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Can waist circumference clinically be useful as a predictor of obesity/underweight in children?

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SUMMARY

Waist circumference is accepted as a better index of nutrition-related health risks. In this study we aimed to evaluate whether the measurement of waist circumference may clinically be useful as a predictor of obesity/underweight in children or not. This descriptive and cross-sectional study was carried out on 2572 children selected by the cluster sampling method from 178 primary and high schools in Konya. Height, weight, hip and waist circumference were measured in all the cases. The differences of waist circumference according to age and gender were compared to Body Mass Index specific to age and gender. The mean value of waist circumference in boys was statistically greater than that of girls at the ages of 8, 10, 11, 15, 16, 17 and 18. Body Mass Index was statistically greater in boys than girls in the age group of 18 (p=0.037). Obesity prevalence was 7.7% in 8-year-old girl students and 5.3% in 9- and 14-year-old boy students. Prevalence of being overweight was 10.9% in 13-year-old girl students and 11.5% in 8 year-old boy students. Prevalence of being underweight was 17.9% in 18-year-old girl students and 20.0% in 7-year-old boy students. Waist circumference measurement is a very cheap, simple, easy and non-invasive method. Therefore, child nutrition can be closely monitored by measurement of waist circumference.

Key words: *Body mass index, nutrition, obesity, underweight, waist circumference*

ÖZET

Bel çevresi çocuklarda obesite veya zayıflığın klinik belirleyicisi olarak yararlı olabilir mi?

Bel çevresi beslenme ile ilgili sağlık risklerini göstermede daha iyi bir indeks olarak kabul edilir. Bu çalışmada çocuklarda obesite/zayıflığın klinik belirleyicisi olarak bel çevresi ölçümünün yararlı olup olmayacağını değerlendirmeyi amaçladık. Bu tanımlayıcı ve kesitsel çalışma Konya'da 178 ilköğretim okulu ve liseden küme örneklem yöntemi ile seçilen 2572 çocuk üzerinde yapıldı. Tüm olgularda boy, kilo, kalça ve bel çevreleri ölçüldü. Yaşa ve cinse göre bel çevresi farklılıkları yaş ve cinse özel vücut kitle indeksi ile karşılaştırıldı. Erkeklerde 8, 10, 11, 15, 16, 17 ve 18 yaşlarda ortalama bel çevresi değerleri kızlarınkilerden istatistiksel olarak daha yüksek idi. Erkeklerde 18 yaşta vücut kitle indeksi değeri kızlarınkilerden istatistiksel olarak daha yüksek idi (p=0.037). Obesite sıklığı 8 yaşındaki kız öğrencilerde %7.7, 9 ve 14 yaşlarındaki erkek öğrencilerde ise %5.3 idi. Fazla kiloluluk 13 yaşındaki kız öğrencilerde %10.9 ve 8 yaşındaki erkek öğrencilerde %11.5 idi. Düşük kiloluluk 18 yaşındaki kız öğrencilerde %17.9 iken, 7 yaşındaki erkek öğrencilerde %20.0 olarak bulundu. Bel çevresi ölçümü çok ucuz, basit, kolay ve invaziv olmayan bir yöntemdir. Bu yüzden bel çevresi ölçümü ile çocuk beslenmesi yakından izlenebilir.

Anahtar kelimeler: *Vücut kitle indeksi, beslenme, obesite, düşük kilolu, bel çevresi*

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Introduction

Increasing obesity prevalence among children and adolescence is one of the most important public health problems (1). The number of children who are overweight has doubled in the last two to three decades, and currently one child in five is overweight in the United States (2). The increase has been presented in both children and adolescents, and in all age, race and gender groups. Progress toward reducing the national prevalence of overweight and obesity is monitored using data from the National Health and Nutrition Examination Survey (NHANES). Data from two NHANES surveys (1976-1980 and 2003-2004) show that the prevalence of overweight is increasing: for children aged 2–5 years, prevalence increased from 5.0% to 13.9%; for those aged 6-11 years, prevalence increased from 6.5% to 18.8%; and for those aged 12-19 years, prevalence increased from 5.0% to 17.4% (1).

Being overweight is the result of caloric imbalance (too few calories expended for the amount of calories consumed) and mediated by both genetic and environmental factors. An estimated 61% of overweight young people have at least one additional risk factor for heart disease, such as high cholesterol or high blood pressure (2,3). In addition, children who are overweight are at greater risk for bone and joint problems, sleep apnea, and social and psychological problems such as stigmatization and poor self-esteem (2). Overweight young people are more likely to become overweight or obese adults than children of normal weight, and therefore more at risk for associated adult health problems, including heart disease, type 2 diabetes, stroke, several types of cancer, and osteoarthritis. Healthy lifestyle habits, including healthy eating and physical activity, can lower the risk of becoming overweight, underweight and developing related diseases (2,3).

Because of their public health importance, the trends in childhood obesity should be closely monitored (3). Classifications of overweight for children and adoles-

cents are age and sex-specific because children's body composition varies as they age and varies between boys and girls (4). While BMI is an accepted screening tool for the initial assessment of body fatness in children and adolescents, it is not a diagnostic measure because BMI is not a direct measure of body fatness. Recent studies have shown that obesity, especially the central type obesity, increases the risk of developing metabolic syndrome in adults (3). The severity of central obesity is determined by taking waist and hip measurements. Waist circumference (WC) is the anthropometric indicator of fat distribution which are most closely related to cardiovascular disease (CVD) risk factors (3). The prevalence of the metabolic syndrome in the pediatric age group was 27.2% among Turkish children identified as obese (5). Each country must have its own reference values to identify obesity within the country. Bundak et al. reported data and curves for body mass index values in healthy Turkish children aged 6-18 years in 2006 (6).

Since WC is a highly sensitive and specific measure of upper body fat in childhood and adolescence, to identify overweight and obese children at risk of developing metabolic complications, it should be used routinely (7). Early identification and treatment of children with central adiposity is very important due to metabolic complications. WC percentiles have been developed for children and adolescents in several countries. Hatipoglu et al. reported data and smoothed percentile curves for waist circumference of healthy Turkish children aged 7-17 years in 2007 (8).

WC is a marker for central body fat accumulation; a large WC is linked to an increased risk of metabolic complications (9). In this study, we aimed to evaluate whether the waist circumference may clinically be useful as a predictor of obesity/underweight in children or not.

Material and Methods

Subject selection: This descriptive and cross-sectional study was carried out between October 2007 and May 2008. The universe of this study constituted 2572 cases who were educated at the 6 primary and high schools in Konya. Konya Province which has more than 1.500.000 inhabitants is a leading industry and trade center in Turkey. Before beginning this research, ethical consideration was approved by the ethical committee of Meram Medical Faculty of Selcuk University. For this research, first approval was obtained from governorship and then second approval was obtained from National Education Administration. In the first step, 6 primary and high schools located in the center of Konya where the research was performed were selected by the cluster sampling method. In the second step, children and adolescents aged 7-18 years were selected randomly from school enrollments. Among these, students with growth retardation such as acondroplasia, pituitary gland dwarfism and students who refused to participate in this study and the ones who could not be found at school were excluded from the study. This research was started with the official permission and cooperation of the directors of the selected schools. All of the participants were all volunteers and healthy school children. Initially, we aimed to include 3000 children and adolescents in this research. In this study, 2572 participants has been reached (85.7%) (2572/3000). A standardized questionnaire was applied to determine the sociodemographic characteristics. The participants'names, surnames, the chronological ages, genders, grade and parents'education levels were recorded on this paper.

Measurements: The chronological age was calculated as the decimal age by subtracting the birth date from the observation date. Each year elapsed from their birthday was noted as one age (8). WC, height, weight, and hip were measured by a well- trained research assistant. WC was measured in the standing position at the level of the umbilicus (halfway between the lower border of the ribs, and the iliac crest in a horizontal plane) to the nearest 0.1 cm with a flexible anthropometrical tape. Hip was measured with a flexible anthropometrical tape by taking reference of the participant's hip circumference that passes through the middle of gluteal region transversely (the widest point over the buttocks). For each of waist and hip circumference, two measurements to the nearest 0.5 cm were recorded. Weight was measured after removal of shoes and with light clothes only by using a stadiometer and was recorded to the nearest 0.1 kg. Height was measured to the nearest 0.5 cm without shoes by using the Height Measuring Scale, and the cases stood still on the middle of the scale without leaning or holding on anything. While the height of a schoolchild is measured standing straight, without shoes, heels together, back against the wall and looking straight ahead. The research assistant put a ruler horizontally on top of her/his head to mark off the corresponding spot on the chart or measuring stick. All measurements were taken twice. If the variation between the measurements was greater than 2 cm, a third measurement was taken. The mean of the two closest measurements was calculated. Body mass index (BMI) was calculated as weight (kg)/(height $(m)^2$) (10).

Cole et al. defined the internationally acceptable criteria of childhood overweight and obesity. In that study, the resulting curves were averaged to provide

age- and sex-specific cut off points from 2-18 years. For each of the surveys, centile curves determined at the age of 18 years were widely used as cut off points of 25 and 30 kg/m^2 for adult overweight and obesity (4).

Bundak et al. reported data and curves for body mass index values in healthy Turkish children aged 6-18 years in 2006 in Turkey (6).

In children, we focused on the specific percentile of the WC according to age and gender. WC percentiles indicate the following: WC-for-age less than the 5th percentile means underweight, WC-for-age 5th to 85th percentile means the child is healthy weight (normal), WC-for-age 85th to 95th percentile means the child is overweight, WC-for-age greater than 95th percentile means the child is obese (11).

Ethical considerations: The study protocol was approved by the Ethics Committee of Meram Medical Faculty of Selcuk University and a written informed consent was taken from parents of all included subjects.

Statistical analysis: The SPSS 13.0 statistical software package was used in data entry and analysis. The statistical analysis and evaluations were conducted by the authors. The variables were described by mean, frequency and standard deviation (SD). To compare the statistical significance between groups, Chi-square and Student T tests were used. Statistical significance was defined as $p<0.05$.

Results

Of all 2572 students, 1381 (53.7%) were male, 1191 (46.3%) were female, mean age was 13.28±2.59 (min: 7, median: 13, max: 18), mean number of sibling was 2.41±1.44 (min: 0, median: 2, max: 10). When we evaluated the fathers' occupation, we found that 45.3% (n=1165) were tradesmen, 25.7% (n=660) civil servants, 20.7% (n=532) workers. For women, we found that 89.9% (n=2310) were housewives and 7.9% (n=203) were civil servants. We found that WC increased with age in both genders. The mean value of WC in boys at the age of 8, 10, 11, 15, 16, 17 and 18 was statistically greater than that of girls. The boys had usually higher WC values than the girls except for the age group of 12-14 years. The prevalence of obesity was 7.7% in 8-year-old female students and 5.3% in 9- and 14-year-old male students. The prevalence of overweight was 10.9% in 13-year-old female students and 11.6% in 8-year-old male students. The prevalence of underweight was 17.9% in 18-year-old female students and 20.0% in 7-year-old male students. Table I presents the means and standard deviations of WC according to age and sex of the participants. In this study, smoothed percentile values for the 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th and 97th percentiles were calculated for boys and girls separately by the authors. At the age of 18 years, BMI was used as cut off points of 25 and 30 kg/m^2 for adult overweight and obesity. Table II

Table I. Mean values of waist circumference (cm) according to age and sex

Ages*	Boys		Girls		Total	
	n	Mean (SD)	n	Mean (SD)	n	%
7	20	58.25 (8.55)	22	59.46 (4.39)	42	1.6
8	26	58.39 (5.22)	26	57.88 (5.17)	52	2.0
9	19	61.58 (7.29)	19	61.58 (7.29)	38	1.5
10	156	64.31 (8.10)	126	62.33 (7.32)	282	11.0
11	168	63.14 (8.19)	143	61.97 (6.02)	311	12.1
12	162	64.13 (7.16)	151	64.64 (8.01)	313	12.2
13	123	67.15 (8.51)	138	69.25 (9.07)	261	10.1
14	188	69.10 (8.27)	205	69.33 (8.39)	393	15.3
15	171	69.74 (6.83)	119	68.91 (7.28)	290	11.3
16	166	73.49 (7.79)	91	70.11 (8.27)	257	10.0
17	123	73.90 (7.91)	113	68.85 (6.79)	236	9.2
18	58	75.09 (7.92)	39	66.64 (6.69)	97	3.8
Total	1381		1191		2572	100.0

*: Age indicates the whole age group, e.g. 8.0 to 8.99 years

Table II. Waist circumference percentile values (cm) of study group for boys in the age groups of 7-17 years

Ages*	3rd	5rd	10rd	25rd	50rd	75rd	85rd	90rd	95rd	97rd
7	50.0	50.0	50.0	51.5	56.0	60.0	71.5	76.6	77.9	78.0
8	49.0	49.4	52.1	54.8	57.5	61.3	64.9	65.0	69.6	72.0
9	56.0	56.0	56.0	57.0	62.0	66.0	70.0	72.0	80.0	80.0
10	51.7	54.0	55.0	59.0	63.0	68.0	72.0	76.0	82.0	85.0
11	52.1	53.0	54.0	57.2	61.0	67.8	71.0	73.1	79.0	83.8
12	52.9	54.1	57.0	59.0	63.0	69.2	73.0	74.0	77.0	80.0
13	54.7	55.2	58.0	61.0	66.0	72.0	77.0	78.0	81.6	83.8
14	56.6	58.0	60.0	64.0	68.0	74.0	78.0	80.0	83.6	88.4
15	58.0	60.0	63.0	65.0	69.0	73.0	77.0	79.6	82.4	86.4
16	61.0	62.4	65.0	69.9	72.0	77.0	80.0	83.6	89.7	93.9
17	61.7	64.0	65.0	68.0	73.0	78.0	81.0	86.0	91.8	94.0

*: Age indicates the whole age group, e.g. 8.0 to 8.99 years

presents smoothed age-specific WC percentile values (cm) for boys at 7-17 years. Table III presents the smoothed age-specific WC percentile values (cm) for girls at 7-17 years. Table IV presents the differences of WC according to age and gender among children and adolescents. Table V presents the comparison of

Table III. Waist circumference percentile values (cm) of study group for girls in the age groups of 7-17 years

Age*	3rd	5rd	10rd	25rd	50rd	75rd	85rd	90rd	95rd	97rd
7	48.0	49.1	55.0	56.7	59.5	62.2	65.0	65.7	66.8	67.0
8	49.0	49.7	51.7	53.7	57.0	62.2	64.9	65.3	68.6	70.0
9	52.0	52.0	53.0	56.0	61.0	64.0	66.0	66.0	86.0	86.0
10	51.0	52.3	55.0	57.0	61.0	66.0	68.0	70.0	76.0	82.2
11	53.0	54.0	55.0	58.0	61.0	65.0	68.0	69.6	72.8	76.0
12	53.0	54.0	56.0	59.0	63.0	69.0	73.0	75.0	81.0	83.3
13	56.0	56.9	58.0	62.0	68.0	74.0	79.0	85.0	88.0	88.8
14	57.0	58.0	60.0	64.0	68.0	73.5	77.1	81.0	86.0	89.6
15	59.0	60.0	61.0	64.0	68.0	72.0	76.0	78.0	81.0	87.0
16	60.7	61.0	62.0	64.0	68.0	73.0	78.0	80.0	88.0	93.7
17	60.0	61.0	63.0	65.0	68.0	72.0	74.0	76.0	78.3	79.5

*: Age indicates the whole age group, e.g. 8.0 to 8.99 years

Table IV. The differences of waist circumference (cm) according to gender in the age subgroups

*Age**	*Gender*						*Total (n=2572)*	*p***
	Male (n=1380)			*Female (n=1192)*				
	n	*Mean*	*SD*	*n*	*Mean*	*SD*		
7	20	58.25	8.55	22	59.46	4.39	42	0.576
8	26	58.39	5.22	26	57.88	5.17	52	0.730
9	19	61.58	7.29	19	61.58	7.29	38	0.512
10	156	64.31	8.10	126	62.33	7.32	282	0.032
11	168	63.14	8.19	143	61.97	6.02	311	0.146
12	162	64.13	7.16	151	64.64	8.01	313	0.552
13	123	67.15	8.51	138	69.25	9.07	261	0.054
14	188	69.10	8.27	205	69.33	8.39	393	0.789
15	171	69.74	6.83	119	68.91	7.28	290	0.325
16	166	73.49	7.79	91	70.11	8.27	257	0.002
17	123	73.90	7.91	113	68.85	6.79	236	0.000

*: Age indicates the whole age group, e.g. 8.0 to 8.99 years
**: Means were compared with Student's t test

Table V. The comparison of body mass index according to gender in the age subgroups

*Age**	*Gender*						*Total (n=2572)*	*p***
	Male (n=1380)			*Female (n=1192)*				
	n	*Mean*	*SD*	*n*	*Mean*	*SD*		
7	20	17.28	2.96	22	17.18	2.16	42	0.897
8	26	16.39	2.12	26	16.30	1.84	52	0.866
9	19	17.13	2.35	19	17.00	2.44	38	0.864
10	156	17.93	3.50	126	17.40	2.69	282	0.153
11	168	18.31	3.25	143	17.82	2.49	311	0.130
12	162	18.49	2.87	151	18.66	2.87	313	0.587
13	123	19.88	5.38	138	19.68	3.09	261	0.723
14	188	19.54	3.18	205	20.04	3.14	393	0.119
15	171	19.49	3.01	119	19.91	2.83	290	0.223
16	166	20.82	2.96	91	20.75	3.35	257	0.877
17	123	20.95	2.99	113	20.63	3.38	236	0.450

*: Age indicates the whole age group, e.g. 8.0 to 8.99 years
**: Means were compared with Student's t test

BMI according to age and gender among children and adolescents. Table VI and VII present the weight classifications based on an age- and sex-specific percentiles for Turkish boys and girls at 7-17 years.

Discussion

In this study, the mean values of WC by age and sex, smoothed age-specific WC percentile values (cm) for Turkish children aged 7–18 years, the differences of WC between age and gender, the comparison of BMI according to age and gender were presented. The weight classifications based on an age- and sex-specific percentile were computed. In our study, we found that the mean values of WC were more frequently higher in males than females. Particularly, there were statistically significant differences between females and males at the age of 8, 10, 11, 15, 16, 17 and 18. Overweight in childhood and adolescence is an important public health issue because of its rapidly increasing prevalence and associated adverse medical and social consequences. Recent studies have estimated that 15 percent of children in the United States are at risk of overweight. Important predictors of overweight include age, sex, race/ethnicity, and parental weight status (12). Chinn and Rona reported that from 1984 to 1994 overweight increased from 5.4% to 9.0% in English boys (increase 3.6%, 95% confidence interval 2.3% to 5.0%) and from 6.4% to 10.0% in Scottish boys (3.6%, 1.9% to 5.4%) (13). These rising trends are likely to be reflected in increases in adult obesity and associated morbidity. Overweight in children is a serious public health problem in Britain (13). In another study, WC in British youth has increased over the past 10-20 years at a greater rate than BMI, the increase being greatest in females (9). In our study, increasing obesity/overweight prevalence among children has

Table VI. Weight classifications based on an age-specific waist circumference percentile values (cm) in the male cases

Age	Underweight			Healthy weight (Normal)			Overweight			Obese		
	Range	n	%	Range	n	%	Range	n	%	Range	n	%
7	<50.00	4	20.00	50.00-71.49	13	65.0	71.50-77.95	2	10.0	>77.95	1	5.0
8	<49.40	1	3.8	49.40-64.90	21	80.8	64.90-69.60	3	11.6	>69.60	1	3.8
9	<56.00	2	10.5	56.00-70.00	15	78.9	70.00-80.00	1	5.3	>80.00	1	5.3
10	<54.00	9	5.8	54.00-72.00	125	80.1	72.00-82.00	16	10.3	>82.00	6	3.8
11	<53.00	11	6.5	53.00-71.00	136	81.0	71.00-79.00	14	8.3	>79.00	7	4.2
12	<54.10	8	4.9	54.10-73.00	134	82.7	73.00-77.00	14	8.6	>77.00	6	3.8
13	<55.20	6	4.9	55.20-77.00	101	82.1	77.00-81.60	10	8.1	>81.60	6	4.9
14	<58.00	11	5.9	58.00-78.00	153	81.4	78.00-83.60	14	7.4	>83.60	10	5.3
15	<60.00	9	5.3	60.00-77.00	138	80.7	77.00-82.40	16	9.3	>82.40	8	4.7
16	<62.40	8	4.8	62.40-80.00	134	80.7	80.00-89.70	16	9.6	>89.70	8	4.9
17	<64.00	7	5.7	64.00-81.00	100	81.3	81.00-91.80	10	8.1	>91.80	6	4.9

Table VII. Weight classifications based on an age-specific waist circumference percentile values (cm) in the female cases

Age	Underweight			Healthy weight (Normal)			Overweight			Obese		
	Range	n	%	Range	n	%	Range	n	%	Range	n	%
7	<49.05	1	4.50	49.05-65.00	19	86.5	65.01-66.85	1	4.5	>66.85	1	4.5
8	<49.70	1	3.8	49.70-64.90	21	80.0	64.90-68.60	2	7.7	>65.30	2	7.7
9	<52.00	---	---	52.00-66.00	17	89.5	66.00-86.01	1	5.3	>66.01	1	5.3
10	<52.30	6	4.8	52.30-68.00	104	82.5	68.00-76.00	11	8.7	>76.00	5	4.0
11	<54.00	10	7.0	54.00-68.00	113	79.0	68.00-72.80	13	9.1	>72.80	7	4.9
12	<54.00	8	5.3	54.00-73.00	122	80.8	73.00-81.00	16	10.6	>81.00	5	3.3
13	<56.90	6	4.3	56.90-79.00	113	81.9	79.00-88.00	15	10.9	>88.00	4	2.9
14	<58.00	11	5.4	58.00-77.10	164	80.0	77.10-86.00	21	10.2	>86.00	9	4.4
15	<60.00	9	7.6	60.00-76.00	97	81.5	76.00-81.00	8	6.7	>81.00	5	4.2
16	<61.00	7	7.7	61.00-78.00	73	80.2	78.00-88.00	8	8.8	>88.00	3	3.3
17	<61.00	6	5.3	61.00-74.00	94	83.2	74.00-78.30	8	7.1	>78.30	5	4.4

been determined. This can be attributed to social, economical and traditional customs in this province.

McCarthy and Ashwell have reported that the values of the waist: height ratios (WHtR) during the past 10-20 years have increased greatly showing that central fatness in children has risen dramatically (14). WHtR is more closely linked to childhood morbidity than body mass index (BMI) and they suggest it should be used as an additional or alternative measure to BMI in children as well as adults. Consequently, they declared a simple public health message that is the same for adults and children of both sexes and all ages could be stated as "keep your waist circumference to less than half your height" (14). This slogan might be the starting point of reducing the spread rate of obesity together with the protective measures.

Savva et al. also reported that visceral adipose tissue was associated with increased risk for cardiovascular disease risk factors and morbidity from cardiovascular diseases (15). They used the waist measurement and WHtR as proxy measures of visceral adipose tissue. In their study, they validated the BMI, WC and WHtR as predictors for the presence of cardiovascular disease risk factors in children of Greek-Cypriot origin. Consequently, they have declared that waist circumference and WHtR are better predictors of cardiovascular disease risk factors in children than BMI (15). While BMI according to age and sex was different at the age of 18, WC differences for age and sex at the ages of 8, 10, 11, 15, 16, 17 and 18 were more important in our study.

Moreno et al. presented that WC showed higher values in boys than in girls, especially after 11.5 y, and waist values increased with age both in 1360 males and females Spanish children (16). WC tended to be higher in males than females and this difference was significant after 11.5 y. In general, hip circumference was higher in females than in males (statistically significant differences at 7.5, 10.5, 12.5 and 13.5 y). These findings justify the use of age and gender specific reference standards (16). Generally, the mean WC values in our study were higher in males than females. Especially it was statistically greater in males than females at the ages of 10, 16, 17 and 18. As a result, young female adolescents seem to tend to be thinner to have an aesthetic look.

Katzmarzyk presented the age- and sex-specific WC reference data for 3064 Canadian youth 11-18 y of age. WC increased with age in both boys and girls, and boys had higher values of WC than girls at every age and percentile level. In conclusion, these reference data can be used to identify those who have an elevated risk of developing obesity-related disorders and can serve as a baseline for future studies of temporal trends in WC (17). In our study, WC values of males were generally higher than those of females, and they were in the tendency of increasing with age.

In another study, overweight was a serious health concern for children and adolescents. Recently redefined BMI classifications are not appropriate for children, because BMI shows profound changes from birth through to early adulthood. WC seems to be the best predictor of children with the metabolic syndrome in pediatric clinical settings (18). Pouliot et al. have presented that central obesity is associated with a statistically higher risk of heart disease, hypertension, dyslipidemia, insulin resistance, and diabetes mellitus type 2 (3). We emphasize in our study that WC is an important predictor of obesity during the childhood.

Eisenmann has presented that mean WC increases in both males and females, with the values being similar between Australian males and females prior to age 11 y, after which values are slightly higher in males (19). In our study, WC values increased with age in both sexes. The mean value of WC in boys at the age of 10, 16, 17 and 18 was statistically greater than girls.

Garnett et al. have reported that BMI may not indicate the level of central adiposity associated with the clustering of cardiovascular disease (CVD) risk factors. Hence, it has been recommended that waist circumference be used as an alternative measure (20). In our study, BMI was statistically greater in boys than girls in 18 age group ($p=0.037$).

Taheri et al. presented that the prevalence rates of overweight and obesity were 4.8% and 1.8% in 7- to 18-year-old children in Iran, respectively. These rates are lower than our results (21).

The study of Hatipoğlu et al. from Kayseri is important as it can be a reference to other studies. These data can be added to the existing international reference values for WC of children and adolescents (8). Obesity prevalence among children is an important public health problem (22,23). In this study, we aimed to evaluate whether the WC may clinically be useful as a predictor of obesity/underweight in children or not.

The limitations of our study should be considered. Although the overall sample was relatively large, we reached a small group. In addition, although a quite close match, this study group is not entirely representative of the Turkish population. The study includes only the province of Konya. It should not be disregarded the possibility of the side effects of nutrition habits of Central Anatolia Region on the results since the main nutrition of the region is based on cereals. Smoothed percentile values for the 3rd, 5th, 10th, 25th, 50th, 75th, 85th, 90th, 95th and 97th percen-

tiles were calculated for boys and girls separately (23). In conclusion, WC values increased with age in both sexes in our study. The mean value of WC in boys at the ages of 8, 10, 11, 15, 16, 17 and 18 was statistically greater than girls. Current and future morbidity in Turkish youth may be seriously affected due to accumulation of excess central fat. We emphasize in our study that WC is an important predictor of obesity during the childhood. We expect that our study will contribute to Turkish literature for age and sex-specific reference values for WC. These findings deserve further prospective study and highlight the importance of early recognition and improved treatment models for children and adolescents with overweight and obese.

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