.6
Live Children	8486	7.0	7.0	2.5
Birth Order	8426	4.0	3.6	2.4
No. of Bedrooms	8432	2.7	2.7	0.7

*Total number of Cases is 8511.

7.2 Distribution of Socio-economic Variables

Family Size:

The family size is the number of people living together in one house (including grandparents) sharing all the facilities of the house and the family properties under the supervision of one member (usually the father). The distribution of the Libyan family size is given in Table B1 (Appendix). The mean Libyan family size is eight persons (Table 7.1.1) which agrees with other studies (Tajouri, 1979).

Total and Live Children:

The distribution of total and live children in this study is given in Table B2 (Appendix). The means of the total and live children were 7.7 and 7.0 children per family(Table 7.1.1). Some indication of the impact of childhood mortality in Libya can be gained from Table 7.2.1. From this table it can be seen that about 72% of the children have lost none of their siblings, 14.2% of the children have lost only one of their siblings, and 2.6% lost four or more of their siblings.

Birth Order:

In this study the mean parity is four (Table 7.1.1). The parity distribution given in Table B1 (Appendix) shows that about 16% of the children are in each of the first, second and third parities. About 85% of the children are of sixth parity or less.

Father's and Mother's Education:

From Table B3 (Appendix) it is clear that 14.2% of fathers were illiterate, 18.6% finished the compulsory level (preparatory) of education, and 11% have University level of education. For mothers, 59.7% of them were illiterate, 6.4% finished the compulsory level of education and only 1.5% of mothers had University level of education.

Table 7.2.1 Distribution of Dead Children per Family

Dead Children	No. of Cases	%
0	6090	71.8
1	1206	14.2
2	674	8.0
3	291	3.4
4	220	2.6
Total	8481	100.0
Not known	30	

Tajouri (1979) found that 22% of fathers were illiterate. The difference between what he found and what this study shows is probably due to different sampling strategies; his sample also included suburban areas where the level of education is generally lower. However, for mother's education, the two studies agreed that about 59% of mothers were illiterate.

Father's and Mother's Occupation:

The most common father's occupations are administration 28.6%, supermarket employee 19.4%, different ranks of Army 11.7%. Table B4 (Appendix) gives a fuller list of father's occupations. Also it can be seen from Table B5 (Appendix) that 91% of the Libyan mothers are housewives. Tajouri (1979) found that 93% of mothers were housewives, which is similar to the present study. Teaching is the most common occupation after housewife for mothers. This is because teaching is a more convenient occupation for women than other occupations in Libyan society.

Type of Housing and Number of Bedrooms:

This study shows that 37% of families live in good villas, 16% live in large and good terraced houses or large apartments, and about 61% of the total dwellings have three bedrooms or more (Table B6, Appendix).

Tajouri (1979) found 13% live in "villas", 73% live in "good houses" and 14% live in "less comfortable" houses. The difference between the housing results in the two studies is due to firstly, the difference in definition and classifications of housing and secondly, because his sample included surburban areas where the style and the standards are different from those in urban areas.

An index of overcrowding which is the number of persons living in one bedroom is shown in Table B8 (Appendix). It is clear from the table that

34.3% of the children are from households where the overcrowding index is less than three, 35% where the overcrowding index is between 3 and 3.99 and 30.7% where the overcrowding index is 4 or more.

Trend in Parent's Education over Time:

When investigating the relationship between height and socio-economic factors using analysis of covariance (Section 7.4), it was noted that the distribution of fathers' and mothers' education differed substantially in the age groups 6-11 years, 12-14 years and 15-19 years. These distributions are summarised in Tables 7.2.2 and 7.2.3.

Parents' age was not recorded in the survey, but it is likely that the average age of parents of older children will be greater than the average age of parents of younger children. From this, some indication of the change in the educational levels in the community over the last 10-15 years can be obtained.

It is clear from Table 7.2.2 that there is an improvement of about 10% in father's education at the first level "illiterate and primary" between age group 6-11 years and age group 12-14 years. This change is about 13.5% between age group 6-11 years and age group 15-17 years. Also for "University or higher" level of education there is about 4% increase between age group 6-11 years and age group 15-17 years. These results suggest a large change in father's level of education during the last 15 years. From Table 7.2.3 which gives distribution of mothers' education by age group of child, there is a reduction of about 24% in mother's illiteracy between age group 6-11 years and age group 15-17 years. For "secondary or higher" level of mother's education, there is an increase of about 11% which

Table 7.2.2: DIstribution of Father's Education by Age Group of Child

Age Group of Child		Total	Illiterate and Primary	Preparatory	Secondary	University or Higher
6-11	No.	3576	1385	661	834	696
	%	100.0	38.7	18.5	23.3	19.5
12-14	No.	2488	1185	464	508	331
	%	100.0	47.6	18.6	20.4	13.3
15-17	No.	2280	1190	361	374	356
	%	100.0	52.2	15.7	16.4	15.6

Table 7.2.3: Distribution of Mother's Education by Age Group of Child

Age Group of Child		Total	Illiterate	Primary	Preparatory	Secondary or Higher
6-11	No.	3576	1775	893	311	597
	%	100.0	49.6	25.0	8.7	16.7
12-14	No.	2488	1542	596	129	221
	%	100.0	62.0	24.0	5.2	8.8
15-17	No.	2281	1675	386	88	132
	%	100.0	73.4	16.9	3.9	5.8

shows the interest of Libyan girls for seeking knowledge which is not satisfied by low levels of education. Indeed the numbers of Libyan girls in Universities is large now by comparison with 15 years ago. These are good indications for the big effort made to improve levels of education in Libyan society, and also it reflects the interest of the new generation in acquiring knowledge.

7.3 Effect of Socio-economic Variables on Height

The height of children is well recognised and used as a sensitive measure of socio-economic status and of changes in living standards in a society (Scott, 1961; Tanner, 1962; Grant, 1964; Goldstein, 1971 and Bielicki et al. 1981).

This section will examine the effect of each of the socio-economic variables mentioned in Section 7.1 on the height of Libyan boys and girls.

Family Size:

Table B9 (Appendix) shows the mean height of Libyan boys and girls by family size and age group. From the table it is clear that as the family size increases, the child's height tends to decrease. The height difference between children of family size five people or less, and children belonging to family size eleven people or more, is about 3 cm. for boys and girls of age group below 13 years. This also agrees with what others found (Scott, 1961).

Total and Live Children:

Rona (1981) found that of all the socio-economic variables, the number of children in the family (number of siblings) is one of the most strongly related to variability in height. The height of the children decreases as the number of the total and live children increases. Tables B10 and B11 (Appendix) give the mean height of children broken down by total and live children respectively and by age and sex. It can be seen from the tables that the height difference between children from families with three or less children and children of families who have nine or more live children is about 4 cm. for boys and 2.5 cm. for girls of age group below 13 years (Table B11, Appendix). Scott (1961) found 3 cm. difference in mean height of both boys and girls at age 8 years who are from families with one child and those who are from families with five or more children. Bielicki et al. (1981) found a difference of 3.0 cm. in mean height of Polish conscripts who have only one sibling and those who have six siblings or more.

Birth Order (Parity)

For age group below 13 years there is a difference in height of about 2 cm. for girls and about 1.5 cm. for boys between children of first parity and those who are from sixth parity and over (Table B12, Appendix). This difference was found to be about 3 cm. for 8 year old English schoolchildren (Scott, 1961). Goldstein (1971) has also reported that later born children tend to be shorter than their older siblings.

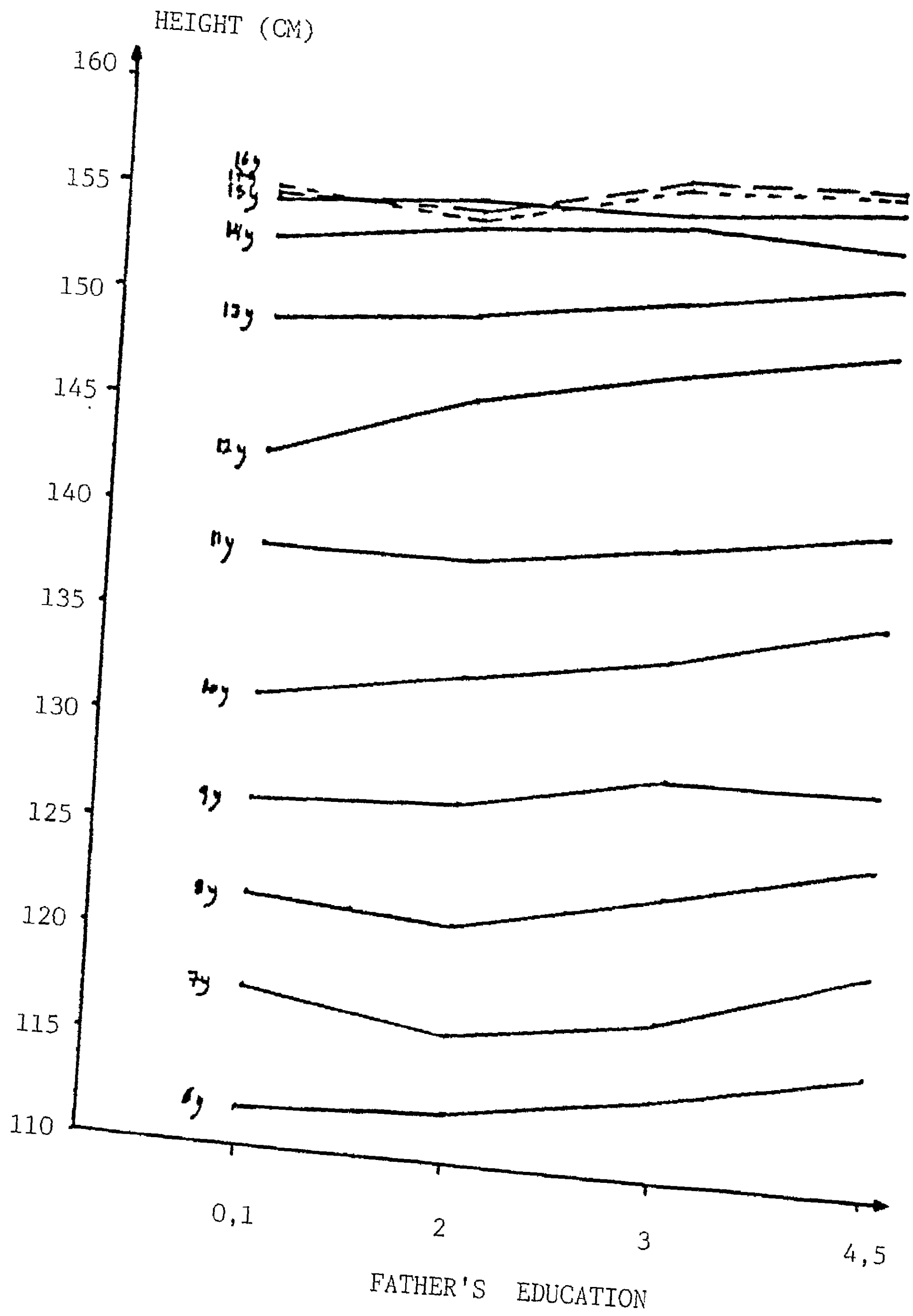
Father's and Mother's Education:

Figures 7.3.1 and 7.3.2 which present data from Tables B13 andB14 (Appendix) show that girls whose father and/or mother have University or higher level of education are taller on average by about 3.5 cm. than those whose parents have only primary education or less. The pattern of Boys' height is similar. Categories of mother's and father's education have been grouped in different ways for presentation of mean height to avoid having any categories with small numbers of children in them. Bielicki et al. (1981) found a difference of 3.8 cm. in height of Polish conscripts whose fathers have college education and those whose fathers are unskilled manual workers.

Father's and Mother's Occupation:

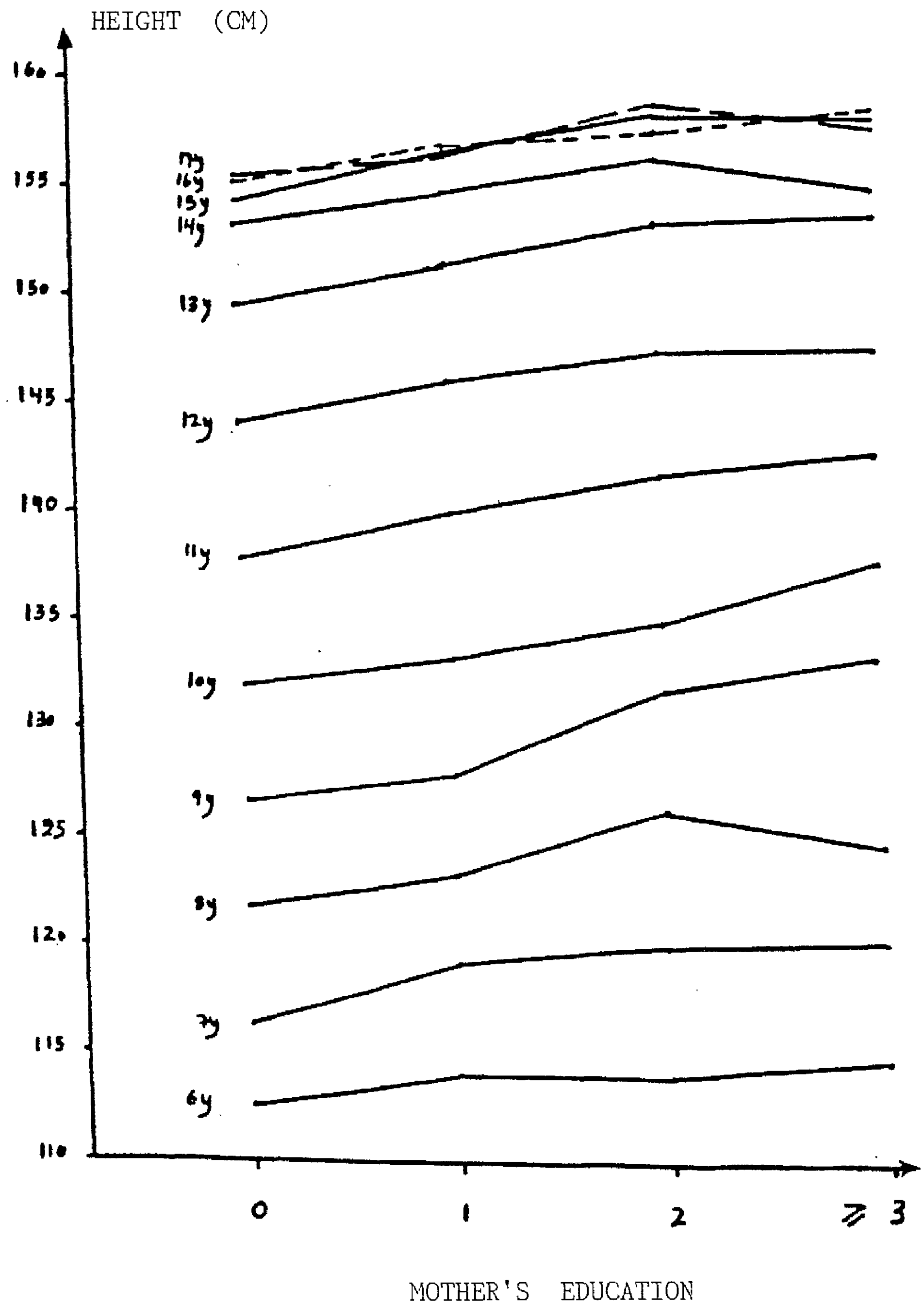
Parents' social class is commonly used to assess the association between the socio-economic status of the family and children's growth. The father's occupation is usually used in Britain and in most developed

Figure 7.3.1 Girls Mean Height by Father's Education*



*See text for details about Father's education levels.

Figure 7.3.2: Girls Mean Height by Mother's Education*



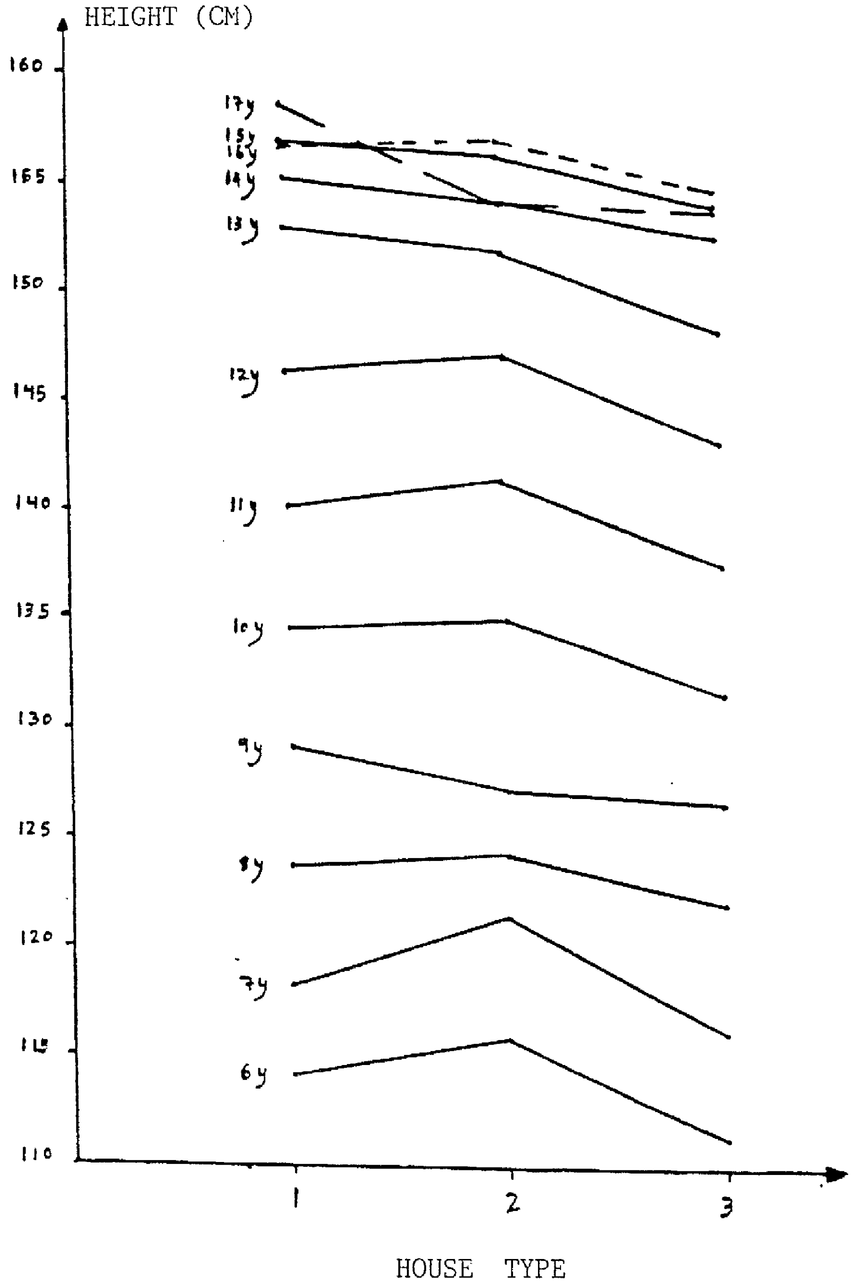
*See text for details of Mother's education level.

countries to assign subjects to social classes. It was difficult to determine social class in Libya on the basis of occupation due to the changes happening from time to time in the new Libyan society. No classification of occupations into social classes exists at present for Libya, and it is beyond the scope of the present study to construct such a classification. The father's occupations used in this study are shown in Table B4 (Appendix) and grouped for the purpose of comparing mean heights into teaching, administration, manual (electrician, mechanics and maintenance), supermarket employee, army, and other occupations. The effect of father's and mother's occupation on their children's heights is shown in Tables B15 and B16 (Appendix), where the mean height of the boys and girls is given by age group. It is clear from the tables that the children whose father's and/or mother's occupation is teaching are taller than other children. In other studies, Van Wieringen et al. (1965) found 2-3 cm. for boys and 1-3 cm. for girls aged 4-19 years of a difference in mean height between the high and low socio-economic groups. Rona et al. (1978) found a mean difference of 2 cm. between children of fathers in non-manual and manual occupations.

Type of Housing and Number of Bedrooms:

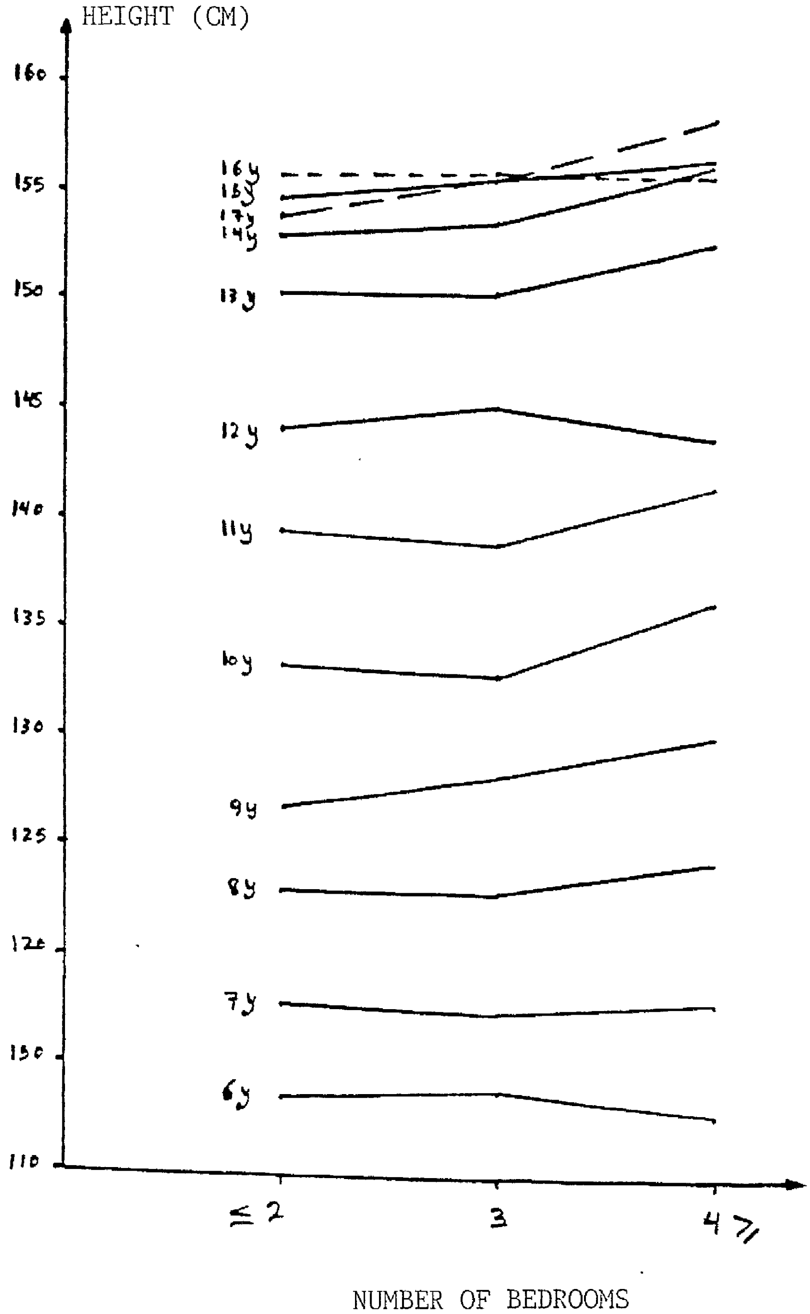
The mean height of boys and girls by type of housing and number of bedrooms is given in Tables B17 and B18 (Appendix) and presented for girls in Figures 7.3.3 and 7.3.4. It is clear from Table B17 that there is a difference of about 3 cm. for boys and girls below 13 years between children living in large, good houses or apartments and those who live in small houses or small apartments. Figure 7.3.4 shows that the girls whose families have four or more bedrooms are taller than those whose families have one or two bedrooms by about 2.5 cm.

Figure 7.3.3: Girls Mean Height by Type of House*



*See text for definition.

Figure 7.3.4: Girls Mean Height by Number of Bedrooms



7.4 Joint Effect of Socio-economic Variables on Height: Analysis of Covariance:

The previous section examines the effect on height of each of the socio-economic variables on its own. However, it is of interest to look at the joint effect of these variables on height and to see, for example, whether father's education has any relationship with height in addition to the effect of mother's education. Clearly age must be allowed for in any such analysis, and in order to use analysis of covariance, the sample was divided into three age groups within which the relationship between mean height and age is roughly linear. These groups are:

(i) pre-adolescent: 6-11 years

(ii) adolescent: 12-14 years

(iii) post-adolescent 15-17 years

In analysis of covariance the dependent variable is height, the covariate is age group and the factors are the total number of children, the birth order, father's education, mother's education, house type and crowd index. Analysis of covariance was carried out for boys and girls separately. The categories of each factor were grouped to ensure a satisfactory number of cases (at least 40) in each cell. Because the SPSS analysis of covariance subprograms allows only up to five factors together with one independent variable, the factors "total children" and "birth order" were entered in separate runs with the other group of four factors (father's and mother's education, house type and crowd index) and they were excluded because neither of them had a significant effect on height in any of the 6 age-sex subgroups after age and other factors had been allowed for.

The factors which will be presented in the results are only the father's education, mother's education, house type and crowd index, with age group as a covariate. Also, interactions between all pairs of factors were examined to find whether or not they were significant.

(i) Age Group 6-11 Years:

There were 1815 boys and 1761 girls in this age group. Tables 7.4.1,2 show the results of the analysis of covariance, the value of F ratio and the significance of F.

The covariate (age group) and each of the factors separately except the crowd index for girls, have a significant effect on height for both boys and girls. The total of the second order interactions was not significant at the 5% level for boys or for girls; the interaction between father's education and house type, mother's education and house type and crowd index and house type were significant at 5% level for boys. No other interactions were significant for boys or for girls in other age groups. Since the three interactions terms were only just significant at the 5% level and since the two way interaction was not significant and since no other interactions were significant, the two-way interactions for boys were ignored, and the simple model of Table 7.4.3 was used.

Tables 7.4.3, 4 give the overall mean height which is 128.0 cm. for boys and 127.8 cm for girls and the regression coefficients of age on height which are 4.8 cm per year for boys and 5.2 cm per year for girls. Also given is the number of cases in each category of each factor, and the mean height of each of these categories expressed as a deviation from the overall mean. Expressed in deviation form, the category means reflect the magnitude of the effect of each category

Table 7.4.1: Analysis of Covariance for Height of Libyan Boys aged 6-11 Years

Source of Variation	D.F.	Mean Square	F	Significance of F
Covariate (age group)	1	107275.37	2959.55	0.000
Father's education	3	126.88	3.50	0.015
Mother's education	3	105.53	2.91	0.033
House Type	2	648.60	17.89	0.000
Crowd Index	3	286.00	7.89	0.000
Total explained	12	9421.15	259.91	0.000
Residual	1748	36.25		
Total	1760	98.33		

Table 7.4.2: Analysis of Covariance for Height of Libyan Girls aged 6-11 Years

Source of Variation	D.F.	Mean Square	F	Significance of F
Covariate (age group)	1	136064.94	3503.64	0.000
Father's education	3	258.83	5.81	0.001
Mother's education	3	429.91	9.65	0.000
House Type	2	414.65	9.30	0.000
Crowd Index	3	74.17	1.66	0.173
Total explained	12	11907.21	267.23	0.000
Residual	1748	44.56		
Total	1760	125.44		

of a factor. The category effects are chosen after adjustment for the effects of all other factors and covariates. Only factors which have a significant effect on height are included in the tables. Also given is the partial beta which indicates the magnitude of the effect of each factor on height, after adjusting for the effects of all other factors. For example, house type has the largest effect of all the factors on boys height in this age group.

From Tables 7.4.3, 4 it can be seen that the trend in mean height is not consistent over all categories of the factors for either boys or girls. The reason is not clear, but it may be mostly due to random variation. For father's education, the difference in mean height between children whose father's level of education was "illiterate or primary" and "University or higher" is about 0.6 cm for boys and 1.6 cm for girls. For mother's education, the children whose mother's education level is "secondary or higher" are taller on average than those whose mother's education level is "illiterate" by 0.9 cm for boys and 2.3 cm for girls. For house type the children who live in "villa" are taller on average than those who live in "small house or small apartment" by about 1.2 cm for boys and 1.1 cm for girls. For crowd index, boys whose families have one or two persons per bedroom are about 3.2 cm taller than those whose families have five or more persons per bedroom.

For boys, house type and crowd index have the strongest effect on height, while for girls mother's education has the strongest effect on height.

Table 7.4.3: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other Socio-economic Factors for Libyan Boys aged 6-11 Years

Grand Mean Height = 128.0 cm

Regression Coefficient for Age Group 4.79 cm per year

Factors	Number	Adjusted Deviation from Grand Mean	Beta
Father's education			
University or Higher	344	0.28	0.05
Secondary	397	0.82	
Preparatory	318	-0.50	
Illiterate or Primary	755	-0.35	
Mother's Education			
Secondary or Higher	282	0.44	0.05
Preparatory	157	0.27	
Primary	417	0.63	
Illiterate	959	-0.45	
House Type			
Villa	722	0.31	0.09
Large Apartment	291	1.67	
Small (House or Apartment)	802	-0.88	
Crowd Index			
0 -1.99	114	2.33	0.08
2.00-2.99	541	0.48	
3.00-3.99	633	-0.14	
4.00+	527	-0.84	

Table 7.4.4: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other Socio-economic Factors for Libyan Girls aged 6-11 Years

Grand Mean Height = 127.8 cm

Regression Coefficient for Age Group 5.23 cm per year

Factors	Number	Adjusted Deviation From Grand Mean	Beta
Father's Education			
University or Higher	352	1.34	0.07
Secondary	437	-0.01	
Preparatory	342	-0.91	
Illiterate or Primary	630	-0.25	
Mother's Education			
Secondary or Higher	315	1.33	0.09
Preparatory	154	1.52	
Primary	476	0.34	
Illiterate	816	-1.00	
House Type			
Villa	775	0.29	0.07
Large Apartment	299	1.19	
Small (House or Apartment)	687	-0.84	

(ii) Age Group 12-14 Years:

In this group there were 1175 boys and 1313 girls. Tables 7.4.5 and 7.4.6 show the results of anaylsis of covariance. All the factors have a significant effect on height except the house type and crowd index for boys and mother's education for girls which were not significant at the 5% level. None of the two-way interaction effects were significant for boys or for girls.

From Tables 7.4.7, 7.4.8, the overall mean height is 147.8 cm for boys and 150.2 cm for girls, the regression coefficient of age on height was 5.3 cm per year for boys and 4.2 cm per year for girls. Also in this age group the trend in mean height is not consistent over the categories of any of the factors except crowd index for girls.

For father's education, the children whose father's education level is "University or higher" are taller on average than those whose father's education level is "illiterate or primary" by 1.0 cm for boys and 0.4 cm for girls. For mother's education, the difference in mean height between boys whose mother's education level is "illiterate" and "secondary or higher" is about 1.5 cm. For house type the girls who live in "Villas" are taller than those who live in "small house or small apartments" by about 2.0 cm. For crowd index, the girls whose families have "one or two persons" per bedroom are taller than those whose families have "five or more people" per bedroom by about 2.9 cm. In this age group for boys, the mother's education has the largest effect on height. For girls, house type has the largest effect on height.

Table 7.4.5: Analysis of Covariance for Height of Libyan Boys aged 12-14 Years

SOurce of Variation	D.F.	Mean Square	F	Significance of F
Covariate (Age Group)	1	23600.69	386.43	0.000
Father's Education	3	167.08	2.73	0.042
Mother's Education	3	197.05	3.22	0.022
House Type	2	6.35	0.104	0.901
Crowd Index	3	116.31	1.90	0.127
Total Explained	12	2177.03	35.64	0.000
Residual	1162	61.07		
Total	1174	82.70		

Table 7.4.6: Analysis of Covariance for Height of Libyan Girls aged 12-14 Years

Source of Variation	D.F.	Mean Square	F	Significance of F
Covariate (Age Group)	1	15739,98	307.44	0.000
Father's Education	3	142.03	2.77	0.040
Mother's Education	3	125.32	2.45	0.062
House Type	2	503.89	9.84	0.000
Crowd Index	3	176.01	3.44	0.016
Total Explained	12	1744.96	34.08	0.000
Residual	1300	51.19		
Total	1312	66.69		

Table 7.4.7: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other Socio-economic Factors for Libyan Boys aged 12-14 Years

Grand Mean Height = 147.8 cm.

Regression Coefficient for Age Group 5.33 cm per year

Factors	Number	Adjusted Deviation from Grand Mean	Beta
Father's Education			
University of Higher	138	0.39	0.08
Secondary	234	0.71	
Preparatory	204	0.95	
Illiterate or Primary	599	-0.69	
Mother's Education			
Secondary or Higher	75	0.95	0.09
Preparatory	64	2.26	
Primary	267	0.69	
Illiterate	769	-0.52	

Table 7.4.8: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other SOcio-economic Factors for Libyan Girls aged 12-14 Years

Grand Mean Height = 150.2 cm

Regression Coefficient for Age Group 4.22 cm per year

Factors	Number	Adjusted Deviation From Grand Mean	Beta
Father's Education			
University or Higher	193	-0.17	0.07
Secondary	274	0.93	
Preparatory	260	0.45	
Illiterate or Primary	586	-0.58	
House Type			
Villa	443	0.84	0.12
Large Apartment	277	0.97	
Small (House or Apartment)	593	-1.09	
Crowd Index			
0 -1.99	59	2.40	0.09
2.00-2.99	359	0.68	
3.00-3.99	457	-0.39	
4.00+	438	-0.47	

(iii) Age Group 15-17 Years:

There were 1285 boys and 995 girls in this age group.

Table 7.4.9 shows the analysis of covariance. Father's education, house type and crowd index had no significant effect on boy's height at 5% level, but the age and mother's education were significant at the same level.

In Table 7.4.10 the analysis of covariance showed only the mother's education and house type were significant at the 5% level. The age group, father's education and crowd index have no significant effect on height.

Tabled 7.4.11, 7.4.12 give overall mean height which is 163.3 cm for boys and 155.8 cm for girls, the regression coefficients of age on height are 3.66 cm per year for boys and 0.25 cm per year for girls. The regression coefficient for girls is small because the girls' height growth is about complete by this age. Also in this age group the trend in mean height is not consistent over all categories of the factors. There are differences of 3.5 cm and 2.2 cm for mean height between children whose mother's education level is "secondary or higher" and "illiterate" for boys and girls. For house type, the girls who live in "Villas" are taller on average than those who live in "small house or small apartments" by 1.6 cm.

Summary:

Table 7.4.13 shows the significance of the socio-economic factors by age group for boys and girls.

Over all, mother's education seems to be the most important factor influencing children's height. In 5 out of the 6 age-sex subgroups examined, it had a significant effect on height after allowing for age

Table 7.4.9: Analysis of Covariance for Height of Libyan Boys aged 15-17 Years

Source of Variation	D.F.	Mean Square	F	Significance of F
Covariate (Age Group)	1	10057.01	160.35	0.000
Father's Education	3	43.91	0.70	0.552
Mother's Education	3	167.41	2.67	0.046
House Type	2	77.56	1.23	0.291
Crowd Index	3	134.26	2.14	0.091
Total Explained	12	986.18	15.72	0.000
Residual	1273	62.72		
Total	1285	71.34		

Table 7.4.10: Analysis of Covariance for Height of Libyan Girls aged 15-17 Years

Source of Variation	D.F.	Mean Square	F	Significance of F
Covariate (Age Group)	1	33.51	0.91	0.339
Father's Education	3	33.92	0.92	0.427
Mother's Education	3	205.77	5.62	0.001
House Type	2	223.03	6.09	0.002
Crowd Index	3	47.62	1.30	0.273
Total Explained	12	217.49	5.94	0.000
Residual	982	36.60		
Total	994	38.78		

Table 7.4.11: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other Socio-economic Factors for Libyan Boys aged 15-17 Years

Grand Mean Height = 163.3 cm

Regression Coefficient for Age Group 3.66 cm per year

Factors	Number	Adjusted Deviation From Grand Mean	Beta
Mother's Education			
Secondary or Higher	46	3.28	0.08
Preparatory	29	0.28	
Primary	178	0.34	
Illiterate	1033	-0.21	

Table 7.4.12: The Effect of Socio-economic Factors on Mean Height after Adjustment for Age and all other Socio-economic Factors for Libyan Girls aged 15-17 Years

Grand Mean Height = 155.8 cm

Regression Coefficient for Age Group 0.25 cm per year

Factors	Number	Adjusted Deviation From Grand Mean	Beta
Mother's Education			
Secondary or Higher	86	1.55	0.15
Preparatory	59	2.02	
Primary	208	0.73	
Illiterate	642	-0.63	
House Type			
Villa	367	0.85	0.12
Large Apartment	179	0.28	
Small (House or Apartment)	449	-0.80	

Table 7.4.13: The Significance of Socio-economic Factors on Height of Libyan Children by Age Group and Sex, after allowing for all other Factors

Factors	Age Group 1		Age Group 2		Age Group 3	
	Boys	Girls	Boys	Girls	Boys	Girls
Father's Education	S	S	S	S	NS	NS
Mother's Education	S	S	S	NS	S	S
House Type	S	S	NS	S	NS	S
Crowd Index	S	NS	NS	S	NS	NS
Total Children	NS	NS	NS	NS	NS	NS
Birth Order	NS	NS	NS	NS	NS	NS

S = Significant at 5% Level

NS = Not Significant at 5% Level

Table 7.4.14: The Multiple Correlation Coefficient, R, R^2 and Regression Coefficient for Age by Age Group and Sex

Age Group	R		R^2		Regression Coefficient	
	Boys	Girls	Boys	Girls	Boys	Girls
6-11 Years	0.79	0.80	0.63	0.64	4.79	5.23
12-14 Years	0.52	0.49	0.27	0.24	5.33	4.22
15-17 Years	0.35	0.26	0.13	0.07	3.66	0.25

and all other factors. It was the most important factor influencing height in 4 of these subgroups.

The multiple correlation coefficient for age group 6-11 years is about 0.8 for boys and girls, which indicates that 64% of the height variation is explained by the factors in age group 6-11 years (Table 7.4.14). For age group 12-14 years, the multiple correlation coefficient is about 0.5 for boys and girls, so that about 25% of the height variation is explained by these factors. The multiple correlation coefficients for age group 15-17 years are 0.35 for boys and 0.26 for girls, so that only 12 % for boys and 7 % for girls of the variation in height is explained by the factors.

The difference in the size of the multiple correlation coefficient R between the three age groups could be largely attributed to the effect of age on height being less strong in the older age groups. A substantial amount of the variation in the height of children is unexplained. Some may be explained by other factors such as parent's height and child's birth weight about which we have no information in this study, while the remainder is just random variation.

Although the structure of the Libyan society is different from that of English society, the major socio-economic factors, such as family size, birth order, parents' education, income and crowd index, have a direct or indirect effect on children's growth in both societies.

CHAPTER EIGHT

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Local growth distance standards were established for Libyan boys and girls aged 6 to 17 years. There are differences between the English standards which are currently in use in Libya, and the results of this study for all the anthropometric variables studied which gives strong evidence against the use of the English standards in assessing the growth of Libyan children aged 6-17 years.

2. The Libyan boys in the 1983 study have much greater skinfold thicknesses than those in the 1957 study. The large significant difference in the distribution of skinfold thickness between the two studies confirms the distinct improvement in nutrition, health, education and income levels in Libya during this period of time.

3. The distributions of height and weight of Libyan children aged 6 to 17 years are similar to those of the neighbouring Arabic countries of Egypt and Tunisia.

4. Out of all the socio-economic variables under study, mother's education has the largest effect on children's height.

5. Local growth velocity standards for weight, skinfolds, arm and calf circumferences were constructed. Unfortunately, results for height velocity could not be established due to an error in calibration of the stadiometer counters at the start of the second survey.

6. There is a difference between the Libyan and English weight velocity standards, where the English 97th percentile of weight velocity for boys is larger than the Libyan 97th percentile and the 97th percentile

of weight velocity for Libyan girls is greater than the 97th percentile weight velocity for English girls. Although there is little difference between the Libyan and English 3rd and 50th percentiles of weight velocity at pre-adolescence, there are quite substantial differences at adolescence and after, where the Libyan weight velocity is larger than the English weight velocity for both boys and girls. The local weight velocity standards should be used instead of the English weight velocity standards which are currently in use in Libya.

7. The Libyan schoolchildren have larger skinfold thickness velocities and arm and calf circumference velocities than Dutch children. This difference is most likely due to differences in nutrition and environment. These differences demonstrate the need for local velocity standards in addition to local distance standards.

RECOMMENDATIONS:

1. The results of this study have made clear the necessity for local growth standards for Libyan school-age children and it is recommended that these standards should replace the English standards, which are currently in use in Libya.

2. If the above recommendation is accepted, convenient practical growth charts based on these standards should be constructed for use in health centres and paediatric hospitals.

3. Regular measurements of children's weight and height should be obtained from schools, health centres and paediatric hospitals. These could be used in health and nutritional surveillance.

4. The analysis of growth velocities and /or attained growth in different areas of the country could be used to improve resource allocation and evaluation of health standards.

Further Work to be Carried Out:

In order to have complete local growth standards for school-age children in Libya, the following work should be done:

1. A further survey is needed to set up height velocity standards for school children aged 6-17 years in Libya.

2. The existing data can be used to estimate age at menarche as a developmental variable in girls.

3. A long term longitudinal study should be set up to follow a group of children over the period of their adolescent growth spurt, to obtain information about individual patterns of growth at adolescence, and to estimate peak height velocities.

4. Regular growth surveys should be carried out to monitor the trend of Libyan children's growth and development.

REFERENCES

1. Altman, D.G., Cook, J. (1973):
   A Nutritional Surveillance Study.
   Proceedings of the Royal Society of Medicine 66, 646-647.
2. Anderson, M.A. (1975):
   Use of Height and Arm Circumference Measurements for Nutritional Selectivity in Srilanka School Feeding.
   The American Journal of Clinical Nutrition 28, 775-781.
3. Bielicki, T., Szczotka, H., Charzewski, J. (1981):
   The Influence of Three Socio-economic Factors on Body Height in Polish Military Conscripts.
   Human Biology 53, 543-555.
4. Bogin, B., MacVean, R.B. (1981):
   Body Composition and Nutritional Status of Urban Guatimalan Children of High and Low Socio-economic Class.
   American Journal of Physical Anthropology 55, 543-551.
5. Brozek, J., Keys, A. (1950):
   The Evaluation of Leanness-Fatness in Man:
   Norms and Interrelationships.
   British Journal of Nutrition 5, 192-206.
6. Cameron, N. (1977):
   An Analysis of the Growth of London Schoolchildren.
   The London County Council's 1966-1967 Growth Survey.
   PH.D. Thesis University of London.
7. Cameron, N. Personal Communication.

8. Cole, T.J. (1976):

A Method of Assessing Age-Standardised Weight-for-Height in Children seen Cross-sectionally.

Annals of Human Biology. 6, 3, 349-368.

9. Cole, T.J., Donnet, M.L., Stanfield, J.P. (1981):

Weight-for-Height Indices to Assess Nutritional Status. A New Index on a Slide-rule.

The American Journal of Clinical Nutrition 34, 1935-43.

10. Colley, J.R.T. (1974):

Obesity in Schoolchildren.

British Journal of Preventive and Social Medicine 28, 221-225.

11. Davis, C.T.M., Mbelwa, D., Doré, C. (1974):

Physical Growth and Development of Urban and Rural East African Children, Age 7-16 Years.

Annals of Human Biology. 1, 257-268.

12. Durnin, J.V.G.A., Rahaman, M.M. (1967):

The Assessment of the Amount of Fat in the Human Body from Measurements of Skinfold Thickness.

British Journal of Nutrition 21, 681-689.

13. Durnin, J.V.G.A., Womersley, J. (1974):

Body Fat assessed from Total Body Density.

British Journal of Nutrition 32, 77-97

14. Edwards, D.Q.W., Hammond, W.H., Healy, M.J., Tanner, J.M., Whitehouse, R.H. (1955):

Design and Accuracy of Calipers for measuring Subcutaneous Tissue Thickness.

British Journal of Nutrition 2, 133-145.

15. Eveleth, P.B., Tanner, J.M. (1976)

Worldwide Variations in Human Growth.

Cambridge University Press.

16. Ferro-Luzzi, A., Ferro-Luzzi, G. (1962):

A Study on Skinfold Thickness of Schoolchildren in Some Developing Countries. I. Skinfold Thickness of Libyan Boys.

Metabolism 11, 1064-72.

17. Garn, S.M., Hopkins, P.J., Ryan, A.S. (1981):

Differential Fatness Gain of Low Income Boys and Girls.

The American Journal of Clinical Nutrition. 34, 1465-68.

18. Goldstein, H. (1971):

Factors influencing the Height of Seven Year Old Children - Results from the National Child Development Study.

Human Biology. 43, 92-111.

19. Goldstein, H. (1979)

The Design and Analysis of Longitudinal Studies.

Academic Press.

20. Goldstein, H., Tanner, J.M. (1980):

Child Growth Standards.

The Lancet 1, 35.

21 Grant, M.W. (1964):

Rate of Growth in Relation to Birth Rank and Family Size.

British Journal of Preventive and Social Medicine 18, 35-42.

22. Graitcer, P.L., Gentry, E.M. (1981):

Measuring Children : One Standard for All.

Lancet 2, 297-299.

23. Habicht, J.P., Mortorell, R., Yarborough, C., Malina, R.M., Klein, R.E. (1974): Height and Weight Standards for Pre-schoolchildren. How relevant are Ethnic Differences in Growth Potential? Lancet 1, 611-615.

24. Healy, M.J.R. (1962): The Effect of Age-grouping on the Distribution of a Measurement affected by Growth. American Journal of Physical Anthropology 20, 49-50.

25. Healhy, M.J.R. (1974): Notes on Statistics of Growth Standards. Annals of Human Biology 1, 41-46.

26. Janes, M.D., Macfarlane, S.B.J., Moody, J.B. (1981): Height and Weight Growth Standards for Nigerian Children. Annals of Tropical Paediatrics 1, 27-37.

27. Jelliffe, D.B. (1966): The assessment of the Nutritional Status of the Community. W.H.O. Monographs 53 (Geneva).

28. Jelliffe, E.F.P., Jelliffe, D.B. (1969): The Arm Circumference as a Public Health Index of Protein - Calorie Malnutrition of Early Childhood. Journal of Tropical Paediatrics 15, 177-187.

29. Johnston, F.E., Borden, M., MacVean, R.B. (1973): Height, Weight and their Growth Velocities in Guatimalan Private Schoolchildren of High Socio-economic Class. Human Biology 45, 627-641.

30. Johnston, F.E., McKigney, J.I., Hopwood, S., Smelker, J. (1978):
Physical Growth and Development of Urban Native Americans:
A Study in Urbanization and its Implications for Nutrition.
The American Journal of Clinical Nutrition 31, 1017-1027.

31. Jordan, J., Ruben, M., Hernandez, J., Bebelagua, A.,
Tanner, J.M., Goldstein, H. (1975):
The 1972 Cuban National Childgrowth Study as an Example
of Population Health Monitoring : Design and Methods.
Annals of Human Biology 2, 153-171.

32. Kalbfleish, J.G. (1979):
Probability and Statistical Inference II
Springer-Verlag, New York.

33. Keiller, S.M., Colley, J.R.T., Carpenter, R,G. (1979):
Obesity in Schoolchildren and their Parents.
Annals of Human Biology 6, 443-455.

34. Kemm, J.R. (1982):
Anthropometry and Nutritional Surveillance in Central Sudan.
Thesis for Part II of the Membership of the Faculty of
Community Medicine Examination.

35. Lowenstein, M.S., Phillips, J.F. (1973):
Evaluation of Arm Circumference Measurements for determining
Nutritional Status of Children and its Use in an Acute Epidemic
of Malnutrition : Owerri, Nigeria, following the Nigerian
Civil War.
The American Journal of Clinical Nutrition 26, 226-233.

36. Lohman, T,G, (1981):
Skinfolds and Body Density (Review).
Human Biology 53, 181-225.

37. Marshande, J.P. (1980):
Child Growth Standards.
The Lancet 1, 1195-1196.

38. McDowell, A.J., Tasker, A.D., Sarhan, A.E. (1970):
Height and Weight of Children in U.S.A., India and United Arab Republic.
Public Health Service Publication No. 1000, Series 3, 14. P.H.S., Rockville, Maryland.

39. Ministry of Health, Tripoli, Libya (1973):
Annual Statistics Report.

40. Ministry of Health, Tripoli, Libya (1979):
Annual Statistics Report.

41. Morley, D.C. (1973):
Paediatric Priorities in Developing World.
Publisher: Butterworth, London.

42. Morley, D. (1977):
Growth Charts "Curative or Preventive?"
Archives of Diseases in Childhood 52, 395-398.

43. Nelson, W.E. (1964):
Care and Evaluation of Well Children, Physical Growth and Development.
Textbook of Paediatrics, 6th Edition. W.B. Saunders Company, Philadelphia.

44. Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., Bent, D. (1975):
Statistical Package for the Social Sciences. 2nd Edition.
McGraw - Hill Book Company, New York.

45. Rao, K.V., Singh, D. (1970):

An Evaluation of the Relationship between Nutritional Status and Anthropometric Measurements.

The American Journal of Clinical Nutrition 23, 88-93.

46. Rona, R.J., Altman, D.G. (1977):

National Study of Health and Growth.

Annals of Human Biology 4, 501-523.

47. Rona, R.J., Swan, A.V., Altman, D.G. (1978):

Social Factors and Height of Primary Schoolchildren in England and Scotland.

Journal of Epidemiology and Community Health 32, 147-154.

48. Rona, R.J. (1981):

Genetic and Environmental Factors in the Control of Growth in Childhood.

Scottish Medical Bulletin 37, 265-272.

49. Ryan, T.A., Joiner, B.L., Ryan, B.F. (1981):

Minitab Student Handbook.

Duxbury Press, Boston.

50. Seltzer, C.C., Goldman, R,F., Mayer, J. (1965):

The Triceps Skinfold as a Predictive Measure of Body Density and Body Fat in Obese Adolescent Girls.

Paediatrics 36, 212-218.

51. Stuart, H.C., Meredith, H.V. (1946):

The Use of Body Measurements in School Health Program.

1) General Consideration and the Selection of Measurements.

American Journal of Public Health 36, 1365-1372.

52. Stuart, H.C., Meredith, H.V. (1946):
The Use of Body Measurements in School Health Program.
2) Methods to be followed in taking and interpreting
Measurements and Norms to be used.
American Journal of Public Health 36, 1373-1386.

53. Stuart, H.C., Stevenson, S.S. (1954):
Care and Evaluation of Well Children: Physical Growth and Development.
Nelson, W.E. Textbook of Paediatrics, 7th Edition.
Publisher: Saunders, Philadelphia.

54. Tajouri, R.F. (1979):
Cross-section of Study of Growth in Urban Pre-schoolchildren
in Libya .
Al-Fatih Children Hospital Garyounis University,
Medical School Benghazi, Libya.

55. Tanner, J.M. (1962):
Growth at Adolescence, 2nd Edition.
Publisher : Blackwell, Oxford.

56. Tanner, J.M., Whitehouse, R.H., Takaishi, M. (1966):
Standards from Birth to Maturity for Height, Weight, Height-
Velocity and Weight-Velocity; British Children 1965. Part I.
Archives of Disease in Childhood 41, 454-471.

57. Tanner, J.M., Whitehouse, R.H., Takaishi, M. (1966):
Standards from Birth to Maturity for Height, Weight, Height-
Velocity and Weight-Velocity: British Children 1965. Part II.
Archives of Diseases in Childhood 41, 613-635.

58. Tanner, J.M., Whitehouse, R.H. (1975):

Revised Standard for Triceps and Subscapular Skinfolds in British Children.

Archives of Diseases in Childhood 50, 142-145.

59. Van Venrooij, M.E. (1978):

Mixed Longitudinal Data on Height, Weight, Limb Circumferences and Skinfold Measurements of Dutch Children.

Human Biology. 50, 369-384.

60. Van Wieringen, J.G., Wafelbakker, F., Verbrugge, H.P., Dehaas, J.H. (1971):

Growth Diagrams 1965 Netherlands.

Second National Survey on 0-24 Year-olds.

Netherlands Institute for Preventive Medicine TNO Leiden.

Wolters-Noordhoff Publishing Groningen 1971.

61. Waterlow, J.C., Buzina, R., Keller, W., Lane, J.M., Nichman, M.Z., Tanner, J.M. (1977):

The Presentation and Use of Height and Weight Data for comparing the Nutritional Status of Groups of Children under the Age of 10.

Bulletin, W.H.O. 55, 489-498.

62. Watson, J.D., Dako, D.Y. (1977):

Anthropometric Studies on African Athletes who participated in 1st African University Games.

British Journal of Nutrition 38, 353-360.

63. Weiner, J.S., Lourie, J.A. (1981):

Practical Human Biology.

Academic Press.

64. W.H.O. (1980):

Annual Statistics Report.

65. Womersley, J., Durnin, J.V.G.A. (1973):

An Experimental Study on Variability of Measurements of Skinfold Thickness on Young Adults.

Human Biology 45, 281-292.

66. Zaheer, M., Park, J.E., Aly, H.K. (1982):

Textbook on Community Medicine.

Published by Alfatah University, Tripoli, Libya.

Table A1: Height Distance Centiles (cm)

BOYS

Age Group	3rd	10th	25th	50th	75th	90th	97th
	Centiles						
6	105.8	108.7	111.6	114.9	118.2	121.1	124.0
7	108.2	111.5	114.9	118.6	123.4	125.7	129.0
8	112.5	116.1	119.8	123.8	127.7	131.5	135.1
9	116.6	120.2	123.9	128.0	132.1	135.8	139.4
10	121.7	125.2	127.0	133.8	137.6	141.0	145.0
11	125.3	129.4	133.5	138.1	142.7	146.0	150.2
12	129.2	133.4	137.7	142.4	147.1	151.4	155.6
13	133.7	138.1	142.5	147.5	152.5	156.9	161.5
14	137.7	142.0	147.2	153.0	158.3	164.0	169.2
15	143.6	148.7	153.9	159.6	165.3	170.5	175.6
16	149.7	154.4	159.2	164.6	170.0	174.8	179.5
17	154.0	158.0	162.2	166.7	171.2	175.3	179.5
GIRLS							
6	103.8	106.9	110.0	113.6	117.2	120.3	123.4
7	106.7	110.3	114.0	118.0	122.0	125.7	129.3
8	111.5	115.2	119.0	123.3	127.6	131.4	135.2
9	115.0	118.6	122.9	127.8	132.7	137.0	141.3
10	120.2	124.2	128.7	133.5	138.3	142.6	146.9
11	125.1	129.7	134.4	139.6	144.9	149.5	154.1
12	130.5	135.3	140.0	145.4	150.7	155.5	160.3
13	136.4	141.0	145.6	150.7	155.9	160.4	165.0
14	141.6	145.6	149.1	153.4	157.7	161.5	165.3
15	143.9	147.6	151.4	155.6	159.8	163.5	167.3
16	144.4	148.2	151.9	156.1	160.3	164.0	167.8
17	144.0	147.7	151.5	155.8	160.0	163.9	167.7

Table A2: Height Distance Centiles (cm), empirical method.

BOYS

Age group years	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	104.9	108.1	111.4	115.1	118.3	121.4	122.9
7	108.6	111.6	114.1	118.2	122.4	126.2	130.0
8	112.4	116.4	119.4	123.6	128.2	131.7	135.6
9	116.3	120.2	123.4	127.8	132.6	136.8	138.3
10	121.5	125.0	129.3	133.6	137.9	142.1	147.5
11	125.5	129.6	133.6	137.8	142.6	148.0	150.6
12	129.4	133.7	137.7	142.1	146.6	151.6	155.6
13	134.0	138.0	142.3	147.0	152.5	157.6	162.2
14	137.5	141.8	146.9	152.5	159.5	165.4	169.2
15	143.3	147.8	153.8	160.1	165.8	170.4	174.7
16	149.0	154.5	159.7	165.1	169.8	173.6	177.3
17	153.2	158.1	162.6	166.8	171.3	174.8	178.1
GIRLS							
6	104.4	106.7	109.6	113.5	117.0	121.2	126.0
7	107.0	110.3	114.3	117.5	122.1	125.6	131.4
8	111.3	115.6	118.9	122.9	127.3	130.7	134.8
9	114.7	118.1	123.0	127.4	132.1	137.0	144.0
10	121.2	124.5	127.9	133.3	138.1	143.6	147.5
11	124.8	130.1	133.8	139.3	144.3	149.6	154.8
12	129.6	134.0	140.0	145.5	151.3	155.6	158.7
13	134.9	140.0	146.0	151.0	155.9	160.2	164.4
14	141.3	146.4	150.2	153.7	157.3	161.5	166.5
15	144.1	147.9	151.3	155.5	159.7	163.5	167.5
16	144.2	148.3	152.2	155.9	160.5	164.0	168.2
17	144.3	147.6	151.4	155.6	160.2	163.5	168.8

Table A3: Weight Distance Centiles (kg).

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	16.6	17.5	18.6	20.3	22.4	24.8	27.9
7	17.5	18.6	20.0	21.8	24.2	27.0	30.3
8	18.6	19.9	21.6	24.0	27.0	30.4	34.6
9	19.7	21.3	23.3	26.1	29.6	33.6	38.6
10	21.9	23.9	26.3	29.6	33.7	38.3	43.9
11	23.7	26.0	28.6	32.4	36.9	41.9	47.9
12	25.8	28.4	31.7	36.1	41.6	47.6	54.8
13	27.2	30.3	34.2	39.4	46.0	53.3	62.0
14	29.4	33.1	37.7	44.0	52.0	60.8	71.6
15	33.5	37.6	42.4	49.0	57.0	65.8	76.2
16	38.3	42.2	46.8	52.7	59.6	66.9	75.2
17	41.0	45.0	49.9	56.0	63.0	70.5	78.9
GIRLS							
6	15.9	16.7	17.9	19.7	22.2	25.2	28.8
7	17.2	18.3	19.7	21.7	24.3	27.3	31.0
8	18.4	19.7	21.4	23.8	26.8	30.2	34.5
9	19.2	20.8	22.9	25.8	29.6	34.0	39.5
10	21.3	23.4	26.1	29.9	34.9	40.5	47.6
11	23.5	26.0	29.3	33.9	39.7	45.6	54.6
12	25.7	29.0	33.0	38.8	46.3	54.8	65.3
13	30.1	33.6	36.9	43.8	51.1	59.0	68.6
14	33.6	37.6	42.5	49.1	57.3	66.0	76.4
15	38.3	42.3	46.9	52.9	60.0	67.3	75.8
16	40.3	44.2	48.5	54.1	60.5	67.2	74.8
17	42.9	47.1	51.9	58.0	65.0	72.3	80.6

Table A4: Weight Distance Centiles (kg), empirical method.

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	15.8	17.5	18.9	20.1	22.2	24.5	28.5
7	17.1	18.5	20.2	21.9	23.9	26.2	31.0
8	18.9	20.0	21.5	23.8	26.5	30.7	36.1
9	20.0	21.1	23.3	26.1	29.1	33.3	40.7
10	22.4	24.1	26.3	29.3	33.0	37.9	48.4
11	23.7	26.0	28.8	31.8	36.4	42.6	50.0
12	26.4	28.8	31.5	35.3	40.6	49.1	57.7
13	27.7	30.5	33.8	38.4	45.6	54.1	65.1
14	29.6	32.8	37.7	43.7	51.9	61.8	76.2
15	33.7	37.8	42.8	48.3	56.2	65.5	81.2
16	37.6	42.4	47.1	53.0	59.0	66.7	76.4
17	41.7	45.8	50.0	55.3	61.5	68.8	78.7
GIRLS							
6	15.3	16.8	18.3	19.5	22.0	25.1	29.4
7	16.9	18.4	19.9	21.8	23.8	26.5	31.0
8	18.6	19.9	21.3	23.6	26.4	30.1	33.5
9	19.4	21.2	23.0	25.4	28.8	34.1	41.4
10	21.4	23.5	26.0	29.3	34.8	42.0	51.0
11	23.1	26.2	29.1	33.5	40.2	47.7	54.2
12	25.2	29.2	32.8	38.5	47.0	55.3	66.0
13	29.2	33.4	38.0	44.0	50.7	58.5	72.3
14	32.5	37.9	43.1	49.4	55.7	67.4	77.0
15	40.0	43.6	46.4	51.6	59.0	68.2	79.3
16	41.1	44.5	48.0	53.5	60.7	67.5	77.5
17	43.2	45.8	48.9	55.2	63.5	70.5	78.0

Table A5: Biceps Skinfold Centiles (mm).

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	3.3	3.6	4.1	4.7	5.5	6.5	7.7
7	3.0	3.3	3.8	4.6	5.6	7.0	8.8
8	2.8	3.2	3.7	4.5	5.8	7.5	10.0
9	2.9	3.3	3.8	4.7	6.1	8.0	10.7
10	2.8	3.1	3.7	4.6	6.1	8.3	11.5
11	2.8	3.1	3.7	4.7	6.3	8.6	12.1
12	2.8	3.3	4.0	5.2	7.2	10.2	14.7
13	2.9	3.3	4.0	5.1	7.0	9.8	13.9
14	2.8	3.2	3.9	5.0	6.9	9.7	13.9
15	2.8	3.2	3.8	4.7	6.3	8.4	11.6
16	2.7	3.0	3.5	4.2	5.4	7.0	9.2
17	2.7	3.0	3.5	4.1	5.2	6.5	8.4
GIRLS							
6	3.3	3.7	4.3	5.2	6.4	7.8	9.8
7	3.3	3.7	4.3	5.2	6.4	7.9	9.9
8	3.2	3.6	4.2	5.2	6.6	7.5	11.0
9	3.1	3.5	4.2	5.3	7.1	9.4	12.9
10	3.3	3.8	4.7	6.1	8.4	11.6	16.3
11	3.5	4.1	5.0	6.4	8.5	11.9	15.4
12	3.5	4.2	5.2	7.0	9.9	13.9	19.9
13	3.6	4.3	5.2	6.8	9.3	12.5	17.2
14	3.9	4.7	5.8	7.6	10.4	14.1	19.3
15	4.1	4.9	5.9	7.5	9.8	12.7	16.6
16	4.4	5.1	6.1	7.6	9.7	12.2	15.5
17	4.5	5.3	6.3	8.0	10.2	13.1	16.8

Table A6: Triceps Skinfold Centiles (mm)

BOYS

Age Group	3rd	10th	25th	Centiles 50th	75th	90th	97th
6	4.8	5.3	6.1	7.1	8.5	10.2	12.4
7	4.7	5.2	6.0	7.2	8.8	10.8	13.4
8	4.6	5.3	6.2	7.7	9.8	12.5	16.3
9	4.6	5.3	6.3	7.9	10.4	13.5	17.9
10	4.6	5.3	6.4	8.1	10.7	14.2	19.2
11	4.6	5.4	6.5	8.4	11.2	15.0	20.5
12	5.0	5.9	7.3	9.7	13.5	18.6	26.0
13	4.8	5.7	7.1	9.5	13.3	18.7	26.6
14	4.8	5.7	7.1	9.4	13.1	18.3	26.0
15	4.6	5.4	6.9	8.8	12.2	16.8	23.8
16	4.3	5.0	6.0	7.8	10.7	14.7	20.6
17	4.4	5.1	6.1	7.8	10.4	13.9	18.9
GIRLS							
6	5.3	6.0	6.9	8.3	10.2	12.6	15.6
7	5.6	6.3	7.3	8.7	10.5	12.7	15.5
8	5.2	6.2	7.3	8.9	11.3	14.2	19.5
9	5.2	6.1	7.3	9.3	12.2	16.1	21.5
10	5.5	6.5	8.1	10.6	14.5	19.7	27.1
11	5.8	6.9	8.5	11.0	14.6	19.4	26.0
12	6.1	7.4	9.3	12.4	17.2	23.5	32.6
13	6.5	7.8	9.8	13.0	17.6	23.7	32.2
14	7.6	9.3	11.6	15.3	20.5	27.2	36.3
15	8.8	10.5	12.8	16.2	20.8	26.3	33.5
16	9.4	11.1	13.4	16.8	21.2	26.4	32.9
17	9.9	11.8	14.4	18.2	23.3	29.2	36.9

Table A7: Subscapular Skinfold Centiles (mm)

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	3.6	3.9	4.4	5.2	6.3	7.7	9.7
7	3.4	3.8	4.3	5.1	6.4	8.2	10.8
8	3.4	3.7	4.3	5.3	6.8	9.1	12.6
9	3.4	3.8	4.4	5.5	7.4	10.1	14.2
10	3.4	3.9	4.6	5.8	7.9	10.9	15.6
11	3.4	3.9	4.6	6.0	8.4	12.0	17.9
12	3.6	4.1	5.0	6.7	9.6	14.0	20.9
13	3.6	4.1	5.1	6.8	9.8	14.2	21.3
14	3.7	4.3	5.4	7.3	10.7	15.8	24.0
15	3.9	4.5	5.5	7.3	10.2	14.4	20.7
16	4.2	4.9	5.8	7.3	9.6	12.6	16.8
17	4.5	5.2	6.2	7.7	9.9	12.6	16.4
GIRLS							
6	3.7	4.2	4.9	6.0	7.7	10.0	13.2
7	3.8	4.3	5.0	6.1	7.8	10.0	13.2
8	3.7	4.2	5.0	6.3	8.4	11.3	15.6
9	3.5	4.0	4.8	6.3	8.8	12.5	18.4
10	3.8	4.5	5.6	7.7	11.2	16.4	24.6
11	4.2	5.0	6.2	8.2	11.4	15.7	22.2
12	4.4	5.3	6.8	9.4	13.4	19.7	29.0
13	5.1	6.2	7.8	10.5	14.5	19.9	26.6
14	5.7	7.0	9.0	12.3	17.3	24.0	33.4
15	6.4	7.9	10.0	13.3	18.2	24.4	33.1
16	6.6	8.1	10.2	13.5	18.2	24.2	32.4
17	7.2	8.9	11.3	15.0	20.3	27.0	36.3

Table A8: Suprailiac Skinfold Centiles (mm).

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	3.1	3.4	3.8	4.6	5.9	7.6	10.1
7	3.1	3.5	4.0	4.8	6.2	8.0	10.7
8	3.1	3.6	4.1	5.2	7.0	8.8	13.6
9	3.3	3.8	4.5	5.8	7.9	11.0	15.7
10	3.3	3.8	4.6	6.2	8.8	12.8	19.3
11	3.2	3.8	4.6	6.3	9.3	13.9	21.6
12	3.5	4.2	5.4	7.7	11.7	18.0	28.4
13	3.6	4.3	5.5	7.8	11.9	18.2	28.7
14	3.7	4.5	5.9	8.5	13.2	20.3	32.2
15	3.8	4.6	5.9	8.3	12.3	18.1	27.4
16	3.9	4.6	5.7	7.7	10.9	15.4	22.2
17	4.1	5.0	6.2	8. 5	12.0	17.0	24.3
GIRLS							
6	3.5	3.9	4.5	5.6	7.4	10.0	13.9
7	3.5	3.9	4.5	5.7	7.5	10.1	14.1
8	3.5	3.9	4.6	5.7	8.1	11.4	17.0
9	3.5	3.9	4.7	6.3	7.2	13.8	21.5
10	3.7	4.3	5.4	7.6	11.5	17.8	28.2
11	3.9	4.6	5.8	8.3	12.7	19.5	31.0
12	4.2	5.2	6.8	10.1	16.0	25.2	40.6
13	4.6	5.5	7.0	9.7	13.8	19.7	28.6
14	5.8	7.3	9.5	13.4	19.4	27.8	40.1
15	6.9	8.5	10.9	14.5	19.8	26.7	36.1
16	7.1	8.8	11.1	14.8	20.0	26.8	36.0
17	6.9	8.5	10.9	14.8	20.5	27.9	38.3

Table A9: Arm circumference centiles (cm)

BOYS

Age Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6	14.9	15.3	15.9	16.7	17.7	18.9	20.1
7	15.0	15.5	16.1	16.9	18.0	19.2	20.7
8	15.2	15.8	16.6	17.6	18.9	20.4	22.3
9	15.5	16.1	16.9	18.1	19.5	21.2	23.3
10	15.9	16.6	17.5	18.8	20.5	22.5	24.9
11	16.3	17.1	18.0	19.4	21.1	23.1	25.4
12	16.9	17.8	19.0	20.6	22.6	24.8	27.6
13	17.2	18.2	19.4	21.1	23.3	25.7	28.6
14	17.7	18.8	20.2	22.0	24.3	26.9	30.1
15	18.6	19.7	21.0	22.8	24.9	27.3	30.2
16	19.4	20.5	21.9	23.7	25.8	28.1	30.8
17	20.0	21.1	22.4	24.2	26.2	28.4	30.9
GIRLS							
6	14.4	15.0	15.7	16.7	17.9	19.3	21.0
7	14.9	15.5	16.2	17.1	18.3	19.6	21.2
8	15.1	15.8	16.6	17.6	19.0	20.5	22.2
9	15.1	15.8	16.8	18.1	19.8	21.8	24.2
10	15.6	16.5	17.6	19.2	21.2	23.6	26.4
11	16.3	17.2	18.4	20.0	22.0	24.2	26.9
12	16.7	17.9	19.3	21.3	23.7	26.6	30.0
13	17.9	19.0	20.4	22.2	24.5	27.0	30.0
14	18.7	20.0	21.5	23.6	26.1	28.8	32.0
15	19.7	21.0	22.4	24.3	26.6	29.0	31.8
16	20.3	21.5	22.9	24.8	26.9	29.1	31.6
17	20.7	21.9	23.4	25.3	27.5	29.8	32.4

Table All: Comparison between triceps skinfold thickness of Libyan boys 1957 and 1983

Age Group	3rd 1957	3rd 1983	10th 1957	10th 1983	25th 1957	25th 1983	50th 1957	50th 1983	75th 1957	75th 1983	90th 1957	90th 1983	97th 1957	97th 1983
6	3.9	4.8	4.6	5.3	5.3	6.1	6.2	7.1	7.2	8.5	8.3	10.2	9.3	12.4
7	3.7	4.7	4.4	5.2	5.1	6.0	6.0	7.2	6.9	8.8	8.0	10.8	9.0	13.4
8	3.7	4.6	4.5	5.3	5.0	6.2	5.8	7.7	6.8	9.8	7.7	12.5	8.8	16.3
9	3.7	4.6	4.4	5.3	5.0	6.3	5.9	7.9	6.8	10.4	8.0	13.5	9.3	17.9
10	3.8	4.6	4.5	5.3	5.0	6.4	5.9	8.1	6.9	10.7	8.0	14.2	9.5	19.2
11	3.8	4.6	4.5	5.4	5.1	6.5	5.9	8.4	6.9	11.2	7.9	15.0	9.4	20.5
12	3.7	5.0	4.3	5.9	5.0	7.3	6.0	9.7	7.5	13.5	8.3	18.6	9.5	26.0
13	3.7	4.8	4.5	5.7	5.2	7.1	7.0	9.5	7.3	13.3	8.3	18.7	10.5	26.6
14	3.7	4.8	4.1	5.7	4.9	7.1	6.0	9.4	7.4	13.1	8.7	18.3	10.1	26.0

Table A12: Comparison between subscapular skinfold thickness of Libyan boys 1957 and 1983.

Age Group	3rd		10th		25th		50th		75th		90th		97th	
	1957	1983	1957	1983	1957	1983	1957	1983	1957	1983	1957	1983	1957	1983
6	2.8	3.6	3.5	3.9	3.8	4.4	4.3	5.2	5.0	6.3	5.5	7.7	6.4	9.7
7	2.9	3.4	3.6	3.8	3.9	4.3	4.4	5.1	5.2	6.4	5.5	8.2	6.4	10.8
8	3.0	3.4	3.6	3.7	3.9	4.3	4.4	5.3	5.0	6.8	5.4	9.1	6.3	12.6
9	3.1	3.4	3.6	3.8	3.9	4.4	4.5	5.5	5.2	7.4	5.6	10.1	6.4	14.2
10	3.5	3.4	3.7	3.9	4.1	4.6	4.7	5.8	5.3	7.9	5.9	10.9	6.8	15.6
11	3.5	3.4	3.7	3.9	4.1	4.6	4.8	6.0	5.4	8.4	6.1	12.0	6.7	17.9
12	3.5	3.6	3.8	4.1	4.3	5.0	4.9	6.7	5.5	9.6	6.3	14.0	7.4	20.9
13	3.6	3.6	3.9	4.1	4.5	5.1	5.7	6.8	5.9	9.8	6.5	14.2	8.2	21.3
14	3.6	3.7	4.1	4.3	4.7	5.4	5.4	7.3	6.2	10.7	6.9	15.8	7.5	24.0

Table B1: Distribution of Family Size and Birth Order

Family Size	No. of Cases	%	Birth Order	No. of Cases	%
≤ 3	50	0.6	1	1334	15.8
4	188	2.2	2	1400	16.6
5	502	5.9	3	1357	16.1
6	805	9.5	4	1277	15.1
7	1074	12.6	5	952	11.3
8	1147	13.5	6	806	9.5
9	1263	14.8	7	512	6.0
10	1219	14.3	8	394	4.6
11	967	11.4	9	218	2.6
12	654	7.7	10	100	1.2
13	337	4.0	11	44	0.5
14	166	1.9	12	21	0.2
15	55	0.6	13	6	0.0
16	18	0.2	14	2	0.0
17	24	0.3	15	3	0.0
18	6	0.0	Total	8426	100.0
19	5	0.0	Unknown	85	
Total	8489	100.0			
Unknown	22				

Table B2: Distribution of Total and Live Children

Total Number of Children	No. of Cases	%	Number of Live Children	No. of Cases	%
1	36	0.4	1	44	0.5
2	143	1.7	2	160	1.9
3	442	5.2	3	495	5.8
4	723	8.5	4	809	9.5
5	915	10.7	5	1049	12.3
6	980	11.5	6	1112	13.1
7	1076	12.7	7	1266	14.9
8	1177	13.9	8	1230	14.5
9	967	11.4	9	1002	11.8
10	803	9.5	10	672	7.9
11	551	6.5	11	351	4.1
12	324	3.8	12	179	2.1
13	166	2.0	13	60	0.7
14	77	0.9	14	27	0.3
15	63	0.7	15	24	0.3
16	28	0.3	16	3	0.0
17	9	0.1	17	3	0.0
18	7	0.1	Total	8486	99.8
Total	8487	100.0	Unknown	25	
Unknown	24				

Table B3: Distribution of Father's and Mother's Educational Level

Level of Education	Father		Mother	
	No. of Cases	%	No. of Cases	%
Illiterate	1153	14.2	5020	59.7
Primary	2645	32.6	1887	22.5
Preparatory	1511	18.6	541	6.4
Secondary	1748	21.5	815	9.7
University	877	10.8	128	1.5
Higher	181	2.2	11	0.1
Total	8115	100.0	8402	100.0
Unknown	396		109	

Table B4: Distribution of Father's Occupation

Father's Occupation	No. of Cases	%
Administration	2304	28.6
Supermarket Employee	1562	19.4
Army	941	11.7
Electrician, Mechanics and Maintenance	665	8.3
Teaching	430	5.3
Driver (Government and Private)	359	4.5
Private Business	342	4.2
Police and Customs	327	4.1
Farmers	191	2.4
Accountants	183	2.3
Retired	104	1.3
Science and Engineering	83	1.0
Law	66	0.8
Nursing	61	0.8
Diplomatic	55	0.7
Civil Pilot and Engineer	51	0.6
Petroleum Employee	49	0.6
Hotel and Restaurant Employee	44	0.6
Transport Technicians	35	0.4
Medical Doctors and Pharmacist	33	0.4
Media	32	0.4
Other Occupations	132	1.6
Total	8049	100.0
Dead	325	
Unknown	137	

Table B5: Distribution of Mother's Occupation

Mother's Occupation	No. of Cases	%
Housewife	7632	90.7
Teaching	536	6.4
Administration	96	1.1
Supermarket Employee	67	0.8
Nursing	27	0.3
Accountants	15	0.2
Tailor	8	0.1
Medical Doctor	7	0.1
Student	7	0.1
Police and Customs	7	0.1
Science and Engineering	6	0.1
Media	2	0.0
Cashier and Bookkeeper	2	0.0
Telecommunications	2	0.0
Total	8418	100.0
Dead	58	
Unknown	39	

Table B6: Distribution of House Type and Number of Bedrooms

House Type	No. of Cases	%
Villa	3151	37.4
Large Apartment or Terraced House	1347	16.0
Small Apartment or House	3936	46.7
Total	8437	100.0
Unknown	77	

Number of Bedrooms	No. of Cases	%
One Bedroom	170	2.0
Two Bedrooms	3077	36.5
Three Bedrooms	4240	50.3
Four Bedrooms	810	9.6
Five Bedrooms	108	1.3
Six Bedrooms	27	0.3
Total	8432	100.0
Unknown	79	

Table B7: Distribution of Father's and Mother's Income

Father's Income	No. of Cases	%	Mother's Income	No. of Cases	%
Grade 1	11	0.3	Grade 1	4	1.4
Grade 2	38	1.2	Grade 2	5	1.7
Grade 3	100	3.1	Grade 3	5	1.7
Grade 4	195	6.1	Grade 4	3	1.0
Grade 5	284	8.8	Grade 5	14	4.8
Grade 6	440	13.7	Grade 6	31	10.6
Grade 7	446	13.9	Grade 7	54	18.4
Grade 8	383	11.9	Grade 8	62	21.2
Grade 9	323	10.1	Grade 9	56	19.1
Grade 10	535	16.7	Grade 10	56	19.1
Grade 11	200	6.2	Grade 11	1	0.3
Grade 12	147	4.6	Grade 12	1	0.3
Grade 13	93	2.9	Grade 13	1	0.3
Grade 14	13	0.4	Total	293	100.0
Total	3208	100.0	Unknown	586	
Unknown	5303		Housewife	7632	

Table B8: Distribution of Persons per Bedroom (Index of Overcrowding)

No. of Persons per Bedroom	No. of Cases	%
0 -1.99	420	5.0
2.00-2.99	2427	28.8
3.00-3.99	2964	35.1
4.00-4.99	1489	17.7
5.00-5.99	716	8.5
6.00-6.99	281	3.3
7.00+	133	1.6
Total	8430	100.0
Unknown	81	

Table B9: Mean Height for Libyan Boys and Girls by Family Size and Age Group

Age Group	Family Size					
	Boys			Girls		
	≦ 5	6-10	11+	≦ 5	6-10	11+
6	115.8	115.2	113.2	114.4	113.3	111.9
7	120.7	117.5	118.6	120.7	117.4	117.5
8	126.4	123.3	123.7	125.0	123.1	122.4
9	129.4	128.2	126.5	129.0	128.1	125.6
10	137.7	133.4	133.2	135.8	133.3	133.1
11	138.6	138.4	137.1	140.7	139.6	137.9
12	145.7	142.8	142.0	147.6	145.7	145.5
13	150.3	147.8	146.4	154.1	150.6	150.5
14	154.9	153.6	151.2	154.2	153.8	153.4
15	157.9	159.9	159.3	158.5	155.5	155.6
16	163.2	165.0	163.9	158.6	155.9	155.8
17	166.4	165.8	165.2	156.2	166.3	157.1

Table B10: Mean Height for Libyan Boys and Girls by Total Number of Children in Family and Age Group

Age Group	Total Children					
	Boys			Girls		
	≤ 3	4-8	9+	≤ 3	4-8	9+
6	114.9	115.3	113.8	114.0	113.6	112.1
7	120.5	117.9	118.1	120.1	117.7	117.2
8	126.5	123.6	123.4	124.4	123.0	122.5
9	129.7	128.4	126.6	128.6	128.2	125.9
10	137.4	133.6	133.1	135.4	133.5	132.9
11	139.1	138.5	136.9	140.2	140.2	138.6
12	141.6	142.8	141.7	148.2	145.9	144.8
13	154.3	147.7	147.3	154.2	151.1	150.0
14	155.5	153.9	151.8	156.4	154.0	153.3
15	156.3	160.3	159.1	158.8	155.9	155.0
16	167.0	166.0	163.9	158.9	156.2	155.9
17	168.7	168.0	166.4	159.4	155.0	156.1

Table B11: Mean Height for Libyan Boys and Girls by Number of Live Children in Family and Age Group

Age Group	Live Children					
	Boys			Girls		
	≤3	4-8	9+	≤3	4-8	9+
8	115.1	115.0	113.9	114.4	113.3	112.1
7	120.5	117.7	118.3	121.1	117.5	117.2
8	126.5	123.3	123.8	124.2	123.0	122.6
9	129.4	128.1	126.6	129.3	128.2	125.6
10	137.5	133.6	133.1	136.0	133.3	133.1
11	138.8	138.2	137.2	140.6	139.5	139.3
12	142.0	142.5	141.9	147.5	145.8	154.2
13	154.2	147.8	146.7	154.0	150.8	150.3
14	154.4	153.7	151.1	155.8	153.9	153.5
15	160.3	159.6	159.7	158.6	155.7	155.3
16	168.0	165.6	163.7	158.4	156.1	155.8
17	168.2	167.1	165.0	157.1	155.2	156.8

Table B12: Mean Height for Libyan Boys and Girls by Birth Order and Age Group

BOYS

Age Group	Birth Order (Parity)				
	1	2	3	4,5	6+
6	116.5	115.4	115.5	115.2	114.4
7	119.9	118.5	119.8	117.8	118.6
8	124.6	124.4	124.0	123.6	123.1
9	128.9	129.1	127.7	127.5	127.4
10	135.5	133.2	133.0	132.8	133.0
11	138.7	138.4	137.8	137.7	137.6
12	143.8	142.6	142.3	142.2	142.6
13	148.1	148.6	147.0	146.2	146.0
14	154.0	152.9	153.1	152.9	152.5
15	160.1	159.4	159.8	159.6	159.2
16	164.6	164.5	162.4	163.8	163.2
17	165.8	167.2	167.2	167.5	165.3
GIRLS					
6	114.4	113.8	113.9	113.6	112.8
7	119.1	119.0	119.1	117.4	117.2
8	124.0	124.0	122.4	122.2	122.0
9	129.4	129.0	126.8	127.0	127.0
10	135.8	133.6	133.5	132.4	132.3
11	141.2	140.3	138.7	139.6	139.7
12	146.5	145.3	144.5	145.0	145.3
13	150.6	150.4	150.5	149.8	150.0
14	154.8	153.1	154.1	153.8	153.9
15	155.7	155.3	155.4	155.1	155.1
16	156.1	156.5	156.6	155.9	155.9
17	156.8	156.5	156.3	154.7	155.4

Table B13: Mean Height for Libyan Boys and Girls by Father's Education and Age Group

BOYS

Age Group	Father's Education			
	Primary or Less	Preparatory	Secondary	University or Higher
6	113.8	115.4	115.7	115.4
7	116.6	118.9	120.1	119.9
8	123.1	122.8	124.5	125.0
9	126.7	126.9	129.3	130.3
10	132.6	132.3	135.9	136.5
11	137.4	138.1	139.5	138.9
12	141.2	143.0	143.5	143.8
13	146.2	148.0	148.7	149.9
14	152.2	154.7	154.6	152.2
15	159.1	160.0	159.9	160.8
16	163.8	165.0	166.6	165.1
17	166.8	168.4	164.5	166.3
GIRLS				
6	112.0	112.5	114.0	115.8
7	117.7	116.2	117.5	120.5
8	122.2	121.4	123.5	125.6
9	126.6	127.1	129.1	129.2
10	131.6	133.3	134.7	137.0
11	138.6	138.7	140.1	141.5
12	143.0	146.2	148.4	146.2
13	149.4	150.2	151.8	153.3
14	153.1	154.5	155.4	154.1
15	155.0	155.7	156.0	156.9
16	155.4	154.9	157.3	157.6
17	155.0	155.4	157.5	157.7

Table B14: Mean Height for Libyan Boys and Girls by Mother's Education and Age Group

BOYS

Age Group	Mother's Education			
	Illiterate	Primary	Preparatory	Secondary or Higher
6	114.2	116.5	114.4	114.1
7	116.9	119.0	119.6	120.1
8	122.4	124.3	125.5	126.2
9	126.8	128.6	129.5	130.1
10	133.0	134.8	134.6	135.8
11	137.1	139.5	139.4	148.6
12	141.7	143.5	144.0	143.8
13	146.6	148.1	152.1	148.9
14	152.4	154.2	156.0	155.9
15	159.3	160.0	158.4	164.3
16	164.1	165.3	167.2	168.8
17	166.6	167.2	168.9	166.5
GIRLS				
6	112.5	114.3	114.1	114.9
7	116.2	119.1	119.1	120.3
8	121.7	123.3	126.4	124.7
9	126.6	127.8	131.7	129.1
10	132.0	133.4	135.0	138.0
11	137.8	140.0	141.9	142.9
12	144.1	146.0	147.6	147.9
13	149.6	151.4	153.5	154.0
14	153.2	154.8	156.6	155.4
15	154.4	156.7	158.7	158.7
16	155.4	156.5	159.2	158.2
17	155.3	157.0	157.7	159.0

Table B15: Mean Height for Libyan Boys and Girls by Father's Occupation and Age Group

BOYS

Age Group	Father's Occupation					
	Teaching	Adminis- tration	Electrician Mechanics Maintenance	Supermarket Employee	Army	Other Occupations
6	116.3	115.8	116.0	112.9	113.0	114.9
7	118.6	119.1	118.2	117.1	116.8	119.9
8	125.0	124.0	124.4	122.0	124.1	124.2
9	128.3	128.1	129.5	127.2	126.4	128.7
10	134.4	134.7	133.3	132.5	133.3	134.0
11	136.0	138.3	137.2	138.4	138.1	138.8
12	143.4	143.5	141.0	142.2	142.6	141.9
13	147.1	148.8	147.0	147.0	146.0	147.4
14	149.7	153.7	151.4	152.9	153.5	153.4
15	158.4	161.1	159.2	158.7	158.7	159.7
16	165.8	166.4	164.6	163.5	162.1	164.2
17	167.7	166.6	166.6	166.4	165.8	167.4
GIRLS						
6	112.8	113.1	113.0	112.4	112.4	116.7
7	117.1	118.5	118.0	117.5	116.8	118.8
8	123.0	123.2	123.6	122.1	121.0	124.8
9	126.0	128.8	130.0	126.7	125.1	128.8
10	133.3	133.4	133.6	132.8	132.6	134.8
11	140.7	139.6	139.8	137.8	137.8	140.8
12	143.5	146.4	147.0	142.8	144.6	146.0
13	149.7	152.3	152.1	148.6	149.6	150.5
14	154.5	155.0	155.3	152.7	152.7	153.6
15	154.1	156.6	156.2	154.4	153.9	155.9
16	157.3	156.9	157.4	155.1	154.6	155.6
17	155.9	157.0	156.4	153.4	158.6	156.5

Table B16: Mean Height for Libyan Boys and Girls by Mother's Occupation and Age Group

BOYS

Age Group	Mother's Occupation		
	Housewife	Teaching	Other Occupations
6	115.1	113.4	114.9
7	118.3	118.3	122.2
8	123.2	126.4	126.7
9	127.7	129.9	130.8
10	133.7	133.7	134.3
11	137.9	141.2	138.5
12	142.3	143.5	144.2
13	147.5	147.1	147.8
14	152.9	157.0	153.0
15	159.7	159.8	153.6
16	164.5	167.7	167.3
17	166.7	166.5	167.9
GIRLS			
6	113.4	113.8	115.1
7	117.8	118.2	121.5
8	123.0	123.7	126.1
9	127.7	128.1	129.6
10	133.2	135.3	135.5
11	139.3	142.8	138.9
12	145.1	147.7	146.2
13	150.4	153.5	152.5
14	153.9	155.5	153.7
15	155.5	159.3	154.6
16	156.0	159.3	154.7
17	155.8	158.9	153.0

Table B17: Mean Height for Libyan Boys and Girls by Type of Dwelling and Age Group

BOYS

Age Group	House Type		
	Villa	Large * Apartment	Small* House
6	115.7	115.8	113.4
7	119.0	120.5	117.0
8	124.3	125.3	122.6
9	129.3	129.0	126.3
10	135.7	135.0	132.3
11	139.0	141.4	136.5
12	143.5	143.1	141.3
13	148.3	146.6	146.9
14	153.4	153.4	152.6
15	160.1	160.7	159.1
16	165.8	164.5	164.0
17	166.9	167.8	166.5
GIRLS			
6	114.2	115.8	111.4
7	118.3	121.5	116.2
8	123.7	124.3	122.1
9	129.3	127.3	126.7
10	134.6	135.2	131.8
11	140.2	141.5	137.9
12	146.4	147.3	143.5
13	153.0	152.2	148.5
14	155.3	154.4	142.7
15	157.0	156.5	145.3
16	156.7	157.2	155.0
17	158.8	154.4	154.5

*See text for description of these categories

Table B18: Mean Height for Libyan Boys and Girls by Number of Bedrooms and Age Group

BOYS

Age Group	Number of Bedrooms		
	One or Two Bedrooms	Three Bedrooms	Four or more Bedrooms
6	114.0	115.6	116.1
7	117.8	118.6	121.6
8	123.3	124.1	124.9
9	127.8	127.9	129.7
10	133.9	133.6	134.3
11	137.8	137.9	140.1
12	142.0	142.6	142.1
13	147.2	147.4	148.5
14	153.0	153.9	153.6
15	158.5	160.9	156.3
16	162.7	165.0	166.6
17	167.2	166.5	166.5
GIRLS			
6	113.5	113.4	112.8
7	117.9	118.0	118.4
8	123.0	123.0	124.5
9	126.8	128.4	130.2
10	133.4	132.9	136.6
11	139.5	138.9	141.9
12	144.2	145.3	149.2
13	150.3	150.5	153.1
14	153.0	153.8	156.6
15	154.8	155.8	157.0
16	155.8	156.3	156.4
17	154.1	156.1	158.8

Table B19: Mean Height for Libyan Boys and Girls by Father's Income and Age Group

BOYS

Age Group	Father's Income		
	≤ Grade 5	Grade 6-9	Grade 10-16
6	115.3	114.1	114.3
7	117.9	118.1	120.4
8	124.2	122.5	124.5
9	127.7	127.6	130.1
10	133.7	133.5	134.5
11	138.0	138.1	138.8
12	140.9	142.5	145.3
13	146.9	148.9	150.0
14	153.0	152.3	154.4
15	159.8	158.2	160.2
16	164.8	163.4	163.5
17	166.5	167.8	169.0
GIRLS			
6	113.6	114.4	112.7
7	117.6	118.1	119.3
8	123.0	122.4	124.6
9	127.3	127.9	130.2
10	133.2	133.0	136.2
11	139.4	137.0	142.4
12	144.9	145.9	147.0
13	150.0	150.3	153.7
14	153.8	154.5	154.0
15	155.3	156.2	156.9
16	156.3	156.5	156.9
17	155.9	155.7	156.2

Figure C1: Program used in MINITAB to calculate minus log likelihood and plot it against the constant.

```
Let K90 = n
- - STORE
>LET K1 = K1 + K2
>JOIN  K1 C11    C11
>LET C12 = LOGE (C3 + K1)
>STAN  C12        K3
>LET   K4 = K90* LOGE (K3) + SUM(C12)
>JOIN  K4   C13      C13
>END
- - LET K1 = - 15.0
- - LET K2 = 0.5
- - EXECUTE 30
- - PLOT C13    C11
```

Notes:
1) Untransformed weight is in column C_3
2) This will plot minus log likelihood against the constant in the range 0 to 15 in steps of 0.5.
3) n = number of observations.

Table C2: Values of $\hat{c}_j$ by age group and sex for each variable.

Age (age group j)	Number	Sex	Weight	Biceps	Triceps	Subsc.	Suprai.	Arm	Calf
6(1)	162	M	10.8	19.6	27.5	20.4	22.2	80.0	-
	189	F	11.3	22.5	41.7	22.1	28.8	119.7	146.6
7(2)	272	M	13.4	18.6	29.7	24.0	19.6	130.0	180.5
	288	F	11.0	15.6	31.0	25.7	26.2	100.8	143.1
8(3)	324	M	13.8	18.0	27.6	21.3	26.2	130.0	188.0
	278	F	13.2	18.6	37.3	29.0	26.8	134.4	123.0
9(4)	344	M	11.7	23.2	30.3	25.8	28.0	129.0	172.0
	292	F	15.3	24.8	34.4	24.8	28.4	115.2	145.6
10(5)	352	M	16.0	20.2	31.8	28.9	26.9	141.0	191.0
	350	F	15.5	22.2	38.8	29.0	30.0	122.8	161.6
11(6)	394	M	16.3	21.5	38.0	27.3	27.8	144.0	132.0
	404	F	14.5	26.7	41.4	37.0	27.6	117.6	169.0
12(7)	401	M	20.0	22.4	36.8	27.4	28.0	140.4	190.0
	423	F	13.2	23.2	38.7	37.0	26.4	132.9	154.5
13(8)	350	M	20.5	25.8	34.8	28.7	30.2	138.0	164.0
	435	F	15.4	22.2	21.0	38.5	30.5	131.8	168.0
14(9)	442	M	19.5	20.5	28.4	26.4	30.9	135.0	170.0
	484	F	4.5	26.4	18.0	31.4	25.5	111.6	167.4
15(10)	456	M	17.7	22.0	28.8	29.2	32.7	153.0	198.0
	431	F	18.7	23.0	27.6	43.5	40.5	141.6	185.0
16(11)	525	M	3.9	20.9	29.2	34.8	33.0	132.0	-
	413	F	23.6	15.2	20.0	32.5	37.0	122.0	157.0
17(12)	319	M	21.2	24.0	36.0	34.8	34.8	146.0	192.0
	182	F	28.4	12.4	2.5	18.5	35.1	162.5	212.0

Table C3: Values of $\hat{c}_j$ for weight with 10% Likelihood Intervals.

Age (agegroup j)	Interval width					
	BOYS			GIRLS		
6(1)	5.4	10.8	13.2	8.0	11.3	13.2
7(2)	10.7	13.4	14.7	6.5	11.0	13.2
8(3)	11.5	13.8	15.4	10.0	13.2	15.0
9(4)	8.1	11.7	13.8	12.6	15.3	16.3
10(5)	13.0	16.0	17.5	12.0	15.5	17.5
11(6)	12.5	16.3	18.5	9.0	14.5	17.6
12(7)	15.9	20.0	21.6	4.5	13.2	17.3
13(8)	16.0	20.5	23.5	6.8	15.4	20.4
14(9)	12.9	19.5	22.8	- 15.7	4.5	14.0
15(10)	9.0	17.7	22.2	7.5	18.7	24.0
16(11)	- 20.0	3.9	15.0	12.4	23.6	29.2
17(12)	10.5	21.2	27.5	14.0	28.4	36.2

Table C4: Value of $\hat{c}_j$ for biceps skinfold with 10% Likelihood Intervals

Age group years	Interval width					
	BOYS			GIRLS		
6(1)	7.2	19.6	26.0	13.6	22.5	27.0
7(2)	12.0	18.6	22.4	6.0	15.6	22.0
8(3)	14.4	18.0	20.0	15.4	18.6	22.2
9(4)	22.4	23.2	24.8	20.8	24.8	27.0
10(5)	18.5	20.2	21.5	9.0	22.2	27.8
11(6)	19.6	21.5	22.5	22.0	26.7	29.5
12(7)	20.2	22.4	23.6	18.0	23.2	26.4
13(8)	23.8	25.8	27.0	17.2	22.2	24.8
14(9)	19.0	20.5	21.5	22.0	26.4	29.4
15(10)	20.9	22.0	22.7	15.6	23.0	27.2
16(11)	19.8	20.9	21.5	0.0	15.2	24.6
17(12)	22.4	24.0	24.7	- 6.0	12.4	24.0

Table C5: Value of $\hat{c}_j$ for triceps skinfold, with 10% Likelihood Intervals

Age Group Years	Interval width					
	BOYS			GIRLS		
6(1)	9.1	27.5	35.0	31.2	41.7	46.2
7(2)	22.2	29.7	34.8	15.0	31.0	39.0
8(3)	20.0	27.6	32.8	28.0	37.3	43.2
9(4)	24.6	30.3	33.2	26.5	34.4	39.2
10(5)	26.7	31.8	35.1	28.0	38.8	44.0
11(6)	34.0	38.0	40.0	33.0	41.4	45.8
12(7)	31.6	36.8	40.2	28.0	38.7	46.0
13(8)	28.4	34.8	38.0	2.0	21.0	32.0
14(9)	24.0	28.4	30.8	3.0	18.0	33.0
15(10)	25.4	28.8	31.0	12.0	27.6	44.0
16(11)	26.4	29.2	31.8	-90.0	-20.0	18.0
17(12)	32.0	36.0	38.4	-	2.5	44.0

Table C6: Values of $\hat{c}_j$ for subscapular skinfold with 10% Likelihood Intervals.

Age Group Years	Interval width					
	BOYS			GIRLS		
6(1)	10.8	20.4	25.8	15.0	22.1	26.0
7(2)	20.2	24.0	26.2	20.0	25.7	28.0
8(3)	17.8	21.3	23.0	26.3	29.0	30.8
9(4)	22.2	25.8	28.2	22.4	24.8	27.6
10(5)	27.3	28.9	29.6	26.0	29.0	30.8
11(6)	25.0	27.3	28.5	34.2	37.0	38.8
12(7)	25.0	27.4	28.7	33.0	37.0	39.1
13(8)	26.8	28.7	29.6	34.5	38.5	41.0
14(9)	24.6	26.4	27.5	24.4	31.4	35.6
15(10)	27.2	29.2	31.2	35.0	43.5	48.7
16(11)	30.8	34.8	37.6	18.5	32.5	42.5
17(12)	30.8	34.8	38.0	-28.0	18.5	38.0

Table C7: Values of $\hat{c}_j$ for suprailiac skinfold, with 10% Likelihood Intervals

Age Group Years	Interval width					
	BOYS			GIRLS		
6(1)	17.2	22.2	24.8	24.8	28.8	30.7
7(2)	16.8	19.6	21.0	22.0	26.2	28.4
8(3)	24.5	26.2	27.3	23.6	26.8	28.8
9(4)	26.0	28.0	29.2	26.0	28.4	29.5
10(5)	25.2	26.9	27.7	27.1	30.0	31.5
11(6)	25.6	27.8	28.7	24.2	27.6	29.3
12(7)	26.4	28.0	29.5	21.6	26.4	29.0
13(8)	28.0	30.2	31.4	21.5	30.5	25.5
14(9)	29.2	30.9	31.7	11.5	25.5	34.0
15(10)	30.9	32.7	33.6	28.0	40.5	50.4
16(11)	31.6	33.0	32.7	21.0	37.0	44.0
17(12)	31.6	34.8	37.2	0.0	35.1	52.5

Table C8: Values of $\hat{c}_j$ for arm circumference, with 10% Likelihood Intervals.

Age Group Years	Interval width					
	BOYS			GIRLS		
6(1)	-	80.0	123.0	99.0	119.7	128.8
7(2)	119.0	130.0	137.0	66.0	100.8	118.5
8(3)	119.0	130.0	136.5	123.2	134.4	140.4
9(4)	110.0	129.0	136.0	91.5	115.2	127.5
10(5)	130.0	141.0	147.0	105.5	122.8	134.0
11(6)	134.0	144.0	152.0	86.0	117.6	132.0
12(7)	126.4	140.4	151.6	110.0	132.9	145.0
13(8)	118.0	138.0	153.0	104.0	131.8	145.0
14(9)	112.0	135.0	147.0	64.0	111.6	136.0
15(10)	136.0	153.0	164.0	110.0	141.6	160.0
16(11)	97.0	132.0	150.0	52.0	122.0	152.0
17(12)	112.0	146.0	164.0	100.0	162.5	184.0

Table C9: Values of $\hat{c}_j$ for calf circumference, with 10% Likelihood Intervals.

Age Group Years	Interval width					
	BOYS			GIRLS		
6(1)	-	-	-	75.0	146.6	171.0
7(2)	160.3	180.5	191.0	86.0	143.1	172.0
8(3)	155.0	188.0	199.0	0.0	123.0	168.0
9(4)	140.0	172.0	190.0	90.0	145.6	170.0
10(5)	171.0	191.0	201.0	114.0	161.6	186.0
11(6)	78.0	132.0	168.0	108.0	169.0	192.0
12(7)	156.0	190.0	208.0	78.0	154.5	189.0
13(8)	98.0	164.0	204.0	112.0	168.0	203.0
14(9)	107.0	170.0	200.0	50.0	167.4	212.0
15(10)	156.6	198.0	224.0	112.0	185.0	220.0
16(11)	-	-	-	0.0	157.0	210.0
17(12)	108.0	192.0	224.0	96.0	212.0	252.0

Table C10: Values of $\hat{c}_j$, $L^{(j)}_{min}(\hat{c}_j)$, $\hat{c}$ and $L^{(j)}_{min}(\hat{c})$ for biceps skinfold by sex.

BOYS

Age (Age group) j	$\hat{c}_j$	$L^{(j)}_{min}(\hat{c}_j)$	Values of Overall Constant 25	24	23	22	21	20	19
6(1)	19.6	377.0	378.4	377.6	377.4	377.1	377.0	377.0	377.0
7(2)	18.6	702.6	714.3	708.0	705.9	704.7	703.5	702.9	702.6
8(3)	18.0	878.4	-	-	-	-	881.0	880.7	878.7
9(4)	23.2	964.0	967.2	964.4	964.0	964.4	965.0	966.8	968.0
10(5)	20.2	1012.0	-	-	-	-	1012.0	1012.0	1012.9
11(6)	21.5	1156.3	-	-	-	1156.6	1156.6	1158.1	1159.9
12(7)	22.4	1262.4	-	1267.6	1262.4	1262.4	1263.0	1264.8	1267.2
13(8)	25.8	1075.2	1075.8	1077.0	1079.1	1081.2	1082.0	1085.1	1087.8
14(9)	20.5	1365.2	-	-	-	-	1365.2	1365.6	1367.6
15(10)	22.0	1315.2	-	-	1321.6	1315.2	1316.8	1320.0	1324.8
16(11)	20.9	1376.8	-	-	-	-	1376.8	1378.4	1381.8
17(12)	24.0	790.8	-	790.8	794.2	795.6	797.0	802.2	809.2
TOTAL		12275.9	-	-	-	-	12295.9	12313.6	12337.5
							$\hat{c}$=21		
GIRLS									
6(1)	22.5	512.0	512.6	512.2	512.0	512.0	512.2	512.4	512.6
7(2)	15.6	778.8	785.4	783.6	782.4	781.2	780.6	780.0	779.4
8(3)	18.6	788.4	-	-	794.8	790.0	789.2	788.5	788.4
9(4)	24.8	883.1	883.1	883.1	883.5	884.3	885.1	886.1	887.2
10(5)	22.2	1149.5	1150.9	1149.5	1149.5	1149.5	1149.5	1149.5	1150.1
11(6)	26.7	1308.8	1309.6	1310.0	1311.2	1311.2	1312.8	1313.6	1314.2
12(7)	23.2	1477.6	1477.8	1477.6	1477.6	1477.6	1478.2	1478.8	1479.3
13(8)	22.2	1464.8	1464.0	1465.6	1465.5	1465.6	1465.6	1465.6	1466.4
14(9)	26.4	1693.8	1694.1	1695.0	1695.3	1695.5	1695.9	1697.7	1698.3
15(10)	23.0	1439.5	1440.0	1439.7	1439.5	1439.6	1439.7	1440.0	1440.4
16(11)	15.2	1344.8	1347.2	1346.8	1346.4	1345.6	1345.6	1345.4	1345.2
17(12)	12.4	613.8	617.4	616.2	615.9	615.6	615.0	614.7	614.4
TOTAL		13454.9	-	-	13473.7	13467.7	13469.4	13472.3	13475.9

$\hat{c}$=22

Table C11: Values of $\hat{c}_j$, $L^{(j)}_{min}(\hat{c}_j)$, $\hat{c}$ and $L^{(j)}_{min}(\hat{c})$ for triceps skinfold by sex.

Age (Age group) j	$\hat{c}_j$	$L^{(j)}_{min}(\hat{c}_j)$	Values of Overall Constant						
			35	34	33	32	31	30	29
6(1)	27.5	464.0	466.3	465.4	465.1	464.6	464.4	464.2	464.2
7(2)	29.7	820.2	822.7	821.4	820.8	820.6	820.3	820.2	820.2
8(3)	27.6	1057.0	1065.3	1061.5	1059.8	1058.7	1057.8	1057.2	1057.0
9(4)	30.3	1160.8	-	1168.0	1162.8	1161.6	1160.8	1160.8	1161.0
10(5)	31.8	1212.6	1214.8	1213.8	1212.6	1212.6	1212.6	1213.2	1213.2
11(6)	38.0	1388.4	1390.2	1390.8	1391.4	1392.6	1393.8	1394.4	1395.6
12(7)	36.8	1516.0	1516.4	1516.8	1517.4	1518.6	1518.8	1519.6	1520.4
13(8)	34.8	1329.5	1329.5	1329.5	1330.0	1330.0	1330.5	1331.0	1331.5
14(9)	28.4	1689.0	-	-	-	-	1691.8	1690.0	1689.0
15(10)	28.8	1671.5	-	-	-	1682.5	1674.0	1672.5	1672.0
16(11)	29.2	1840.8	-	-	-	-	1842.4	1840.8	1840.8
17(12)	36.0	1084.8	1085.4	1085.4	1086.0	1087.1	1087.8	1089.0	1089.6
TOTAL		15234.6	-	-	-	-	15255.0	15252.9	15254.5
								$\hat{c}=30$	
GIRLS									
6(1)	41.7	601.5	602.3	603.0	603.5	603.2	604.0	604.5	604.5
7(2)	31.0	911.9	912.3	912.2	911.9	911.9	911.9	911.9	911.9
8(3)	37.3	936.6	936.6	937.4	937.4	938.0	938.0	938.0	938.9
9(4)	34.4	1043.5	1043.5	1043.5	1043.5	1044.0	1044.1	1044.7	1044.9
10(5)	38.8	1340.5	1341.0	1341.1	1341.4	1341.5	1342.0	1342.2	1342.3
11(6)	41.4	1534.2	1536.0	1536.0	1536.5	1536.5	1536.9	1537.5	1538.1
12(7)	38.7	1693.8	1694.1	1694.4	1694.7	1695.0	1695.3	1695.6	1695.9
13(8)	21.0	1755.6	1761.0	1759.2	1758.3	1758.0	1757.4	1757.1	1756.8
14(9)	18.0	2016.8	2021.6	2020.8	2019.2	2018.4	2018.0	2017.8	2017.6
15(10)	27.6	1749.5	1750.0	1749.9	1749.8	1749.7	1749.6	1749.5	1749.5
16(11)	20.0	1665.8	1671.3	1671.0	1670.9	1670.6	1670.3	1670.1	1670.0
17(12)	2.5	764.3	765.5	765.5	765.3	765.2	765.1	765.0	764.9
TOTAL		16014.0	16033.8	16033.8	16032.4	16032.0	16032.6	16034.8	16035.3
						$\hat{c}=32$			

Table C12: Values of $\hat{c}_j$, $L_{min}^{(j)}(\hat{c}_j)$, $\hat{c}$ and $L_{min}^{(j)}(\hat{c})$ for subscapular skinfold by sex

Age (Age group) j	$\hat{c}_j$	$L_{min}^{(j)}(\hat{c}_j)$	Values of Overall Constant							
			31	30	29	28	27	26	25	24
BOYS										
6(1)	20.4	417.0	-	-	429.0	425.4	422.4	419.7	418.5	418.2
7(2)	24.0	741.6	-	-	-	-	747.6	743.4	742.2	741.6
8(3)	21.3	951.5	-	-	-	-	-	-	-	962.0
9(4)	25.8	1051.4	-	-	1064.0	1054.2	1051.4	1051.4	1051.4	1052.8
10(5)	28.9	1110.0	-	1118.2	1110.0	1111.2	1113.6	1116.0	1119.0	1122.0
11(6)	27.3	1298.4	-	-	1304.0	1299.2	1298.4	1299.2	1300.8	1302.4
12(7)	27.4	1395.5	-	-	1400.0	1396.4	1395.5	1396.4	1397.8	1400.0
13(8)	28.7	1222.5	-	-	1222.8	1223.1	1225.2	1226.7	1228.8	1231.2
14(9)	26.4	1606.8	-	-	-	-	1607.2	1606.8	1608.4	1610.4
15(10)	29.2	1596.0	1596.8	1596.0	1596.0	1597.2	1598.7	1600.8	1602.0	1604.4
16(11)	34.8	1726.0	1731.0	1732.0	1734.0	1738.0	1740.0	1742.0	1744.0	1749.8
17(12)	34.8	1064.0	1066.5	1067.0	1068.4	1069.5	1070.5	1071.7	1073.3	1074.0
TOTAL*		13229.2	-	-	-	-	13270.5	13274.1	13286.2	13306.8
							$\hat{c}$=27			
GIRLS										
6(1)	22.1	565.6	-	-	581.6	573.6	569.6	568.0	567.2	566.4
7(2)	25.7	867.6	-	878.4	871.2	869.9	868.8	867.6	867.6	867.6
8(3)	29.0	883.2	885.6	883.5	883.2	883.5	884.1	885.3	885.9	887.0
9(4)	24.8	976.8	-	1002.0	986.4	981.6	977.4	976.8	976.8	977.4
10(5)	29.0	1284.0	1287.0	1284.6	1284.0	1284.3	1285.4	1286.4	1287.3	1288.8
11(6)	37.0	1447.5	1454.5	1456.0	1457.3	1458.5	1460.0	1461.7	1463.0	1465.0
12(7)	37.0	1631.0	1635.0	1635.8	1637.0	1638.0	1639.5	1640.0	1641.3	1643.0
13(8)	38.5	1676.5	1682.1	1688.5	1684.9	1685.6	1686.6	1687.4	1688.4	1689.8
14(9)	31.4	1974.6	1974.6	1975.2	1975.2	1975.2	1975.8	1976.4	1976.4	1977.0
15(10)	43.5	1751.0	1754.7	1755.4	1755.5	1756.0	1756.5	1757.0	1757.5	1758.0
16(11)	32.5	1677.6	1677.6	1677.6	1677.8	1678.0	1678.2	1678.2	1678.5	1678.8
17(12)	18.5	766.4	766.7	766.6	766.5	766.4	766.4	766.4	766.4	766.4
TOTAL		15501.8	-	-	15560.6	15550.6	15548.3	15551.2	15556.3	15565.0
							$\hat{c}$=27			

*Excluding age group 3.

Table C13: Values of $\hat{c}_j$, $L_{min}^{(j)}(\hat{c}_j)$, $\hat{c}$ and $L_{min}^{(j)}(\hat{c})$ for suprailiac skinfold by sex.

BOYS

Age (Age group) j	$\hat{c}_j$	$L_{min}^{(j)}(\hat{c}_j)$	Values of Overall Constant: 31	30	29	28	27	26	25	24	23
6(1)	22.2	427.5	-	-	-	-	-	-	430.4	428.4	427.8
7(2)	19.6	767.5	-	-	-	-	-	-	-	-	-
8(3)	26.2	976.8	-	-	-	-	978.0	976.8	978.0	980.4	982.8
9(4)	28.0	1093.2	-	-	1095.0	1093.2	1093.8	1095.9	1097.7	1100.4	1102.8
10(5)	26.9	1192.0	-	-	-	-	1192.2	1192.8	1194.7	1197.0	1199.6
11(6)	27.8	1370.9	-	-	-	1370.9	1371.5	1373.1	1375.5	1378.0	1380.8
12(7)	28.0	1517.2	-	-	1517.4	1517.4	1518.8	1520.4	1522.2	1524.4	1526.0
13(8)	30.2	1325.6	1327.8	1325.6	1327.8	1328.0	1330.4	1332.0	1333.6	1336.0	1337.6
14(9)	30.9	1734.0	1734.0	1735.0	1736.0	1738.0	1741.0	1743.0	1745.0	1748.0	1750.0
15(10)	32.7	1716.0	1720.2	1721.6	1722.0	1725.5	1726.6	1730.8	1731.2	1735.4	1738.2
16(11)	33.0	1872.0	1876.4	1879.2	1882.8	1885.5	1888.2	1891.8	1895.4	1899.0	1902.6
17(12)	34.8	1173.0	1176.3	1177.5	1178.7	1180.2	1181.1	1182.6	1184.1	1185.6	1186.8
TOTAL*		14398.2	-	-	-	-	-	-	14487.8	14512.6	14535.0
									$\hat{c}$=25		

GIRLS

GIRLS			33	32	31	30	29	28	27	26	25
6(1)	28.8	572.4	-	-	576.0	573.2	572.4	572.8	573.2	573.6	574.4
7(2)	26.2	876.0	-	-	-	885.2	879.6	877.2	876.2	876.0	876.4
8(3)	26.8	888.6	-	-	-	898.8	891.6	889.2	888.6	888.6	889.2
9(4)	28.4	1008.3	-	-	-	1015.5	1008.6	1008.3	1009.2	1010.7	1011.6
10(5)	30.0	1314.0	-	1322.0	1314.5	1314.0	1314.0	1315.0	1316.5	1318.0	1319.5
11(6)	27.6	1565.2	-	-	-	-	1566.4	1565.2	1565.3	1565.8	1566.6
12(7)	26.4	1750.3	-	-	-	-	1752.6	1750.7	1750.6	1750.6	1750.7
13(8)	30.5	1794.8	1795.2	1794.8	1794.8	1794.8	1794.8	1794.8	1795.2	1795.6	1795.8
14(9)	25.5	2062.4	2064.4	2063.6	2062.8	2062.6	2062.4	2062.4	2062.4	2062.4	2062.4
15(10)	40.5	1796.4	1797.6	1797.6	1797.6	1797.6	1797.6	1798.8	1798.8	1798.8	1798.8
16(11)	37.0	1723.5	1723.8	1723.8	1723.8	1724.0	1724.5	1724.5	1724.5	1725.0	1725.5
17(12)	35.1	798.0	798.0	798.0	798.0	798.0	798.0	798.0	798.2	798.2	798.2
TOTAL		16149.9	-	-	-	-	16162.5	16156.9	16158.7	16163.3	16169.1
								$\hat{c}$=28			

* Excluding age group 2.

Table C14: Values of $\hat{c}_j$, $L^{(j)}_{min}$ $(\hat{c}_j)$, $\hat{c}$ and $L^{(j)}_{min}$ $(\hat{c})$ for arm circumference by sex.

BOYS

Age (Age Group) j	$\hat{c}_j$	$L^{(j)}_{min}$ $(\hat{c}_j)$	Values of Overall Constant 160	150	140	130	120	110	100	90
6(1)	80.0	409.6	-	-	-	414.8	411.2	410.4	409.6	409.6
7(2)	130.0	720.6	-	-	732.7	720.6	722.7	725.4	729.2	732.7
8(3)	130.0	926.4	-	-	-	926.4	928.8	931.5	934.5	937.8
9(4)	129.0	1015.5	-	-	1033.6	1015.5	1016.3	1020.0	1021.5	1029.3
10(5)	141.0	1086.4	-	-	1086.4	1088.8	1094.4	1099.2	1102.4	1106.4
11(6)	144.0	1226.4	-	1227.8	1226.4	1230.6	1234.1	1239.0	1241.8	1245.3
12(7)	140.4	1315.2	-	1316.8	1315.2	1316.8	1320.0	1321.6	1324.8	1325.6
13(8)	138.0	1172.8	1188.5	1174.4	1172.8	1172.8	1174.4	1176.0	1177.6	1197.2
14(9)	135.0	1514.0	-	-	1514.2	1514.2	1515.2	1516.8	1518.4	1520.0
15(10)	153.0	1537.0	1537.0	1537.0	1538.5	1540.5	1543.0	1545.4	1548.0	1550.0
16(11)	132.0	1762.0	-	1764.3	1762.3	1762.0	1762.3	1763.1	1764.4	1765.0
17(12)	146.0	1060.4	1061.6	1060.4	1060.6	1061.2	1062.0	1063.4	1064.0	1065.2
TOTAL		13746.3	-	-	-	13764.2	13784.4	13811.8	13836.2	13884.1
						$\hat{c}$=130				

GIRLS

Age (Age Group) j	$\hat{c}_j$	$L^{(j)}_{min}$ $(\hat{c}_j)$	160	150	140	130	120	110	100	90
6(1)	119.7	527.6	-	-	-	531.6	527.6	528.0	529.2	531.0
7(2)	100.8	792.6	-	-	-	806.4	795.0	792.9	792.6	793.2
8(3)	134.4	796.4	-	-	798.4	796.4	798.8	801.6	804.4	806.0
9(4)	115.2	910.4	-	-	-	915.6	910.4	910.4	911.2	912.8
10(5)	122.8	1152.6	-	-	-	1153.2	1152.6	1153.8	1156.2	1158.0
11(6)	117.6	1331.5	-	-	1341.0	1333.0	1331.5	1332.5	1333.5	1333.5
12(7)	132.9	1468.5	-	1475.0	1469.0	1468.5	1469.5	1472.5	1474.0	1474.0
13(8)	131.8	1490.4	-	1495.2	1491.0	1490.4	1491.0	1493.4	1494.6	1494.6
14(9)	111.6	1705.6	-	-	1710.0	1707.0	1705.6	1705.8	1706.4	1706.4
15(10)	141.6	1475.0	1477.3	1475.0	1475.0	1475.0	1476.0	1478.0	1478.5	1478.5
16(11)	122.0	1394.0	-	1395.8	1394.0	1394.0	1394.0	1394.3	1394.6	1394.6
17(12)	162.5	630.5	630.5	631.0	631.5	631.5	632.3	633.0	633.3	633.3
TOTAL		13675.1	-	-	-	13702.6	13684.3	13694.2	13708.5	13715.9
							$\hat{c}$=120			

Table C15: Values of $\hat{c}_j$, $L_{min}^{(j)}(\hat{c}_j)$, $\hat{c}$ and $L_{min}^{(j)}(\hat{c})$ for calf circumference by sex.

BOYS

Age (Age Group) j	$\hat{c}_j$	$L_{min}^{(j)}(\hat{c}_j)$	Values of Overall Constant								
			200	190	180	170	160	150	140	130	120
6(1)	-	-	-	-	-	-	-	-	-	-	-
7(2)	180.5	796.8	-	798.6	796.8	797.6	799.2	800.4	802.4	804.0	805.2
8(3)	188.0	976.8	979.2	976.8	977.4	978.6	980.1	981.6	983.4	984.4	985.8
9(4)	172.0	1083.0	1096.8	1086.6	1084.2	1084.2	1084.8	1085.4	1086.6	1087.2	1088.4
10(5)	191.0	1143.2	1145.6	1143.2	1144.0	1145.6	1147.6	1149.2	1150.4	1152.4	1154.0
11(6)	132.0	1302.2	-	1314.4	1308.8	1305.4	1304.8	1303.8	1303.2	1303.2	1303.2
12(7)	190.0	1373.5	1374.0	1373.5	1374.0	1374.3	1375.5	1376.2	1377.5	1378.5	1379.5
13(8)	164.0	1228.3	1229.8	1229.1	1228.6	1228.3	1228.3	1228.4	1228.8	1229.0	1229.6
14(9)	170.0	1604.4	1606.5	1605.0	1604.4	1604.4	1604.4	1604.7	1605.3	1605.6	1606.0
15(10)	198.0	1587.6	1587.6	1587.6	1588.0	1588.6	1589.6	1590.2	1590.8	1591.2	1592.4
16(11)	-	-	-	-	-	-	-	-	-	-	-
17(12)	192.0	1083.8	1083.8	1083.8	1084.0	1084.2	1084.6	1084.9	1085.4	1085.7	1086.2
TOTAL		12179.6	-	12198.6	12190.2	12191.2	12198.9	12204.8	12213.9	12221.0	12229.3
					$\hat{c}$=180						
GIRLS											
6(1)	146.6	557.8	-	-	-	560.1	558.1	557.8	557.8	558.1	558.4
7(2)	143.1	854.5	-	-	859.8	855.5	854.8	854.5	854.5	854.5	854.5
8(3)	123.0	850.2	-	-	862.2	854.4	852.3	851.4	850.8	850.2	850.2
9(4)	145.6	960.4	-	-	968.4	962.8	960.8	960.4	960.4	960.8	961.2
10(5)	161.6	1186.0	-	-	1187.8	1186.4	1186.2	1186.6	1187.0	1187.2	1188.0
11(6)	169.0	1367.6	1372.8	1368.8	1367.7	1367.6	1367.6	1368.2	1368.5	1368.9	1369.3
12(7)	154.5	1511.0	1518.0	1514.0	1512.0	1511.5	1511.0	1511.0	1511.0	1512.0	1512.0
13(8)	168.0	1522.8	1525.2	1524.6	1522.8	1522.8	1522.8	1523.4	1524.0	1524.0	1524.0
14(9)	167.4	1719.2	1719.2	1719.2	1719.2	1719.2	1719.2	1719.2	1720.6	1720.6	1720.6
15(10)	185.0	1488.0	1488.4	1488.0	1488.0	1488.0	1488.4	1488.8	1489.4	1489.6	1490.3
16(11)	157.0	1400.0	1401.4	1400.6	1400.2	1400.0	1400.0	1400.0	1400.0	1400.2	1400.3
17(12)	212.0	630.0	630.0	630.3	630.3	630.8	631.0	631.0	631.3	631.8	631.5
TOTAL		14047.5	-	-	-	14059.1	14052.2	14052.3	14055.3	14057.9	14060.3
							$\hat{c}$=160				

Table C16: Constant Values ($\hat{c}_j$) used in log transformation for skinfolds of Libyan and Sudanese children.

Age Group**	BICEPS		TRICEPS		SUBSCAPULAR		SUPRAILIAC	
	Libyan	*Sudanese	Libyan	Sudanese	Libyan	Sudanese	Libyan	Sudanese
BOYS								
6	19	8	27	0	20	20	22	20
7	18	16	30	4	24	18	19	10
8	18	18	27	22	21	30	26	16
9	23	12	30	8	26	22	28	16
10	20	10	32	22	29	28	27	22
11	21	6	38	10	27	14	28	16
12	22	20	37	32	27	32	28	22
13	26	20	35	22	29	32	30	24
14	20	20	28	18	26	32	31	22
15	22	20	29	32	29	36	33	24
GIRLS								
6	22	20	42	8	22	22	29	6
7	15	10	31	16	26	28	26	8
8	18	14	37	2	29	30	27	20
9	25	14	34	16	25	22	28	18
10	22	18	39	18	29	32	30	18
11	27	16	41	22	37	30	27	16
12	23	18	39	14	37	28	26	14
13	22	8	21	32	38	34	30	24
14	26	32	18	28	31	32	25	22
15	23	0	27	0	43	36	40	36

* Source of Sudanese data is Kemm, 1982.

** The age was grouped as (6-6.99, 7-7.99) for Sudanese, but for Libyan children, grouped as mentioned in the text.

Table D1: Percentiles of Weight Velocity for Libyan Children (Kg/y)

BOYS

Age-Centre Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6.5	1.4	1.6	1.8	2.1	2.5	2.9	3.0
7.5	1.2	1.6	2.0	2.5	2.9	3.2	3.4
8.5	1.4	2.0	2.2	2.5	3.2	3.8	4.7
9.5	0.5	1.6	2.3	3.0	3.8	4.6	5.5
10.5	0.9	1.4	2.1	2.9	3.7	4.6	5.5
11.5	1.2	1.7	2.1	3.0	4.0	5.0	6.0
12.5	0.9	1.7	2.7	3.9	5.5	7.5	8.9
13.5	0.9	1.8	3.0	4.6	7.0	9.0	10.6
14.5	-0.6	1.8	3.0	5.2	7.1	8.6	9.9
15.5	0.2	1.4	3.0	4.9	6.8	8.5	10.7
16.5	-0.9	0.1	1.7	3.7	5.6	6.6	8.2
17.5	-2.7	-0.4	1.0	2.3	4.1	6.2	8.0
GIRLS							
6.5	0.9	1.4	1.9	2.4	3.2	3.8	5.0
7.5	0.5	1.3	1.7	2.3	3.3	4.1	5.1
8.5	0.9	1.4	2.0	2.7	3.9	5.6	6.9
9.5	1.2	1.7	2.2	2.9	4.4	6.9	7.5
10.5	0.8	1.9	2.6	2.4	5.6	7.5	9.6
11.5	1.0	2.3	3.8	5.0	7.0	8.9	11.0
12.5	1.0	2.5	4.5	5.9	7.7	9.8	12.5
13.5	-0.6	1.7	3.5	5.5	3.3	8.9	11.3
14.5	-0.8	0.6	2.4	4.1	6.0	7.4	9.0
15.5	-1.5	-0.3	1.5	2.8	4.8	6.2	7.7
16.5	-4.0	-1.5	0.2	2.1	3.8	6.2	9.0
17.5	-2.2	-1.0	0.2	1.5	2.9	4.4	6.1

Table D2:: Percentiles of Biceps Skinfold Velocity for Libyan Children (0.1mm/y)

BOYS

Age-centre Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6.5	-10.6	-7.5	-2.1	2.1	4.3	6.2	9.6
7.5	-14.7	-10.6	-3.7	2.9	4.3	8.5	14.0
8.5	-11.4	-8.5	-1.9	2.1	5.6	8.5	10.2
9.5	-12.0	-8.7	-1.9	2.3	6.9	11.3	18.4
10.5	-11.5	-5.6	0.0	3.7	6.4	11.3	16.9
11.5	-19.0	-8.6	-3.9	1.9	6.0	13.0	19.3
12.5	-23.0	-12.7	-4.2	3.8	8.3	15.0	20.9
13.5	-17.3	-11.3	-5.7	2.1	6.8	10.8	17.0
14.5	-25.0	-15.1	-7.6	-1.0	4.3	10.3	17.2
15.5	-17.5	-13.5	-7.1	-2.1	4.2	10.7	15.2
16.5	-18.0	-12.7	-6.6	-1.5	4.7	8.5	14.9
17.5	-14.9	-8.5	-5.3	0.0	6.3	12.6	19.2
GIRLS							
6.5	-15.9	-11.8	-6.0	1.0	7.5	13.5	20.9
7.5	-16.0	-10.1	-3.7	3.7	7.8	14.0	19.8
8.5	-12.2	-5.0	-0.5	5.0	10.1	20.1	30.5
9.5	-15.0	-5.6	-1.9	5.9	10.3	18.0	29.2
10.5	-16.1	-6.0	-1.9	5.6	9.9	17.0	24.5
11.5	-13.1	-6.8	1.9	9.0	14.9	23.1	30.1
12.5	-11.5	1.9	5.9	11.8	19.7	27.0	40.3
13.5	-6.0	2.9	6.5	11.9	19.2	24.8	39.4
14.5	-11.3	1.9	6.7	12.1	19.7	27.1	38.0
15.5	-9.8	1.9	7.7	14.2	23.5	33.2	39.6
16.5	-5.7	-2.0	7.9	16.0	27.0	35.0	40.0
17.5	0.0	3.1	6.2	10.5	17.8	23.1	34.6

Table D3: Percentiles of Triceps Skinfold Velocity for Libyan Children (0.1mm/y)

BOYS

Age-centre Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6.5	-12.1	-6.9	-1.0	4.1	6.5	8.6	15.0
7.5	-7.4	-2.0	2.1	5.6	10.0	19.3	25.7
8.5	-13.0	-7.8	1.9	5.6	9.3	15.1	20.5
9.5	-12.8	-6.9	-0.5	7.5	13.1	26.3	39.0
10.5	-8.6	-1.2	2.8	7.2	10.5	15.1	23.1
11.5	-18.4	-9.1	-1.9	8.1	15.0	23.0	30.0
12.5	-28.1	-12.9	-1.9	7.6	15.6	29.2	38.3
13.5	-20.7	-12.3	-5.2	4.2	12.0	21.0	41.0
14.5	-35.4	-23.7	-11.7	1.0	9.6	18.7	29.2
15.5	-29.0	-21.3	-10.0	2.1	10.5	16.5	30.3
16.5	-19.3	-11.7	-3.8	4.3	9.7	16.6	24.5
17.5	-21.3	-10.8	-2.1	6.3	12.8	21.4	28.7
GIRLS							
6.5	-15.9	-7.0	1.9	6.2	11.9	21.4	27.1
7.5	-15.0	-8.4	1.9	7.5	13.7	24.2	38.0
8.5	-18.7	-10.0	0.9	7.8	18.5	28.0	47.4
9.5	-11.2	-4.7	4.0	10.0	18.8	35.0	54.8
10.5	-9.0	1.9	5.7	10.4	17.9	31.0	44.5
11.5	-13.4	-1.0	7.9	15.8	27.8	43.2	63.0
12.5	-10.0	4.0	9.9	17.4	31.3	48.0	64.3
13.5	-7.6	4.9	9.4	17.2	31.7	46.7	66.5
14.5	-8.5	4.8	9.4	15.5	24.0	41.7	58.0
15.5	-9.8	2.0	10.0	14.9	25.7	36.4	56.5
16.5	-10.5	-1.0	9.9	14.6	21.2	30.7	47.7
17.5	-7.6	2.9	8.4	12.3	15.7	20.5	39.4

Table D4: Percentiles of Subscapular Skinfold Velocity for Libyan Children (0.1mm/y)

BOYS

Age-centre Group	Centiles						
	3rd	10th	25th	50th	75th	90th	97th
6.5	-3.8	-1.9	1.9	4.7	6.5	10.6	12.8
7.5	-9.4	-3.8	-0.9	4.7	9.5	15.0	22.3
8.5	-10.9	-3.8	0.9	4.4	8.5	14.9	21.0
9.5	-11.0	-3.7	0.9	7.5	11.5	17.7	25.8
10.5	-4.9	-1.9	2.1	4.7	9.2	13.9	23.5
11.5	-12.1	-5.7	-0.9	5.8	12.9	22.2	36.6
12.5	-11.0	-4.2	3.1	8.6	15.1	24.7	41.8
13.5	-12.7	-4.3	1.9	8.3	16.0	25.0	38.5
14.5	-18.7	-7.2	0.0	6.5	11.4	20.6	25.5
15.5	-17.0	-5.8	-0.5	7.3	12.8	21.0	31.2
16.5	-11.5	-6.3	0.0	4.8	10.5	15.6	21.5
17.5	-12.9	-6.4	2.0	6.4	13.6	21.4	26.9
GIRLS							
6.5	-12.7	-7.5	-1.0	4.7	12.1	20.8	39.7
7.5	-12.0	-6.0	0.0	5.8	12.0	20.3	28.3
8.5	-10.5	-5.0	1.9	8.1	17.9	29.5	50.0
9.5	-10.0	-0.9	2.4	7.5	17.0	28.0	45.4
10.5	-14.2	-2.0	3.0	7.9	14.1	24.0	28.0
11.5	-13.2	-1.0	5.0	12.0	21.9	35.5	52.0
12.5	-11.0	-1.0	6.0	13.5	23.8	39.6	65.0
13.5	-16.9	1.9	8.0	14.5	24.6	41.5	59.2
14.5	-15.0	0.9	8.2	14.1	23.2	36.0	70.0
15.5	-22.7	-1.4	9.0	16.2	25.6	42.0	67.0
16.5	-8.0	3.8	9.5	13.9	23.6	40.4	70.5
17.5	0.0	2.8	8.4	12.3	15.8	25.6	39.8

Table D5: Percentiles of Suprailiac Skinfold Velocity for Libyan Children (0.1mm/y)

BOYS

Age-centre Group	Centile 3rd	10th	25th	50th	75th	90th	97th
6.5	-5.6	-3.0	2.8	6.0	9.3	13.1	15.0
7.5	-5.6	-0.9	2.1	7.5	11.9	18.6	29.0
8.5	-9.8	-2.1	2.0	7.5	10.9	20.6	25.6
9.5	-11.0	-3.8	2.2	8.5	14.0	26.2	36.6
10.5	-13.8	-0.9	3.8	7.5	12.3	19.1	30.3
11.5	-22.0	-10.5	0.8	8.3	17.9	32.3	48.0
12.5	-18.5	-8.3	2.1	9.4	17.2	32.2	44.0
13.5	-20.7	-10.7	-2.0	6.4	15.3	29.5	45.5
14.5	-34.5	-17.2	-6.5	4.8	11.4	20.6	33.0
15.5	-21.3	-12.6	-3.8	4.2	12.0	21.0	27.5
16.5	-15.0	-7.6	-1.1	6.3	12.8	21.8	31.0
17.5	-19.2	-10.7	-4.3	6.3	12.8	21.2	32.7

GIRLS

Age-centre Group	3rd	10th	25th	50th	75th	90th	97th
6.5	-16.8	-7.4	0.0	7.0	20.8	33.9	51.9
7.5	-19.7	-8.8	1.9	7.9	15.1	24.2	38.0
8.5	-10.5	-2.4	7.3	13.1	24.4	36.1	57.2
9.5	-14.0	-1.9	4.0	11.9	23.5	41.6	64.1
10.5	-12.1	1.9	5.0	10.3	21.1	36.5	55.0
11.5	-16.2	0.0	6.5	13.2	28.4	50.0	72.5
12.5	-16.2	1.9	7.5	14.5	28.8	48.0	66.0
13.5	-11.4	2.0	8.1	14.6	26.7	42.6	67.1
14.5	-21.1	0.0	8.4	14.1	24.1	47.0	74.5
15.5	-24.0	-1.0	8.3	13.8	23.0	47.0	90.6
16.5	-11.8	2.1	8.4	15.9	25.6	48.4	85.8
17.5	0.0	3.8	6.3	12.3	14.7	23.7	41.3

Table D6: Percentiles of Arm Circumference Velocity for Libyan Children (mm/y)

BOYS

Age-centre Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6.5	0.0	2.1	4.3	5.6	7.5	9.7	12.2
7.5	0.0	2.8	5.0	6.6	9.6	12.4	16.0
8.5	1.9	3.0	4.7	6.5	10.1	14.1	19.0
9.5	0.5	3.0	4.7	7.1	11.4	16.9	20.5
10.5	0.0	2.3	4.8	8.1	11.3	16.0	20.7
11.5	1.5	3.2	5.2	8.5	12.5	17.8	22.2
12.5	0.0	2.5	5.4	9.0	13.0	20.7	23.9
13.5	-1.5	3.2	5.7	10.3	14.9	20.6	24.0
14.5	1.0	3.1	5.2	9.2	16.1	21.6	25.7
15.5	2.1	4.2	5.7	10.4	15.7	21.3	25.3
16.5	2.1	3.2	5.2	7.8	13.6	18.3	21.6
17.5	1.1	2.1	4.9	7.5	10.7	16.1	19.5
GIRLS							
6.5	1.9	2.8	4.7	7.3	11.9	14.2	18.8
7.5	-1.0	1.9	4.7	8.1	12.0	17.0	22.9
8.5	2.8	4.1	5.9	9.5	14.0	19.7	44.4
9.5	0.0	3.1	6.0	9.8	14.1	18.8	24.4
10.5	2.8	4.7	6.6	11.3	18.0	25.0	30.7
11.5	3.4	5.0	7.9	13.1	19.0	24.0	32.0
12.5	1.0	5.0	9.0	13.8	20.8	26.1	33.1
13.5	1.9	4.7	6.9	11.3	17.3	24.7	33.9
14.5	2.8	4.8	7.0	10.6	15.7	23.5	29.4
15.5	-1.0	2.0	5.9	10.2	14.7	22.8	25.9
16.5	-1.1	2.9	5.9	10.5	15.7	21.0	26.8
17.5	0.0	2.4	6.7	9.5	12.6	19.0	21.8

Table D7: Percentiles of Calf Circumference. Velocity for Libyan Children (mm/y)

BOYS

Age-centre Group	Centiles 3rd	10th	25th	50th	75th	90th	97th
6.5	1.1	4.3	5.2	8.5	10.7	12.8	16.1
7.5	3.4	4.7	7.2	10.3	13.9	17.8	25.5
8.5	4.2	5.3	6.6	9.0	13.1	18.2	21.5
9.5	1.6	4.7	7.5	10.1	14.2	19.8	25.2
10.5	2.2	5.0	7.2	10.4	16.0	21.9	26.3
11.5	1.1	3.8	7.4	9.7	14.0	19.0	23.8
12.5	2.1	4.7	8.3	11.4	16.2	23.7	30.5
13.5	0.0	5.2	8.3	13.2	19.1	25.8	32.3
14.5	1.0	4.8	7.2	11.5	20.5	25.2	29.1
15.5	2.5	4.3	6.4	10.7	16.3	22.5	28.3
16.5	3.2	4.3	5.8	9.4	13.7	18.8	23.6
17.5	2.1	3.2	6.4	8.6	12.7	17.4	20.5
GIRLS							
6.5	-2.0	3.0	5.6	9.9	15.0	21.5	26.2
7.5	0.0	4.0	7.0	10.7	15.0	20.1	25.4
8.5	1.9	3.7	7.0	11.7	16.9	22.7	29.0
9.5	2.8	4.7	7.5	12.2	17.8	22.1	27.8
10.5	4.1	5.6	8.5	13.2	20.1	28.1	32.2
11.5	3.8	6.3	10.0	15.7	22.7	27.8	32.2
12.5	3.9	6.0	9.5	15.0	23.0	28.7	36.5
13.5	1.9	5.8	8.9	13.6	20.2	28.2	36.1
14.5	1.0	4.9	7.7	11.7	16.5	23.1	31.0
15.5	-0.9	3.0	7.9	11.5	19.2	25.7	33.4
16.5	-3.0	3.8	8.3	11.5	16.7	28.6	36.5
17.5	1.0	5.2	7.3	10.4	14.4	21.8	14.9

Table D8: Skewness and Kurtosis for Weight Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	0.49*	-0.33	125	0.54**	1.26
7.5	152	-0.34	-0.63	172	0.97**	0.39
8.5	143	0.87**	1.01	185	0.84**	0.11
9.5	152	-0.22	1.82	213	0.84**	0.87
10.5	141	0.33	-0.32	237	0.69**	0.70
11.5	203	1.07**	2.10	285	0.41**	0.20
12.5	248	0.56**	-0.11	303	0.72**	1.61
13.5	211	0.55**	-0.41	281	0.83**	0.62
14.5	196	-0.06	-0.17	284	-0.05	0.47
15.5	204	0.22	0.01	236	0.13	-0.34
16.5	287	-0.08	-0.43	208	0.43**	1.61
17.5	167	0.32	0.20	76	0.42**	0.11

* = significant at 5% level

** = significant at 1% level

Table D9: Skewness and Kurtosis for Biceps Skinfold Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	-0.55**	0.10	125	0.27	0.12
7.5	152	-0.33	0.31	172	-0.01	0.18
8.5	143	-0.67**	0.09	185	0.45*	1.01
9.5	152	-0.01	0.12	213	0.11	2.27
10.5	141	-0.09	0.98	237	0.06	1.52
11.5	203	-0.09	1.47	285	0.13	-0.04
12.5	248	-0.52	1.80	303	0.36*	2.02
13.5	211	-0.10	0.09	281	0.72**	2.94**
14.5	196	-0.14	1.37	284	0.08	1.67
15.5	204	0.11	0.00	236	0.09	0.15
16.5	287	0.02	0.40	208	0.20	-0.38
17.5	167	0.55**	0.77	76	0.97**	0.69

* = significant at 5% level

** = significant at 1% level

Table D10: Skewness and Kurtosis for Triceps Skinfold Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	-0.37	-0.34	125	0.14	0.70
7.5	152	0.92**	2.27	172	0.43**	0.42
8.5	143	-0.22	1.11	185	0.49	0.73
9.5	152	1.18**	2.66*	213	0.87	1.77
10.5	141	0.26	1.23	237	1.38**	3.46*
11.5	203	0.09	0.41	285	0.78	0.96
12.5	248	0.24	2.23	303	0.93	1.61
13.5	211	0.80**	1.47	281	1.13**	1.70
14.5	196	-0.18	0.14	284	1.12*	2.61
15.5	204	-0.32	0.38	236	0.87	3.07**
16.5	287	-0.09	0.18	208	0.25	1.08
17.5	167	-0.02	0.92	76	1.55	5.50**

* = significant at 5% level

** = significant at 1% level

Table D11: Skewness and Kurtosis for Subscapular Skinfold Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	0.20	0.49	125	1.49**	3.24
7.5	152	0.38*	0.66	172	0.38	1.27
8.5	143	0.25	0.86	185	1.25**	2.27
9.5	152	0.09	0.23	213	1.55**	3.73*
10.5	141	1.31**	3.38	237	0.54**	2.88
11.3	203	1.02**	2.55	285	0.79**	1.61
12.5	248	1.21**	3.37	303	0.87**	2.04
13.5	211	0.88**	2.12	281	1.14**	3.29
14.5	196	-0.24	0.98	284	1.79**	7.74**
15.5	204	-0.16	1.16	236	0.30*	2.48
16.5	287	0.03	0.73	208	1.54**	3.83*
17.5	167	0.29	0.77	76	3.06**	12.89**

* = significant at 5% level

** = significant at 1% level

Table D12: Skewness and Kurtosis for Suprailiac Skinfold Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	0.24	0.73	125	1.62**	5.72**
7.5	152	1.42**	3.69*	172	0.20	1.21
8.5	143	0.59**	1.63	185	0.95**	1.13
9.5	152	0.62**	1.19	213	1.01**	3.30
10.5	141	0.62**	2.66	237	1.07**	1.60
11.5	203	0.87**	2.12	285	1.10**	2.24
12.5	248	0.48**	1.21	303	0.69**	1.07
13.5	211	0.78**	1.16	281	1.35**	3.35
14.5	196	-0.51**	0.82	284	1.52**	5.75 **
15.5	204	0.13	0.54	236	1.29**	4.15**
16.5	287	0.06	0.28	208	1.95**	5.57**
17.5	167	0.05	0.72	76	2.55**	9.56**

* = significant at 5% level

** = significant at 1% level

Table D13: Skewness and Kurtosis for Arm Circumference Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	0.56**	1.66	125	0.69**	0.21
7.5	152	1.19**	3.01	172	0.66**	0.58
8.5	143	0.91**	0.16	185	0.86**	0.40
9.5	152	0.84**	0.08	213	0.67**	0.46
10.5	141	1.14**	2.27	237	0.96**	0.83
11.5	203	0.86	0.63	285	0.76**	0.57
12.5	248	0.92**	0.88	303	0.49**	0.31
13.5	211	0.39*	0.35	281	1.53**	3.38
14.5	196	0.65**	-0.56	284	1.20**	1.70
15.5	204	1.24**	1.85	236	0.51**	0.53
16.5	287	0.02	-0.13	208	0.58**	0.84
17.5	167	0.69**	-0.07	76	0.66**	0.36

* = significant at 5% level

** = significant at 1% level

Table D14: Skewness and Kurtosis for Calf Circumference Velocity Distributions

Age-centre Group	BOYS			GIRLS		
	Number	Skewness	Kurtosis	Number	Skewness	Kurtosis
6.5	86	0.21	0.49	125	0.52**	0.01
7.5	152	1.18**	1.72	172	0.41*	0.06
8.5	143	0.94**	0.42	185	0.61**	-0.08
9.5	152	0.79**	0.49	213	0.40**	-0.31
10.5	141	0.65**	-0.01	237	0.63**	-0.32
11.5	203	0.69**	0.34	285	0.35**	-0.45
12.5	148	1.03**	1.10	303	0.62**	0.00
13.5	211	0.51**	0.81	281	0.98**	1.34
14.5	196	0.51**	-0.02	284	1,15**	2.33
15.5	204	0.82**	0.05	236	0.58**	-0.11
16.5	287	1.13**	1.38	208	0.91**	1.15
17.5	167	0.82	0.81	76	0.98**	0.75

* = significant at 5% level

** = significant at 1% level