The Turkish Journal of Pediatrics 32:93-100, 1990

DETERMINATION OF ARM FAT AREA AND ARM MUSCLE AREA NORMS IN CHILDREN 6-12 YEARS OF AGE IN BURSA*

*Ünsal Günay MD***, Nihat Sapan MD***, Celal Salih MD****
*Hasan Doğruyol MD*****

Summary: Günay Ü, Sapan N, Salih C, Doğruyol H. (Departments of Pediatrics and Pediatric Surgery, Uludağ University Faculty of Medicine, Bursa, Turkey). Determination of arm fat area and arm muscle area norms in children 6-12 years of age in Bursa. Turk J Pediatr 32: 93-100, 1990.

Since arm fat area and arm muscle area measurements are said to assess the calorie and protein reserves in the body more accurately than triceps skinfold thickness measurements, we decided to use this system on 1497 girls and 1651 boys who were pupils in elementary schools in Bursa. From the data obtained, percentile norms for the children aged between 6-12 were calculated and percentile curves were drawn. The data that we collected can be used in future nutritional surveys. *Key words: malnutrition, arm fat area, arm muscle area.*

Anthropometric measurements are used universally for the evalution of growth in childhood. Although genetic factors influence somatic growth, environmental factors, such as nutrition, effect somatic growth too. Inadequate calorie and protein intake causes varying degrees of growth and developmental delays. Percentile curves are very useful in the evaluation of growth in children. In field investigations, the simplest means to assess nutritional status is body-weight for age measurement. The growth of a child should not only be considered an increase in body weight, but conditions of various body components such as fat and muscle masses must also be taken into account. For that reason measurements of midupper arm circumference (MUAC) and triceps skinfold thickness (TST) are very important since they reflect both fat and muscle masses. Subcutaneous fat layers and muscle masses are considered to be indirect indicators of calorie and protein reserves, respectively[1].

For these reasons, MUAC and TST are used in assessing the nutritional status of children[1-7]. But recently arm fat area (AFA) and arm muscle area (AMA)

* From the Departments of Pediatrics and Pediatric Surgery, Uludağ University Faculty of Medicine, Bursa.
** Professor of Pediatrics, Uludağ University Faculty of Medicine.
*** Assistant Professor of Pediatrics, Uludağ University Faculty of Medicine.
**** Pediatrician, Uludağ University Faculty of Medicine.
***** Professor-of Surgery, Uludağ University Faculty of Medicine.

Presented at the XXXIII National Congress of Pediatrics, Bursa, Turkey, October 8-12, 1989.

measurements have been found to determine calorie and protein reserves better than MUAC and TST. Few studies on this subject have been reported in the literature[4-8], and to our knowledge no reports have been published in Turkey.

Material and Methods

Over a period from March 1, 1988 to April 30, 1988, elementary school pupils from the city of Bursa were studied. Of the 1952 classes from 87 elementary schools, 75 classes were chosen at random (3168 children). There were 1497 girls and 1671 boys.

MUAC and TST were measured in all of the children. From this data AFA and AMA were calculated using the following equations[4-8].

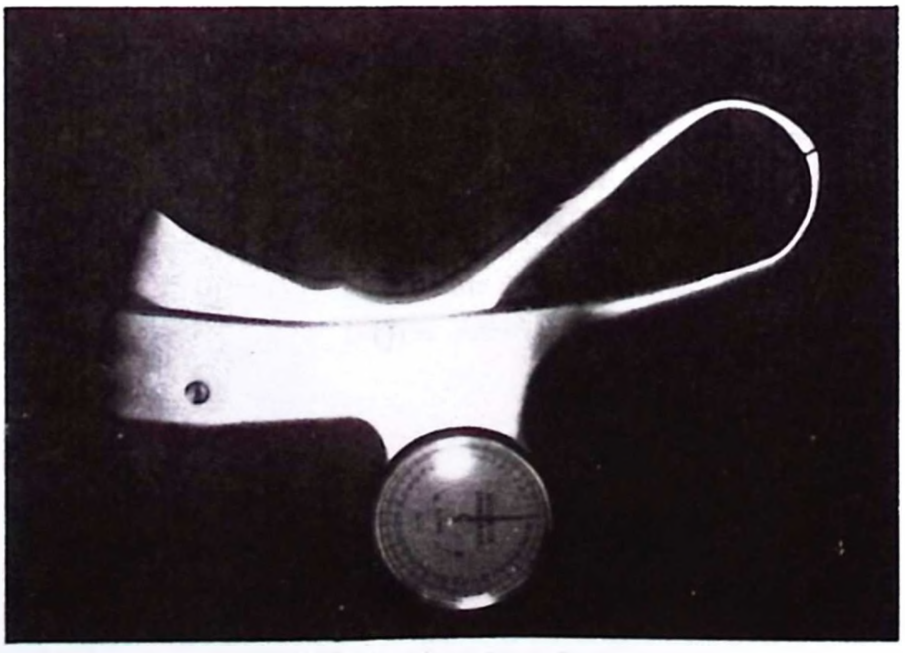
$$\text{Arm area (AA)} = \text{MUAC}^2 / 4\ \pi$$
$$\text{AMA} = (\text{MUAC} - \pi\ .\ \text{TST})^2/4\ \pi$$
$$\text{AFA} = \text{AA} - \text{AMA}$$

The ages of the children were obtained from their birth certificates and whole ages were taken into consideration.

The same investigator took measurements from the midpoint between the tip of the acromion and olecranon processes in the flexed left arm of all the patients.

MUAC and TST measurements were taken from the same point of the left arm which was extended and hanging freely.

MUAC was measured with a plastic tape, the accuracy of which was controlled daily with a steel tape. TST was measured with a Holtain Skinfold Caliper designed to give a constant pressure of 10 g/sq mm (Holtain LTD., Crosswell, Crymych, Dyfed SA 41 3 UF, U.K.) (Fig. 1). Readings were done at the 15th second



Holtain Skinfold Caliper

after the application of the caliper[7]. The millimeter was used as the unit of measurement. Percentiles for all age groups were calculated[9]. In order to show the results in graphical form, the relationship between each pair of variables was examined[9]. Since there was a linear relationship between age, AFA and AMA, smooth curves were drawn using a linear regression formula[9].

Results

Table I illustrates the distribution of boys and girls in all age groups. The proportion of girls and boys in each age group was very similar.

TABLE I: Distribution of Girls and Boys in All Age Groups

Age (yrs)	Girls n (%)		Boys n (%)		Total
6	179	(45.2%)	217	(54.8%)	396
7	265	(47.0%)	298	(53.0%)	563
8	294	(46.8%)	333	(53.2%)	627
9	320	(51.3%)	303	(48.7%)	623
10	290	(46.6%)	332	(53.4%)	622
11	120	(44.1%)	152	(55.9%)	272
12	20	(44.6%)	36	(55.4%)	65
Total	1497	(47.2%)	1671	(52.8%)	3168

A. AFA measurements :

AFA percentile norms of girls and boys are shown in Tables II and III; the curves are shown in Figs. 1 and 2, respectively. There was a linear relationship found between age and AFA in the 6-12 year-old age groups.

TABLE II: Linear Percentile Norms of AFA (mm^2) of Girls

Age (yrs)	Percentile (%) 5	10	25	50	75	90	95
6	340.6	401.7	484.6	613.0	758.9	916.2	1030.3
7	381.0	438.4	524.1	656.4	818.7	1007.3	1149.6
8	421.3	475.0	563.5	699.9	878.5	1098.4	1269.0
9	461.6	511.7	603.0	743.3	938.4	1189.4	1388.3
10	502.0	548.3	642.5	786.7	998.2	1280.5	1507.6
11	542.3	584.9	682.0	830.2	1058.0	1371.5	1627.0
12	582.6	621.6	721.5	873.6	1117.9	1462.6	1746.3

TABLE III: Linear Percentile Norms of AFA (mm^2) of Boys

Age (yrs)	Percentile (%) 5	10	25	50	75	90	95
6	317.2	381.2	460.8	563.3	647.6	769.7	832.1
7	337.5	396.4	478.2	589.0	701.2	858.1	953.4
8	357.8	411.6	495.7	614.7	754.8	946.5	1074.8
9	378.1	426.9	513.1	640.4	808.3	1035.0	1196.1
10	398.4	442.1	530.5	666.1	861.9	1123.4	1317.5
11	418.7	457.3	548.0	697.8	915.4	1211.9	1438.8
12	439.0	472.5	565.4	717.5	969.0	1300.3	1560.2

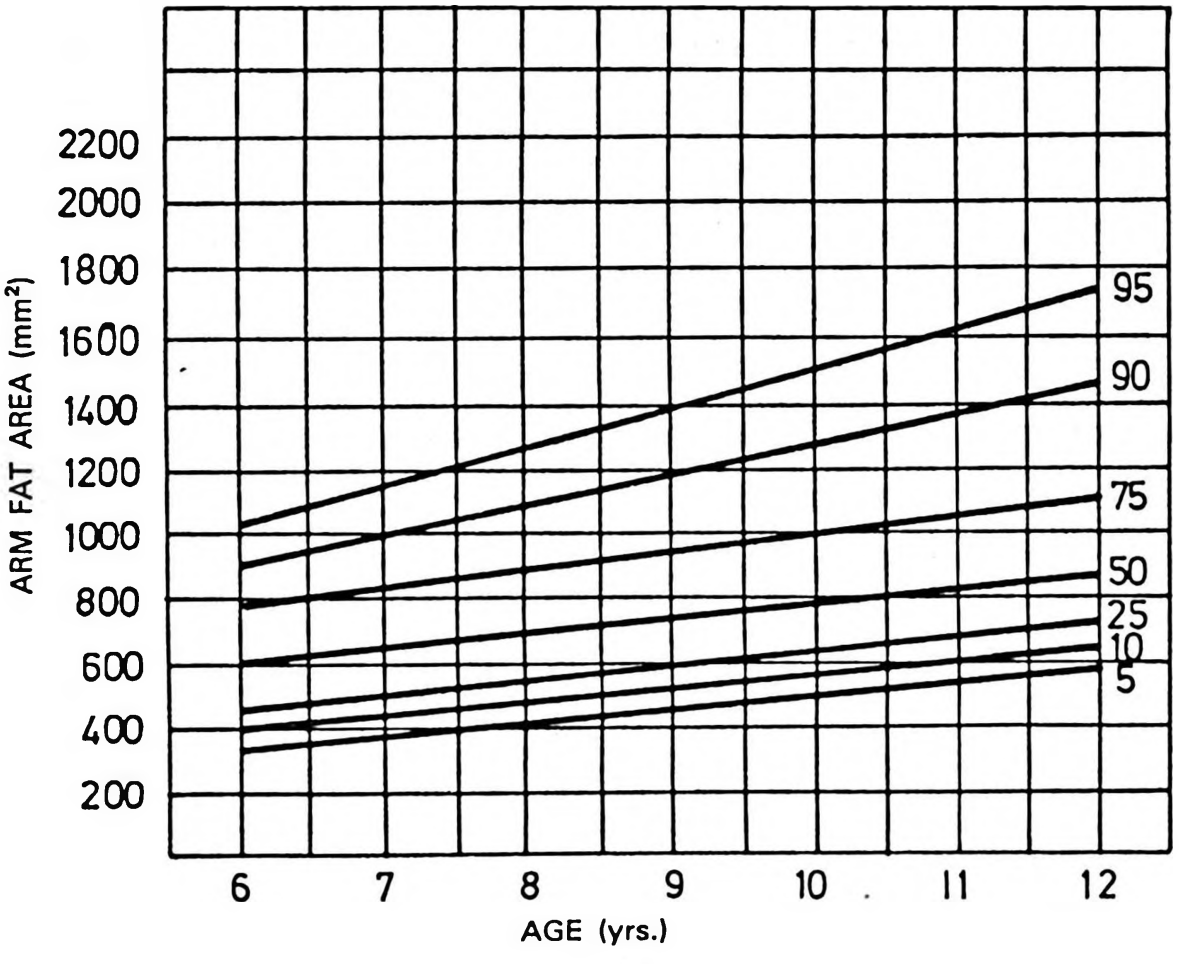


Fig. 1: Smooth percentile curves of AFA of girls (aged 6-12 years).

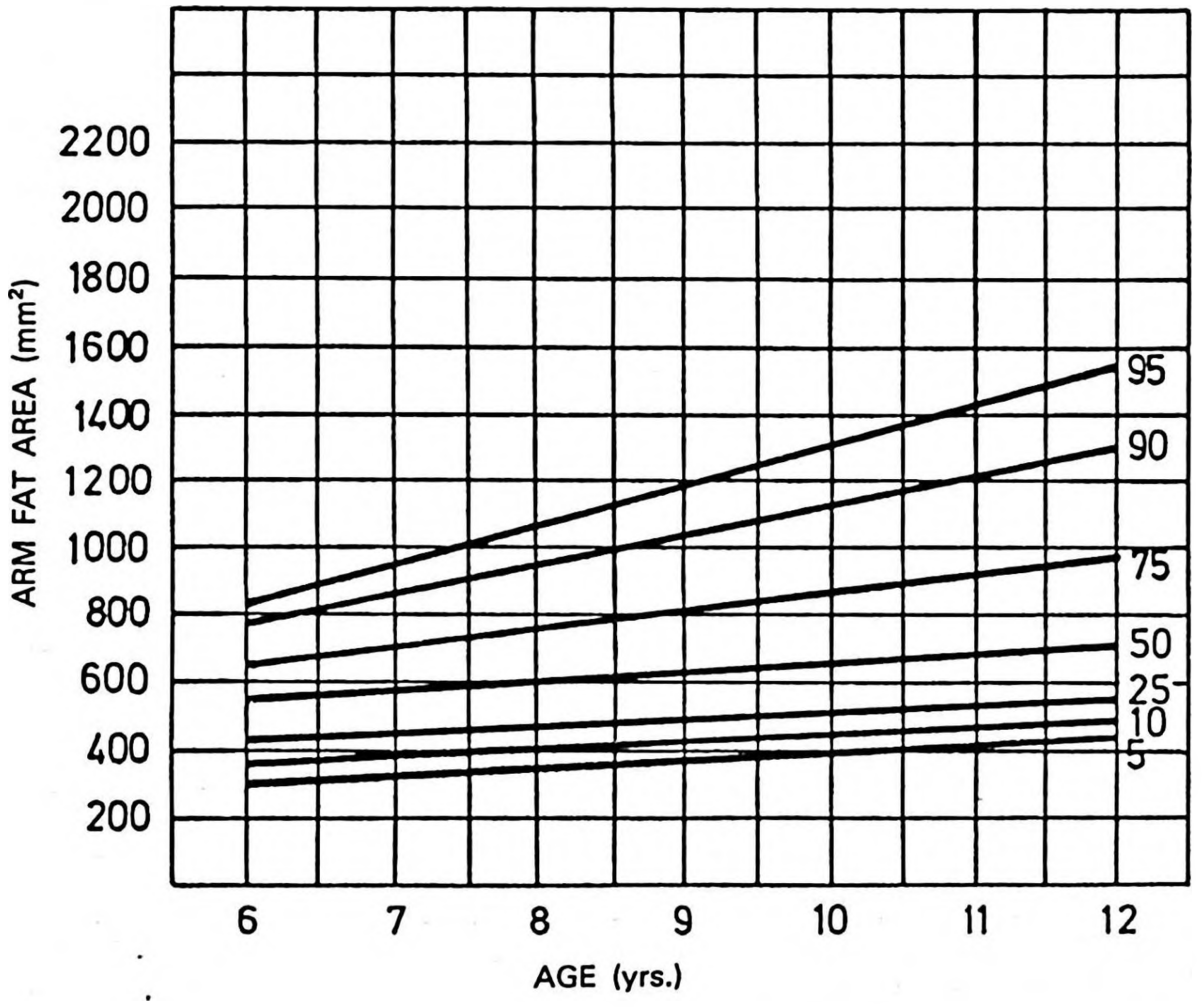


Fig. 2: Smooth percentile curves of AFA of boys (aged 6-12 years).

B. AMA measurements :

AMA percentile norms of girls and boys are shown in Tables IV and V; the curves are shown in Figs. 3 and 4, respectively. A linear relationship was also found between AMA and age.

TABLE IV: Linear Percentile Norms of AMA (mm^2) of Girls

Age (yrs)	Percentile (%) 5	10	25	50	75	90	95
6	1242.1	1348.9	1483.6	1654.2	1772.0	1962.7	2077.7
7	1324.7	1431.1	1577.1	1761.1	1927.5	2132.8	2272.4
8	1407.4	1513.3	1670.5	1868.1	2082.9	2302.8	2467.1
9	1490.0	1595.5	1763.9	1975.1	2238.4	2472.9	2661.8
10	1572.6	1677.7	1857.4	2082.0	2393.9	2942.9	2856.5
11	1655.3	1759.9	1950.8	2189.0	2549.4	2812.9	3051.2
12	1737.9	1842.1	2044.2	2295.9	2704.8	2983.0	3245.9

TABLE V: Linear Percentile Norms of AMA (mm^2) of Boys

Age (yrs)	Percentile (%) 5	10	25	50	75	90	95
6	1305.9	1381.1	1532.0	1696.8	1893.6	2083.3	2161.3
7	1417.9	1493.4	1642.9	1816.6	2020.7	2229.4	2342.4
8	1529.9	1605.7	1753.8	1936.5	2147.8	2375.5	2523.6
9	1641.9	1718.0	1864.7	2056.3	2274.9	2521.6	2704.7
10	1753.9	1830.3	1975.7	2176.1	2402.0	2667.7	2885.8
11	1865.9	1942.6	2086.6	2296.0	2529.1	2813.8	3067.0
12	1977.9	2054.9	2197.5	2415.8	2656.2	2959.9	3248.1

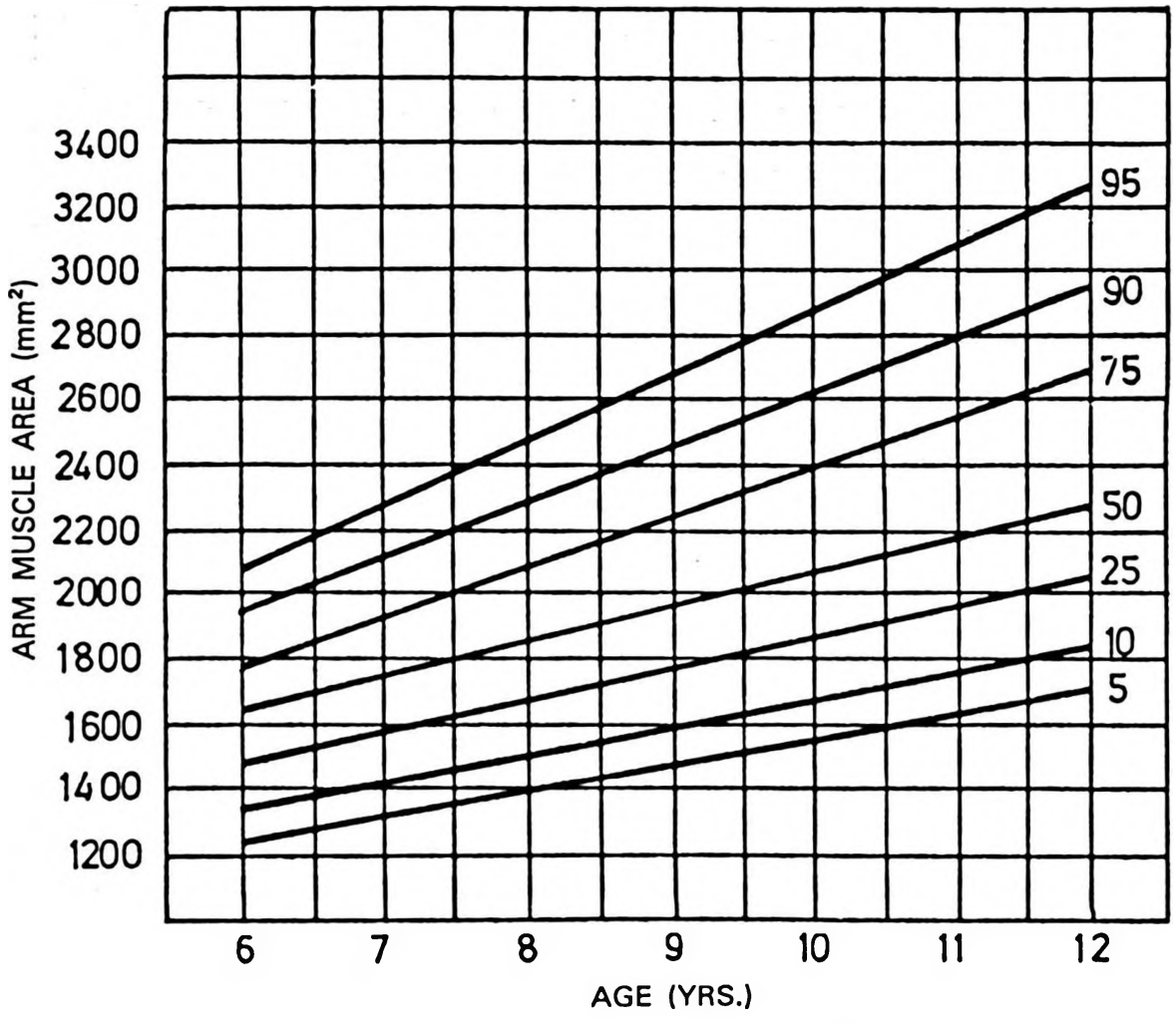


Fig. 3: Smooth percentile curves of AMA of girls (aged 6-12 years).

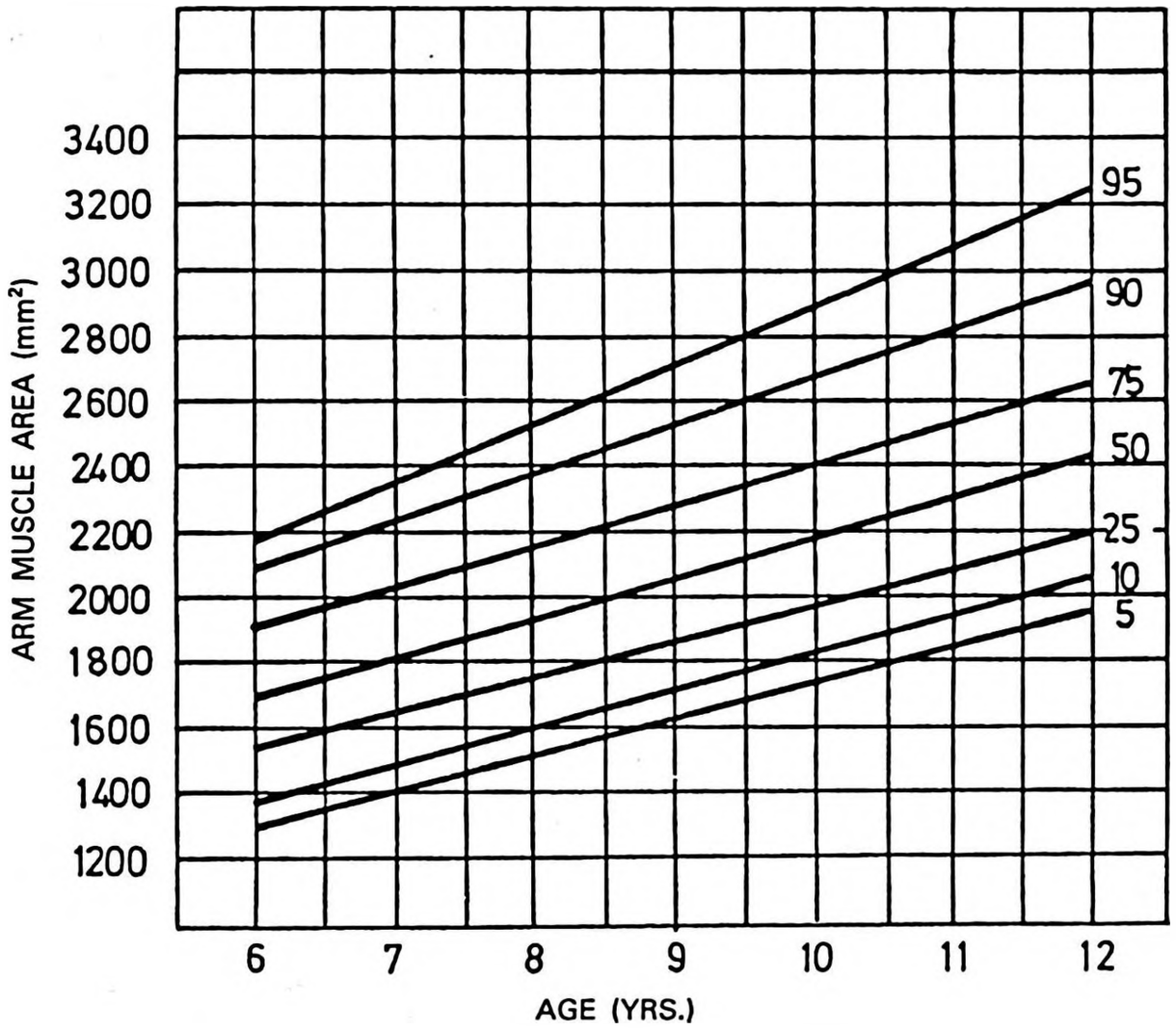


Fig. 4: Smooth percentile curves of AMA of boys (aged 6-12 years).

Discussion

The most widely used anthropometric measurement in the evaluation of growth is weight for age. But the World Health Organization has recommended that not only weight for age, but also weight for height should be used[10]. However, none of these measurements gives information about the protein and fat reserves of the body[11]. Especially in severe malnutrition, because of water retention in the extracellular compartment, the total amount of body water increases abnormally, resulting in a false increase in body weight. But at the same time calorie and protein reserves may be decreased[8]. In these kinds of situations, body weight measurements give erroneous results.

The main protein reserve in the body is the skeletal muscle mass, and the calorie reserve is the subcutaneous fat layer. Because of the reasons stated above, MUAC and TST measurements offer more accurate information, since they reflect both the muscle mass and the subcutaneous fat layer[1].

Many authors believe that in assessing the nutritional status of children, MUAC and TST measurements should be used[6,12]. But in recent years, results of some studies have shown that AFA and AMA measurements reflect the status of the muscle mass and subcutaneous fat layers more accurately than MUAC and TST measurements[4-7].

In two studies carried out by Frisancho et al[4,6] in the United States, one involving 12,496 subjects aged 0-44 years, and the other involving 19097 subjects aged one to 74 years, they observed that the AFA and AMA measurements were more accurate indicators of body protein and calorie reserves than the MUAC and TST measurements. Sann et al[7] performed a study on 100 infants in France and reached the same conclusion.

We presented the AFA and AMA percentiles of girls and boys aged between 6-12 years who reside in Bursa. This data can be used in future nutritional surveys in Turkey.

REFERENCES

1. Gurney JM. The arm circumference as a public health index of protein-calorie malnutrition of early childhood. (XIII) Field experience in Abeokuta, *Nigeria (with special reference to differentiating protein and calorie reserves). J Trop Pediatr* 15:225, 1969.
2. Young HB. The arm circumference as a public health index of protein-calorie malnutrition of early childhood. (XII) Arm measurements as indicators of body composition in Tunisian children. *J Trop Pediatr* 15:222, 1969.
3. Jelliffe EF, Jelliffe DB. The arm circumference as a public health index of protein-calorie malnutrition of early childhood (I) Background. *J Trop Pediatr* 15:179, 1969.
4. Frisancho AR. New norms of upper limb fat and muscle areas for assessment of nutritional status. *Am J Clin Nutr* 34:2540, 1981.
5. Martorell R, Yarbrough C, Lechtig A, et al. Upper arm anthropometric indicators of nutritional status. *Am J Clin Nutr* 29:46, 1976.
6. Frisancho AR. Triceps skin-fold and upper arm muscle size norms for assessment of nutrition status. *Am J Clin Nutr* 27:1052, 1974.
7. Sann L, Durand M, Picard J, et al. Arm fat and muscle areas in infancy. *Arch Dis Child* 63:256, 1988.
8. Grant JP, Custer PB, Thurlow J. Current techniques of nutritional assessment. *Surg Clin North Am* 61:437, 1981.
9. Heperkan Y. Tıp'ta İstatistik Yöntem ve Uygulamaları, Ankara Üniversitesi Tıp Fakültesi Yayını Sayı 415, 1981 s. 126-130, 521-589.
10. McLaren DS. Protein energy malnutrition (PEM). In McLaren DS, Burman D (eds). *Textbook of Paediatric Nutrition.* New York: Churchill, 1976, pp 105-117.
11. Miller DC, Nichaman MZ, Lane JM. Simplified field assessment of nutritional status in early childhood: practical suggestions for developing countries. *Bull WHO* 55:79, 1977.
12. Frisancho AR, Garn SM. Skin-fold thickness and muscle size: Implications for developmental status and nutritional evaluation of children from Honduras. *Am J Clin Nutr* 24:541, 1971.