Public Health Nutrition: 24(16), 5414–5425 doi:10.1017/S1368980021003323

Four-site skinfolds thickness percentiles of schoolchildren and adolescents in Turkey

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Submitted 4 March 2021: Final revision received 7 June 2021: Accepted 9 August 2021: First published online 12 August 2021

Abstract

Objective: The primary purpose of the current study was to establish Turkish smoothed centile charts and Lambda, Mu, Sigma (LMS) tables for four-site skinfold thickness based on a population-based sample, and secondary purpose was to elaborate a reference for the percentage of body fat.

Design: A cross-sectional and descriptive study was conducted between January and May 2017. Triceps, biceps and subscapular, suprailiac skinfold thicknesses were measured using Holtain skinfold caliper. Age- and gender-specific percentile values were determined with the LMS method, and body fat percentage was calculated using the Westrate and Deurenberg equation.

Setting: Afyonkarahisar province in Turkey.

Participants: The current study was conducted on 4565, 6–18-year-old students.

Results: The triceps, biceps and subscapular skinfolds of the girls were higher than the boys. From the age of seven, the sum of four skinfold thicknesses of the girls was more than those of the boys. This difference became more evident after the age of 12. Although fat percentages of girls showed a fluctuating change, it decreased with the age in boys. Westrate and Deurenberg equation fat percentages of girls until adolescence were lower than boys, but increased after 12 years of age and exceeded that of boys.

Conclusions: The current study has provided sex- and age-specific reference values for skinfold thickness and has shown that obesity in girls is higher than in boys in schoolchildren in Afyonkarahisar. The current study has also shown that skinfold thickness measurements are a valuable tool for screening obesity in children.

Keywords
Anthropometry
Body fat percentage
Children and adolescents
Obesity
Skinfold thickness

Anthropometric references are useful tools to assess the general health status and growth process in children and adolescents. Subcutaneous fat deposition is used as an energy store and reflects the body's nutritional status. On the other hand, subcutaneous fat deposition is influenced by gender, chronological age, stage of maturation and nutritional status[1,2]. Assessment about total body fat deposition with anthropometric measurements is considered as an easy and reliable method. Local differences in growth and nutritional status of children and adolescents have been shown by several studies[3,4]. A previous study indicates that there is a relationship between childhood adiposity and adulthood cardiometabolic risk related to body composition. These disorders can be listed as primarily diabetes mellitus and CVD[5].

Marie *et al.* reported that the prevalence of childhood overweight and obesity has increased both in developed and developing countries, and in the adolescent period, approximately 50 % increase was seen in these figures between 1980 and 2013 in several regions[6]. Although the WHO aims to decrease prevalence of obesity in 2020, Turkey is listed in European countries where childhood and adolescent obesity is still prevalent[7]. Turkey Childhood Obesity Surveillance Initiative (COSI-TUR

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2013) showed that 8·3 % and 14·2 % of children and adolescents were obese and overweight[8]. Only 3 years later, these figures were given as 9·9 % and 14·6 % for obese and overweight, respectively, in COSI-TUR 2016[9].

Although there are several methods such as bioelectrical impedance analysis, dual-energy X-ray absorptiometry, MRI, hydrodensitometry and ultrasound to assess body fat composition and distribution. Almost all of them are expensive, needs time-consuming procedures, may expose children to radiation and not easy to be used in paediatric examination procedures or screening[10–12]. There are several anthropometric measurements including BMI, waist circumference and skinfold thickness to assess obesity and determine body fat composition[13].

Skinfold thickness measurements are non-invasive, simple and less expensive than other laboratory-based methods thus provide a useful and reliable estimate for body fat composition and distribution[14–18]. Additionally, a significant correlation between increased skinfold thickness and increased levels of cardiometabolic disease risk and metabolic syndrome has been reported[19–21].

One of the most frequently used skinfold thickness estimation equations is developed by Weststrate and Deurenberg *et al.* that predict total body fat from triceps and subscapular skinfold thickness's[22]. However, it is also stated that ethnic variations may alter skinfold thickness references significantly[23].

Since skinfold thickness is a reliable and useful tool to assess body fat composition, it is crucial to rely on standardised measurement techniques for skinfold thickness. The Lambda, Mu, Sigma (LMS) method is accepted as a reliable method to get smoothed percentiles of skinfold thickness as in the case of most anthropometric measures. L, M and S represent the skewness (lambda), median (mu) and CV (sigma) curves, respectively[24]. Its interobserver error was reported as <2–3 % for skinfold thickness measurement for experienced healthcare workers[25].

Skinfold thickness is considered as a useful tool in screening childhood growth together with other anthropometric measurements[26]. In Turkey, there are very limited data about skinfold thickness and for most of the geographic regions. A comprehensive study was conducted on 4285 participants in a metropolitan city Kayseri, which is located in Central Anatolia[27]. The current study may provide useful information primarily about Central Anatolia. The present study has provided the data for Western Turkey 10 years after the Central Anatolian study.

The aim of the current study was both to update national skinfold thickness references and provide data about the western part of Turkey. Triceps, biceps, subscapular and suprailiac skinfold data were converted into smoothed references with the LMS method and calculated data was compared with previous national and international data to assess body fat composition and was elaborate a reference for the percentage of body fat, in 6- to 18-year-old children and adolescents in Afyonkarahisar, Turkey.

Methods

Study design

This cross-sectional descriptive study was conducted on 4565 students aged 6 to 18 years between January and May 2017 in Afyonkarahisar/Turkey.

Place

Afyonkarahisar is a city located on the border of Central and Western regions of Anatolia at an altitude of 1034 m and has 725 568 inhabitants. In the current study, Afyonkarahisar was chosen because its demographic and geographic structure which are similar to Turkey[28], and the research team was located in this province and/or in the immediate vicinity.

Participants

In the 2016–2017 academic year, the total number of children between the ages of 6 and 18 was 137 350. The stratification of the final sample size was done according to the socio-economic level of parents and their proportion in the general population. The seven primary, thirteen secondary and fifteen high schools were randomly selected, and the study sample size was reached at these thirty-five schools. Lack of family consent, students' refusal, in attendance to school for several reasons were caused od data loss so that study was conducted with 4565 students consisting of 2133 (46·6 %) boys and 2432 (53·1 %) girls. This final sample size was corresponded to 3·3 % of the students in this age group in Afyonkarahisar/Turkey.

Students' health status was questioned by their parents, educators and health records if available. Those who have any metabolic or chromosomal disorder, using drugs that may alter their growth and development, older than 18 or less than 6 years of age were excluded from the study.

Data collection

The data of the students were collected through a questionnaire filled in by the parents of the students. The questionnaire consisted of questions including socio-demographic characteristics, health status, previous diseases and medications used, etc.

Anthropometric measurements were performed by a trained team consisting of twelve healthcare staff but skilled three personnel measured only the skinfold thicknesses of the students. Others were assigned to make the length and weight measurements. The study team was trained in the pre-study period, about how to make anthropometric measurements. The 5 d long training programme was

composed of theoretical information and practice of anthropometric measurements. In the post-training period, a pilot study was carried out in a school, allowing each team member to perform at least fifty practices. Data obtained from the pilot study were not included in the study.

Two expert observers checked measurement techniques and corrected them during the whole study.

Anthropometric measures

Measurements were done in the morning hours, between 7:00 and 10:00 a.m. Attention was paid to privacy during taking anthropometric measurements of children, and measurements were made in a private room with two personnel. Children were informed before taking the measurements.

Skinfold thickness was measured using Holtain skinfold caliper (Holtain Ltd., United Kingdom) with dial graduation of 0·2 mm. The study team was taught the calibration method and the application standardisation of the measuring instruments and calibration materials to be used during the application was provided.

The four sites of measurement were marked carefully before measurement. Triceps skinfold was measured over the midpoint of the triceps muscle between the olecranon-process and the acromion, as the biceps skinfold was measured at the same point, but in the anterior line of the arm. The subscapular skinfold was measured just below the scapula at an angle of 45° to the lateral side of the body and finally the suprailiac was measured with the natural angle of the iliac crest at the anterior axillary line[29,30].

All measurements of the adipose folds were taken on the right side of the body and were made twice by the same person, and but second scores were made after the first set of all measurements was completed to avoid memory bias. The third measurement was taken when there was 1 mm difference between the two measurements and averages were calculated later. Intra- and inter-rater technical errors of measurement were within published reference ranges for all of the measurements[30].

Skinfold thicknesses and body fat percentages were grouped by age and gender.

Data analysis

Descriptive statistics, numbers and percentages for the categorical data, arithmetic mean and SD (S) values were calculated for the anthropometric measurements. In all analyses, $\alpha = 0{\cdot}05$ was chosen as the level of error. SPSS 20.0 software for the windows program was used. The age was calculated for the date of measurement. The smoothed 3rd, 5th, 10th, 25th, 50th, 75th, 90th, 95th and 97th percentiles curves for each gender and age were produced. This is a cross-sectional profile.

We used the LMS method described by Cole and excluded the extreme values in data analysis[24,31]. Body fat percentage was calculated with the Westrate and Deurenberg equation[22].

Results

Some socio-demographic characteristics of children were presented in Table 1. According to this, the education level of the mothers of the children was lower than the fathers, and most of them were housewives. Monthly income of 31·4 % of fathers is below the minimum wage.

Smoothed age- and sex-specific percentiles and L, M, S values for triceps and biceps skinfold thickness (mm) were presented in Tables 2 and 3.

There was a steady increase in triceps and biceps skinfold thickness of girls, from 6 to 18 years of age, in all percentiles. In boys, increase in triceps and biceps skinfold thickness peaked at 12 years old then decreased gradually. In particular, this decrease in the 97th percentile of boys' biceps was quite evident. The triceps skinfold thickness percentiles in the preadolescent period increased significantly. However, triceps and biceps skinfold thickness values of the 18-year-old boys were lower than 6-year-old boys.

In all age groups, girls' triceps and biceps skinfold thickness were higher than boys. The 50th percentile triceps skinfold thickness of boys ranged from 8·8 mm to 12·2 mm through 6–18 years and biceps skinfold thickness ranged from 4·9 mm to 6·3 mm. Triceps skinfold thickness ranged from 10·5 mm to 17·4 mm, and biceps skinfold thickness ranged from 6 mm to 8·6 mm in girls (Tables 2 and 3).

Increases in subscapular and suprailiac skinfold thicknesses with increasing age were observed in both girls and boys. In boys, decreases in subscapular skinfold were observed in the 97th percentile over 13 years, 95th percentile over 15 years and 90th percentile over 17 years. The subscapular skinfold thickness of 6-year-old boys for 97th percentiles at 16 years was lower than those of 6-year-old boys. There was no such similar difference in girls' percentiles. The subscapular and suprailiac skinfold thicknesses of the girls were higher than boys, other than the 97th percentile. We found that girls' suprailiac skinfold thickness decreased over 14 years of age for 97th and over 16 years for 95th percentile. The subscapular skinfold thickness through 6 to 18 years of age ranged from 17·2 mm to 16·5 mm and 18·9 to 26·8 mm in boys and girls, respectively. The corresponding suprailiac skinfold thicknesses ranged from 22·3 mm to 28·1 and 19·6 mm to 27·4 mm for boys and girls, respectively (Tables 4 and 5). In 18-year-old obese children, the subscapular skinfold was between 16·5 mm and 26·8 mm, respectively, for boys and girls. The subscapular skinfolds were much higher in girls indicating a higher level of subcutaneous adiposity than boys.

Table 1 Some socio-demographic characteristics of children*

	n	%
Mother's educational status (*n*: 4459)		
Literate	148	3·3
Primary school	2378	53·3
Secondary school	948	21·3
High school	698	15·7
University	287	6·4
Father's educational status (*n*: 4450)		
Literate	24	0·5
Primary school	1466	33
Secondary school	1053	23·7
High school	1261	28·3
University	646	14·5
Mother's profession (*n*:4449)		
Salaried worker	801	18
Housewife	3648	82
Father's profession (*n*:4405)		
Salaried worker	4265	96·8
Unemployed	140	3·2
Income-Turkish Liras† (*n*:3867)		
Below minimum wage	1215	31·4
Above minimum wage	2652	68·6

**n* is the people who answered this question.
†In 2017 when the research was carried out, Net Minimum Wage was 1·404 Turkish Liras, and 1 Dollar was equal to 3·7412 Turkish Liras (Central Bank of Turkey).

Table 6 shows the variation in subcutaneous fat with increasing age in both genders. The sum of four skinfold thicknesses in girls increased with age, and it was prevalent during the adolescent period. However, in adolescent boys, skinfolds thickness decreased particularly in the 75th percentile and over. The sum of four skinfold thicknesses of the girls was higher than the boys ($P < 0·001$). This difference became more evident after the age of 12. The sum of four skinfold thicknesses of boys through 6 to 18 years of age ranged from 27·1 mm to 34·4 mm in the 50th percentile. The corresponding change through 6 to 18 years of age girls for the four-site skinfold thicknesses ranged from 30·4 mm to 53·2 mm (Table 6).

Body fat percentiles of girls fluctuated. A decrease from 7 to 12 years of age then increases until the age of 15 years followed by a gradual decrease. However, the body fat percentiles of boys were more consistent, and they gradually decreased with the increasing age. We found that the fat percentiles of the girls were lower than the fat percentiles of the boys until the age of 12, it then increased so that exceeds the boys. The 50th percentile of body fat percentages ranged from 17·9 mm to 19·7 mm and from14·8 mm to 18·5 mm for girls and boys, respectively (Table 7).

The mean values of triceps, biceps, subscapular and suprailiac skinfold thicknesses of girls were higher than boys in all ages except 6 years; the gender difference was significant ($P < 0·001$) (Table 8). Similarly, the sum of four skinfold thickness percentiles was also higher in girls except 6 years of age ($P < 0·001$). However, body fat percentages of girls estimated by Westrate and Deurenberg equation were lower than boys, but it increased in contrast to the decline observed after 12 years of age boys but higher than that of boys ($P < 0·001$) (Table 9).

Discussion

It has been shown that physiologically normal amounts of fat mass vary according to age and gender. Age also affects the distribution of body fat, both genders have equal amounts of central and peripheral subcutaneous adipose tissue in the newborn and infancy period. Although central to peripheral subcutaneous fat distribution remains throughout life in both genders, the lowest central to peripheral tissue body fat mass level was determined in approximately 5 years of age[32,33].

It has been reported that the ratio of subcutaneous adipose tissue to fat mass is almost similar in both boys and girls aged 9–15 years. In girls, a decrease is observed in subcutaneous adipose tissue to fat mass ratio during adolescence period and thereafter it remains stable. In boys, an increase is seen until 20 years of age and then a gradual decrease occurs. During adolescence, because boys gain more central subcutaneous adipose tissue than peripheral subcutaneous adipose tissue, adult males have less subcutaneous adipose tissue and more visceral adipose tissue with the increasing age, whereas females gain fat in both areas[32].

Skinfold thickness measurement is frequently used to estimate the body fat percentage[20,34,35]. Triceps (regional) and subscapular (central) skinfold thicknesses show almost all of the changes in body composition[12].

The peripheral subcutaneous adipose tissue distribution calculated from triceps and biceps skinfold thicknesses have shown that peripheral distribution in 6 years of age is the lowest but then it increases with the age[33]. In the present study, triceps and biceps skinfold thicknesses of girls were higher than boys in all age groups. Triceps and biceps skinfold thickness, increased in all percentiles for girls from 6 to 18 years of age, whereas in boys, these two skinfold thicknesses increased gradually from the age of 6 to 12 years then decreased to the levels of 6 years of age. These findings were consistent with the results of the study conducted in Germany by Rönnecke *et al.* who reported a peak at the beginning of adolescence with a subsequent decrease for biceps and triceps skinfold thicknesses in boys, while a rise among girls percentile values across the age range[11]. The increasing trend in girls and the pubertal peak in boys were also observed in the USA[36], German[33,37], Polish[38] and Norwegian children[12]. Our results also similar to the data reported by Velez *et al.* from Colombia[39] and by Nagy *et al.*[40] from different European countries where girls had higher percentiles triceps skinfold thickness than boys.

Previous studies have shown that there is a steady increase in subscapular skinfold thickness in both genders through 9 to 14 years of age in some geographic areas.[37,41]

Table 2 Smoothed age- and sex-specific percentiles and L, M, S values for triceps skinfold thickness (mm)

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	−0·037	10·556	0·341	5·598	6·057	6·841	7·428	8·394	10·556	13·300	15·069	16·404	18·613	20·210
7	−0·048	11·485	0·349	6·017	6·518	7·377	8·023	9·088	11·485	14·553	16·542	18·050	20·555	22·375
8	−0·052	12·011	0·354	6·238	6·764	7·667	8·348	9·472	12·011	15·277	17·403	19·018	21·708	23·667
9	−0·052	12·383	0·358	6·386	6·931	7·867	8·573	9·740	12·383	15·791	18·014	19·705	22·526	24·582
10	−0·048	12·745	0·361	6·532	7·095	8·063	8·794	10·003	12·745	16·285	18·597	20·356	23·291	25·432
11	−0·034	13·192	0·363	6·715	7·302	8·313	9·075	10·336	13·192	16·871	19·268	21·090	24·123	26·332
12	0·011	13·991	0·362	7·060	7·695	8·784	9·604	10·954	13·991	17·857	20·350	22·230	25·338	27·582
13	0·084	15·073	0·357	7·556	8·259	9·457	10·354	11·821	15·073	19·127	21·692	23·605	26·724	28·947
14	0·158	16·058	0·348	8·044	8·810	10·109	11·074	12·640	16·058	20·222	22·809	24·714	27·783	29·944
15	0·218	16·690	0·341	8·371	9·182	10·550	11·559	13·185	16·690	20·883	23·449	25·323	28·312	30·397
16	0·256	17·012	0·336	8·545	9·381	10·786	11·817	13·473	17·012	21·199	23·738	25·582	28·509	30·538
17	0·283	17·230	0·332	8·667	9·520	10·949	11·997	13·672	17·230	21·409	23·929	25·751	28·632	30·623
18	0·305	17·412	0·329	8·769	9·636	11·086	12·146	13·837	17·412	21·583	24·085	25·889	28·734	30·693
Boys percentiles														
6	−0·350	9·757	0·350	5·398	5·777	6·434	6·936	7·778	9·757	12·482	14·379	15·890	18·552	20·611
7	−0·296	10·293	0·355	5·592	6·002	6·713	7·255	8·164	10·293	13·199	15·203	16·789	19·558	21·679
8	−0·247	10·866	0·361	5·800	6·243	7·011	7·597	8·578	10·866	13·968	16·091	17·760	20·651	22·847
9	−0·208	11·527	0·366	6·054	6·533	7·364	7·998	9·058	11·527	14·857	17·123	18·897	21·953	24·260
10	−0·180	12·046	0·372	6·229	6·738	7·621	8·295	9·423	12·046	15·576	17·970	19·840	23·050	25·464
11	−0·162	12·205	0·379	6·218	6·740	7·648	8·341	9·501	12·205	15·845	18·312	20·237	23·541	26·023
12	−0·157	11·865	0·385	5·975	6·486	7·376	8·056	9·198	11·865	15·471	17·922	19·838	23·131	25·609
13	−0·168	11·189	0·390	5·606	6·088	6·927	7·570	8·652	11·189	14·640	17·000	18·852	22·049	24·465
14	−0·192	10·466	0·391	5·260	5·706	6·486	7·084	8·091	10·466	13·720	15·962	17·729	20·799	23·134
15	−0·225	9·882	0·389	5·018	5·433	6·159	6·716	7·657	9·882	12·953	15·085	16·775	19·731	21·995
16	−0·262	9·482	0·385	4·885	5·277	5·961	6·487	7·375	9·482	12·409	14·454	16·085	18·954	21·168
17	−0·297	9·156	0·380	4·789	5·161	5·810	6·309	7·152	9·156	11·953	13·918	15·492	18·277	20·441
18	−0·330	8·841	0·375	4·692	5·045	5·662	6·135	6·936	8·841	11·509	13·393	14·908	17·602	19·708

Table 3 Smoothed age- and sex-specific percentiles and L, M, S values for biceps skinfold thickness (mm)

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	−0·276	5·999	0·366	3·194	3·437	3·859	4·182	4·724	5·999	7·745	8·954	9·911	11·584	12·866
7	−0·315	6·751	0·391	3·485	3·759	4·240	4·611	5·241	6·751	8·889	10·412	11·643	13·844	15·573
8	−0·341	6·976	0·403	3·554	3·836	4·334	4·720	5·378	6·976	9·279	10·948	12·314	14·792	16·770
9	−0·352	7·050	0·407	3·578	3·863	4·366	4·756	5·424	7·050	9·413	11·138	12·555	15·144	17·225
10	−0·358	7·092	0·409	3·594	3·881	4·386	4·779	5·451	7·092	9·483	11·233	12·676	15·318	17·448
11	−0·367	7·199	0·411	3·647	3·937	4·449	4·848	5·530	7·199	9·642	11·438	12·923	15·651	17·861
12	−0·368	7·474	0·409	3·796	4·097	4·628	5·040	5·747	7·474	9·999	11·851	13·382	16·192	18·465
13	−0·345	7·883	0·404	4·013	4·332	4·894	5·330	6·074	7·883	10·498	12·396	13·952	16·782	19·046
14	−0·313	8·251	0·402	4·187	4·525	5·119	5·578	6·361	8·251	10·953	12·892	14·467	17·301	19·542
15	−0·286	8·466	0·402	4·267	4·617	5·233	5·709	6·518	8·466	11·230	13·199	14·790	17·632	19·862
16	−0·274	8·536	0·403	4·287	4·642	5·266	5·747	6·567	8·536	11·322	13·302	14·898	17·743	19·967
17	−0·273	8·542	0·403	4·288	4·644	5·268	5·751	6·571	8·542	11·331	13·311	14·908	17·752	19·976
18	−0·268	8·573	0·403	4·296	4·654	5·282	5·768	6·593	8·573	11·372	13·357	14·956	17·801	20·022
Boys percentiles														
6	−0·823	5·635	0·365	3·269	3·458	3·792	4·053	4·502	5·635	7·420	8·869	10·176	12·906	15·508
7	−0·744	5·835	0·384	3·275	3·478	3·838	4·119	4·606	5·835	7·777	9·348	10·759	13·674	16·408
8	−0·680	5·976	0·398	3·262	3·477	3·856	4·154	4·670	5·976	8·039	9·700	11·183	14·217	17·019
9	−0·615	6·138	0·412	3·255	3·482	3·884	4·200	4·748	6·138	8·328	10·078	11·630	14·763	17·605
10	−0·564	6·264	0·423	3·246	3·482	3·903	4·233	4·807	6·264	8·550	10·366	11·964	15·157	18·009
11	−0·548	6·287	0·427	3·233	3·472	3·897	4·231	4·813	6·287	8·599	10·432	12·042	15·247	18·097
12	−0·531	6·275	0·431	3·199	3·439	3·867	4·204	4·790	6·275	8·603	10·445	12·059	15·259	18·092
13	−0·522	6·086	0·430	3·099	3·333	3·749	4·076	4·645	6·086	8·335	10·107	11·655	14·712	17·403
14	−0·554	5·696	0·409	3·001	3·215	3·595	3·892	4·406	5·696	7·685	9·237	10·583	13·222	15·528
15	−0·601	5·340	0·375	2·967	3·160	3·501	3·766	4·220	5·340	7·025	8·311	9·412	11·534	13·358
16	−0·639	5·127	0·349	2·965	3·145	3·461	3·704	4·118	5·127	6·616	7·734	8·679	10·477	11·998
17	−0·665	4·996	0·333	2·959	3·131	3·431	3·661	4·052	4·996	6·372	7·395	8·255	9·876	11·237
18	−0·683	4·920	0·323	2·961	3·128	3·418	3·640	4·017	4·920	6·228	7·192	7·999	9·512	10·773

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In the present study, regarding the subcutaneous body fat distribution, the 97th percentile subscapular skinfold thickness in boys over 16 years of age was lower than those of 6 years old. However, we could not find a similar difference in girls. When compared with boys, higher subscapular and suprailiac skinfold in girls were also determined by previous studies[12,34,36,38]. The increase in the distribution of central adipose tissue measured by subscapular and suprailiac skinfold thickness in Sri Lankan children was reported to be prominent in girls[33]. In our study, much higher subscapular skinfold thickness values were obtained in girls that indicate girls have a higher level of subcutaneous adiposity than boys.

We made cross-cultural comparisons of the 50th percentile triceps and subscapular skinfold thickness percentiles with Colombia[15], Spain[42], Germany[11,43], Norway[44] and the USA[36]. This comparison showed that both boys and girls in Afyonkarahisar had higher values for triceps and subscapular skinfolds in all of the age groups than the children in Norway[44], Germany[43] and USA[36] and higher values for triceps and subscapular skinfolds in girls of all of the age groups than German girls[11] but has lower 50th percentile triceps and subscapular skinfold thickness percentiles than the Colombian[15] and Spanish[42] children and adolescents. These results indicate that there may be differences between different ethnic groups concerning both triceps and subscapular skinfolds.

Our findings indicate that the sum of the four skinfold thicknesses of the girls was higher in boys over 7 years of age. This difference became more apparent over 12 years of age. This finding in our study was similar to a study conducted in Germany[11].

We found that the triceps and subscapular skinfold thickness of girls were higher than boys in all age groups boys. This was similar to the results of the study performed by Kromeyer-Hauschild *et al.* on a population of 2132 boys and girls in the city of Jena, Germany[37]. In another study conducted by Marrodán *et al.* in five countries (Argentina, Cuba, Mexico, Spain and Venezuela), four-site skinfolds of girls were detected as greater than boys[45]. The study by Addo and Himes[36] and Aristizabal *et al.*[46] reported similar results with our findings in those girls had higher triceps and subscapular skinfold thickness than boys through 6–18 years old.

Our results were also similar to the limited number of previous studies in Turkey. In the study of Öztürk *et al.* conducted on 5553 students aged 6 to 17 years in Kayseri (Turkey), it was reported that the mid-upper arm circumference, triceps skinfold thickness and arm fat area and fat percentage in each age group were significantly higher in girls than in boys[31]. In another study conducted in Kayseri by Çiçek *et al.*, the overweight category of boys was found as 9–11·9 years of age[27]. Similar to our results, the peripheral skinfolds of girls increased with the advancing age. They found an increase in peripheral skinfolds of boys up to 10 years and thereafter they detected a gradual decrease. However, in our study, increases in peripheral skinfolds were detected in boys through 6 to 12 years and then it decreased gradually.

In the current study, triceps values (except 97th percentile) in all percentiles of 17-year-old girls and subscapular percentile values of 85th and above for all ages were found higher than the values determined in the study conducted in 2008 in Kayseri[27]. On the other hand, 50th percentile of triceps and subscapular skinfold thickness of boys through 6 to 16 years were higher than the values determined in Kayseri.

The results of the present study may show that the rate of adiposity in children increases in Turkey since 2008, or these differences between our study and previous studies may be due to heterogeneity in the timing of data collection, ethnic distribution and statistical methodology.

Schwandt *et al.* calculated the body fat percentage of children aged 3 to 18 years in Nuremberg[47]. Their findings showed a higher median body fat percentage in girls than in boys, and the body fat percentage peak that occurred in 11-year-old boys was similar to our findings. The means of triceps, biceps, subscapular and suprailiac skinfold thickness as well as the mean of the sum of four skinfold thickness were higher in girls of our study group when compared with boys except the age of 6 years was similar to the findings of Çiçek *et al.*[27] Increase in body fat percentage is the evidence of obesity risk for children and adolescents[27]. In the current study, we calculated body fat percentages with the Westrate–Deurenberg equation and when compared with boys, girls had lower body fat percentage before the adolescence period and body fat percentage tended to increase and exceeded that of boys after 12 years of age. Çiçek *et al.* also reported similar trends both in girls and boys and a peripheral (subcutaneous) rather than central (visceral) fat deposition in children and adolescents[27].

According to the Ministry of Health, obesity and overweight have become a dramatic problem in the last decade in Turkey. Compared to 2010, the overweight (64·9 %) and obesity (70·7 %) ratio of adults increased in Turkey Nutrition and Health Survey-2017. In 2017, the ratio of obesity was higher among women than in men (42·6 %, 26·3 % respectively)[48,49]. The current study has also shown that the basis of obesity begins in childhood and adolescence and girls at higher risk of obesity in Turkey.

There are some limitations of the current study. Collection of data from a single province may be regarded as a limitation, but this particular province represents certain characteristics of a specific region (West of Central and East of Aegean region of Anatolia the Turkish mainland). Additionally, the puberty stages of children affecting body composition could not be determined due to the large sample size. Another limitation, the nutritional profile and physical activity of children/adolescent could not be evaluated due to the large sample size and the need for long time and specialized methods and trained personnel.

Table 4 Smoothed age- and sex-specific percentiles and L, M, S values for subscapular skinfold thickness (mm)

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	−0·681	7·014	0·383	3·901	4·151	4·591	4·934	5·527	7·014	9·321	11·147	12·757	15·989	18·909
7	−0·657	7·422	0·389	4·083	4·350	4·821	5·190	5·826	7·422	9·901	11·860	13·583	17·033	20·136
8	−0·640	7·676	0·393	4·191	4·469	4·961	5·345	6·009	7·676	10·263	12·304	14·098	17·678	20·886
9	−0·628	7·835	0·395	4·257	4·542	5·047	5·442	6·123	7·835	10·491	12·583	14·419	18·075	21·340
10	−0·612	8·044	0·398	4·344	4·639	5·161	5·569	6·274	8·044	10·784	12·938	14·822	18·561	21·884
11	−0·577	8·518	0·400	4·558	4·875	5·435	5·872	6·628	8·518	11·424	13·686	15·650	19·500	22·871
12	−0·513	9·290	0·398	4·931	5·284	5·906	6·391	7·225	9·290	12·400	14·765	16·778	20·623	23·882
13	−0·451	10·312	0·388	5·490	5·888	6·587	7·129	8·054	10·312	13·619	16·062	18·094	21·864	24·953
14	−0·449	11·354	0·370	6·196	6·628	7·386	7·969	8·961	11·354	14·796	17·298	19·356	23·122	26·163
15	−0·486	11·957	0·353	6·725	7·169	7·943	8·538	9·544	11·957	15·399	17·888	19·928	23·651	26·651
16	−0·523	12·282	0·340	7·070	7·516	8·291	8·885	9·888	12·282	15·686	18·142	20·153	23·825	26·785
17	−0·554	12·519	0·331	7·333	7·779	8·553	9·145	10·143	12·519	15·887	18·314	20·301	23·928	26·855
18	−0·580	12·714	0·323	7·556	8·001	8·774	9·363	10·356	12·714	16·049	18·447	20·411	23·994	26·887
Boys percentiles														
6	−1·302	5·859	0·308	3·805	3·970	4·261	4·486	4·875	5·859	7·465	8·853	10·198	13·409	17·221
7	−1·246	6·042	0·315	3·879	4·053	4·358	4·596	5·005	6·042	7·730	9·179	10·576	13·857	17·646
8	−1·188	6·239	0·321	3·957	4·141	4·463	4·713	5·145	6·239	8·015	9·530	10·979	14·330	18·090
9	−1·118	6·536	0·329	4·084	4·281	4·627	4·896	5·361	6·536	8·436	10·042	11·562	15·007	18·738
10	−1·050	6·857	0·335	4·227	4·439	4·810	5·099	5·598	6·857	8·876	10·563	12·139	15·626	19·263
11	−0·997	7·104	0·337	4·344	4·567	4·958	5·262	5·786	7·104	9·196	10·922	12·512	15·950	19·413
12	−0·959	7·278	0·337	4·435	4·666	5·071	5·385	5·925	7·278	9·406	11·139	12·715	16·057	19·329
13	−0·920	7·490	0·334	4·564	4·803	5·223	5·547	6·105	7·490	9·639	11·359	12·899	16·088	19·107
14	−0·882	7·850	0·323	4·824	5·075	5·514	5·853	6·430	7·850	10·002	11·680	13·151	16·099	18·775
15	−0·857	8·325	0·304	5·225	5·489	5·946	6·297	6·890	8·325	10·433	12·024	13·381	16·006	18·283
16	−0·837	8·828	0·280	5·703	5·977	6·448	6·806	7·406	8·828	10·846	12·316	13·537	15·813	17·704
17	−0·815	9·259	0·257	6·157	6·436	6·913	7·273	7·871	9·259	11·164	12·507	13·594	15·558	17·132
18	−0·786	9·639	0·235	6·597	6·879	7·357	7·714	8·302	9·639	11·416	12·629	13·589	15·276	16·584

Table 5 Smoothed age and sex-specific percentiles and L, M, S values for suprailiac skinfold thickness (mm)

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	−0·388	6·280	0·489	2·858	3·117	3·582	3·952	4·603	6·280	8·941	11·048	12·885	16·485	19·610
7	−0·339	7·076	0·494	3·154	3·451	3·987	4·412	5·160	7·076	10·078	12·418	14·432	18·307	21·600
8	−0·302	7·573	0·497	3·324	3·647	4·230	4·692	5·503	7·573	10·783	13·254	15·360	19·357	22·702
9	−0·272	7·936	0·498	3·445	3·788	4·405	4·896	5·754	7·936	11·289	13·844	16·002	20·055	23·404
10	−0·242	8·326	0·498	3·582	3·946	4·602	5·121	6·030	8·326	11·816	14·444	16·644	20·730	24·062
11	−0·204	9·010	0·492	3·863	4·263	4·981	5·549	6·537	9·010	12·701	15·430	17·685	21·804	25·104
12	−0·155	10·108	0·475	4·376	4·832	5·647	6·287	7·392	10·108	14·045	16·877	19·172	23·268	26·471
13	−0·098	11·374	0·450	5·042	5·564	6·488	7·207	8·432	11·374	15·483	18·342	20·606	24·546	27·544
14	−0·044	12·423	0·424	5·674	6·251	7·262	8·039	9·350	12·423	16·564	19·358	21·527	25·218	27·965
15	0·002	13·024	0·405	6·076	6·686	7·748	8·557	9·910	13·024	17·115	19·816	21·883	25·349	27·887
16	0·032	13·324	0·394	6·294	6·922	8·009	8·834	10·204	13·324	17·359	19·988	21·984	25·299	27·706
17	0·055	13·532	0·386	6·450	7·091	8·195	9·030	10·410	13·532	17·523	20·100	22·044	25·255	27·572
18	0·074	13·695	0·380	6·576	7·226	8·344	9·186	10·575	13·695	17·650	20·185	22·089	25·219	27·467
Boys percentiles														
6	−0·878	5·750	0·422	3·148	3·344	3·694	3·971	4·460	5·750	7·978	9·985	11·973	16·774	22·381
7	−0·813	6·046	0·437	3·221	3·432	3·810	4·111	4·641	6·046	8·471	10·641	12·775	17·828	23·538
8	−0·748	6·341	0·453	3·281	3·508	3·916	4·241	4·816	6·341	8·970	11·305	13·576	18·844	24·589
9	−0·663	6·878	0·473	3·417	3·671	4·131	4·498	5·149	6·878	9·846	12·449	14·941	20·553	26·399
10	−0·576	7·618	0·493	3·624	3·917	4·445	4·868	5·620	7·618	11·019	13·953	16·709	22·720	28·691
11	−0·512	8·222	0·503	3·800	4·124	4·709	5·178	6·012	8·222	11·937	15·084	17·988	24·139	30·015
12	−0·473	8·587	0·504	3·922	4·265	4·885	5·382	6·264	8·587	12·443	15·654	18·572	24·618	30·233
13	−0·442	8·914	0·500	4·060	4·420	5·071	5·590	6·510	8·914	12·845	16·060	18·938	24·781	30·070
14	−0·413	9·312	0·491	4·259	4·639	5·323	5·868	6·827	9·312	13·295	16·488	19·299	24·879	29·801
15	−0·387	9·692	0·480	4·470	4·868	5·584	6·151	7·146	9·692	13·692	16·831	19·550	24·834	29·380
16	−0·362	10·003	0·469	4·654	5·067	5·808	6·394	7·415	10·003	13·993	17·066	19·690	24·696	28·916
17	−0·338	10·276	0·459	4·818	5·246	6·010	6·611	7·655	10·276	14·248	17·256	19·791	24·554	28·497
18	−0·314	10·532	0·449	4·976	5·417	6·202	6·818	7·884	10·532	14·482	17·426	19·880	24·423	28·125

Table 6 Smoothed age- and sex-specific percentiles and L, M, S values for sum of four skinfold (mm)

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	−0·540	30·422	0·360	17·077	18·193	20·145	21·650	24·212	30·422	39·475	46·165	51·744	62·145	70·735
7	−0·518	32·619	0·367	18·074	19·286	21·408	23·046	25·838	32·619	42·520	49·841	55·945	67·317	76·697
8	−0·495	34·208	0·373	18·721	20·007	22·263	24·007	26·980	34·208	44·766	52·565	59·060	71·135	81·066
9	−0·468	35·346	0·378	19·134	20·480	22·841	24·666	27·780	35·346	46·375	54·495	61·236	73·717	83·928
10	−0·441	36·548	0·380	19·645	21·052	23·519	25·425	28·674	36·548	47·960	56·308	63·203	75·880	86·168
11	−0·411	38·489	0·377	20·657	22·152	24·770	26·788	30·220	38·489	50·349	58·931	65·960	78·750	89·005
12	−0·374	41·334	0·371	22·253	23·872	26·699	28·872	32·550	41·334	53·735	62·570	69·723	82·557	92·688
13	−0·335	44·649	0·361	24·203	25·965	29·029	31·374	35·323	44·649	57·575	66·620	73·850	86·626	96·542
14	−0·296	47·777	0·351	26·145	28·040	31·322	33·822	38·007	47·777	61·064	70·200	77·412	89·972	99·569
15	−0·257	50·127	0·341	27·704	29·701	33·145	35·755	40·100	50·127	63·520	72·576	79·644	91·790	100·942
16	−0·219	51·586	0·331	28·771	30·835	34·378	37·051	41·478	51·586	64·861	73·704	80·534	92·137	100·773
17	−0·181	52·536	0·323	29·530	31·642	35·252	37·964	42·433	52·536	65·607	74·195	80·769	91·824	99·964
18	−0·142	53·225	0·315	30·123	32·273	35·935	38·673	43·165	53·225	66·052	74·375	80·692	91·216	98·891
Boys percentiles														
6	−1·129	27·163	0·321	17·137	17·948	19·371	20·475	22·377	27·163	34·826	41·243	47·257	60·702	74·979
7	−1·023	28·342	0·336	17·406	18·287	19·835	21·039	23·115	28·342	36·683	43·605	50·020	64·047	78·402
8	−0·923	29·529	0·350	17·646	18·601	20·280	21·588	23·845	29·529	38·552	45·959	52·738	67·225	81·524
9	−0·836	31·093	0·363	18·115	19·155	20·988	22·417	24·884	31·093	40·894	48·851	56·046	71·106	85·515
10	−0·764	32·683	0·373	18·633	19·757	21·742	23·290	25·963	32·683	43·222	51·687	59·258	74·814	89·315
11	−0·707	33·760	0·380	18·937	20·124	22·220	23·856	26·678	33·760	44·785	53·549	61·306	76·994	91·301
12	−0·667	34·017	0·382	18·912	20·126	22·268	23·938	26·817	34·017	45·137	53·882	61·549	76·838	90·526
13	−0·640	33·805	0·380	18·777	19·993	22·134	23·801	26·670	33·805	44·709	53·185	60·542	75·008	87·737
14	−0·622	33·589	0·372	18·780	19·989	22·115	23·766	26·597	33·589	44·137	52·223	59·165	72·617	84·247
15	−0·606	33·567	0·362	18·993	20·199	22·312	23·946	26·738	33·567	43·705	51·350	57·832	70·186	80·662
16	−0·589	33·778	0·349	19·397	20·605	22·714	24·339	27·098	33·778	43·511	50·718	56·742	68·023	77·393
17	−0·568	34·089	0·335	19·882	21·095	23·205	24·822	27·554	34·089	43·429	50·211	55·800	66·079	74·444
18	−0·543	34·429	0·322	20·399	21·618	23·729	25·338	28·041	34·429	43·377	49·750	54·927	64·283	71·747

Table 7 Smoothed age- and sex-specific percentiles and L, M, S values for body fat percentage

				Girls percentiles										
Age	L	M	S	3	5	10	15	25	50	75	85	90	95	97
6	0·204	18·876	0·321	9·906	10·792	12·279	13·372	15·124	18·876	23·334	26·050	28·027	31·176	33·368
7	0·262	18·782	0·322	9·717	10·623	12·139	13·248	15·020	18·782	23·197	25·859	27·786	30·834	32·942
8	0·321	18·529	0·322	9·457	10·376	11·907	13·023	14·797	18·529	22·853	25·434	27·290	30·207	32·211
9	0·378	18·192	0·320	9·195	10·120	11·655	12·767	14·527	18·192	22·384	24·859	26·628	29·391	31·277
10	0·425	17·923	0·314	9·072	9·996	11·521	12·621	14·352	17·923	21·957	24·318	25·997	28·603	30·374
11	0·455	17·921	0·304	9·239	10·159	11·669	12·753	14·449	17·921	21·804	24·059	25·656	28·125	29·795
12	0·478	18·288	0·289	9·737	10·657	12·159	13·231	14·900	18·288	22·039	24·203	25·729	28·080	29·665
13	0·496	18·877	0·272	10·474	11·392	12·882	13·940	15·578	18·877	22·496	24·569	26·026	28·263	29·766
14	0·509	19·437	0·253	11·277	12·182	13·642	14·673	16·262	19·437	22·890	24·856	26·233	28·341	29·752
15	0·524	19·771	0·235	11·972	12·849	14·256	15·244	16·761	19·771	23·015	24·852	26·135	28·092	29·399
16	0·542	19·847	0·218	12·492	13·329	14·666	15·601	17·031	19·847	22·859	24·555	25·736	27·532	28·728
17	0·560	19·817	0·203	12·911	13·706	14·970	15·851	17·192	19·817	22·604	24·166	25·250	26·894	27·987
18	0·581	19·727	0·188	13·273	14·024	15·213	16·038	17·290	19·727	22·297	23·730	24·722	26·223	27·217
Boys percentiles														
6	−0·620	18·362	0·272	11·776	12·373	13·394	14·162	15·434	18·362	22·308	25·027	27·189	30·999	33·962
7	−0·477	18·348	0·280	11·477	12·107	13·181	13·987	15·317	18·348	22·355	25·060	27·176	30·831	33·607
8	−0·342	18·338	0·287	11·178	11·842	12·971	13·817	15·205	18·338	22·401	25·090	27·161	30·676	33·291
9	−0·229	18·468	0·293	10·990	11·691	12·882	13·769	15·222	18·468	22·607	25·299	27·348	30·774	33·283
10	−0·137	18·588	0·298	10·836	11·570	12·813	13·738	15·247	18·588	22·788	25·481	27·510	30·865	33·293
11	−0·066	18·474	0·301	10·597	11·350	12·622	13·566	15·100	18·474	22·663	25·319	27·305	30·560	32·894
12	−0·015	17·993	0·302	10·222	10·970	12·233	13·168	14·682	17·993	22·065	24·623	26·525	29·623	31·828
13	0·018	17·297	0·300	9·809	10·536	11·759	12·663	14·122	17·297	21·168	23·585	25·373	28·270	30·323
14	0·038	16·608	0·295	9·477	10·175	11·347	12·209	13·600	16·608	20·251	22·511	24·178	26·868	28·766
15	0·053	16·015	0·288	9·249	9·917	11·036	11·858	13·177	16·015	19·425	21·528	23·072	25·556	27·303
16	0·071	15·563	0·279	9·122	9·765	10·838	11·623	12·879	15·563	18·759	20·716	22·148	24·439	26·043
17	0·095	15·208	0·269	9·047	9·670	10·705	11·459	12·660	15·208	18·212	20·036	21·364	23·478	24·952
18	0·124	14·880	0·260	8·982	9·586	10·586	11·311	12·461	14·880	17·700	19·399	20·629	22·577	23·927

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Table 8 The mean values and sexual dimorphism of the subcutaneous skinfolds

	Boys					Girls						
		Triceps		Biceps			Triceps		Biceps		Triceps	Biceps
Age (years)	*n*	Mean	SD	Mean	SD	*n*	Mean	SD	Mean	SD	*P*-value	*P*-value
6	97	10·74	4·59	6·44	3·29	106	10·88	3·57	6·33	2·31	0·801	0·778
7	158	11·41	4·41	7·14	3·70	163	12·70	4·59	7·73	3·17	0·010	0·121
8	178	11·20	4·31	6·80	3·59	187	12·58	4·26	7·56	3·15	0·002	0·033
9	183	12·72	4·91	7·16	3·84	182	13·12	4·65	8·22	3·82	0·426	0·009
10	219	12·93	4·87	7·22	3·62	232	13·96	5·35	8·26	4·67	0·034	0·009
11	229	13·78	4·96	7·70	3·63	254	14·00	5·87	8·28	4·47	0·664	0·118
12	208	13·30	5·49	7·57	4·17	197	14·90	5·31	8·36	3·75	0·003	0·047
13	187	12·07	5·20	7·16	3·89	196	16·00	5·70	8·74	3·75	<0·001	<0·001
14	145	11·57	5·25	6·78	3·64	232	16·88	5·96	9·08	3·99	<0·001	<0·001
15	146	10·56	4·65	5·92	2·53	234	17·78	5·87	9·52	4·15	<0·001	<0·001
16	178	10·49	4·32	5·64	2·19	217	17·43	5·62	9·61	4·21	<0·001	<0·001
17	159	10·07	4·04	5·62	2·47	172	17·99	5·96	9·52	4·67	<0·001	<0·001
18	46	9·64	3·53	5·50	1·71	60	17·85	6·23	9·46	4·41	<0·001	<0·001

	Boys					Girls						
		Subscapular		Suprailiac			Subscapular		Suprailiac			
Age (years)	*n*	Mean	SD	Mean	SD	*n*	Mean	SD	Mean	SD	Subscapular *P*-value	Suprailiac *P*-value
6	97	6·90	4·04	7·27	5·43	106	7·31	2·75	6·90	3·74	0·398	0·571
7	158	7·25	3·70	8·12	5·43	163	8·98	4·40	8·87	4·98	<0·001	0·197
8	178	6·78	2·90	7·73	4·98	187	8·79	4·15	8·73	4·94	<0·001	0·055
9	183	7·73	4·09	8·49	5·08	182	9·24	4·42	9·61	5·15	0·001	0·038
10	219	8·38	4·44	9·80	6·38	232	9·55	5·44	9·99	5·74	0·013	0·745
11	229	8·55	3·97	10·71	6·25	254	10·20	5·74	10·46	5·83	<0·001	0·642
12	208	8·89	4·67	11·11	7·14	197	10·52	4·96	11·51	5·66	0·001	0·533
13	187	8·56	4·06	10·56	6·05	196	11·46	5·03	12·85	6·20	<0·001	<0·001
14	145	9·24	4·26	11·79	7·11	232	12·96	5·67	13·55	5·65	<0·001	0·012
15	146	9·09	3·36	11·69	6·40	234	13·36	5·32	14·52	6·15	<0·001	<0·001
16	178	9·30	2·72	11·24	5·37	217	13·13	5·16	13·87	5·27	<0·001	<0·001
17	159	10·07	3·42	12·02	6·49	172	14·00	5·66	14·73	5·75	<0·001	<0·001
18	46	9·98	2·32	11·95	5·44	60	13·78	5·56	14·3 7	5·89	<0·001	0·032

Age: Indicates the period after the completed age to the last date of the actual age (e.g. 7 00–7 99 years, etc.).

Table 9 The mean values and sexual dimorphism of the sum of four folds and body fat percentage estimated by Westrate and Deurenberg

	Boys					Girls						
		Sum of four skinfold		WD % Fat			Sum of four skinfold		WD % Fat		Sum of four skinfold	WD % Fat
Age (years)	*n*	Mean	SD	Mean	SD	*n*	Mean	SD	Mean	SD	*P*-value	*P*-value
6	97	31·35	16·66	19·37	6·09	106	31·42	11·32	18·70	5·15	0·972	0·396
7	158	33·91	16·14	19·94	5·97	163	38·28	16·10	20·38	6·13	0·016	0·521
8	178	32·50	14·67	18·70	5·70	187	37·65	15·20	19·18	5·59	0·001	0·419
9	183	36·11	17·05	19·46	5·88	182	40·18	16·63	18·97	5·95	0·021	0·430
10	219	38·33	18·48	19·60	5·94	232	41·75	19·82	18·19	6·52	0·060	0·018
11	229	40·74	17·76	19·89	5·74	254	42·94	20·62	17·90	6·00	0·212	<0·001
12	208	40·83	20·35	19·04	6·09	197	45·06	18·46	18·43	5·50	0·029	0·294
13	187	38·26	17·83	17·77	5·48	196	49·05	18·83	19·33	5·14	<0·001	0·004
14	145	39·30	18·83	17·47	5·59	232	52·35	19·27	19·97	4·63	<0·001	<0·001
15	146	36·93	15·97	16·35	5·05	234	55·14	19·30	20·36	4·46	<0·001	<0·001
16	178	36·67	13·48	16·02	4·11	217	58·67	17·99	19·76	4·26	<0·001	<0·001
17	159	37·79	15·17	15·80	4·37	172	56·24	19·71	20·08	4·02	<0·001	<0·001
18	46	37·07	11·50	15·34	3·69	60	55·46	20·00	19·60	4·29	<0·001	<0·001

Age: Indicates the period after the completed age to the last date of the actual age (e.g. 7 00–7 99 years, etc.).
WD % Fat: Westrate and Deurenberg equation derived % fat.

Conclusions

The results of the current study have provided gender- and age-specific reference values for skinfold thickness in children and adolescents of Afyonkarahisar, Turkey. The smoothed LMS curves of girls were high in girls when compared with boys for triceps and subscapular skinfold thickness independent of age that indicates higher adiposity in girls than in boys. Our findings may be used both to compare adiposity with different locations and construct a cause relationship for several independent variables to explain high adiposity in children and adolescents. These additional findings may contribute to developing preventive measures.

Acknowledgements

Acknowledgements: The authors thank everybody in the team especially Gamze Soykan, Kübra Gedik and Gamze Taşdemir for taking skinfold thickness measurements and all students and parents for their participation. The authors are grateful to the Afyonkarahisar Directorate of National Education and their teachers for their cooperation. *Financial support:* The current study was supported by Afyon Kocatepe University Scientific Research Projects Commission Presidency (Project no: 15.HIZ.DES.114). The funding agencies had no role in the design, analysis or writing of this article.The equipment used in the project and study teams finances (travelling, meal, etc) were covered by the funder. *Conflict of interest:* There are no conflicts of interest. *Authorship:* Creating the hypothesis and idea of the manuscript: N.Ş. and M.S. Designing the method that will achieve results: M.S., N.Ş., A.Ö. Organising the conduct of the research: N.Ş., İ.D., N.D. Collecting, organising and reporting data: N.Ş., M.S., İ.D., N.D. Evaluating and concluding the findings: M.S., N.Ş., A.Ö., İ.D., M.M.M. Scanning resources required for the study: M.S., N.Ş., N.D. Writing the whole or important parts of the manuscript: M.S., N.Ş., M.M.M. Making a critical review: N.Ş., M.M.M. *Ethics of human subject participation:* Ethics committee approval was obtained from the Eskişehir Osmangazi University Ethics Committee (80558721/G-176). All procedures involving research study participants were approved by the Eskişehir Osmangazi University, Clinical Research Ethics Committee. The current study was carried out following the latest version of the Helsinki Declaration. Necessary written permission was obtained from the Afyonkarahisar Directorate of National Education for the study to be conducted in schools (Number: 86649407-605-E-11729885). School administrators and teachers were informed about the research. All students and also their parents were informed about research and practice, and the 'Enlightened Written Consent Form' was received from students themselves aged 18 and from the parents of students under 18 years old. Attention was paid to privacy during taking anthropometric measurements of children, and measurements were made in a private room with two researchers.

Supplementary material

For supplementary material accompanying this paper visit https://doi.org/10.1017/S1368980021003323

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