

The Relationship between Neck Circumference and Obesity in Children and Adolescents

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Abstract—Aims: This study was planned to determine the relationship between neck circumference and obesity in children and adolescents. **Method:** The study sample consisted of 868 volunteer children and adolescents, 386 boys and 482 girls aged between 9-17 years. The data were collected by using face to face interviews by way of a questionnaire, then the measurements of body weight, height and neck circumference taken by dietitians. Body Mass Index (BMI) was calculated and percentile classifications were made according to World Health Organization (WHO) reference values. The statistical analyses were performed with SPSS version 23.0 for Windows. **Results:** The average age of the children and adolescents participating in the study was 14.2 ± 1.9 years. It was found that the 28.9% of students were overweight or obese ($p=0.008$). Girls were significantly more overweight or obese than boys ($p=0.004$). Correlations between neck circumference and BMI percentiles were found to be positively correlated in all age groups included in the study ($r=0.627$, $p=0.000$). **Conclusions:** Neck circumference may be used for determining obesity in children and adolescents. It is also cost-effective and practical for large populations. More studies are needed in order to measure of neck circumference to be more effective we need to work more on a larger sample of the population.

Index Terms—Neck circumference, BMI, children, adolescents

I. INTRODUCTION

The prevalence of obesity in children has increased in all countries including Turkey and is associated with risk factors for cardiovascular and metabolic disorders, which, due to their chronic and insidious nature, require for careful monitoring in childhood, aimed at early detection and the establishment of interventions to prevent complications in adulthood [1].

It is thought that adulthood obesity may begin in childhood. Proportion of mild obesity is determined as 14.3% (BMI = 85-95 percentile) and obesity rate is 6.5% (BMI > 95) according to School-Age Children Growth Monitoring (TOCBI) project of 6-10 age group in Turkey. The results of TOCBI show that one in five children is at risk for overweight related illnesses. As reported by Turkey Childhood (Ages 7-8) Obesity Surveillance Initiative, prevalence of obesity (including overweight) in

girls and boys were found 21.6% and 23.3%, respectively [2], [3].

Different anthropometric measurements are commonly used worldwide in order to determine obesity or central obesity. These are BMI, Waist Circumference (WC) and waist-to-hip ratio (W/H). BMI is a valuable measurement of overall obesity. WC is used for defining central obesity besides indicator of the existence abdominal visceral fat [4]. It is also one of the diagnostic criteria of metabolic syndrome [5], [6]. WC measurement has certain limitations such as unclothing and the convenience of ambient temperature. It may vary throughout the day because of fasting – satiety status and health problems which can affect the abdominal wall, e.g. abdominal visceral fat and dyspepsia [7].

In recent years, Neck Circumference (NC), which is an easy and time-saving anthropometric measurement, has been defined to show central obesity [8]. In community-based studies, it has been demonstrated that there is a positive correlation between NC and metabolic risk factors such as insulin resistance and visceral adipose tissue. It is also a determinant for the cardiometabolic syndrome [9]. In addition, the correlation between central obesity and NC has also been stated in different ethnic groups, diabetics and children [10]-[12]. A correlation between NC and metabolic abnormalities has been indicated by Atabek *et al.* [13] in obese Turkish children and by Onat *et al.* [14] in Turkish adults in all age groups.

II. METHODS

A. Subjects

This study sample was included 868 children and adolescent voluntarily. 386 boys (44.5%) and 482 girls (55.5%) aged 9-17 years old were recruited. They were studying at secondary or high school in Ankara, Turkey. The data were collected by using face to face interviews by way of a questionnaire. NC, body weight and height were measured by trained research assistants being dietitians. People with severe disabilities or any lack of limb were excluded. Written informed consent was obtained from all participants.

B. Anthropometric Measurements

Researchers took all anthropometric measurements. Measurement of body height and NC were made with an inelastic tape calibrated weekly. Height was determined

to the nearest 0.1 cm with the subject standing upright, being barefoot and head held in Frankfurt plane. NC was measured in the midway of the neck between mid-cervical spine and mid-anterior neck to within 0.1 cm while the subject was standing upright, with the face directed toward, and shoulders relaxed. Body weight was measured to 0.1 kg using a calibrated electronic weighing scale (Fakir Nigro, Germany) without shoes and with light clothing. BMI of the subjects was calculated as weight divided by height squared (kg/m^2). According to the WHO growth reference for 5-19 years, subjects with a BMI <85th percentile were stratified as having normal weight, whereas subjects with BMI >85 percentile were stratified as being overweight/obese. Ages of subjects were classified into 3 groups (9-11, 12-14 and 15-17 years old).

C. Statistical Analysis

All statistical analyses were carried out using Statistical Package for Social Sciences (SPSS, Windows version 23.0, Chicago, IL, USA). Means \pm standard deviations of BMI percentiles were compared along age groups. Pearson's chi-square tests were used to analyze relationships between BMI percentile and other variables, such as genders and age groups. The differences between obesity and genders were examined using Mann-Whitney

U test and Student's T-test. Spearman's rank-order correlation coefficients were calculated comparing the NC and BMI percentiles of participants. A value of $p < 0.05$ was considered significant.

III. RESULTS

The study sample consisted of 386 (44.5%) boys and 482 (55.5%) girls with a mean age of 14.2 ± 1.9 years. According to BMI percentile, the 27.8% of children and adolescent were overweight or obese (BMI > 85 percentile).

In the three age subgroups in boys (9-11, 12-14 and 15-17), the average of BMI was calculated 19.0 ± 4.0 kg/m^2 , 21.3 ± 3.9 kg/m^2 and 22.3 ± 4.1 kg/m^2 , respectively and in girls 17.9 ± 2.8 kg/m^2 , 21.5 ± 3.7 kg/m^2 and 22.0 ± 3.8 kg/m^2 , respectively. There were significant differences between genders with respect to BMI ($p = 0.000$).

Table I shows the mean and standard deviations of age, height, weight, neck circumference and BMI of participants according to age groups and genders.

In study of Atef *et al.*, NC averages for boys and girls (7 to 12 years) were found 32.9 ± 1.63 and 33.87 ± 1.47 cm, respectively [15].

TABLE I. DESCRIPTIVE STATISTICS FOR AGE, HEIGHT, WEIGHT, BMI AND NECK CIRCUMFERENCES OF PARTICIPANTS

Ages (y)		Neck Circumference (cm)	BMI* (kg/cm^2)	Weight (kg)	Height (cm)	Age (year)
		$\bar{x} \pm \text{SD}$	$\bar{x} \pm \text{SD}$	$\bar{x} \pm \text{SD}$	$\bar{x} \pm \text{SD}$	$\bar{x} \pm \text{SD}$
Boys	9-11	29.99 \pm 2.77	19.03 \pm 4.02	41.07 \pm 11.76	145.76 \pm 6.44	11.06 \pm 0.51
	12-14	35.59 \pm 2.77	21.30 \pm 3.95	59.83 \pm 14.03	166.97 \pm 9.96	14.02 \pm 0.83
	15-17	35.89 \pm 2.74	22.38 \pm 4.15	69.09 \pm 13.16	175.67 \pm 5.96	16.48 \pm 0.50
Girls	9-11	28.96 \pm 1.83	17.99 \pm 2.83	38.69 \pm 8.76	146.18 \pm 7.89	11.04 \pm 0.75
	12-14	31.40 \pm 1.98	21.56 \pm 3.75	56.09 \pm 11.02	161.07 \pm 6.41	14.12 \pm 0.75
	15-17	31.70 \pm 1.99	22.01 \pm 3.84	57.92 \pm 11.24	162.05 \pm 6.06	16.47 \pm 0.51

TABLE II. THE RELATIONSHIP AMONG GENDERS, AGE GROUPS AND BMI PERCENTILES OF STUDENTS

		BMI Percentile				Total (n=868)	
Gender		Normal Weight / Underweight (n=591)		Overweight / Obese (n=242)			
	Ages (y)	n	%	n	%	n	%
Boys	9-11	40	62.5	24	37.5	64	100.0
	12-14	140	62.5	84	37.5	224	100.0
	15-17	75	76.5	23	23.5	98	100.0
Girls	9-11	60	75	20	25	80	100.0
	12-14	185	72.3	71	27.5	256	100.0
	15-17	117	80.1	29	19.9	146	100.0
<div><div>$\chi^2= 8.156 *$</div><div>$p=0.004*$</div></div> <div><div>$\chi^2= 9.714**$</div><div>$p=0.008**$</div></div>							

*Between genders and BMI Percentiles

**Between Age Groups and BMI Percentiles

In this study, subjects with BMI >85 percentile were stratified as being overweight / obese while subjects with a BMI \leq 85th percentile were stratified as having normal

weight. A significant association was found using the χ^2 test between BMI and genders ($\chi^2 = 8.156$; $p = 0.004$) (Table II).

TABLE III. THE RELATIONSHIP BETWEEN OBESITY AND NECK CIRCUMFERENCES

Gender	Ages (y)	Neck Circumference		<i>p</i>
		Normal Weight (cm) $\bar{x} \pm SD$	Overweight (cm) $\bar{x} \pm SD$	
Boys	9-11	28.4 \pm 1.6	32.4 \pm 2.5	0.000*
	12-14	32.7 \pm 2.2	35.1 \pm 2.9	0.000*
	15-17	34.9 \pm 2.0	38.8 \pm 2.7	0.000 ⁺
Girls	9-11	28.3 \pm 1.4	30.8 \pm 1.6	0.000*
	12-14	30.7 \pm 1.6	33.2 \pm 1.7	0.000*
	15-17	31.1 \pm 1.6	34.0 \pm 1.8	0.000*

*Mann Whitney-U Test

⁺Student t-Test

Table III shows the mean and standard deviations of NC values of students according to age groups, genders and BMI percentile. There was a significant difference among neck circumferences for all age groups and genders.

In both gender, for all age groups NC correlated positively with BMI percentile. Table IV shows the correlation for both age and genders.

TABLE IV. CORRELATION BETWEEN NECK CIRCUMFERENCE AND BMI PERCENTILES OF PARTICIPANTS

Ages (y)		<i>r</i>	<i>p</i> -value
Boys	9-11	0.703	0.000
	12-14	0.420	0.000
	15-17	0.595	0.000
Girls	9-11	0.618	0.000
	12-14	0.562	0.000
	15-17	0.580	0.000

This study aimed to find out whether NC was a valid parameter for determinate obesity or not. BMI is indicator of general obesity, and is an important first step in determining the level of obesity. The results show a strong positive correlation of NC with BMI in students both boys and girls. In a study involving 50 healthy weight and 50 obese children, NC of obese children was significantly higher than healthy children for genders. ($p=0.000$) [15].

Neck circumference is a useful screening tool of cardiovascular risk in children. A study in Brazil, statistically significant relationship was founded between insulin resistance and neck circumferences for both boys and girls ($p=0.01$ and $p<0.001$, respectively) [16]. A research of relationship between cardiovascular risk and NC in children (9 to 13 years) showed a significant association between NC and some cholesterol types such as HDL and LDL [17].

IV. CONCLUSIONS

This study aimed to figure out relationship between obesity and NC in children and adolescents. BMI was used for determinate obesity in this study. It was founded that high significant between NC and BMI for both genders. This study consists of 868 children and adolescents. NC may be used for large population because it's a simple technique and cost-effective. More studies are needed in order to measure of NC to be more effective. A larger sample of the population's studies are required.

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