

WEIGHT, HEIGHT AND BODY MASS INDEX REFERENCE CURVES FOR CHILDREN AGED 6-11 YEARS LIVING IN ANKARA

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ABSTRACT

This study has been carried out for the purpose of determining anthropometric measurement values of height, weight and Body Mass Index of 6 - 11 year old school children. A sample of, 866 individuals of higher socioeconomic class, consisting of 458 boys and 408 girls with ages ranging from 6 to 11 years, was studied. For each student, his height and weight were measured by means of the technique stipulated in International Biological Program. Percentile values of height, weight and Body Mass Index (BMI) of children were established by means of the LMS-method. Using the LMS-method, smooth percentile curves were plotted. Suitability of the model was tested by means of Q-Q plot test. Height, weight, and BMI values in the all age group indicate that the boys have relatively larger values than girls. Finally, using the LMS-method we developed weight, height and BMI reference values for children 6 to 11 years old living in Ankara.

Key words: Height centiles, weight centiles, BMI centiles

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ANKARA'DA YAŞAYAN 6-11 YAŞ GRUBU ÇOCUKLARIN AĞIRLIK, BOY VE BEDEN KİTLE İNDEKSİ REFERANS DEĞERLERİ

ÖZET

Bu araştırmanın amacı Ankara'da yaşayan 6 - 11 yaş arası çocuklarda ağırlık, boy ve beden kitle indeksi değerlerini ortaya koymaktır. Bu amaç doğrultusunda üst sosyoekonomik düzeye mensup 458 erkek, 408 kız olmak üzere toplam 866 çocuk ölçülmüştür. Her birey üzerinde International Biological Program'ın öngördüğü teknikler doğrultusunda alınan ölçümlerden ağırlık, boy ve beden kitle indeksi için LMS-metodu yardımıyla persentiller oluşturulmuştur. Elde edilen bu yumuşatılmış (smooth) eğriler grafiklerle sunulmuştur. Elde edilen bu persentillerin doğruluğu Q-Q plot ile test edilmiştir. Araştırmamız verilerine göre, boy, ağırlık ve beden kitle indeksi değerlerinin incelenen bütün yaş gruplarında, erkeklerin kızlara göre daha büyük değerler gösterdiği yönündedir. Sonuç olarak bu çalışmada Ankara'da yaşayan 6 - 11 yaş grubu çocuklar için LMS-metodu yardımıyla boy, ağırlık ve beden kitle indeksi referans değerleri oluşturulmuştur.

INTRODUCTION

Childhood growth is the result of the interaction of many regulatory factors, both hereditary and environmental. Optimal growth can be achieved only when all these factors work in harmony (Delemarre-Van De Waal, 1993). After birth, the environment may exert either a positive or negative effect on growth. It is well known that postnatal growth is affected by nutrition, socio-economic status, diseases, and other factors. It was demonstrated that the differences between urban and rural living conditions alone may cause up to a 12% difference in height and a 30% difference in weight (Habicht et al, 1974). Height and weight are important indicators of growth, nutrition and health of an individual and of a population. BMI is also measured simply, cheaply and without much difficulty, and so BMI is frequently used as a measure of health and nutritional status both in clinical medicine and in research (Bellizzi and Dietz, 1999; Poskitt, 1995). BMI varies considerably with sex and age, particularly before adulthood. Therefore, a measured BMI must be compared with appropriate sex- and age-specific reference values, for example expressed as Z-scores (Poskitt, 1995). More recently the LMS methodology developed by Cole and Green (1992) has been used widely as the preferred technique to develop accurate centiles from growth survey data. Thus the tradition of innovation and excellence in growth chart research continues.

Turkey is a country with significant regional differences in socio-economic, demographic and epidemiological phenomena. This is partly due to its geography, and to past economic crises. The latter caused massive migratory movements of population from rural areas to big cities such as Istanbul and Ankara. At present there are only a few case studies on the growth of school children in Turkey the most important being of school children of high socio-economic background (Neyzi et al, 1978; Saatçioğlu, 1988; Duyar, 1992). Nowadays, the most popular growth chart used in Turkey is still Neyzi et al.'s (1978) and Saatçioğlu's (1988) because recent study implies some drawback in terms of lack of adequate samples. In Neyzi et al.'s (1978) study, all subjects were selected from among healthy children of well-to-do families in Istanbul. Saatçioğlu (1988) presented a comparative study of primary school children's growth standards within the highest socio-economic level among the population from seven cities, each representing a model city in the seven geographical region of Turkey.

Growth charts are widely used as a clinical and research tool to assess nutritional status and the general health and well-being of infants, children and adolescent. In this respect, the aims of the present study are to generate weight, height and BMI reference values for Turkish children (6 to 11 years old) living in Ankara from other Turkish samples, to compare these reference values with published reference values.

MATERIAL AND METHODS

The study sample consists of 866 pupils (408 girls, 458 boys), aged 6-11 years, who were measured during the year 1997. The survey was cross-sectional, with a restricted period of data collection to avoid the effect of secular changes within the survey period. Measurements were performed throughout the year except during school holiday periods.

The data are cross-sectional and represent the upper socio-economic class. The subjects belonged to the population living in Ankara, Turkey. Table 1 shows the number of subjects according to age. Since age is very important in this type of study, every effort was made to record the age of pupils correctly. Exact decimal age was calculated from the dates of birth and measurement dates.

Table 1: Frequency distribution of the number of children by age

Age	Boys	Girls	Total
6 ± (5.5-6.4)	39	37	76
7 ± (6.5-7.4)	77	69	146
8 ± (7.5-8.4)	97	83	180
9 ± (8.5-9.4)	101	93	194
10 ± (9.5-10.4)	86	82	168
11 ± (10.5-11.4)	58	44	102
Total	458	408	866

All measurements were collected from the state primary schools situated in the following districts of Ankara: Kavaklıdere, Teğmen Kalmaz, Yunus Emre, Kurtuluş, Dede Korkut and Gazi Osman Paşa. The subjects were randomly selected from public schools (six primary schools) and the schools were randomly selected from the list composed by each local area's board of education. Measurements of height, weight, calculated body mass index (BMI), were measured according to the International Biological Program (IBP) procedures (Saller, 1957; Tanner, Hiernaux and Jarman, 1969). Height was measured to the nearest millimeter, using a Martin type anthropometer, while weight was measured with a scale/weighing device accurate to 100 g. The accuracy of the balance was checked before each session and the unladen scale was adjusted to zero. Subjects wore only a light school uniform (pants and short-sleeved shirt for boys, and light blouse and dress for the girls) with shoes removed. The BMI was calculated by dividing weight (in kilograms) by height (Habitch et al, 1974) (in metres). All calculations were performed with SPSS 11.0-PC statistical software.

A family information form was used for deriving demographic information concerning father's job, father's education, mother's education, number of siblings, and type of residence. To describe concisely the social classes of our sample, we have classified the fathers' professional status into four categories, which were defined as follows: 1: Expert; 2: Civil servant; 3: Unqualified workers; 4: Unemployed. Table 2 shows the frequency distribution of the fathers' professional status. All students' mothers were housewives. Tables 3 and 4 respectively show the frequency distributions of fathers' and mothers' educational status, classified into six categories: 1: Illiterate, 2: Literate, 3: Primary school; 4: Middle school; 5: High school and 6: University degree.

Tables 5 and 6 respectively show the number of sibling in the family and residential status. Tables 7 also show frequency distribution of the number of rooms in the household.

Regarding the methods applied in this study, firstly the samples were randomly selected. However, without considering the socio-economic levels of the schools that were used in this work, two different socio-economic level scores were developed for boys and girls. In this respect, the boys with scores equal to or above 3.20 and the girls equal to or above 3.17 point are considered to belong to families with high socio-economic status. These point value were assessed with the help of all subject mean socioeconomic score. A total of 1717 pupils were questioned in this study. After exclusions and the rejection of outliers, data on 458 boys and 408 girls were retain for analysis. Within the scope of the socio-economic scoring that has been developed, only 866 pupils of the total population represented high socio-economic level. The remaining pupils have not been included in any statistical analyses.

Growth centiles based on the original height and weight and BMI data were constructed by using the LMS-method (Cole and Green, 1992; Cole, Freeman and Preece, 1998). The method summarizes the centiles with three smooth curves. The *L*-curve (Box-Cox power transformation to remove skewness) is the smoothed curve of the Box-Cox power transformation plotted against age. The *M*-curve (median) is the smoothed median of the measurement plotted against age. It corresponds to the median curve on a conventional growth chart. The *S*-curve (coefficient of variation) is the smoothed curve of the measurement's coefficient of variation as it changes with age. It can determine the value that best approximates the median (50th centile of the distribution) and gives the minimum *S*. Though the *L*, *M* and *S* values obtained display considerable oscillation, the LMS method allows one to draw smooth curves of *L*, *M* and *S*. Once the LMS curves are known, and then any required centile curve can be constructed based on them, using the formula:

$$C_{100\alpha} = M (1 + L S Z_{\alpha})^{1/L}$$

Where Z_{α} is the standard deviation score (SDS) of the required centile. For example for the third centile, $100_{\alpha} = 3$, $\alpha = 0.03$, $Z_{\alpha} = -1.88$ and $C_3 = M (1 - 1.88 LS)^{1/L}$.

Each curve is estimated as a cubic spline using maximum penalized likelihood. To obtain the z -score (Z) and corresponding percentile for a given measurement (x), we used the following equation:

$$Z = \frac{((X/M) \times L) - 1}{LS}, L \neq 0$$

$$Z = \ln(X/M) / S, L = 0$$

The Z -scores, once known, can be converted to a centile using normal distribution tables. Selected percentile curves (3, 10, 25, 50, 75, 90 and 97) were constructed using KaleidaGraph graphical software (version 3.52).

RESULTS

Table 2 shows distribution of the father's professional occupation. Nearly fifty six percent of fathers were civil servants and approximately 27 % of fathers were experts. It can be seen that 29.12 % of mothers and 46.48 % of fathers had university degrees. Of the rest 36.84 % of mothers and nearly 38 % of fathers had a high school degree (Table 3 and 4). Table 5 shows the frequency distribution of the number of siblings. Sixty-two percent of the children had one sibling and 19 % of the children didn't have any siblings. Nearly thirty four percent of the families owned a house and children had private rooms (Table 7).

Figures 1 and 2 present the 3rd, 10th, 25th, 50th, 75th, 90th, and 97th centiles (denoted by z -score of -1.881, -1.645, -1.282, -0.674, 0, 0.674, 1.036, 1.282, 1.645 and 1.881) of height by age for the children living in Ankara. The rate of increase for the P 50 for the height of girls in the age range of 6 to 8 years declines and after this age height continues to rise. The girls P 50 centile increases until 10 years but before this age the height increase rate shows a minor decrease. We noted that during childhood (6 - 11 years), the height values of boys were always higher than for girls. The girls' weight centiles are presented Figure 3. From the curves we noted that the girls' rate of increase for mean weight centiles increase accelerate after 10 years of age. From Figure 4 we noted that median weight increases steeply throughout the sample age range among the boys. Beyond 8 years the boys' centiles became the wider gap among the centiles. In the all age group boys weight values higher than girls values.

The obtained L, M and S values by age and sex are shown in Table 8. It can be seen that the L values are low in both sexes, indicating considerable skewness. Figure 5 and 6 show the centiles of Body Mass Index (BMI) for boys and girls. The girls P 50 values decline during the age 6 to 7 years, but after 7 years it increases until the age 8. In the age groups 8 - 10, height mean centile is somewhat flat, increasing again after this age. The boys P 50 centiles increased in the age group 6 - 8 years, but after 8 years rates of increase decline. We can also see that there were wider gap between the top two centiles compared to the bottom two. In all age groups boys had higher values than girls.

Generally, the mean values (P50) for heights and weights increased with age in both sexes. While body weight increases linearly with age during childhood, the BMI declines from the ages of 6 - 7 age years old. It reaches its lowest point at about 7 years of age.

Table 2: Frequency distribution of the father's professional occupations

Categories	Score	Total	
		N	%
Expert	6	230	26.78
Civil servant	4	482	56.11
Unqualified	2	145	16.88
Unemployed	0	0	0
Unknown	-	2	0.1
Total		859	100

Table 3: Frequency distribution of the mother's educational status

	Score	Total	
		N	%
Illiterate	0	4	0.00
Literate	1	8	0.01
Primary school	2	145	16.99
Middle school	3	138	16.14
High school	4	315	36.84
University	5	249	29.12
Total		855	100

Table 4: Frequency distribution of the father's educational status

	Score	Total	
		N	%
Illiterate	0	0	0
Literate	1	9	0.01
Primary school	2	43	5.00
Middle school	3	81	9.48
High school	4	326	37.99
University	5	399	46.48
Total		859	100

Table 5: Frequency distribution of the number of sibling

Sibling	Score	Total	
		N	%
0	4	165	19.05
1	3	537	62.01
2	2	155	17.90
3+	1	9	1.03
Total		866	100

Table 6: Frequency distribution of the available devices at home

Devises	Score
Tv	1
Car	2
Washing machine	1
Dish masher	1
Refrigerate	1
Computer	1
Video	1

WEIGHT, HEIGHT AND BODY MASS INDEX REFERENCE CURVES FOR 47
CHILDREN AGED 6-11 YEARS LIVING IN ANKARA

Table 7: Frequency distribution of the number of rooms in the household

Rooms and household	Score	Total	
		N	%
Hire&own	4	326	37.95
own+own room	3	296	34.46
own+no own room	1	142	16.53
Hire+own room	0	94	10.94
Hire+no own room	-	1	0.00
Total		859	100.00

Table 8: LMS values for body mass index in Ankara children, by age and sex. M is the median, S the coefficient of variation and L the Box-Cox power transform required to remove the distribution's skewness.

Age	Female			Male		
	L	M	S	L	M	S
6	-1.060	136.38	0.1189	-3.473	139.86	0.0011
7	-1.474	127.33	0.1149	-3.160	158.43	0.1001
8	-2.005	130.28	0.1108	-2.618	148.37	0.1141
9	-2.057	153.11	0.1140	-2.207	165.65	0.1210
10	-1.745	147.51	0.1184	-1.924	144.29	0.1250
11	-1.212	160.67	0.1284	-1.801	160.99	0.1279

DISCUSSION

This study aims to describe the changes in weight, height and BMI in school children. Cross-sectional studies can provide a record of the nutritional status for a precise period and for a specific population. In our case we measured growth in weight and height among children of the Ankara area.

According to 2000 census of population result, while a woman in the 15 - 49 age groups in the provincial centers bears 2.2 children, girls in the same age group in the district centers bear 2.6 children and women in the villages bear 3 children. The total fertility rate is 2.5 in Turkey. In our study 62 % of mothers have two children and 19.5 % of mothers have one child (Table 5) suggesting an average of less than two.

The proportion of individuals who are at least junior high school graduates in the 25 years of age and over population is higher for male than it is for female at all localities in Turkey. While the proportion of junior high school graduates for male and female are 48 % and 29 % in the provincial centers, the proportion of at least junior high school graduates in this study is nearly 82 % for females and 94 % for males (Table 3 and 4). Finally, taking into account these result and comparisons, it is reasonable to assume that the sample represents high socio-economic classes. Owing to the important strategic position it occupies (for historical and geographical reasons), Ankara has been the frequent target of immigration from the various Turkish regions so we may reasonably claim that our data are sufficiently representative of this socio-economic group within the Turkish population as a whole.

Several recent methodological advances were utilized in the analysis of this dataset. First, the use of the LMS method as introduced by Cole and Green (1992) has enabled us to construct smooth percentile curves from our cross-sectional data. Secondly centiles were constructed and our data have been compared with the most important growth studies of Turkish school children of high socio-economic background (Neyzi et al., 1978; Saatçioğlu, 1988). The P 50 for height of boys of our data presented same patterns as Neyzi et al.'s (1978) values but after the age 9 years our data showed lower values than the Neyzi et al's (1978) data. In the whole age group Saatçioğlu (1988) data were higher than our data. The girls of P 50 values centiles were respectively similar to each other until 8 years of age. Beyond 8 years Neyzi et al's (1978) and Saatçioğlu's (1988) mean centiles were higher than our values (Figure 1 and 2).

The plateau in growth velocity occurring between 5 and 10 years of age is interrupted between 6 to 8 years in both sexes by a growth spurt called the 'mid-growth spurt' (Horacio-Lejarraga, 2001). In our study height and weight this small spurt was present only for boys in age group 7 - 8 years. Although some authors claim that this spurt is present only in boys, others have found it to occur in both sexes at similar ages and magnitudes (Gase et al, 1985; Tanner and Cameron, 1980).

Figures 3 and 4 show the centile distribution of weight by age compared with the Neyzi et al. (1978), Saatçioğlu (1988). The P 50 for weight of girls of our data higher than Neyzi et al's (1978) values in the age group 6 - 8 years. However, as Neyzi et al's (1978) the girls get older they become heavier than our sample. Beyond 9 years Neyzi et al's (1978) mean value correspond to our P 50 value. Girls' mean weight values are heavier than the Saatçioğlu (1988) values in the age group of 7 - 11 years. Boys were similar to the Saatçioğlu's (1988) and Neyzi et al's (1978) values in the age group 6 - 9 years, while Neyzi et al's (1978)

mean value were near to our 75 percentile in the age group 10 - 11 years. In terms of Body Mass Index value (Figure 5 and 6) Saatçioğlu's (1988) median value were lower than our values in the age groups 7 - 11 years. It is known that BMI reflects changes in body fat levels (Rolland et al, 1987). BMI is also widely used to define obesity (WHO, 1998). It has been suggested that early childhood may be a critical period for the development of obesity (Dietz and Bellizzi, 1999). In this respect we can say that today's children have more fat than the children of some 20 years ago. It has been suggested that adult BMI level can be more easily predicted by BMI levels at age 7 years (Williams et. al, 1999). Data from Rolland-Cachera et al (1987) indicate that childhood (age 7 - 9) BMI levels are associated with an early age and subsequently Freedman et al. (2001) study presented that BMI at age 7 was correlated with both adult BMI ($r = 0.70$) and early age ($r = - 0.53$). As a result, the current study can give an idea about Turkish adult BMI level.

The results show some limits of BMI in estimating nutritional status: the greater the diversity of variables influencing body weight (such as race, diet, the period and methods of measurement), the greater the differences in the results. As regards BMI, the very nature of its data is such that it can be verified and corrected on subsequent occasions through the use of a carefully chosen sample. In this way one can evaluate changes in the population under study, describe nutritional status for well-defined periods of time and assess the factors responsible for change, with a view to taking steps against excess body weight, which, as we well know, is a risk factor in many adult problems. A final consideration: BMI curves show the different values of BMI in relation to age, representing one of the simplest methods for approaching an overweight subject.

We developed weight, height and BMI reference values for 6 to 11 years children living in Ankara based on LMS-method. These references are used to infer whether children are either obese or undernourished for their height, weight and BMI. Thus in 1997, Ankara's children age 6 - 11 years were relatively heavier and taller than measured up to 20 years earlier. We may say that rates of growth have increased considerably during the past 20 years. The sexual difference is very low but boys are always slightly larger than girls.

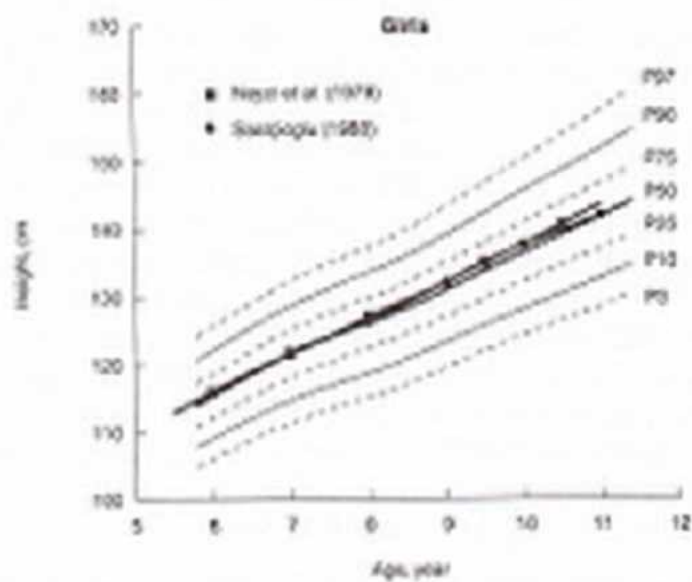


Figure 1: Ankara girls' growth centile curves for height compared to Neyzi et al. (1978), Saçoğlu (1988).

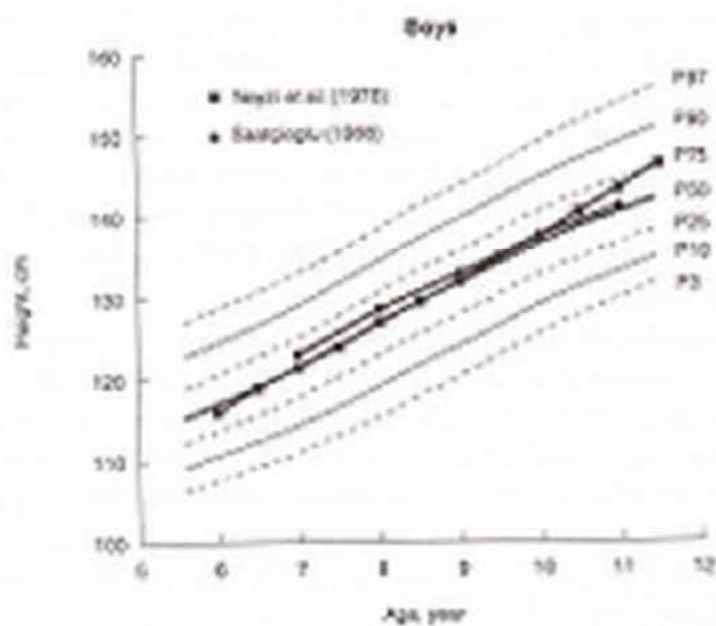


Figure 2: Ankara boys' growth centile curves for height compared to Neyzi et al. (1978), Saçoğlu (1988).

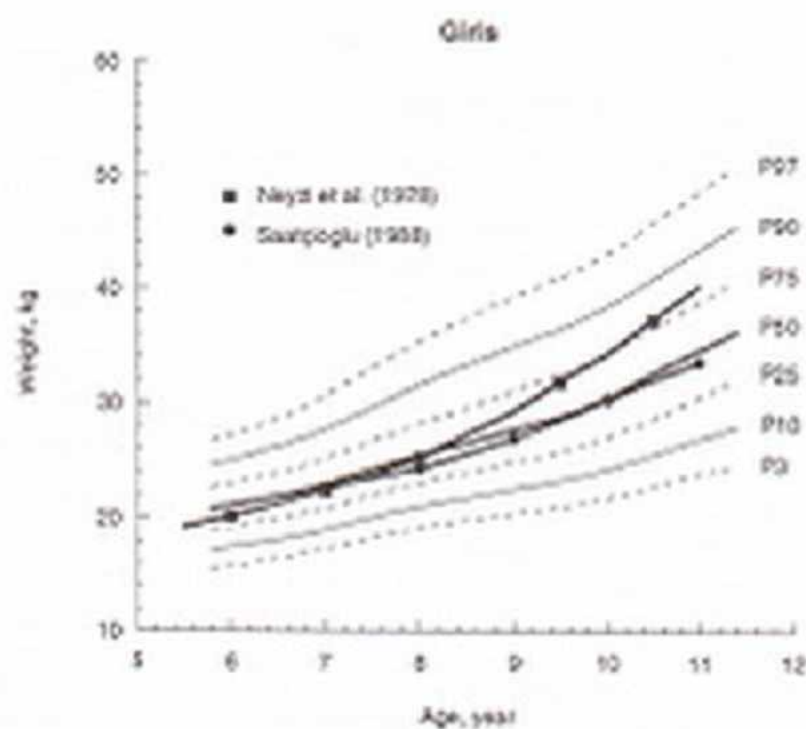


Figure 3. Ankara girls' growth centile curves for weight compared with that of Neyzi et al. (1978), Saatçioğlu (1988).

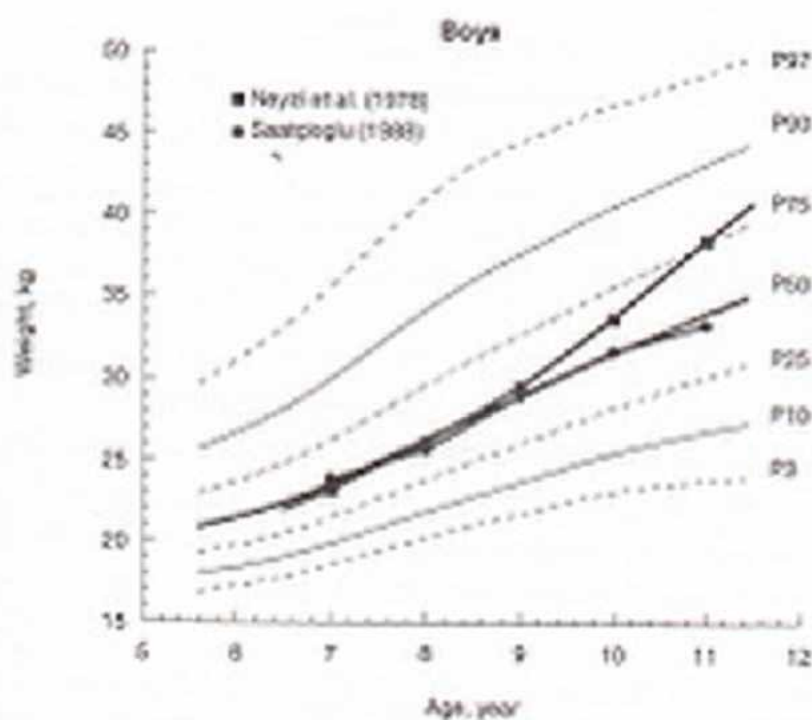


Figure 4. Ankara boys' growth centile curves for weight compared with that of Neyzi et al. (1978), Saatçioğlu (1988).

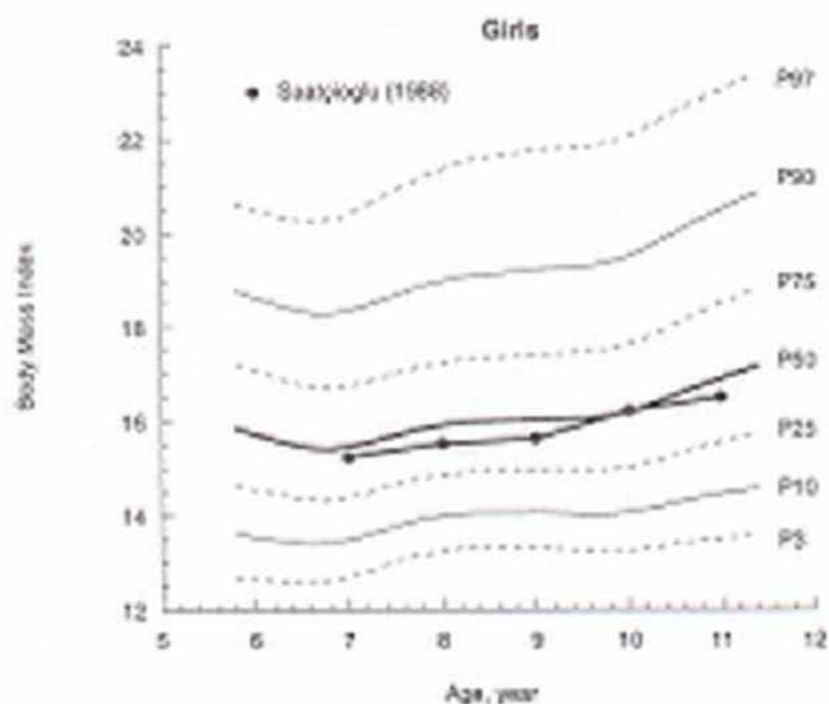


Figure 5. Ankara girls' growth centile curves for BMI compared with that of Saatioglu (1988).

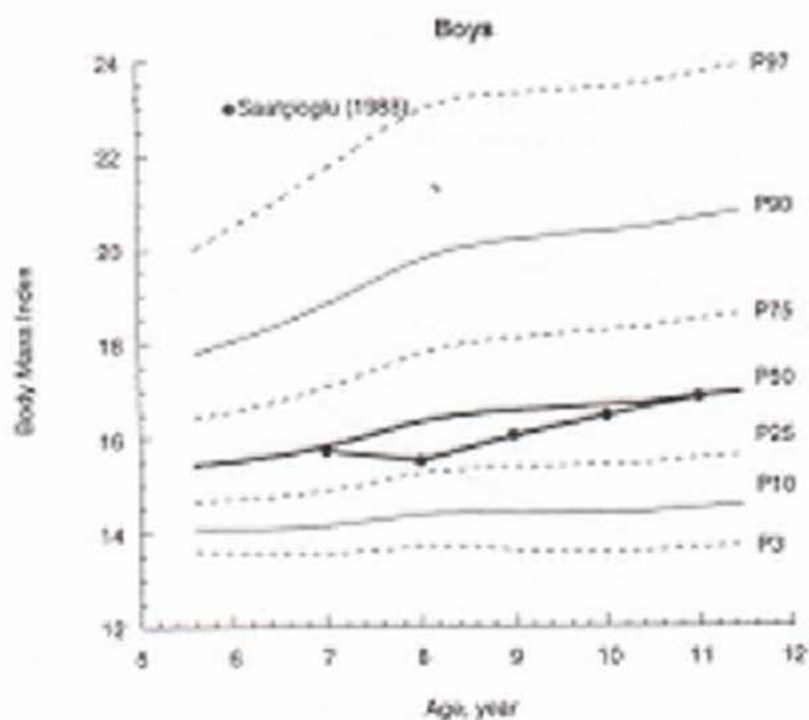


Figure 6. Ankara boys' growth centile curves for BMI compared with that of Saatioglu (1988).

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