ORIGINAL ARTICLE

Four-site skinfolds and body fat percentage references in 6-to-17-year old Turkish children and adolescents

Betul Cicek,[1] Ahmet Ozturk,[2] Demet Unalan,[3] Meral Bayat,[4] Mustafa Mumtaz Mazicioglu,[5] Selim Kurtoglu[6]

Abstract

Objective: As skinfolds from four-sites (triceps, biceps, subscapular, suprailiac) and body fat percentage in 6-17 years is lacking in Turkey. This study was undertaken to produce references for four-site skinfolds and body fat percentage in children and adolescents.

Methods: The cross-sectional study was conducted between September 2007-May 2008 in Kayseri, Turkey, after approval by ethics committee of Erciyes University and local educational authority. Data were obtained from the Determination of Anthropometric Measures of Turkish Children and Adolescents Study-II. Using multistage sampling method, 4285 children were selected from the schools representing city centre, rural and urban areas of the province. Skinfolds were measured from four sites and body fat percentage was calculated according to Westrate and Deurenberg equation. LMS Chart Maker Pro version 2.3 software was used to obtain skinfold references.

Results: There were 1914(44.6%) boys, 2371(55.3%) girls in the study; the age range being6-17 years. The peripheral skinfolds increased with age for girls (7.2 mm at age 10 versus 8.7 mm at age 17), while this was true for boys until 10 years (6.2 mm at age 10 versus 4.2 mm at age 17) after which the values gradually decreased. In terms of central skinfolds, girls had higher numbers in each age (11.7 mm for boys versus 12.8 mm for girls at age 6; 24.9 mm versus 26.3 mm at age 17).

Conclusion: Skinfolds and body fat percentage provide information that helps monitor secular trends in obesity in Turkey and may be used to make national and international comparisons in the future.

Keywords: Anthropometry, Body fat percentage, Obesity, Skinfolds, Turkish children. (JPMA 64: 1154; 2014)

Introduction

The assessment of body composition is an important issue of current paediatric research to investigate the effect of lifestyle interventions on body compartments as fat and fat-free tissues.[1]

Body mass index (BMI) is often used as a surrogate marker, but it does not provide an accurate assessment of body fat.[1] More sensitive and accurate methods for assessing body composition like underwater weighing, plethysmography, magnetic resonance imaging (MRI) and dual-energy X-ray absorptiometry (DEXA) are difficult to be accessed for daily clinical practice and epidemiologic studies.[2] Thus, skinfolds can be considered a "midway" marker that is more sensitive than BMI in determining body fat and is more useful for both clinical applications and epidemiological studies than the more sensitive methods.[3,4] Additionally, skinfold thickness determines nutritional status and assesses disorders and/or diseases related to malnutrition and obesity.

Different body regions where skinfold thickness is measured may indicate different patterns of fat distribution. Triceps and biceps skinfolds reflect peripheral fat, whereas subscapular and suprailiac skinfolds refer to central/visceral fat. The present study was planned to provide references for triceps, biceps (peripheral fat) and subscapular and suprailiac (central fat) skinfold thicknesses and also body fat percentages derived from these four indices in Turkish children and adolescents.

Subjects and Methods

The cross-sectional study was conducted between September 2007 and May 2008 in Turkey's Kayseri province. Data was obtained from the study of the Determination of Anthropometric Measures of Turkish Children and Adolescents (DAMTCA II)[5] which was performed in the same region that has more than 1,200,000 inhabitants and is a leading industrial trade center in Turkey. The study protocol was approved by the Ethics Committee of Erciyes University and the administration of the local educational authority.

Using multi-stage probability sampling for school children living in Kayseri, 4285 subjects were recruited for the study from 17 randomly selected schools including (primary, secondary and high schools) from both public and private sectors. Once the schools were selected, the students were recruited according to their ages. Children with known growth disorders and those taking any kind of medication were excluded. Chronological age was calculated as the decimal age by substracting the observation date from the birth date. Each year elapsed from their birthdates was noted

[1]Department of Nutrition and Dietetics, Faculty of Health Sciences, [2]Department of Biostatistics and Medical Informatics, Faculty of Medicine, [3]Department of Medical Documentation and Secretariat, Halil Bayraktar Vocational Health College, [4]Department of Nursing, Faculty of Health Sciences, [5]Department of Family Medicine, Faculty of Medicine, [6]Department of Pediatric Endocrinology, Faculty of Medicine, Erciyes University, Kayseri, Turkey.
Correspondence: Betul Cicek. Email: betul.cicek@gmail.com

as one age (e.g. 6.00-6.99 is accepted as six years of age). Parents' written consent was obtained prior to the study, and the procedures were in accordance with those outlined by the Declaration of Helsinki.

Each of the four sites of measurement (triceps, biceps, subscapular, suprailiac) was marked carefully before measurement. All marks and measurements were made on the left side of the body. The procedure was explained to the child before taking the measurements. All measurements were taken using Holtain skinfold calipers. The skinfold thickness was measured to the nearest 0.1mm, while the fingers continued to hold the skinfold. The actual measurement was read from the caliper about 3 seconds after the caliper tension was released.[6]

For peripheral skinfolds, triceps was measured at a marked midpoint in the posterior surface of the left upper arm between the acromium and the olecranon process, at the point previously marked for the mid-upper-arm circumference. The child stood upright with weight evenly distributed and feet together, shoulders relaxed, and the arms hanging freely at the sides. The biceps was measured at the same point, but in the anterior line of the arm.[6]

For central skinfolds, subscapular was measured with the child standing erect with shoulders relaxed and arms hanging loosely at the side. The inferior angle (or triangle portion) of the left scapula was palpated and a cross (+) was made on the inferior angle of the scapula. The suprailiac was measured by lifting a horizontal skinfold at the suprailiac area, about 2cm above the iliac bone.[6]

Due to the large sample size, pubertal stages were not determined, thus body fat percentage was calculated with Westrate and Deurenberg equation.[7]

For statistical analysis, construction of the centile curves was performed with LMS Chart Maker Pro version 2.3 software (The Institute of Child Health, London), which fits smooth centile curves to reference data. This method summarises percentiles at each age based on the power of age-specific Box-Cox power transformations that are used to normalise data. The final curves of percentiles are produced by three smooth curves representing L (Lambda; skewness), M(Mu; median), and S (Sigma; coefficient of variation). These three quantities depend on age.[8]

Results

The 17 schools in the study represented 2.4% of the 708

Table-1A: LMS values for peripheral and central skinfolds.

Boys		Peripheral						Central					
		Triceps			Biceps			Subscapular			Suprailiac		
Age	n	L	M	S	L	M	S	L	M	S	L	M	S
6	127	-0.793	8.655	0.270	-0.753	5.405	0.315	-1.306	5.698	0.248	-0.983	4.427	0.356
7	171	-0.676	9.289	0.313	-0.636	5.729	0.368	-1.172	5.984	0.286	-0.882	5.029	0.398
8	184	-0.579	10.019	0.346	-0.547	6.156	0.409	-1.053	6.366	0.318	-0.783	5.586	0.439
9	156	-0.506	10.617	0.370	-0.484	6.458	0.435	-0.946	6.677	0.343	-0.687	6.074	0.475
10	178	-0.458	10.767	0.387	-0.446	6.483	0.449	-0.863	6.874	0.360	-0.605	6.502	0.501
11	168	-0.436	10.500	0.398	-0.434	6.300	0.452	-0.815	7.064	0.368	-0.547	6.832	0.518
12	122	-0.436	10.014	0.406	-0.449	6.035	0.449	-0.795	7.311	0.370	-0.513	7.158	0.526
13	136	-0.448	9.478	0.413	-0.482	5.759	0.442	-0.792	7.697	0.367	-0.499	7.656	0.527
14	151	-0.465	9.040	0.418	-0.528	5.546	0.434	-0.801	8.278	0.360	-0.496	8.372	0.522
15	220	-0.483	8.727	0.424	-0.578	5.374	0.425	-0.812	8.936	0.352	-0.496	9.082	0.513
16	217	-0.501	8.520	0.428	-0.629	5.235	0.417	-0.823	9.582	0.343	-0.491	9.687	0.504
17	84	-0.517	8.360	0.432	-0.679	5.113	0.408	-0.834	10.216	0.334	-0.482	10.242	0.495
Girls													
6	135	-0.526	10.027	0.261	-0.442	5.779	0.315	-0.978	5.989	0.285	-1.040	4.983	0.351
7	174	-0.382	10.892	0.292	-0.349	6.306	0.346	-0.791	6.789	0.325	-0.796	5.940	0.410
8	188	-0.253	11.691	0.318	-0.258	6.863	0.371	-0.632	7.544	0.356	-0.580	7.052	0.458
9	161	-0.144	12.380	0.340	-0.172	7.375	0.391	-0.493	8.265	0.379	-0.383	8.293	0.492
10	190	-0.057	12.871	0.356	-0.095	7.761	0.405	-0.377	8.943	0.393	-0.210	9.454	0.512
11	136	0.005	13.210	0.367	-0.037	8.007	0.414	-0.292	9.578	0.400	-0.067	10.432	0.518
12	150	0.032	13.561	0.373	-0.014	8.191	0.418	-0.249	10.187	0.398	0.037	11.319	0.511
13	164	0.023	14.022	0.374	-0.036	8.388	0.415	-0.254	10.782	0.389	0.097	12.222	0.494
14	150	0.000	14.515	0.372	-0.090	8.575	0.408	-0.286	11.351	0.376	0.131	13.121	0.471
15	378	-0.020	14.938	0.368	-0.159	8.708	0.398	-0.329	11.884	0.360	0.152	13.949	0.445
16	412	-0.034	15.283	0.363	-0.230	8.775	0.388	-0.376	12.382	0.345	0.169	14.698	0.419
17	133	-0.045	15.582	0.359	-0.298	8.797	0.379	-0.420	12.848	0.330	0.184	15.381	0.394

Table-1B: LMS values for sum of skinfolds and body fat percentage.

Boys		Sum of skinfolds			Body fat percentage		
Age	n	L	M	S	L	M	S
6	127	-1.367	24.380	0.245	-0.919	16.757	0.222
7	171	-1.195	26.199	0.295	-0.699	17.181	0.260
8	184	-1.055	27.966	0.334	-0.518	17.560	0.288
9	156	-0.945	29.355	0.360	-0.373	17.693	0.308
10	178	-0.865	30.181	0.377	-0.266	17.484	0.319
11	168	-0.818	30.589	0.385	-0.204	17.032	0.325
12	122	-0.804	30.885	0.387	-0.190	16.527	0.325
13	136	-0.815	31.281	0.385	-0.218	16.096	0.322
14	151	-0.841	31.859	0.380	-0.270	15.789	0.317
15	220	-0.872	32.523	0.375	-0.332	15.557	0.310
16	217	-0.904	33.206	0.369	-0.393	15.363	0.304
17	84	-0.933	33.871	0.363	-0.451	15.190	0.297
Girls							
6	135	-1.152	26.940	0.260	-0.580	17.065	0.248
7	174	-0.922	30.118	0.299	-0.287	17.617	0.268
8	188	-0.710	33.462	0.331	-0.003	18.169	0.283
9	161	-0.515	36.649	0.356	0.270	18.652	0.292
10	190	-0.351	39.300	0.371	0.507	18.969	0.295
11	136	-0.230	41.432	0.378	0.681	19.126	0.291
12	150	-0.164	43.477	0.375	0.768	19.273	0.280
13	164	-0.154	45.770	0.364	0.764	19.502	0.263
14	150	-0.175	48.124	0.349	0.709	19.744	0.243
15	378	-0.204	50.251	0.332	0.636	19.897	0.222
16	412	-0.231	52.106	0.315	0.564	19.969	0.201
17	133	-0.256	53.754	0.298	0.498	19.990	0.181

Table-2: Peripheral skinfold thickness references.

	Triceps percentiles																	
	3		5		10		15		50		85		90		95		97	
Age	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	5.6	6.5	5.9	6.8	6.4	7.4	6.7	7.8	8.7	10.0	11.9	13.4	13.0	14.5	15.0	16.3	16.6	17.7
7	5.7	6.6	6.0	7.0	6.5	7.7	6.9	8.2	9.3	10.9	13.4	15.0	14.8	16.3	17.5	18.5	19.7	20.2
8	5.8	6.7	6.1	7.2	6.8	7.9	7.2	8.5	10.0	11.7	15.0	16.5	16.7	18.0	20.0	20.5	22.7	22.4
9	5.8	6.7	6.2	7.2	6.9	8.1	7.5	8.8	10.6	12.4	16.3	17.8	18.3	19.4	22.0	22.2	25.1	24.2
10	5.7	6.7	6.2	7.2	6.9	8.2	7.5	8.9	10.8	12.9	16.8	18.7	18.9	20.4	22.9	23.4	26.1	25.5
11	5.5	6.6	5.9	7.2	6.6	8.2	7.2	9.0	10.5	13.2	16.6	19.3	18.7	21.1	22.7	24.2	26.0	26.3
12	5.2	6.7	5.6	7.3	6.3	8.4	6.8	9.2	10.0	13.6	15.9	19.9	18.1	21.8	22.1	24.9	25.4	27.2
13	4.9	6.9	5.2	7.5	5.9	8.7	6.4	9.5	9.5	14.0	15.2	20.6	17.3	22.6	21.3	25.8	24.6	28.2
14	4.6	7.2	5.0	7.9	5.6	9.0	6.1	9.9	9.0	14.5	14.7	21.3	16.8	23.4	20.7	26.7	24.1	29.2
15	4.4	7.5	4.8	8.2	5.4	9.3	5.9	10.2	8.7	14.9	14.3	21.9	16.4	24.0	20.4	27.5	23.9	30.0
16	4.3	7.8	4.7	8.5	5.2	9.6	5.7	10.5	8.5	15.3	14.1	22.3	16.2	24.4	20.3	28.0	23.9	30.5
17	4.2	8.0	4.6	8.7	5.1	9.9	5.6	10.8	8.4	15.6	13.9	22.7	16.0	24.8	20.3	28.4	24.0	30.9
								Biceps percentiles										
6	3.3	3.4	3.5	3.6	3.8	4.0	4.0	4.3	5.4	5.8	7.9	8.2	8.8	9.0	10.4	10.4	16.6	11.5
7	3.2	3.5	3.4	3.8	3.8	4.2	4.1	4.5	5.7	6.3	8.9	9.2	10.0	10.2	12.3	11.9	19.7	13.2
8	3.2	3.6	3.5	3.9	3.9	4.4	4.2	4.8	6.2	6.9	10.0	10.3	11.4	11.4	14.2	13.3	22.7	14.8
9	3.2	3.7	3.5	4.0	3.9	4.6	4.3	5.0	6.5	7.4	10.7	11.2	12.4	12.4	15.5	14.6	25.1	16.2
10	3.2	3.7	3.4	4.1	3.9	4.7	4.2	5.1	6.5	7.8	10.9	11.9	12.6	13.2	15.9	15.4	26.1	17.1
11	3.1	3.7	3.3	4.1	3.8	4.7	4.1	5.2	6.3	8.0	10.6	12.3	12.3	13.7	15.5	16.0	26.0	17.7
12	2.9	3.8	3.2	4.1	3.6	4.8	4.0	5.3	6.0	8.2	10.2	12.6	11.7	14.0	14.8	16.3	25.4	18.0
13	2.9	3.9	3.1	4.3	3.5	5.0	3.8	5.5	5.8	8.4	9.7	12.9	11.2	14.4	14.1	16.7	24.6	18.5
14	2.8	4.1	3.0	4.5	3.4	5.1	3.7	5.7	5.5	8.6	9.3	13.2	10.7	14.6	13.6	17.1	24.1	19.0
15	2.8	4.3	3.0	4.7	3.3	5.3	3.6	5.8	5.4	8.7	8.9	13.3	10.3	14.8	13.2	17.4	23.9	19.3
16	2.8	4.5	3.0	4.8	3.3	5.5	3.6	6.0	5.2	8.8	8.7	13.4	10.0	14.9	12.8	17.5	23.9	19.5
17	2.8	4.6	2.9	5.0	3.3	5.6	3.5	6.1	5.1	8.8	8.4	13.4	9.8	14.9	12.5	17.5	24.0	19.6

Table-3: Central skinfold thickness references.

	Subscapular percentiles																	
	3		5		10		15		50		85		90		95		97	
Age	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	4.0	3.9	4.1	4.1	4.4	4.4	4.6	4.6	5.7	6.0	7.8	8.5	8.6	9.4	10.2	11.2	11.7	12.8
7	3.9	4.1	4.1	4.3	4.4	4.7	4.6	5.0	6.0	6.8	8.6	10.0	9.7	11.3	11.9	13.6	14.0	15.7
8	4.0	4.3	4.2	4.6	4.5	5.1	4.8	5.4	6.4	7.5	9.5	11.5	10.8	12.9	13.6	15.7	16.4	18.0
9	4.0	4.5	4.2	4.8	4.6	5.3	4.9	5.8	6.7	8.3	10.3	12.8	11.8	14.4	15.0	17.4	18.1	19.9
10	4.0	4.7	4.3	5.0	4.7	5.6	5.0	6.1	6.9	8.9	10.8	13.9	12.4	15.6	15.7	18.8	19.0	21.3
11	4.1	4.9	4.3	5.2	4.7	5.9	5.1	6.5	7.1	9.6	11.2	14.9	12.8	16.7	16.3	19.9	19.5	22.4
12	4.2	5.1	4.5	5.6	4.9	6.3	5.2	6.9	7.3	10.2	11.5	15.7	13.2	17.6	16.8	20.8	20.1	23.3
13	4.4	5.5	4.7	6.0	5.2	6.7	5.5	7.3	7.7	10.8	12.1	16.5	13.9	18.4	17.5	21.7	20.9	24.2
14	4.8	6.0	5.1	6.4	5.6	7.2	6.0	7.8	8.3	11.4	12.9	17.2	14.7	19.1	18.5	22.4	22.0	25.0
15	5.3	6.4	5.6	6.9	6.1	7.7	6.5	8.4	8.9	11.9	13.8	17.7	15.7	19.6	19.5	23.0	23.1	25.6
16	5.7	6.9	6.0	7.4	6.6	8.2	7.0	8.9	9.6	12.4	14.6	18.2	16.5	20.1	20.5	23.4	24.1	26.0
17	6.2	7.4	6.5	7.9	7.1	8.7	7.5	9.3	10.2	12.8	15.4	18.6	17.4	20.5	21.3	23.8	24.9	26.3
	Suprailiac percentiles																	
6	2.6	3.0	2.8	3.2	3.0	3.4	3.2	3.7	4.4	5.0	7.0	7.9	8.1	9.1	10.6	12.0	13.2	15.2
7	2.8	3.3	3.0	3.5	3.3	3.8	3.5	4.1	5.0	5.9	8.4	10.0	9.9	11.7	13.4	15.6	17.1	19.7
8	3.0	3.5	3.2	3.8	3.5	4.3	3.8	4.6	5.6	7.1	9.8	12.3	11.7	14.4	16.2	19.0	21.1	23.2
9	3.0	3.8	3.3	4.1	3.7	4.7	4.0	5.2	6.1	8.3	11.1	14.6	13.3	17.1	18.6	21.9	24.2	26.0
10	3.1	3.9	3.3	4.4	3.8	5.1	4.1	5.7	6.5	9.5	12.1	16.6	14.7	19.2	20.4	23.9	26.3	27.8
11	3.1	4.1	3.4	4.6	3.9	5.4	4.3	6.2	6.8	10.4	12.9	18.0	15.6	20.6	21.5	25.1	27.5	28.6
12	3.2	4.3	3.5	4.8	4.0	5.8	4.4	6.6	7.2	11.3	13.6	19.1	16.4	21.6	22.4	25.9	28.4	29.1
13	3.4	4.6	3.7	5.2	4.3	6.4	4.7	7.2	7.7	12.2	14.5	20.1	17.4	22.6	23.8	26.7	30.0	29.8
14	3.8	5.1	4.1	5.8	4.7	7.0	5.2	7.9	8.4	13.1	15.7	21.1	18.9	23.4	25.6	27.4	32.1	30.3
15	4.1	5.7	4.5	6.4	5.1	7.7	5.7	8.7	9.1	13.9	16.8	21.8	20.1	24.1	27.1	27.9	33.8	30.6
16	4.4	6.3	4.8	7.1	5.5	8.4	6.1	9.4	9.7	14.7	17.7	22.3	21.1	24.6	28.1	28.2	34.7	30.8
17	4.8	6.9	5.2	7.7	5.9	9.1	6.5	10.1	10.2	15.4	18.5	22.8	21.8	24.9	28.8	28.4	35.2	30.8

Table-4: Sum of skinfolds and body fat percentage (calculated by Westrate-Deurenberg equation) references.

	Sum of skinfolds percentiles																	
	3		5		10		15		50		85		90		95		97	
Age	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls
6	17.0	18.3	17.7	19.0	18.8	20.3	19.6	21.3	24.4	26.9	33.3	37.2	36.8	41.0	43.8	48.5	50.5	55.3
7	17.1	19.1	17.9	20.1	19.2	21.7	20.2	22.9	26.2	30.1	38.3	43.4	43.4	48.4	54.2	58.1	65.2	66.6
8	17.3	20.0	18.1	21.1	19.6	23.1	20.8	24.6	28.0	33.5	43.0	49.6	49.4	55.4	63.5	66.6	78.3	76.1
9	17.4	20.6	18.3	22.0	20.0	24.3	21.3	26.2	29.4	36.6	46.5	55.1	53.9	61.6	70.0	73.5	86.7	83.2
10	17.4	21.0	18.4	22.6	20.2	25.3	21.6	27.4	30.2	39.3	48.6	59.4	56.4	66.1	73.3	78.1	90.4	87.6
11	17.3	21.5	18.4	23.2	20.2	26.2	21.7	28.5	30.6	41.4	49.6	62.4	57.5	69.2	74.6	81.0	91.4	89.9
12	17.4	22.3	18.5	24.2	20.4	27.4	21.8	29.8	30.9	43.5	50.1	64.9	58.1	71.7	75.2	83.3	92.1	92.0
13	17.7	23.9	18.8	25.8	20.7	29.2	22.2	31.7	31.3	45.8	50.6	67.5	58.7	74.3	76.1	85.8	93.2	94.4
14	18.2	25.8	19.3	27.8	21.2	31.3	22.7	33.9	31.9	48.1	51.4	69.9	59.6	76.7	77.4	88.1	95.0	96.7
15	18.8	27.9	19.9	30.0	21.8	33.4	23.3	36.0	32.5	50.3	52.2	71.8	60.6	78.4	78.7	89.6	97.0	98.0
16	19.4	29.9	20.5	32.0	22.4	35.4	23.9	38.1	33.2	52.1	53.1	73.1	61.5	79.6	80.0	90.4	98.8	98.4
17	20.0	31.8	21.1	33.9	23.0	37.3	24.5	39.9	33.9	53.8	53.8	74.2	62.3	80.4	81.1	90.8	100.4	98.5
	Body fat percentage (calculated by Westrate-Deurenberg equation) percentiles																	
6	11.8	11.3	12.2	11.8	13.0	12.8	13.6	13.4	16.8	17.1	21.7	22.5	23.3	24.2	26.2	27.2	28.4	29.4
7	11.3	11.0	11.8	11.6	12.7	12.7	13.4	13.5	17.2	17.6	23.1	23.5	25.1	25.3	28.5	28.2	31.2	30.3
8	10.9	10.7	11.5	11.4	12.5	12.7	13.3	13.6	17.6	18.2	24.3	24.4	26.5	26.1	30.2	28.9	33.2	30.9
9	10.5	10.3	11.1	11.1	12.2	12.6	13.1	13.6	17.7	18.7	24.8	25.0	27.1	26.6	31.0	29.3	33.9	31.1
10	10.0	9.9	10.7	10.9	11.9	12.5	12.7	13.6	17.5	19.0	24.7	25.2	27.0	26.8	30.8	29.3	33.6	31.0
11	9.6	9.6	10.3	10.7	11.4	12.4	12.3	13.6	17.0	19.1	24.1	25.2	26.3	26.7	30.0	29.0	32.7	30.5
12	9.3	9.8	9.9	10.9	11.1	12.7	11.9	13.9	16.5	19.3	23.4	25.1	25.5	26.5	29.0	28.6	31.7	30.0
13	9.1	10.5	9.8	11.5	10.8	13.2	11.7	14.4	16.1	19.5	22.8	25.0	24.8	26.3	28.2	28.4	30.8	29.7
14	9.1	11.4	9.7	12.3	10.7	13.9	11.5	15.0	15.8	19.7	22.3	24.9	24.3	26.2	27.7	28.1	30.2	29.3
15	9.1	12.3	9.7	13.1	10.7	14.5	11.5	15.5	15.6	19.9	21.9	24.7	23.8	25.8	27.2	27.6	29.8	28.8
16	9.2	13.1	9.7	13.9	10.7	15.1	11.4	16.0	15.4	20.0	21.5	24.3	23.4	25.4	26.8	27.0	29.3	28.1
17	9.2	13.8	9.8	14.5	10.7	15.6	11.4	16.4	15.2	20.0	21.2	23.9	23.1	24.9	26.4	26.4	28.9	27.4

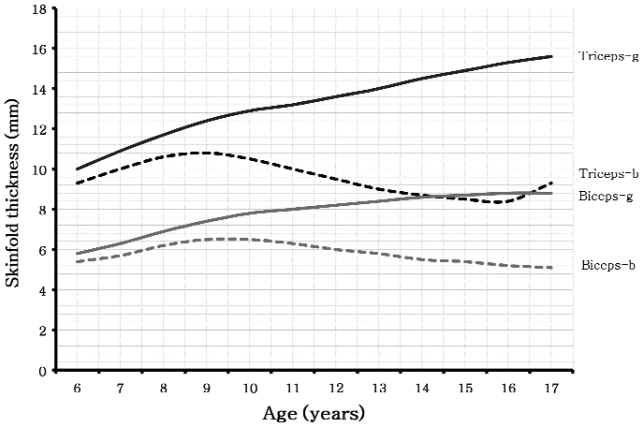

Figure-1: The distribution of peripheral skinfold thicknesses for boys (b) and girls (g).

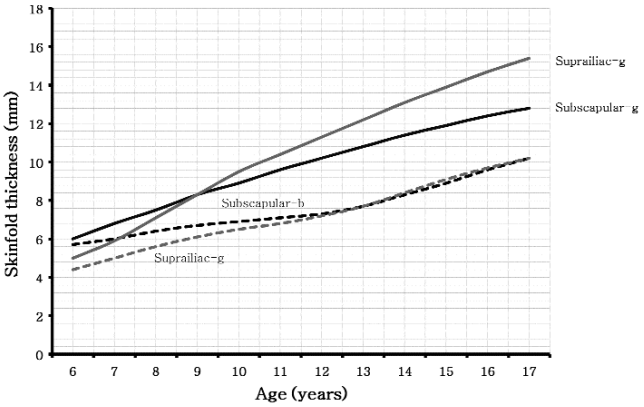

Figure-2: The distribution of central skinfold thicknesses for boys (b) and girls (g).

schools in the region. Of the 4285 subjects, there were 1914(44.6%) boys and 2371(55.3%) girls; the overall age range being 6-17 years. Smoothed and weighed age- and gender-specific LMS values for peripheral (triceps and biceps) and central (subscapular and suprailiac) skinfold thicknesses and the sum of skinfolds and body fat percentages were calculated (Table-1A, 1B).

The peripheral skinfolds increased with age for girls (7.2mm at age 10 versus 8.7mm at age 17), while this was true for boys until 10 years (6.2mm at age 10versus 4.2mm at age 17 for boys) after which the values gradually decreased (Table-2).

In terms of central skinfolds, girls had higher numbers in each age group (11.7mm for boys versus 12.8mm for girls at age 6; 24.9mm versus 26.3mm at age 17) (Table-3).

For both boys and girls, the sum of skinfolds increased with age and girls had higher sum of skinfolds than boys at each stage (17mm for boys and 18.3mm for girls at age 6 versus 20mm and 31.8mm at age 17). The body fat

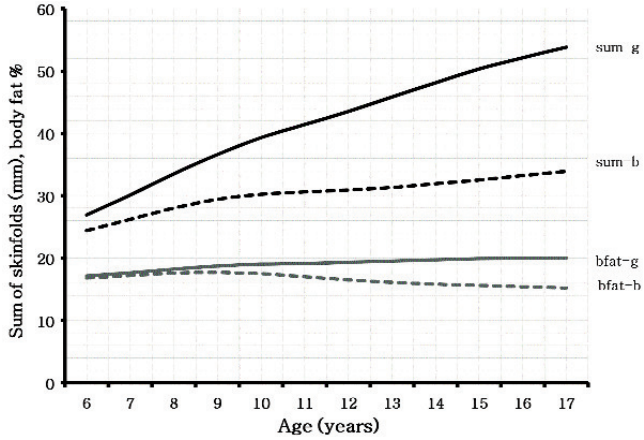

Figure-3: The distribution of sum of skinfolds and body fat percentage (calculated by Westrate-Deurenberg equation) for boys (b) and girls (g).

percentage increased with age for girls (11.3% at age 6 versus 13.8% at age 17), while this was true for boys until 10 years after which the values gradually decreased (10% at age 10 versus 9.2% at age 17). In each age, girls had higher body fat percentage than boys (Table-4).

In both genders, the sum of skinfolds gradually increased between 6 and 17 years, but decreased in peripheral skinfolds for the boys (Figures-1-3).

Discussion

Although BMI is the primary measure to assess overweight and obesity, but it is difficult to discriminate between fat and fat-free mass and also the distribution of fat content in different body compartments. Smoothed percentiles of skinfold thicknesses from different sites will allow better assessment of fat and fat-free mass and also the distribution of fat content.[9] The primary contribution of this study is to provide references — both skinfold references (triceps, biceps, subscapular, suprailiac) and body fat percentages (calculated by Westrate-Deurenberg equation).

Triceps skinfold is the main reference for total body fat reserves and the marker is sensitive to changes in the nutritional status of both children and adolescents.[10-12] Triceps skinfolds have been used to determine total body fat percentage in Spanish boys and adolescents.[13]

As it is relatively easy and more common to measure triceps skinfolds, the current literature has several studies providing the mean values from different countries.[14-18] However, in most of these studies, age distribution is found lacking.[14-16,18]

In two studies,[19,20] data was used to perform comparisons. In boys, smoothed triceps skinfolds were higher than the

two studies — one each in the US and Germany — for 3rd and 50th percentiles. For 97th percentile, the values were similar around 11 years with US boys; afterwards US boys had higher values than their Turkish counterparts. German boys had lower values than those of US and Turkey. In girls, triceps skinfolds were higher than US and Germany for 3rd percentile. For the 50th percentile, the values were similar around 13.5 years, while US had higher values afterwards. Germany had lower values than US and Turkey. For the 97th percentile, Turkey and US had similar values until 9.5 years. Afterwards, US had higher values. German girls had lower values than US and Turkey.

Two other studies are also relevant; one in Nepal[21] (6-10 years) and the other on Pakistani children living in Bahrain[22] (5-17 years)Among boys, Turkey had higher mean values than Pakistan until 9.5 years, after which Pakistan had higher values, while Nepal had the lowest. Among the girls, Turkey had slightly higher values than Pakistan until 10 years; but afterwards Pakistan had higher values, while Nepal had the lowest.

In our previously published data comprising 5553 Turkish children and adolescents aged 6-17 years, triceps skinfolds increased with age for girls, while this was true for boys until 11 years, after which the values gradually decreased.[23] Similar results were obtained in the current study with only one exception for boys: the increment in triceps was until 10 years.

Triceps skinfold reflects the relative distribution of fat in the subcutaneous compartment. There is a major disadvantage of using it alone in children and adolescents. However, mean normal values for tricep skinfolds differ with age and gender, and values for children and adolescents of different ages cannot be compared without reference to age-related norms. It is recommended to use triceps skinfolds that can be expressed as a percentile distribution, the standard deviation score or percentage of mean value for age is used. Thus, the percentile distribution of triceps and additional three sites (biceps, subscapula, suprailiac) were provided in the present study.

Regarding biceps, in boys, Turkey had higher mean values than Pakistan[22] until 11.5 years, followed by a gradual decrease. Pakistan had the highest values for 12 and 14.5 years. In girls, Turkey had higher values than Pakistan for 11.5 years, the values gradually decreased, and Pakistan had the highest values for 15.5 years, and a decrease was seen afterwards.

Although triceps and biceps are primary references for total body fat and are sensitive to the changes in nutritional status of both children and adolescents,[10-12] they also reflect the relative distribution of body fat. The most prominent finding was similarity of triceps and biceps references between each gender and significant difference thereafter until 17 years. This finding is consistent with the results of another study.[24] This prominent difference was considered a result of significant decrease in both triceps and biceps references in boys. This change in peripheral fat can be explained by the compartmental shift from fat to fat-free mass in boys. On the other hand, in both genders, central skinfolds, subscapular and suprailiac, both increased from 6-to-17 years in children and adolescents. The similarity in central fat accumulation indices, but decrease in peripheral fat indices for boys may be explained by male type body formation during pubertal period. We can conclude that peripheral fat accumulation is more sensitive than central in response to pubertal development.

In terms of central skinfolds, subscapular were compared to the four studies cited above.[19-22]

In Turkish boys, subscapular skinfolds were higher than US and Germany for 3rd and 50th percentiles. For the 97th percentile, Turkey and US matched each other around 10.5 years and US values exceeded Turkey beyond that point. In girls, subscapular skinfolds were higher than US and Germany for 3rd and 50th percentile. For the 97th percentile, Turkey had higher values than US around 8.5 years, but US exceeded Turkey after that. Germany had the lowest values for both genders for subscapular skinfolds.

Besides, Turkish boys had higher mean subscapular skinfolds than Pakistani boys until 10 years, after which they had higher values. The highest mean skinfolds were seen around 14.5 years for boys and girls, while Nepal had the lowest values for both genders.

For suprailiac skinfolds, comparisons were performed with the Pakistani study.[22] Turkish boys had lower suprailiac skinfolds than Pakistani boys for 6 years, but after 7 years, Turkey had higher values until 11.5 years. Pakistan had higher values afterwards and two great increases were observed around 12 and 14.5 years. There were sharp decreases in 13 and 16 years. Turkish girls had lower suprailiac skinfolds than Pakistani girls for 6 years, but after 7 years Turkey had higher values until 10.5 years. After 11.5 years, Turkey had lower values than Pakistan until 12.5 years, and the values gradually increased until 14 years for Turkey, while Pakistan had higher values beginning from 11.5 years. Pakistan skinfolds decreased at 15.5 years, getting lower than Turkey, but increased afterwards.

In the current study, the sum of four skinfolds were computed and body fat percentage was calculated according to Westrate and Deurenberg equation.[7] Body fat percentage is an evidence for risk of obesity for children and adolescents. The median (50th percentile) body fat percentage values for Turkish boys increased from 16.8% (at age 6) to 17.5% (at age 10). At age 11, the values began to decrease from 17.0% to 15.2% (at age 17). The median values for Turkish girls gradually increased from 26.9% (at age 6) to 53.8% (at age 17).

Countries like Germany[19] and US[20] have skinfold LMS values for age, but none of them computed the Westrate and Deurenberg equation to calculate body fat percentage. There is only one study from Italy (mean age: 15.4 years) which used the same equation,[15] and according to its results, the body fat percentage for Italian boys and girls were 19.3±5.6 and 23.3±4.4%, respectively. In the current study, Turkish boys had lower body fat percentage than their Italian counterparts at each age (with having the highest value as 17.7% at age 9). Turkish girls had lower body fat percentage than their Italian counterparts at each age (with having the highest value as 20.0% at ages 16 and 17). This may indicate a lower trend towards obesity in Turkish children and adolescents, and they tended to have a lower risk of obesity than their Italian counterparts.

In general, global researches have tended to calculate body fat percentage by using Slaughter equation (including triceps and subscapular skinfolds)[25,26] or Yuan equation[27] rather than measuring four sites and computing other equations to predict body fat percentage. Besides, some others have preferred to use sum of skinfolds, without calculating body fat percentage.[28-30]

When using the Slaughter equation, the pubertal stage should be determined. A study from the United Arab Emirates (UAE) calculated body fat percentage with another pubertal stage-requiring method called the Deurenberg equation (including four sites).[31] Even though it seems more practical to measure two sites, it is not always easy to assess pubertal development. Due to our study's nature (a cross-sectional one with 4285 children) and the difficulty of employing a paediatrician for every school and socio-cultural differences, we did not determine pubertal stages.

From a general point of view, body fat percentage of Turkish boys was higher for ages 6-to-11, 13, 15-to-17, while Turkish girls were higher for ages 6-to-12, than the other countries.

The results of the present study indicate that the skinfolds measured from four sites for Turkish children and adolescents were similar mostly to their Pakistani counterparts. Girls exerted significantly higher percentiles for skinfolds from four sites than boys in each age. In general, the body fat composition of Turkish children and adolescents in the current study reflected peripheral (subcutaneous) rather than central (visceral) fat deposition. Further multi-site, nationwide, prospective, longitudinal studies will provide much more reliable data to produce new references in the future.

Conclusion

So far, this is the most comprehensive study based on a representative sample of Turkish children and adolescents indicating precise evaluation of body fat percentage using skinfold thickness from four sites. The early detection of abdominal fat stores using our data and respective body fat percentage may now be implemented in routine clinical practice. As we provided sufficient number of percentiles (3rd to 97th) for four sites, sum of four sites, and body fat percentage, therefore our data may be a good reference for the evaluation of overweight and obesity status. In order to evaluate the body fat status of children, four-site results may be a beneficial reference. In the light of our results, the change in four sites within ages may be monitored to assess the overweight and obesity status among children for both national and international comparisons.

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