V. GROWTH AND DEVELOPMENT OF BEDOUIN CHILDREN (BOYS) IN SOUTH SINAI

Age Determination

Age determination in the Bedouin population was from the start a complex task. As noted previously, there is no orderly recording of age among the South Sinai Bedouins. Our estimate of chronological age was based on the following criteria:

1) age given by the child himself; 2)age given by the child's teacher; 3) age given by the child's parents.

Hence, in the absence of reliable, recorded information, we had to rely primarily on biological criteria which we compared with the verbal information. The biological criteria were skeletal maturation and dental development, which are considered below.

Skeletal Development

Age estimation by skeletal development is based on the fact that the skeletal system passes through fixed stages in the course of development (Roche,1980).

The technique employed by us was radiography of the bones of the wrist, the palm and the fingers in order to assess their stage and development. The literature, to be sure, contains additional criteria on other regions of the body (Akerlund, 1918; Pyle and Sontag, 1943; Elgenmark, 1946; Harding, 1952). Our technique, first used by Pryor (1907) and Rotch (1908, 1909), was selected because of: (a)A single roentgenogram of the hand (wrist, palm and fingers) provides information at one swoop on the largest number of bones and therefore should increase precision of the final result; and (b)the order of ossification of these bones is relatively fixed (Yarbrough et al., 1973).

Age "identification" was by the "Atlas Method", that is, we compared the X-ray picture of stages of hand development in Bedouin children with those appearing in the radiogaphic atlas of Greulich and Pyle (1959) which is generally considered one of the most reliable (Roche, 1980). We calculated the developmental age for each wrist bone separately; the mean of all the "separate ages" was regarded as the "age" of the subject examined. Our preference for this method (see Roche, 1980) stems from the assumption that radiography of a single bone is less likely to provide as good an estimate of a subject's age since rate of ossification of the bones in the wrist, palm and digits differs among individuals (Todd, 1937; Garn and Rohmann, 1960).

A major drawback of the method used, from our standpoint, is the premise on which it is predicated, namely, that every child undergoes a fixed succession of changes in bone shape throughout his growing years. Moreover, the atlas was primarily designed for children in the U.S.A. and we cannot be sure that it is applicable also for Bedouin children.

Teeth eruption as criterion for child physical maturation

Development and eruption of the teeth is also an index of physical maturation that can be used to about the age of 18-20, in conjunction with other indices of physical maturity, e.g. secondary sexual characteristics. In the absence of suitable radiographic means for checking stage of tooth eruption, we opted for the clinical approach, that is, emergence of a deciduous or permanent tooth in the mouth cavity (Demirjian, 1980).

Stages of tooth eruption have been thoroughly investigated in relation to age, race, sex, socio-economic status, nutrition, etc. (see extensive review by Demirjian, 1980). Some of these variables clearly affect the time of tooth emergence (Voors and Metselaar, 1958; McGregor et al., 1968; Brook and Barker, 1972; Bambach et al., 1973; Garn et al., 1973; Mukherjee, 1973; Trupkin, 1974; Delgado et al., 1975).

Because the present study refers to males only, we cannot assess the possibility of sex-linked dental emergence in the Bedouin. We may note, however, that most investigators hold that there is no significant difference between the sexes regarding the time of dental emergence (e.g. Falkner, 1957; Roche et al., 1964; Billewicz et al., 1973).

Gypsum (Alginate) impressions of the upper and lower dentitions were made on each Bedouin child, and dental age was based on examination of these casts. We chose the dentition of the lower jaw as the primary representation of each dental system (eruption usually earlier here than in the upper jaw) and gave preference to the right side in the estimation of age. We should note that the correlation between right and left sides in stage of tooth eruption is high (Rubin, 1987; Ben-David (kobyliansky) et al. 1991).

We relied on two sources for dental age determination, namely, Schour and Marsler (1940) and Brothwell (1963), although it must be noted that stages of tooth eruption in both sources were based on European populations. To what extent the data may not be applicable to the Bedouin, is a moot point.

Correlations between different methods of age "identification".

Pearson's coefficient of correlation was used to determine the relationships between the three "methods" of determining age, namely, chronological, skeletal, and dental (Table 20).

TABLE 20 Evaluation of Pearson's correlation coefficient vis-à-vis the three methods for determining age.

Ages	Chronological age	Dental age
Dental age	r=.898	-
	n=315	-
	p=.001	-
Skeletal age	r=.852	r=.818
	n=266	n=176
	p=.001	p=.001

We ascertained whether the value of the coefficient of correlation between the results of the three methods used to estimate age in the Bedouin group was statistically significant by use of Student's t-test. We also computed the partial coefficient of correlation between ages in order to evaluate the correlation between skeletal and dental age when chronological age is held constant. Finally, using a linear equation, we carried out a prediction of age from the three methods.

Results and Discussion

Comparison of the mean values of age distribution by the three methods (Table 21) shows that the highest mean of the total age distribution is obtained for the chronological age distribution.

TABLE 21 Age determination according to the specified criteria.

Variable	No. of cases	Mean age	Standard deviation
Chronological age	612	8.66	2.67
Dental age	318	8.36	2.40
Skeletal age	269	8.08	2.50

This finding is in line with the results of other studies (Prahl-Andersen and Roede, 1979) which show that chronological age, particularly in boys, precedes the biological age. The value of the coefficient of correlation between dental and skeletal age is relatively high but still lower than the values of the other two coefficients of correlation measured (Table 20). All the coefficients were statistically significant.

The skeletal age is well predicted from both dental and chronological age whereas the chronological age is predicted at a high level of accuracy only from the dental age (Table 22). The latter probably occurs because children of different ethnic groups but identical in chronological age may differ in their stages of skeletal and sexual development (e.g. Meredith, 1969; Malcolm, 1970). Rates of maturation are undoubtedly affected by factors such as heredity, socio-economic and nutritional status, nosology, climate, etc. (Eveleth and Tanner, 1976). These factors are not always considered separately in order to assess the effects of each on skeletal maturation. Indeed, because of the desert nature of the biotopes of Bedouins, studies on the possible effect of climate on growth is of special interest.

It has been suggested, albeit without convincing verification, that a tropical climate per se is a retarding factor on skeletal growth (Mills, 1937, 1950). In this regard, experiments on laboratory animals have yielded conflicting results (Barnett and Coleman, 1959; Lee et al., 1969); while studies on children in the USA, checking whether growth was correlated with season of the year, have yielded negative results (Sawtell, 1929; Reynolds and Sontag, 1944; Dreizen et al., 1959). In any case, poor nutrition and health in the Bedouin society are highly related to growth and development.

If one keeps chronological age constant and computes the correlation between skeletal and dental age, a relatively high value for partial correlation obtains, to wit, $r_{xz(y)}=0.94$. Also relatively high is the proportion of the predictive variance from the true variance: 80% from chronological age to dental age, 72.4% from chronological age to skeletal age, and 66% from dental to skeletal age. Moreover, the "b" values in the regression equation for predicting chronological from skeletal age and chronological from dental age, are practically identical whereas the "a" values show a relatively large variance, more than a year (see Table 22). These results appear somewhat contradictory to findings of other investigators (e.g. Prahl-Andersen and Roede, 1979).

According to our results (comparison of "a" and "b" values in the regression equations), it would seem that (1) when the chronological age variable is held constant, the skeletal and dental systems apparently develop at about the same rate; and (2) there is a difference between the latter systems of about one year. This one year difference is retained for at least the age interval of 6 to 12 years.

TABLE 22 Single-variable prediction of age by linear equation in Bedouin boys.

		Regression constants	
Dependent variable (Y)	**Independent variable (X)**	**Intercept (a)**	**Slope (b)**
Dental age	Skeletal age	a=.722 S.E.=.403 p=.037	b=.887 S.E.=.047 p=.00001
Chronological age	Skeletal age	a=.654 S.E.=.292 p=.013	b=.879 S.E.=.033 p=.0001
Chronological age	Dental age	a= 1.252 S.E.=.206 p=.00001	b=.855 S.E.=.023 p=.00001
Skeletal age	Dental age	a=2.177 S.E.=.366 p=.00001	b=.752 S.E.=.040 p=.00001
Skeletal age	Chronological age	a=1.778 S.E.=.264 p=.00001	b=.824 S.E.=.031 p=.00001
Dental age	Chronological age	a=.430 S.E.=.227 p=.209	b=.942 S.E.=.026 p=.00001

Our above-cited results do not conform with those of Steel (1965), Lacey (1973) and Demirjian (1980). They suggest that the maturation processes of the dental and skeletal systems are based on different genetic factors, as well as being independent of one another, and that even identical environmental factors may affect these processes differently.

In the present study, the relatively high correlation between dental and skeletal age seems due largely to:

(a) The limited age range (5-13 years). During earlier, and later, developmental phases (e.g. 0-5 and the pubertal years), the growth rates within and between the systems occasionally change. Our computation therefore relates only to the "less problematic" portion of the growth curve, therefore perhaps accounting for our larger correlation between the dental and skeletal systems.

(b) Possibly there is a genuine reduction of variance between the age distributions based on skeletal and dental criteria. This reduction could stem from enhanced selection pressures resulting both from size of the group and the nature of its breeding patterns as well as from environmental pressures.

There may also be a stronger selective pressure towards rapid skeletal development in Bedouin children because in tribal societies there is a clear advantage in good walking ability even at an early age whereas in the dentition, the pressure towards rapid development is less urgent; the suckling period often lasts till a relatively advanced age (2.5 years). The above argument is as yet only suggestive.

The above-cited factors may account for the intra-group Bedouin variability being, at least for part of the variables, smaller than that expected when compared with data from Western societies, and which in turn would lead to an increase in the values of the coefficients of correlation.

Developmental Differences Between Bedouin And Other Children

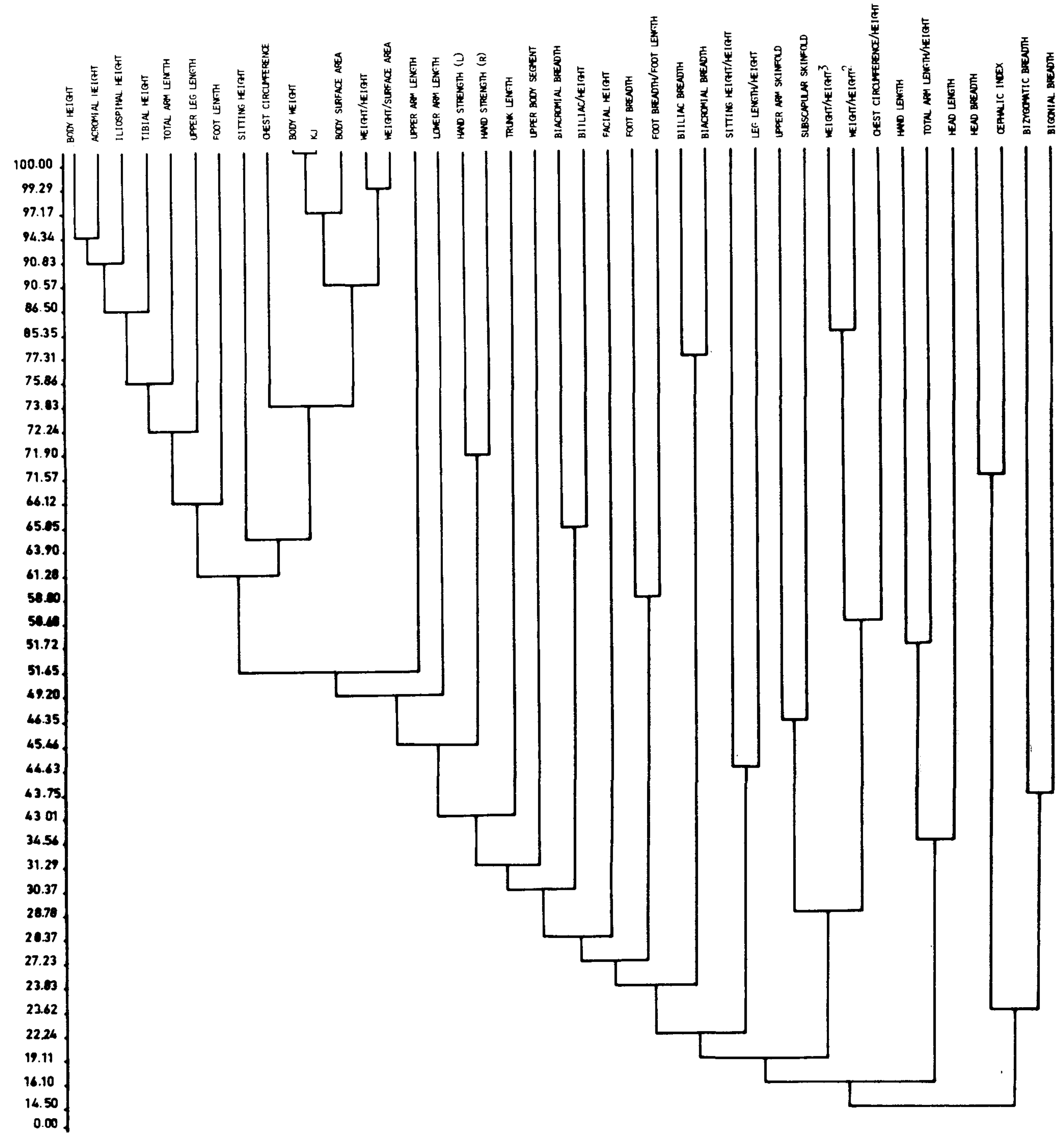
For purposes of comparison, we used growth rate data obtained from Muzeina boys only. The Muzeina tribe was chosen because of its relative homogeneity and good numerical child representation.

The usual standard for comparing physical development of different groups of children is chronological age. The manner in which we defined chronological age for Muzeina and other bedouin children, however, perforce differed in this respect, since exact age was not known and had to be estimated. Another problem is the definition of age categories. We defined age within the range of 5.5-6.4 years as age group 6, 6.5-7.4 years as age group 7, etc. When we compared literature data on children whose age group categories differed from ours, their mean values were calculated; for example, values of anthropometric traits were averaged for given age groups 6.5 and 7.5 to compare with values of our age group 7. Since our Bedouin samples are numerically inadequate for ages 14-18, we limited our discussion to the 5-13 years age range, except in the case of height and weight development. Our consideration of the 14-18 year range was necessary in order to more fully understand the developmental processes of Bedouin boys compared to those of others.

Certain landmarks, and measuring techniques, may differ according to the text followed (e.g. Martin and Saller, 1957 vs. Tanner, 1964). In the literature on child growth, not every investigator has indicated the measuring techniques employed. In this regard, we have appended a relevant comment next to "problematic" characters in our study. Historically there has been an effort to standardize landmarks.

The need to include as many anthropometric traits as possible for comparison forced us, owing to the wide range of morphometric traits used in growth studies, to resort to a relatively large number of growth studies on different populations.

FIGURE 13: Cluster Analysis of the Morphometric Traits of Boys 5-13 Years Measured in the Present Study: the Muzeina Tribe*.



* Figures on vertical axis are correlation coefficients x 100 Based on correlation matrix of morphometric traits. All ages were united after normalization by age in each age group.

Thus, for example, the European continent is represented by a wide array of populations, e.g. Russian, French, Polish and English (see Appendix 3). Consequently for some traits the European population is represented by Polish children while for other traits, English children are the subjects.

We decided to use a wide array of morphometric traits representing every region of the body, despite the fact that some are intercorrelated (Fig. 13) and therefore probably provide similar information. This was done because of the sizeable differences among various studies in number and kinds of the investigated traits. Our problem here was that if we reduced to ten or five the number of traits to be presented, we increased the risk that the particular traits considered would not be represented in many of the studies with which we intended to compare our results.

A number of traits deemed especially significant will now be considered, with following, the Muzeina boys compared to boys of other groups of like ages.

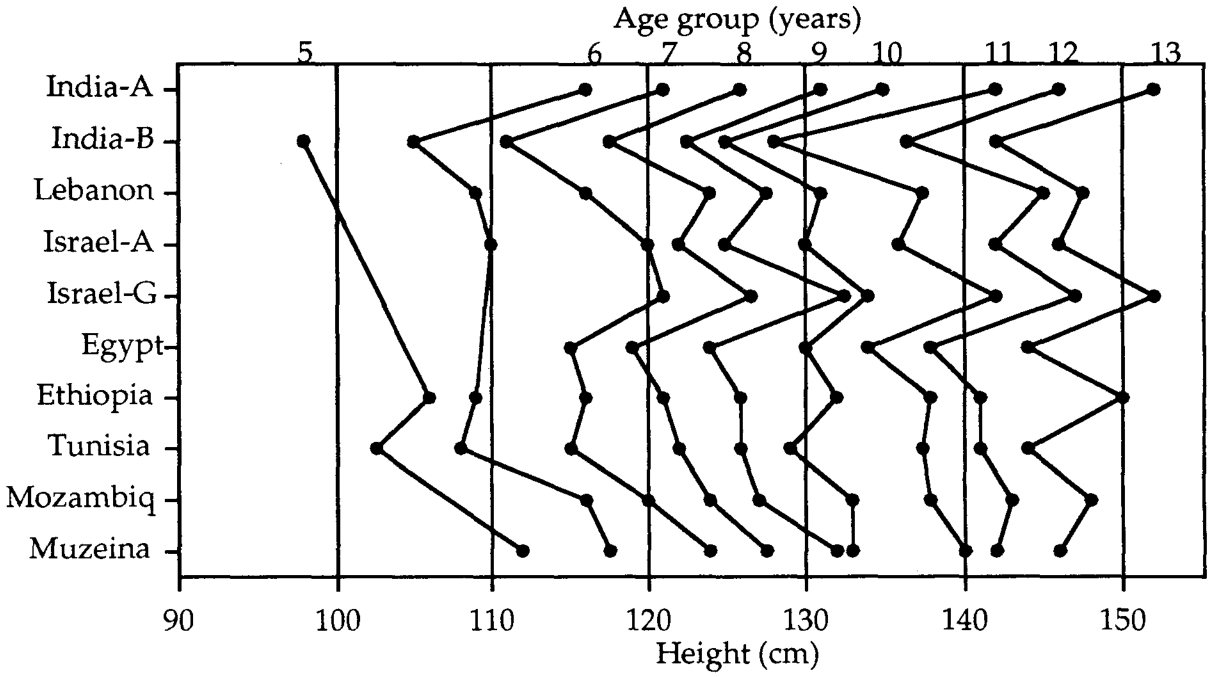
Stature

Body height and body weight appear to be two primary traits indicative of the general growth processes.

In average stature, boys of the Muzeina Bedouin, compared with Indian and Mediterranean boys, appear taller in the early years (ages 6-9), about the same at ages 10-12, and shorter at age 13 years. The same tendencies prevail also in a comparison of Muzeina boys with European, American and African groups (Fig. 14-16). Eveleth and Tanner (1976) discuss the differences in height attainment between children of Indian, Mediterranean and Western European parents. According to these authors, Indian children 2-10 years old are taller than European children of the same age. After the age of 10, height increment in the former is at a slower rate and they are now shorter than either their European or American counterparts.

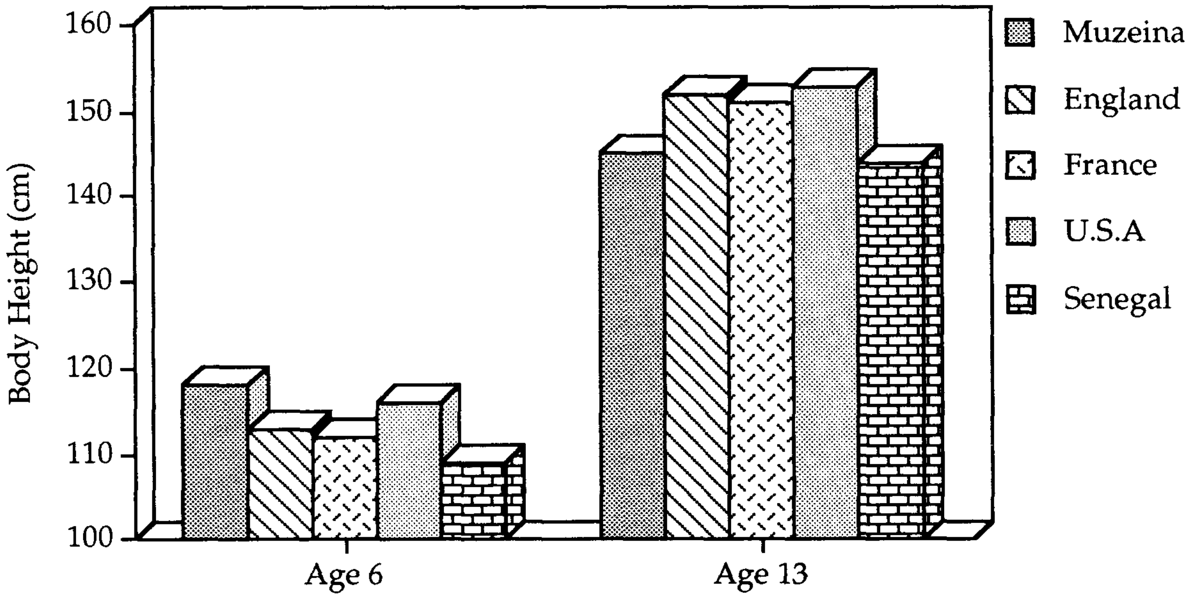
The Muzeina boys compared with children in Israel (see Fig. 14) are exceeded in average height by the Jewish children at age 9, but the Israeli Arab children attain the mean stature of Muzeina boys only at age 12 and do not exceed them even at age 13.

FIGURE 14: Stature of Muzeina Boys Aged 5-13 Years Compared With That of Boys of Indian, Mediterranean and African Populations*.



*Note: for explanations of population references see Appendix 3.

FIGURE 15: Mean Stature of Muzeina Boys at Ages 6 and 13 Years Compared With That of Boys of Comparable Ages in Mediterranean, European, American and African Populations.



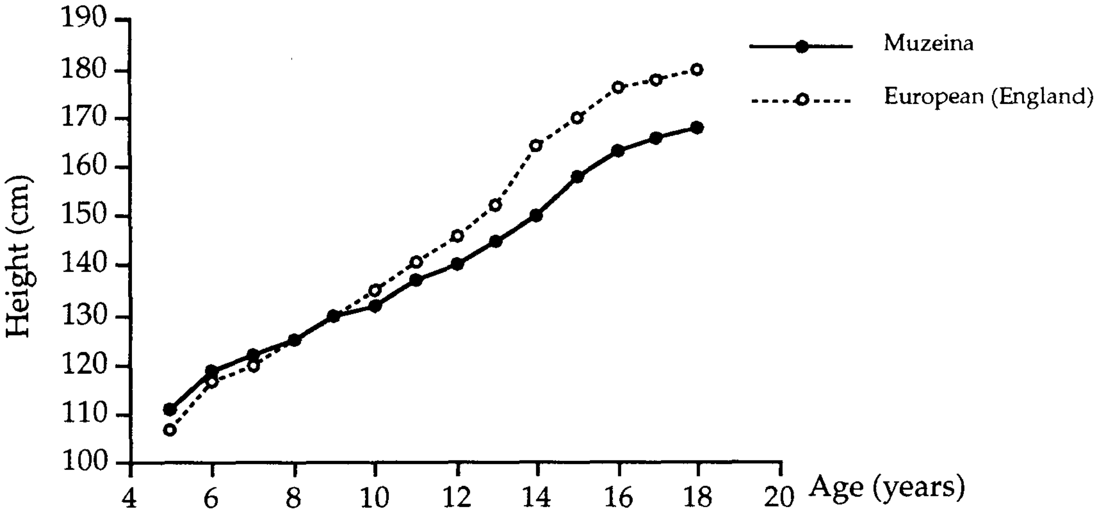
Note: For explanations of population references see Appendix 3.

A very similar picture is obtained for the Muzeina children when compared, for example, to English children (Fig. 16).

In order to overcome problems related to the effect of inaccurate age determination and small sample sizes in some groups on growth rate values, we employed the "smoothing" technique. This method "moderates" the curve but makes it more reliable than that obtained directly from the actual growth data. Also, the occurrence of peak height velocity of the adolescent spurt in height of the Muzeina boys is based on the interpretation of cross-sectional rather than longitudinal data. Hence, for the sake of comparability, all other data used for comparison were also from cross-sectional studies and were "smoothed".

Growth rates in stature of Muzeina and Egyptian boys show an essentially similar trend, that is, a gradual drop in the rate of development from age 6 up to age 10-11 and subsequently an increase to age 15 (Fig. 17). In Indian children there is a sharp decline in growth rate between the ages 6-10, and afterwards, a sharp increase to age 12. The growth rate remains relatively high for Indian children until the age of 15, when it begins to decrease sharply (Fig. 17).

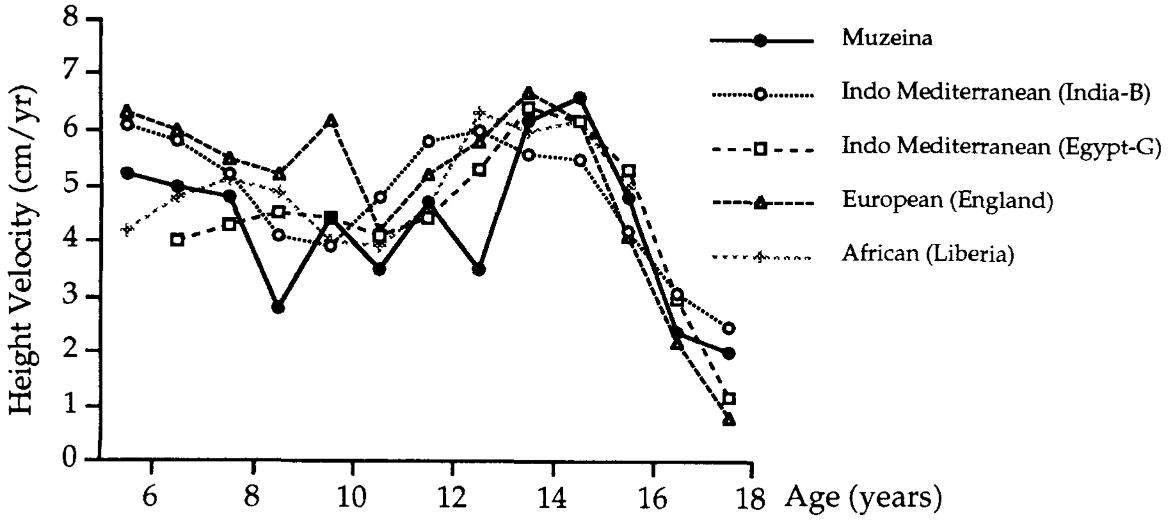
FIGURE 16: Mean Stature of Muzeina Boys Compared With That of London Boys, by Age; Data "Smoothed".



Note: For explanations of population references see Appendix 3.

The peak velocity of the adolescent spurt in height seems to occur later in Muzeina boys than in the London and Egyptian boys (Fig. 17). The magnitude of the peaks, however, appears to be equal for all three groups. From the age of 5 years (and possibly earlier) until the end of the spurt, Muzeina boys have a height velocity smaller than in London boys, but similar to that of Indian and Mediterranean (Egyptian) and African (Liberia) boys (Fig. 17).

FIGURE 17: Velocity of Growth in Stature in Bedouin Boys From South Sinai (Muzeina Tribe) Compared With Boys From Egypt, India, Europe (England) and Africa (Liberia), 6-18 Years of Age; Data "Smoothed".



Note: For explanations of population references see Appendix 3.

One of the central questions that arises from the data presented thus far is whether the observed difference between the growth curves of Muzeina boys and those of children of some Indian, Mediterranean, European and African populations, stem from the relative paucity of late-maturing children in the Muzeina sample. If so, then possibly the Muzeina curve reflects the influence of inadequeate sampling or is an artifact of the cross-sectional method rather than a genuine difference in the growth rate. Only a longitudinal study could fully resolve this question. However, since such a study is not feasible for nomad societies like the Bedouin, we have attempted another course, described below.

First we chose the mean height in the adult Muzeina male population (166.7 cm) as our point of reference (Monk, 1993). The initial parameter computed was the ratio (in percent), P_i between the mean height in each age group and the mean height in the adult male population ($\overline{X}$).

The P_i values for different ages are shown in Fig. 18, which indicates what percentage of the adult male stature each age group of the Muzeina tribe attains compared with like ratios in the corresponding age groups in other populations. Thus by age 5 the Muzeina children have already attained 68% of their ultimate adult average height (Fig. 18) whereas the Indian and English boys have attained 61% of this stature at the same age. At age 11, the Muzeina children have already attained 84% of their final height, compared with 80% for Indian children and 81% for English boys.

FIGURE 18: Percentage of Mean Stature of Adult Males Attained by Bedouin Boys From South Sinai (Muzeina Tribe), Europe (England) and India, Ages 5-18 Years.

Note: For explanations of population references see Appendix 3.

Heretofore we have compared several populations at comparable ages. However, since age determination of Bedouin children is not totally accurate, we have estimated an average P_i value by combining children of different ages into one age group, (e.g. from 5 to 11 years and from 5 to 13 years). We thereby obtained a new index (P_i) which indicates the mean distance of a certain child population from the height of the adult population. In this way we could evaluate the percentage (P_i) that the mean height of a given age group (A_i) comprises of the mean height of the adult population.

The data in Table 23 show that the overall boy population in the Muzeina tribe, ranging from 5 to 11 years of age, attains on the average 75.6% of the development of the adult population, more than any of the other compared groups. This clearly indicates that on the average, prior to their adolescent spurt in height, they already have less to attain than other populations in order to reach adult height. The differences between the Muzeina and European (London) boys, in mean percentage in the first age group (5-11 years) is 3.8%, which is reduced to 3.0% in the wider age group (5-13 years).

TABLE 23 Comparison of P_i values in stature among different boy populations[1], aged 5-11, and 5-13 years

Parameters	Population			
	South Sinai Muzeina	India*	Europe (England)	New Guinea (Kiapit)
$\overline{X}$ (cm)	166.7	162.5	174.7	163.2
P_1 (%)	75.6	70.9	71.8	72.3
P_2 (%)	78.0	74.1	75.0	74.7

$\overline{X}$ = average height of adult males

P_1 = mean percent of average adult height for age group 5-11 years

P^2 = mean percent of average adult height for age group 5-13 years

*=Indian national

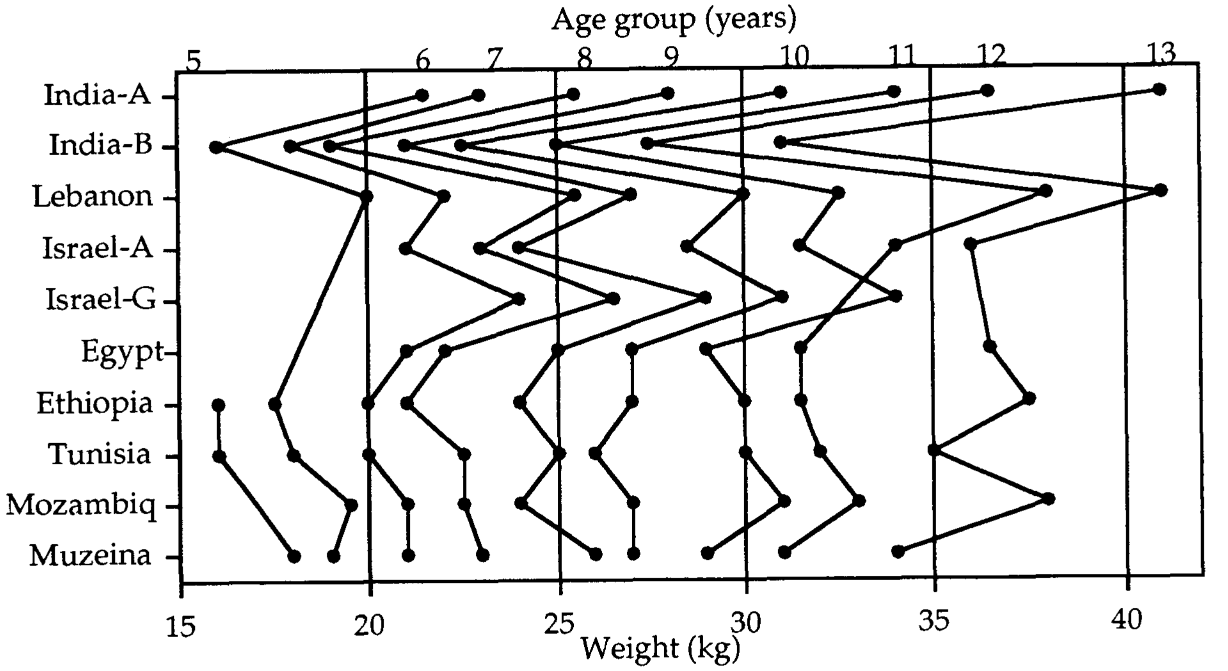
[1]= For explanation of population references see Appendix 3

Body Weight

Average weight of Muzeina boys aged 5-9 years is more than that noted for African (Mozambique, Tunisia, Ethiopia and Egypt) and Indian boys, and very similar to that of Israeli Arab boys. The Muzeina boys generally weigh less than boys of comparable ages in Lebanon, "high" Indian castes or Jewish children in Israel (Fig. 19). At ages 10-11 the Muzeina boys are almost identical in weight with children of the compared African populations and exceed in weight the Indian (National) boys (Fig. 19). Compared with boys of other countries at ages 6 and 13, respectively (Fig. 20), the Muzeina children show much the same mean weight at 6 years of age but definitely less at age 13.

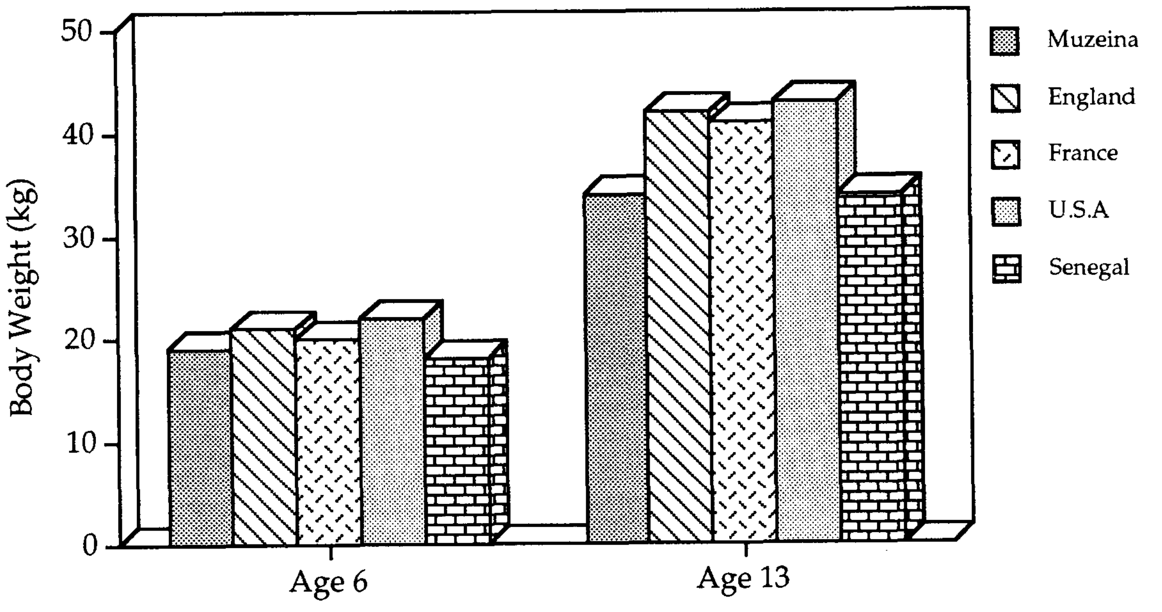
Jewish Israeli children at all comparable ages weight more than Muzeina children (Fig. 19, Israel-G). Arab Israeli children resemble in mean weight the Muzeina children in the 8-9-year age groups but subsequently weigh more. Comparison of the weight values between Muzeina and European (London) children from ages 5 to 18 is presented in Figure 21. This figure reveals that throughout their developmental period, the Muzeina children weigh less than do the English children and that their tendency to diverge from the mean weight of these children increases with age.

FIGURE 19: Mean Body Weight of South Sinai Muzeina Boys Compared With That of Boys From India, Mediterranean and African Populations, ages 5-13.



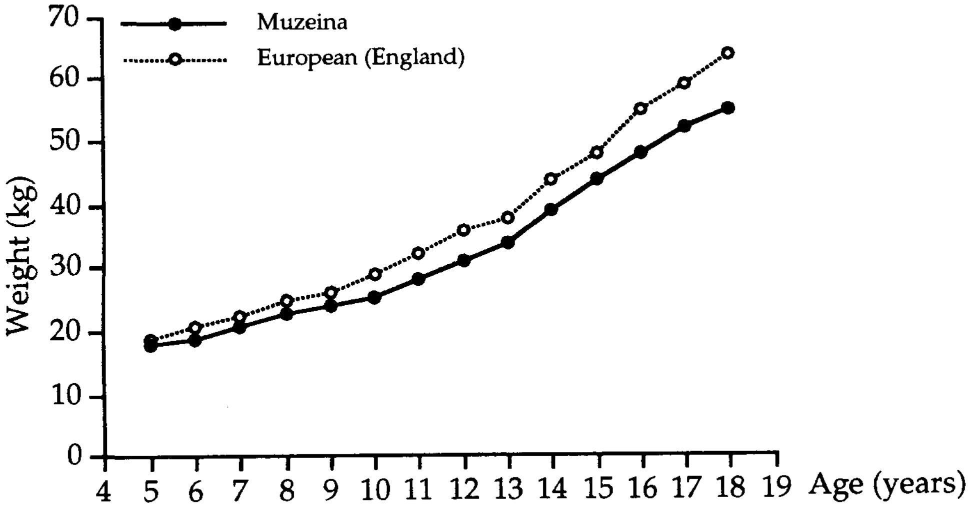
Note: For explanations of population references see Appendix 3.

FIGURE 20: Mean Body Weight of Muzeina Boys Aged 6 and 13 Years Compared With Children of Other Countries at Like Ages.



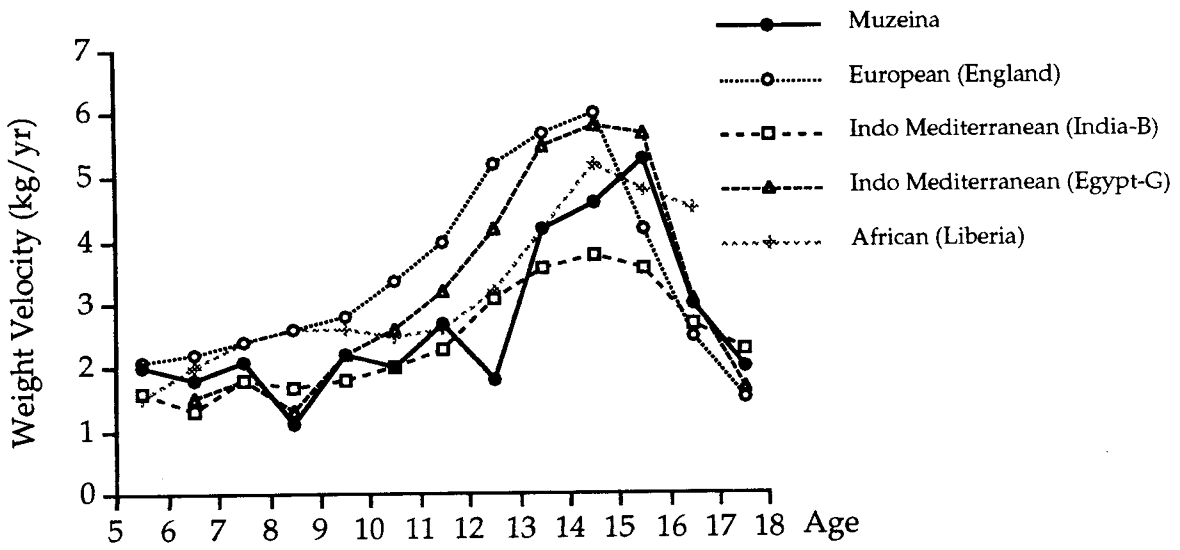
Note: For explanations of population references see Appendix 3.

FIGURE 21: Mean Weight of Bedouin Boys From South Sinai (Muzeina Tribe) and London, by Age; Data "Smoothed".



Note: For explanations of population references see Appendix 3.

FIGURE 22: Mean Annual Velocity in Weight of Boys between Ages 5-18 in South Sinai (Muzeina Tribe), Europe (England), African (Liberia), Egypt, and India; Data "Smoothed".



Note: For explanations of population references see Appendix 3.

Figure 22 depicts the annual rate of weight gain in Muzeina boys compared with that of boys from India and Egypt (all data "smoothed"). It is seen that up to age 10-11, the annual weight increment in the Muzeina boys increases steadily, reaching a peak between 14 and 16 years of age. The annual increment in weight among Indian children after age 11 is much less pronounced than that of Muzeina and Egyptian boys. Although the weight gain curves of Muzeina and Egyptian boys are very similar, it seems that Egyptian boys tend to grow faster and reach their maximum rate of weight increase a year earlier.

If we superpose the weight gain rates of Muzeina children at different ages on weight gain plots of European and African boys, we see (Fig. 22) that the weight gain curve of Muzeina children differs significantly from that for European (England) boys and is very similar to that of African boys (Liberia). From ages 11-14 years European (England) boys manifested a greater increase in annual weight velocity (average of 1.5 kg more per year).

In Figure 23 we learn that by age 5, the Muzeina children have attained 34% of their total weight development whereas Indian children of the same age have completed 31% and London children, only 30% of their total weight development. At age 13 the situation reverses in that the London boys have by then completed 67% of their weight development while the Muzeina children and the Indian children have completed only 64% and 65%, respectively.

If we estimate the average P_i values for ages 5-11, we see (Table 24) that insofar as weight gain (toward the adult mean), the Muzeina children precede the children from the Indian subcontinent, the European (English) children and also the children from the aborigine tribes of New Guinea.

Body weight related to stature is considered in Figure 24. It is seen here that Muzeina boys actually weigh less relative to their height than do English boys, but similar to Indian boys. The rapid height gain with age among Muzeina boys is not accompanied by a corresponding weight gain. Only up to age 9 are they taller than English children but weigh less at all ages (5 to 13 years).

<u>TABLE 24</u> Comparison of P_i values in body weight among different boy populations, aged 5-11 and 5-13 years.

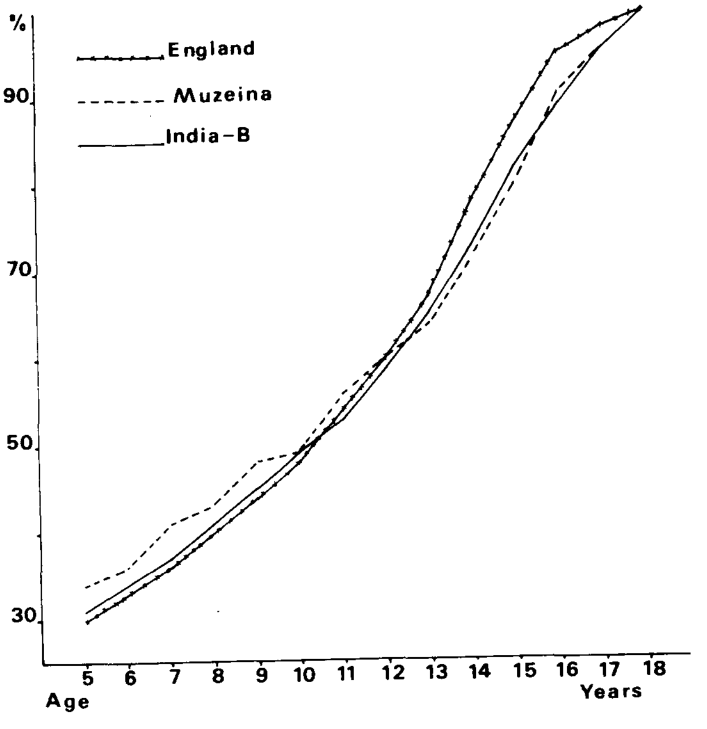
	Population			
Parameters	South Sinai Muzeina	India	Europe (England)	New Guinea (Kiapit)
$\overline{X}$ (kg)	53.3	46.5	63.0	53.5
P_1 (%)	43.7	41.4	40.7	40.4
P^2 (%)	51.2	46.0	45.0	43.6

$\overline{X}$= average weight of adult males;

P_1 = mean percent of average adult weight for 5-11 age group

P_2 = mean percent of average adult weight for 5-13 age group

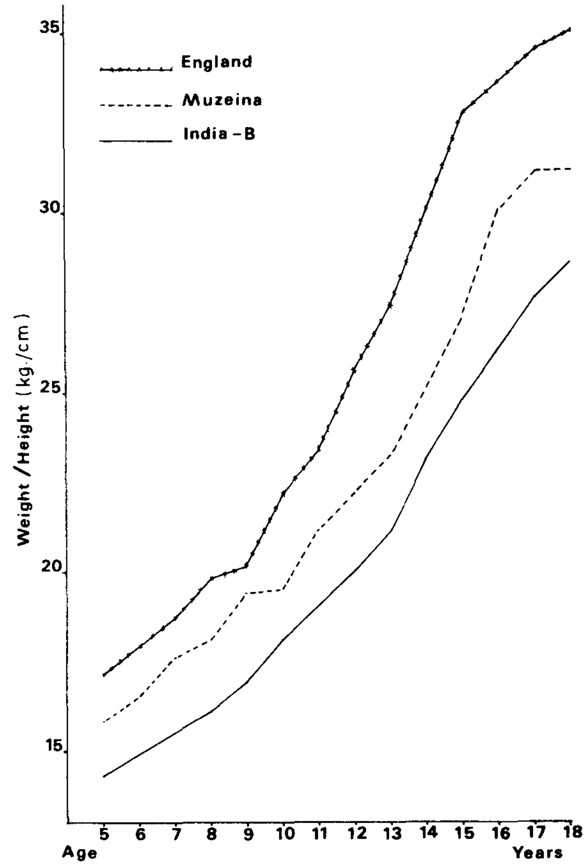
FIGURE 23: Percentage of Mean Male Adult Weight Attained by Boys From South Sinai (Muzeina Tribe), England, and India, at Annual Intervals, Ages 5-18.



Note: For explanations of population references see Appendix 3.

If we calculate a new parameter K_i (K_i=P_i weight/P_i height), which generally expresses the ratio between weight and height development in relation to adult weight and height, we see that the K_i value for Muzeina boys at age 5 is 45.3 whereas in European children of the same age the ratio is 48.4. This may indicate a more balanced height and weight growth pattern at early ages in London boys, probably as a result of more favorable economic conditions which have a crucial influence on weight growth rate. At age 5 the Muzeina boy on average is taller by almost 3 cm (Fig. 16) than the London boy but weighs 1 kg less. At age 13, the K value for Muzeina boys is 73.6 whereas that for London boys is 76.3, thus suggesting the relationship between weight and height development in each is different. The London boy at age 13 is taller on average than the Muzeina boy by more than 7 cm and weighs 8 kg more. Indian boys at the same age have a K value of 74.7, very similar to that of Muzeina boys, although the former are shorter than Muzeina boys by 4.7 cm and weigh 3.7 kg less.

FIGURE 24: Ratio of Weight to Height in Muzeina Boys, 5-13 Years of Age, Compared with Like Data for Boys in England and India



Note: For explanations of population references see Appendix 3.

Head and Face

Between the ages of 5-13 years, head length in Muzeina children increases by about 10 mm, an addition of 5.9%. Head breadth increases during this interval by 5.8 mm, an addition of 4.3%. Clearly, the head increases more in length than in breadth, both absolutely and relatively. Hence the cephalic index decreases slightly between age 5 and age 13.

The rate of facial growth is not uniform in its various anatomical regions. The face broadens by a larger measure than does the head and changes shape from trapezoid to more hexagonal. These shape changes are due to the fact that the bizygomatic breadth increases relatively by a rate of almost twice that for the distance between the rami of the lower jaw (bigonial breadth) and almost three times that of the rate of expansion of the minimum frontal breadth. Between the ages of 5 and 13 facial height increases 17.1 mm, or 19.5%.

When we compare development of the face and head in Muzeina boys from South Sinai with that in children of Bedouin tribes from the Egyptian

Western Desert, or with Polish children, we note that the Muzeina have longer heads (Appendix 3).

The mean head length in Muzeina children between 6-7 years of age (the 6.5 age group) is 182 mm, while in Egyptian groups it ranges between 174.5 to 177.4 mm. In the Polish boys it is much smaller, attaining only 169.8 mm. Between 12-13 years of age (the 12.5 age group), the head length in the Muzeina group reaches a mean of 188.1 mm, in the Egyptian boys, between 182.2 mm and 183.4 mm, and in the Polish boys, only 175.5 mm. The gain in head length between the 6.5 and 12.5 age groups is 3.3% for the Muzeina society, 3.9% for the Egyptian and 3.3% for the Polish, that is, almost identical growth rates with the differences evident only in absolute terms. On the other hand, the head breadth in the Muzeina children is noticeably less than in the Polish boys, and markedly smaller than in the Egyptian boy sample (for population references see Appendix 3).

In all the groups compared, the cephalic index tends to decline with age. Yet there are considerable differences between the groups in the cephalic index (Appendix 3). The Muzeina boys show the lowest cephalic index when compared with Polish and Egyptian boys of comparable ages.

The fact that none of the compared groups shows very much change in this index with age suggests that shaping of the head is largely effected relatively early in life, before age 6. Furthermore, the data indicate a distinct difference in head shape in the three cited groups, mainly between the Muzeina and the Polish boys, the latter presenting a relatively short and broad head (brachycephaly) while the Muzeina have a relatively long and narrow head (dolichocephaly).

In facial structure, the Muzeina boys differ from the Egyptian and Polish groups, having shorter faces (Appendix 3). At 6.5 years the mean facial height is 96.5 mm for Polish boys, 98.3 mm for Egyptian boys and only 94.5 mm for the South Sinai Bedouin Muzeina boys. At 12.5 years of age, mean facial height is 107.3 mm for Polish, ca. 108.0 mm for Egyptian, and 103.5 mm for Muzeina boys; the relative increment in facial height from age 6.5 to 12.5 is 11.2% in the Polish boys, 9.9% in the Egyptian, and 9.5% for the Muzeina boys.

Mean facial breadth (bizygomatic) of the Muzeina children tends to be less than in the Polish boys but higher than that of the Egyptian boys (Appendix 3). Thus at 6.5 years the bizygomatic breadth attains a mean of about 114.4 mm in the Muzeina, 118.1 mm in the Polish, and 107.2-112.8 mm in Egyptian boys. In the 12.5 age group, the mean bizygomatic breadth is 123.0 mm in the Muzeina Bedouin boys, 125.6 mm in the Polish and 117.3-121.1 mm in two groups of Egyptian Bedouin boys; rate of increment in byzygomatic breadth in the Muzeina boys is 7.5%, 7.4-9.4% in the Egyptian groups, and 6.3% in the Polish boys.

The bicondylar breadth is not strictly comparable in the several groups owing to differences in measuring methods. However, the trends seem to be identical to those obtained for bizygomatic breadth.

We may conclude that facial breadth in the Muzeina boys tend to be considerably less than in the Polish boys but greater than in the Egyptian groups.

In sum, we note that:

a) In absolute terms, the head of the Muzeina children is long and narrow compared with the head of children in the European and Egyptian populations. The head length at age 5 reached 94.3%, and head breadth - 95.8%, of those values at age 13.

b) The face increased in different height measurements by 9-12% and in different breadth measurements by 6.9-11.6%. At age 5 the bizygomatic breadth achieved 89.6% of its size at age 13 and facial height reached 83.7%, whereas the head length at age 5 reached 94.4%, and head breadth- 95.8%, of those values at age 13. The Bedouins have a comparatively short and narrow face.

The Chest, Abdomen and Pelvis

The mean breadth of the body in the shoulder region, the biacromial distance, increased in the Muzeina boys between the ages of 5 to 13 from 23.6 cm to 30.8 cm, or 30.5%.

During the same age span, breadth of the body in the hip region, the biiliac distance, increased from a mean of 17.3 cm to a mean of 20.6 cm, a gain of 19.1%. Hence, between ages 5 and 13 the shoulders developed at a faster rate and to a greater extent than did the hip region. It should be pointed out that the measurement in the shoulder region, between the two acromial crests, is between two separate bones which are not directly linked to the axial skeleton, whereas the measurement in the lower pelvic region is between the two crests of the pelvic bones which are interconnected by an additional bone, the sacrum. Consequently the two measurements differ in that the first represents growth of osseous, muscular and adipose tissue, whereas the second is largely of osseous tissue only.

The increase in trunk length (suprasternal height minus anterior superior iliac spine height) is from a mean of 27.5 cm at age 5 to 34.6 cm at age 13, a gain of 25.8%. The increase in length of the trunk, head and neck combined, or "sitting height", is from a mean of 51.2 cm at age 5 to 62.6 cm at age 13, a gain of 22.3%. Height in the sitting position, measured as the distance from the top of the head to the sitting plane, between ages 5-13 increased from a mean of 61.2 cm to 75.8 cm, a gain of 23.9%.

Comparison between Muzeina boys and the children of various other ethnic groups (Appendix 3) reveals that the Muzeina children possess, up to age 9, a mean body girth in the shoulder region (biacromial breadth) which is larger than that in boys from India and Egypt, but is smaller than in London boys. After age 9, the biacromial breadth of Muzeina boys is larger than in Indian children, and smaller than in Israeli and London boys.

The biiliac breadth to age 9 is greater in Muzeina children than in Israeli or Egyptian boys, and remains large relative to Israeli children also at later ages. The Egyptian boys, on the other hand, equal the Muzeina from age 10 and in some cases even exceed them (Appendix 3).

The chest circumference in Muzeina boys up to age 7 is greater than in Indian, Israeli and English boys. At the ages of 8 and 9, this measure drops below the equivalent value for English children, is smaller than in Israeli children whose parents derive from East Europe (E.E.), but is similar to that of Israeli children born to Mediterranean parents (M.E.). After the age of 10 years both Israeli groups (E.E. and M.E. have a significantly larger chest circumference than do the Muzeina children (Appendix 3).

The mean sitting height in Muzeina children is smaller than in London and Israeli boys starting at age 8-9, but is larger than in the Indian or Egyptian boys at all ages (Appendix 3).

If we consider the biacromial breadth/Body height ratio (Appendix 3), we note that compared to Israeli, Egyptian and Polish children, the Muzeina Bedouin boys are narrow in the shoulders relative to their height (Appendix 3) and broad in the pelvic region relative to height only when compared with Israeli boys (Appendix 3). However, the Muzeina boys when compared with London boys, show lower biiliac/stature values at all ages. In both of the latter populations, this ratio decreases significantly with age; however, this ratio among London boys at 13 years of age is very similar to that of Muzeina boys at age 5! (Appendix 3). Moreover, the size of the biiliac/height ratio is reduced between ages 5 and 13 by 10.2% among Muzeina boys and by only 6% among London boys. The significance of this difference is that height gain in the Bedouin boys between ages 5 and 13 years is much faster than in the pelvic girth of the compared boys. The ratio of chest circumference to body height changes with age in the Muzeina boys, as well as in the other compared groups (Appendix 3). At ages 9 to 13, the Egyptian children have a small chest circumference relative to their height, the Bedouin Muzeina and Polish boys are about the same in this measure, and the Israeli children display a higher ratio of chest circumference to height at ages 10-13.

The Extremities

The upper and lower limbs are each composed of three parts: the upper limb has the upper arm, lower arm or forearm, and hand; the lower limb includes the thigh, lower leg or shank, and foot. Each segment has its own rate of growth, which changes with age. Thus, with changes in age, there are changes also in the proportions, both within and between the parts.

Upper Limb

Krogman (1972), commenting on growth of the upper limb in U.S. white children, notes that up to puberty the patterns of growth of the upper limb and its component parts are the same in boys as in girls. Subsequently, however, the growth rate in the males is greater than in the females. In American "White" children between the ages of 3 and 12 years, the upper limb grows at a rate of 2-3 cm per year. At puberty the rate increases and subsequently declines sharply.

According to Krogman (1972), the lengths of the upper arm and lower arm (forearm) are equal at birth. On maturation, after about age 18, the lower arm comprises only 75% of the length of the upper arm. A young child has a relatively long hand compared to length of the entire arm. The ratio of arm length to body length also changes with age. All these rates and ratios may differ in different ethnic groups (Krogman, 1972).

In the Muzeina boys, total arm length increased by 15.95 cm, or 32.7% between the ages of 5 and 13 years. Separately, the upper arm increased by 6.6 cm (32.9%), the lower arm by 5.6 cm (34.3%) and the hand by 3.8 cm (30.4%). Thus the forearm grows relatively more rapidly than the upper arm but remains smaller than the latter throughout the developmental period; both the forearm and the upper arm grow relatively faster than the hand between ages 5-13 years.

Relative to the upper arm, at age 5 the forearm length is 81.6% of the length of the upper arm, and remains much the same proportion at age 9 (82.1%) and at age 13 (82.5%). Hand length at age 5 reaches 63.2% of the length of the upper arm, at age 9 - 62.6%, and at age 13 - 62.0%. Compared to American and Israeli boys, the Muzeina have a longer upper arm and forearm at 5 to 8-9 years, but then the reverse occurs, the Muzeina boys manifesting a shorter upper arm and forearm. A similar process takes place also with the hand, except that here it commences at age 12 (Appendix 3). The Muzeina boys have a slightly longer upper limb relative to body length than Israeli boys (Appendix 3).

Lower Limb

Krogman (1972) has demonstrated that the upper limb, as the lower limb, develops at about the same rate in both sexes till puberty, whereupon the lower limbs of the male (all three component parts) become longer than in the females. He also found that growth of the thigh proceeds more rapidly than the lower leg, albeit the proportions of these two components are the same in different ethnic groups.

Development of the lower limb.

In the South Sinai Muzeina boys, between 5 and 13 years the total length of the entire lower limb increased 24.3 cm or 40.7%; 12.4 cm is contributed by the lower leg (measured by tibial height. However, growth rate of the lower leg is not uniform relative to growth of the entire limb. Thus at age 5 the lower leg comprises 48.1% of the total leg length, and at age 9 - 49.2%.

Our data indicate (Appendix 3) that until age 8, South Sinai Muzeina boys have longer legs (total length and segments) than do Israeli and American boys, although the American boys manifest more rapid leg growth at age 9 and after.

The ratio of total leg length to stature (Appendix 3) shows that up to age 9 the Muzeina boys have a longer leg relative to stature than Israeli boys but after age 9, the curves are much the same.

The Foot

The foot here receives a special chapter because of the importance we assign to its development in nomad and seminomad peoples. According to Krogman (1972), in European populations the length of the foot at birth is about 31% of the average in the adult male, and by age 10 reaches about 82%. Average length of the foot relative to stature at age 13 in males is 15.5%. While length and width dimensions of the foot differ among various groups, the width/length ratio appears to be relatively fixed.

In the South Sinai Muzeina boys between ages 5 and 13, foot length increases by 5.3 cm, or 29.0%, and in breadth by 2.0 cm (27.8%). Thus rate of growth was practically identical in both length and width between ages 5 and 13.

Growth in foot length and width of Muzeina boys, compared with like dimensions in Israeli Jewish boys, shows more rapid development in the former from 5 to 9 years, but the reverse afterward (Appendix 3). Average incremental growth in breadth is very similar in Muzeina and Israeli boys (Appendix 3). Consequently, the foot differs significantly in that the Muzeina boys acquire a foot "mold" which is broad relative to length, whereas the Israeli boys develop a foot which is comparatively narrow relative to its length (Appendix 3).

It is important to note, concerning foot development, that Bedouin children walk barefoot from early childhood whereas Israeli children wear shoes beginning approximately one year of age, a difference which probably affects both rate and pattern of development of the foot in each group.

Adipose Tissue

It is customary to suppose that circumferential measures (e.g. the chest) are influenced to a greater extent than other bodily measurements by involving more adipose tissue (Krogman, 1972). Yet differences in physical activity also affect development or non-development of adipose tissues. According to Krogman (1972), changes with age in the thickness of subcutaneous adipose tissues are of a rather fixed pattern, namely, rapid increase during the first year of life, followed by a decrease to age 8, followed again by a rapid upsurge, although there is marked variability in this pattern among different ethnic groups.

Our evidence for Muzeina boys (Appendix 3) indicates that their subcutaneous adipose tissue, measured by skinfolds, is considerably less than on boys from Israel or England, and appears to be about the same as in Egyptian boys. The noted differences are probably due to the disparity among the boys in both the amount and quality of the food consumed. When comparable measures in the increment of subcutaneous fat with age are made in Bedouin boys (Muzeina) and Egyptian boys, who are also deprived nutritionally, we find only slight differences between the two, possibly genetic in origin (Appendix 3).

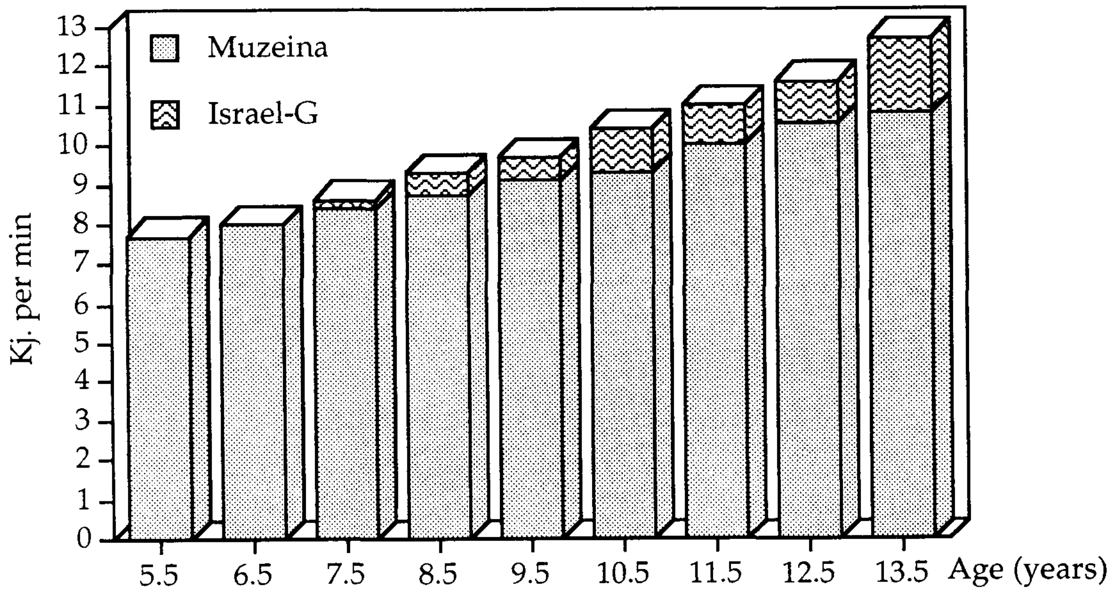
Energy Consumption

The Basal Metabolic Rate (BMR) can be expressed by various units, to wit: liters of oxygen consumed per minute, kilocalories (Kcal), kilojoules (KJ) per minutes or relative to body surface as Kcal or KJ per m^2. Due to objective difficulties in the course of our study, we were unable to obtain precise data on the oxygen consumption and lung volume of Bedouin children and therefore had to rely on kilojoules. The KJ unit is defined as the energy expended when 1 kg is moved a distance of 1 meter by 1 Newton. A Newton is the force which accelerates 1 kg by a rate of 1 meter per squared second (1kg by $1m/sec^2$). The energy unit in nutritional studies is usually the Kilocalorie (Kcal) which is equivalent to 4.185KJ. On occasion one finds in the literature the term Megajoules (MJ) which is equivalent to 10^6J.

Energy consumption by individuals is dependent on four interconnected variables, namely, age, level of physical activity, body size and composition, and environmental factors. Accordingly we selected an equation which enabled computation of the energy consumption per fixed activity (e.g. walking at a rate of 3 miles per hour) regardless of age or sex of the individual. The resulting equation is: $KJ/min = 0.197 \times weight + 4.284$ (from Harrison et al., 1977, p.401)

Comparing our results with those for Jewish boys in Israel (Fig. 25), we find that, except for ages 5 and 6 where we did not have data for Israeli children, energy expenditure for performing the aforementioned task for 1 minute is less in Muzeina Bedouin boys than in contemporary Israeli Jewish boys of the same age. This result suggests that lower mean body weight of the Bedouin boys is the primary factor which enables them to perform physical activities at a lower energy "cost".

FIGURE 25: Change With Age in Energy Expenditure Required to Perform a Defined Task, in Muzeina and Jewish Boys in Israel.



A word of caution is perforce necessary: in our formula, body weight is the only criterion or factor considered,which undoubtedly causes some bias in the obtained results.

To be sure, the existence of nomad or semi-nomad desert populations subsisting largely on grazing, primitive agriculture limited to constricted regions, and perhaps occasional "outside" work, is dependent on a precise balance between energy expenditure and the food resources available to the group (Harrison et al., 1977). Studies have shown that populations subsisting under severe environmental and/or economic conditions do not display a special physiological adaptation but rather a behavioral adaptation, meaning that the group generally refrains from "excess" activity, or any activity not vital for its existence, thereby limiting its energy consumption (see review by Lange Anderson et al., 1978). Our own experience with the Bedouin in South Sinai over the years confirms this finding.

There is need, also, to evaluate anew the appellation of nomadism, which has been attributed almost automatically to Bedouin populations. In this connection, Palmer (1871) more than a century ago remarked that the Bedouins were far from being the exclusive nomads depicted in numerous literary `romances'. He noted:

> *The idea prevalent in Europe of the nomad character of the Arabs is erroneous. They are generally described as wandering incessantly with their tents from place to place, but in reality no people wander less than the Bedouin, or are more attached to their native homes* (p.78).

Body Size and Shape

In addition to the usual measures by which shape is defined (e.g. ratio of limbs to torso, ratio of weight to stature, etc.), we used also two other working equations. The first computed body surface area by the DuBois formula:

$A = W^{0.425} \times H^{0.725} \times 71.84$ (Harrison et al., 1977, p.401)

where A = body surface area in cm^2; W = body weight in kg; and H = body height in cm. This formula was developed as European criteria and therefore tends to bias the results in favor of populations for which it was developed.

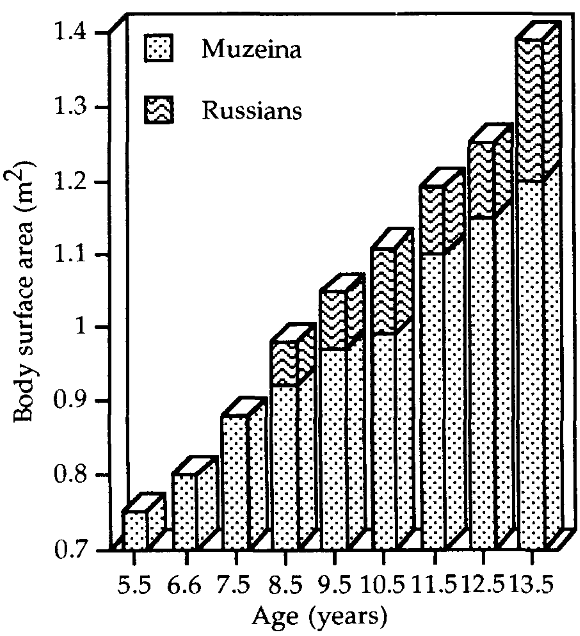
The association between body size and shape has been the subject of numerous investigations ever since publication of the Bergmann and Allen laws (1847, 1877). Later many anthropologists (e.g. Roberts, 1953) attempted to demonstrate that the laws stipulating that body size in warm-blooded animals of a particular species or subspecies usually increases with a drop in the temperature of their biotope (the Bergmann Law) or that there is an increase in the relative proportions of projecting organs, such as ears, tail, etc., with a rise in the ambient temperature (Allen's Law), are applicable also for humans. For example, an extensive study in the early 1950's by Roberts showed that the mean body weight to body surface area ratio in populations residing in warm regions is lower than in populations living in temperate and cold regions; furthermore, that the ratio of sitting height to stature diminishes with increase in temperature, that is, the lower limbs tend to become longer in the warm regions, and the trunk dimensions smaller in hot climates.

Most of the previous findings on the subject were assembled by Schreider (1951), who then demonstrated that the ratio of weight to body surface area diminishes as one proceeds from temperate to hot climates. He determined a ratio of 38 kg (body weight) to 1 m^2 (of body surface) in a French adult male population, 36kg/m^2 in an Arab population, 35kg/m^2 in a Somali population and 32kg/m^2 in an Indonesian population. Other investigators (e.g. Harrison et al., 1977) point out, however, that the correlation between body shape and temperature accounts for only 50-60% of the overall morphologic variability in a population and hence other factors should also be sought as responsible for the variability.

The data collected by us on South Sinai Muzeina boys on both body surface area as well as body surface relative to body weight, are shown in comparison with like measures in European children of Russian extraction in Figure 26a,b. It is evident from these figures that average body surface area in the Bedouin Muzeina boys is considerably smaller than in the European boys, and the ratio of surface area unit to weight unit is higher in the former (Fig. 27 a,b).

These results testify not only to absolute differences in weight and stature between the Bedouin (Muzeina) and Israeli and Russian boys, but also to a difference in proportionality, a fact apparent also in earlier data presented in this chapter.

<u>FIGURE 26a</u>: Body Surface Area in Muzeina Boys ComparedWith Russian Boys, Ages 5-13*.



<u>FIGURE 26b</u>: Body Surface Weight Area/ in Muzeina Boys Compared With Russian Boys, Ages 5-13*.

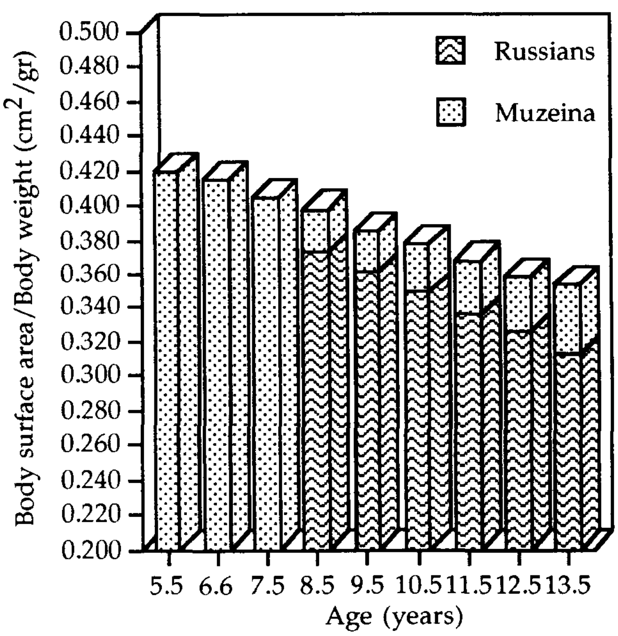


FIGURE 27a: Body Surface Area in Muzeina Boys Compared With Israeli Jewish Boys, Ages 5-13*.

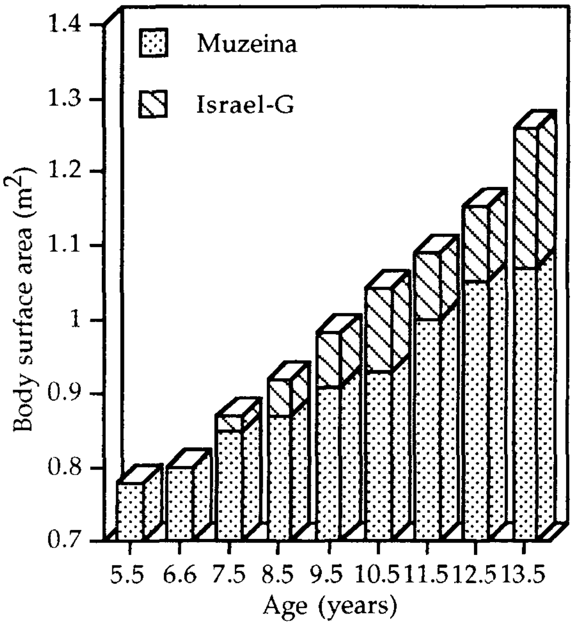
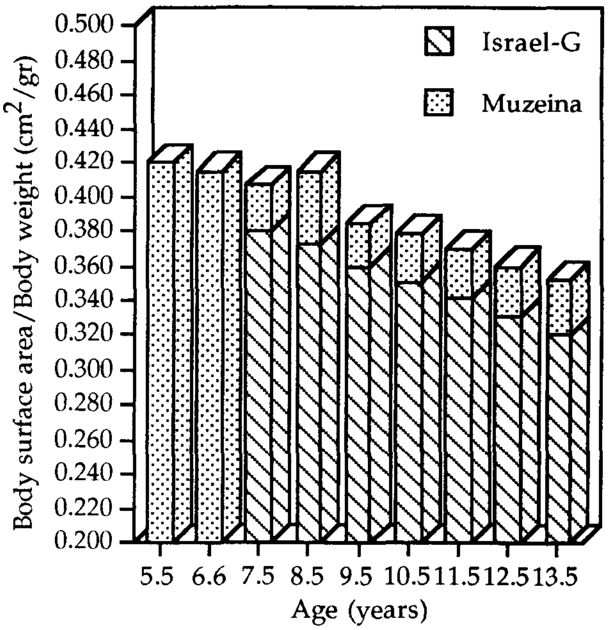


FIGURE 27b: Body Surface Area/Weight in Muzeina Boys Compared With Israeli Jewish Boys, Ages 5-13*.



*No data for age 5 and 6 years for Israeli and Russian children

In sum, Bedouin (Muzeina) boys, compared with Russian (Moscow) and Israeli boys, appear to have a narrower body relative to their stature, longer limbs relative to stature, a lower weight per unit of body surface area, and a smaller amount of subcutaneous adipose tissue. Perhaps such body features help to regulate the internal body temperature in regions of a warm climate, although there is controversy in the literature as to whether body size really contributes to the body's thermal regulation. Animal studies have shown that in warm climates the animals with a small body have advantages over large-sized animals in body thermal regulation. Riesenfeld (1981), for example, tested the tolerance of two types of rats to extreme heat and cold conditions with small-sized and large-sized representations. He reached the following conclusion (Riesenfeld, 1981):

Thus the present study confirms a functional correlate to Bergmann's ecological rule. Results obtained by this writer's previous study (Riesenfeld, 1980) further showed that the differences in temperature tolerance between Buffalo and Fisher rats are due to their differences in body weight and not any temperature-specific genetic differences. This follows from the fact that in both Buffalo and Fisher rats of both sexes, temperature tolerance is *significantly correlated with body weight or rather their weight to surface ratio...* (pp.96-97).

The conclusions drawn from these experiments designed to evaluate the correlation between body weight, race and climate in animals, seem consistent with those of similar studies on human populations, namely, that there is an inverse correlation between body weight and the ambient temperature, which would support the validity of the Bergmann Rule for human populations (Newman and Munro, 1955; Schreider, 1963; Roberts, 1973; etc.). Yet, diametrically opposite conclusions were drawn by Austin and Ghesquiere (1976), who observed groups of Bantu and Pygmies in Africa. According to these authors, small-bodied populations possess a lower tolerance to heat than do large-bodied populations. A year later, Austin (1977) underscored the limitations of such studies, using a computer simulation to prove his argument. He wrote (Austin, 1977):

The results do not fully support the concept, implicit in Bergmann's `Rule', that small body size is advantageous in warm environments...in hot humid conditions large body size is apparently more advantageous than small body size (p.116).

The experimental method and conclusions of the latter author have been severely criticized (see Riesenfeld, 1981, p.99). In sum, it would seem that matters as laid down in the Bergmann-Allen Rule are not as clear-cut or conclusive, especially for humans, as previously believed. The Bedouins have a body structure which apparently affords them advantages in severe desert climatic conditions. However, as indicated in a previous study of Bedouins in Israel (McCance et al., 1974), internal systems (e.g. the excretory system) in these individuals offered no special advantages over those extant in the "ordinary" population. The conclusion drawn by McCance et al. is that:

Physiologically speaking....Bedouin did not appear to be better adapted to life in the desert than other human ethnic groups (p.263).

Summary

In rates of development and general morphology, there are significant differences between South Sinai Muzeina, and some European[1] and American White boys.

Thus, up to age 9 Muzeina boys are taller than European boys but subsequently the latter exceed the Muzeina boys. A developmental spurt in Bedouin boys does occur almost at the same age as in European boys.

[1] European refers to boys from England (London), Poland, and to Israeli Jewish boys of European extraction.

At age 5, the Muzeina boys attain 68% of mean stature of the adult male population of the tribe, compared to 61% in the European boys considered, and at age 11 the Muzeina already attain 84% of the mean adult male stature versus 81% in the European boys.

In mean body weight, the Muzeina boys are lighter than their European counterparts, and with age this disparity probably increases. We may note that at age 5 the average Muzeina boy attains 34% of his weight at age 18, whereas the average European boy at the same age attains 30% .

Mean stature of the Muzeina boy at age 5 exceeds that of European boys by about 3 cm, but weight is at least 1 kg less. However, at age 13 the mean stature of European boys is greater than that of Muzeina boys by 7 cm and their mean weight by 8 kg.

In morphological structure there are sizeable differences between Bedouin (Muzeina) and European boys. Thus the Muzeina boys have a relatively longer head than European boys.

If we take into account the fact that mean head breadth in adult Bedouins is identical to that in European children at age 5-6, it is clear that a relatively narrow head is a general morphologic characteristic of the Bedouin population.

The face of Muzeina boys is shorter and narrower than that of the European boy at all ages. The rapid development in stature compared to the slow gain in width in the shoulder and pelvic regions in the Muzeina boys results in a pronounced ectomorphy type compared to that in European populations. As for proportions between the different parts of the upper limb, the Muzeina boys have a longer upper arm and forearm at age 5 to 8-9 years than European boys, but then the reverse occurs, the Muzeina boys acquiring a shorter upper arm and forearm. The same is true with the hand except that a reversal commences at age 12. Nevertheless, compared to European boys the Muzeina still have on average a longer upper limb relative to stature.

As for the lower limb, in the Muzeina up to age 9 it is longer relative to stature than in European boys, but subsequently this ratio equalizes in the two populations. The foot of the Muzeina boys is very different from that of the European boys at all ages. Basically the Muzeina have a foot which is broad relative to its length whereas in the European boys it is narrow relative to length (Appendix 3).

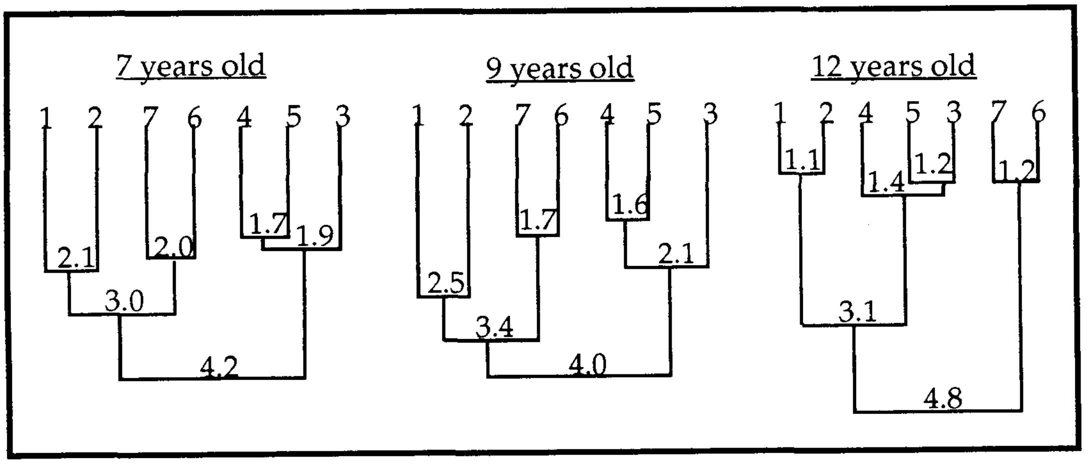
An additional morphologic `identifier' of the Bedouin Muzeina population is their amount of subcutaneous adipose tissue, which is very meager compared to that in the European populations and becomes even less with age. Body surface area in Muzeina boys was found to be greater relative to weight compared to that in European boys (Appendix 3).

Finally, we have also shown that, owing to their special body build the Bedouin children expend less energy than European children of comparable ages in performing the same physical tasks (e.g. walking).

Changes In Morphological Resemblance Between Sinai, Egyptian And Israeli Boys With Age

Thus far we have examined changes in single morphological traits with age, or have compared single traits between groups. We shall now look at overall morphological changes among Bedouin boys of South Sinai. Based on 8 morphometric traits - sitting height, biacromial breadth, arm length, stature, facial height and breadth, and head length and breadth - we calculated for ages 7, 9 and 12 years the morphological similarity and/or disparity between Mediterranean boys of different ethnic and geographical location, namely, those from South Sinai Muzeina and Gebeliya tribes, Egypt (Kenous, Arab-Nubian and Fededji) and Israel (parents born in the Middle East and in North Africa).

FIGURE 28: Morphological Similarity and Disparity Between Seven Different Groups of Boys at Ages 7, 9 and 12, Respectively (groups are indicated beneath).



1=Muzeina-S. Sinai | 3=Kenous-Egypt | 5=Fededji-Egypt | 7=Israeli Jews (North African origin)

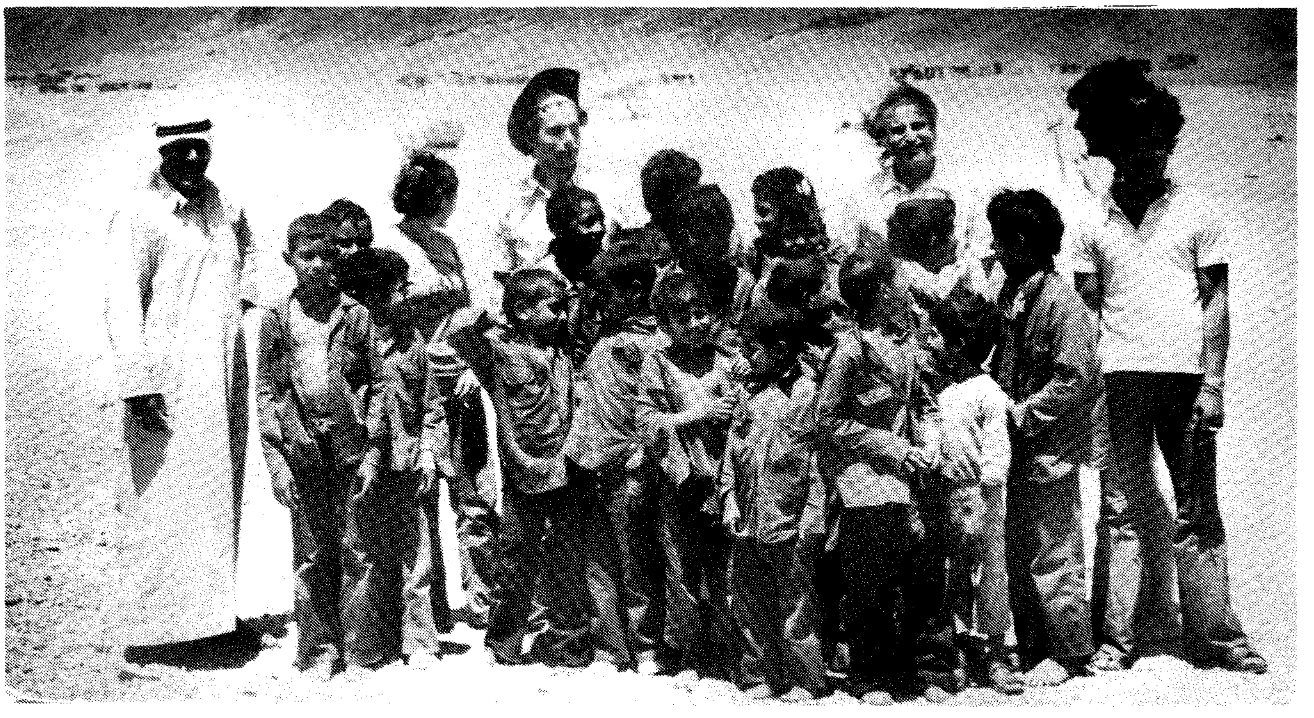
2=Gebeliya-S. Sinai | 4=Arab Nubian-Egypt | 6=Israeli Jews (Middle East origin)

* level of morphological association measured as Euclidean distances

Pairwise morphological associations among the groups were obtained by the Euclidean distance, according to Lalovel, (1980): $D=\sum_{k=1}^{n}(\bar{X}_{ik}-\bar{X}_{jk})^2$ where D is the morphological difference between two populations (i and j), $\bar{X}$ is the mean value of the kth trait in these populations, and n is the number of traits. Since many of the morphological traits could not be compared by their absolute values, all the traits were standardized by dividing each mean value by its standard deviation. Thus, $\bar{X}_i$ actually represents not the average, but rather $\bar{X}_i$/S.D. The results of the calculations were further subjected to cluster analysis (UPGMA Method), which in turn led to the construction of single dendrograms (Fig. 28). In these dendrograms it can be seen that: (a)clusters are organized in accordance with geographical location of the groups; and (b)level of morphological association between the groups changes with age.

The overall morphological similarity between South Sinai and Israeli groups decreases with age, the mean distances being 3.0 for age 7, 3.4 for age 9, and 4.8 for age 12. The similarity increases with age, however, between the Egyptian groups and South Sinai Bedouin boys (Fig. 28).

The above results seem to indicate that until age 9, South Sinai children develop, in general, very much like other Mediterranean groups, regardless of nutritional status and other environmental factors. After age 9, the influence of environmental factors apparently becomes more pronounced, resulting in changes in cluster order and an increase in morphological similarity between groups of the same geographical region.



Prof. Ben David (hat), Prof. Arensburg, S. Gur-Lavy and Fatchi (the Bedouin driver of the team).