

Appropriate Neck Circumference Cut-Off Points for Overweight and Central Obesity In Turkish University Students

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Summary. *Background:* NC is an easier and faster anthropometric measurement and has been demonstrated that there is strong correlation between NC and WC. *Material and Methods:* In addition to our preliminary study we have demonstrated that; the NC has strong correlation with overweight and central obesity. In this step of the preliminary study, we investigated to evaluate the correlation of the neck circumference with BMI, WC, W/H ratio and to establish cut off values of the NC for prediction of overweight and central obesity in larger population. *Results:* The prevalence of overweight was 17.1%. An NC of >37 cm for men and >32.5 cm for women was the best cut off point for determining subjects with overweight (P<0.001). The AUC was 0.918 for men and 0.907 for women. The prevalence of abdominal obesity was 15.1%. NC of >38.5 cm for men and >33.5cm for women was the best cut-off point for determining subjects with obese (P<0.001). *Conclusions:* NC >37 cm for men and >32.5 cm for women was the best cut-off point to determine subjects with overweight and a NC >38.5 cm for men and >33.5cm for women was the best cut-off point to determine subjects with central obesity.

Key words: Neck circumference, Waist circumference, Central Obesity, Overweight, Cut-off

Introduction

Obesity and metabolic syndrome are a public health problem in developed and developing countries. In general, weight gain or fat accumulation in certain areas of the body can cause serious illness and cause an increase in cardiovascular mortality and morbidity (1). Also Turkey is a country in which the obesity problem gradually increases and the mean age at which it is seen gradually decreases. According to the Turkish Diabetes Epidemiology Study (TURDEP) 2011 data, prevalence of obesity is 31.2% and during the 12 years, it has increased by 34 % (from 32.9 to 44.2) in women and by 107% (from 13.2 to 27.3) in men (2).

Different anthropometric measurements are commonly used worldwide in order to determine obesity and

central obesity. These are the body mass index (BMI), waist circumference (WC), waist-to-hip ratio (W/H) and in the recent years, neck circumference (NC) (3).

NC is an easier and faster anthropometric measurement and has been demonstrated that there is strong correlation between NC and WC and that it may be used as an indicator of central obesity (4).

The correlation between central obesity and NC has been demonstrated in different ethnic group, diabetics and children (5-9). A correlation between NC and metabolic abnormalities has been demonstrated by Kondolot et al (8) in obese Turkish children and by Onat et al (5) in Turkish adults in all age groups.

In addition in our preliminary study we have demonstrated in 1157 (838 females, 319 males) university students that; the NC has strong correlation

with overweight and central obesity (10). In this step of the preliminary study, we investigated to evaluate the correlation of the neck circumference with BMI, WC, W/H ratio and to establish cut off values of the NC for prediction of overweight and central obesity in larger population of young male and female (18-25 years of age) Turkish university students.

Subjects and Methods

This study approved by Kırklareli University Review Board. A total of 3290 students aged 18-25 years were included in the study. They were studying at Kırklareli University. The subjects were selected by “random”. The sampling was made by choosing even-numbered students. The even-numbered students among those students, who were attending the school during the 30 days period of the measurements, were chosen. This study complied with the Declaration of Helsinki (11) and written informed consent was obtained from all participants. Past medical history was determined with a standardized questionnaire. Anthropometric measurements such as height, weight, waist circumference, hip circumference and neck circumference, have been made.

Those not agreed to participate in the study (n:390 men, n:228 women), those with thyroid disease (n=169), those with metabolic disorder except for obesity (n=211), pregnant (n=2), lactating women (n=3), those on medication for any reason (n=210), body builders or professional/amateur athletes (n=10) and physically handicapped students (n=13) were excluded from the study. As a result 2562 (1807 females, 755 males) of students were examined.

The measurements have been obtained in light clothes, in a fasting, standing, without shoes, bare feet condition and at the end of expiration. Weight was measured using digital scale to the nearest 0.1 kg with only undergarments, and height was determined using a portable stadiometer to within 1 mm in bare feet. Waist circumference was taken horizontally to the nearest 1 mm, using plastic tape measure at midpoint between the costal margin and iliac crest in the mid-axillary line. Hip circumference was measured at the level of greater trochanters with the legs

close together (12). Neck circumference was measured in the midway of the neck, between mid cervical spine and mid anterior neck, to within 0,5 mm, with non stretchable plastic tape. In men with a laryngeal prominence (Adam’s apple), it was measured just below the prominence. While taking this parameter the subject was asked to look straight ahead, with shoulders down, but not hunched. Body mass index (BMI) was calculated as weight (kilogramme) divided by the square of height (meter). Waist to hip ratio (W/H) was calculated as waist circumference divided by the hip circumference.

Overweight was defined as ≥ 25 kg/m² and central obesity was defined as waist circumference ≥ 94 cm (men) and ≥ 80 cm (women) (13)

Statistical Analysis

Descriptive parameters were shown as estimated mean \pm , standard deviation, or in percentages. Two-sided t-tests and Pearson’s chisquare tests were used to analyze the differences between means and proportions of groups. Likelihood estimates (OR) and 95% confidence intervals (CI) were obtained by use of logistic regression analyses in models. Receiver operating characteristics (ROC) curve analysis were performed. The Youden index, defined as “sensitivity + specificity -1”, was used to determine the optimal cut off points. A value of $P < 0.05$ was considered statistically significant. Statistical analyses were performed using SPSS-20 for Windows

Results

The sample group consisted of persons aged 18–24 years, with a weight of 40–132 kg, BMI varying between 15.3–49.5 kg/m², The 256² subjects had a mean BMI of 23.6 \pm 6.2 (men: 27.1 \pm 6.0, women: 22.1 \pm 5.6) a mean WC of 81.0 \pm 19.1 (men: 94.9 \pm 18.5, women: 75.1 \pm 14.4) a mean HC of 99.3 \pm 12.6 (men: 106.7 \pm 12.8, women: 96.1 \pm 11.1), and a mean NC of 32.2 \pm 4.2 (men: 35.9 \pm 4.6, women: 30.6 \pm 2.6). All anthropometric measurements were significantly higher in men compared to women ($p < 0.001$). The prevalence

of overweight (BMI ≥ 25 kg/m²) was 16.1% for men and 17.9% for women. The prevalence of central obesity was 13.7% for men and 15.8% for women.

The correlation between the neck circumference and the other anthropometric measurements by gender is shown in Table 1. In male subjects, NC revealed a positive correlation with BMI ($r=0.617$, $p<0.01$), WC ($r=0.588$, $p<0.01$) and W/H ratio ($r=0.437$, $p<0.01$). Similarly, in female subjects NC revealed a positive correlation with BMI ($r=0.611$, $p<0.01$), WC ($r=0.635$, $p<0.01$) and W/H ratio ($r=0.309$, $p<0.01$).

The ROC curves are presented in Figure 1 and 2 for overweight students.. All the AUCs for NC were statistically significant ($p<0.001$). The prevalence of overweight was 17.1%. An NC of >37 cm for men and >32.5 cm for women was the best cut off point for determining subjects with overweight ($P<0.001$) (table 2). The AUC was 0.918 for men and 0.907 for women.

The ROC curves are presented in Figure 3 and 4 for abdominal obese students. All the AUCs for NC were statistically significant ($p<0.001$). The prevalence of abdominal obesity was 15.1%. An NC of >38.5 cm for men and >33.5 cm for women was the best cut off point for determining subjects with obese ($P<0.001$)(table 2). The AUC was 0.938 for men and 0.952 for women.

After the logistic regression analysis, considering the overweight as the dependent variable and NC as the independent variable, the results showed that the relationship between NC and overweight was statistically significant (odds ratio 1.63 (95% CI 1.57-1.7; $P<0.001$).

Table 1. Relationship between NC and other anthropometric variables by gender

Variables	Men (n=755) r	Women (n=1807) r
BMI (kg/m ²)	0.617*	0.611*
Waist circumference (cm)	0.588*	0.635*
Hip circumference (cm)	0.565*	0.583*
Waist/Hip ratio	0.437*	0.309*

* Correlation is significant at the 0.01 level.

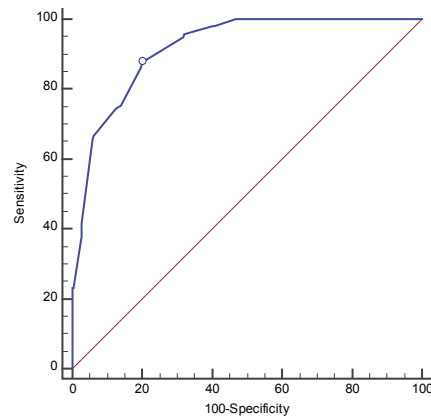


Figure 1. Receiver operating characteristic curves related to overweight and neck circumference in men

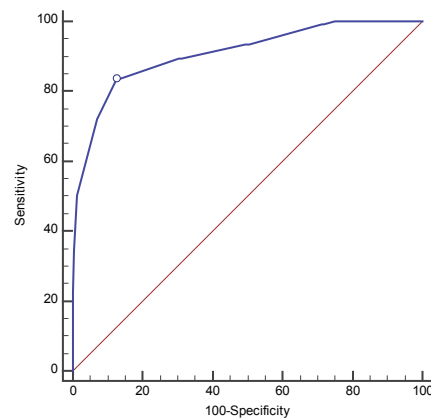


Figure 2. Receiver operating characteristic curves related to overweight and neck circumference in women

Discussion

This study among Turkish university students showed that an NC >37 cm for men and >32.5 cm for women was the best cut off point to determine subjects with overweight and a NC >38.5 cm for men and >33.5 cm for women was the best cut off point to determine subjects with central obesity.

In studies performed on different groups of age in different communities, different NC cut off levels were defined for overweight persons (14-17)

According to a survey by 21-55 years old in Egypt, NC ≥ 38 cm for males and ≥ 36 cm for men

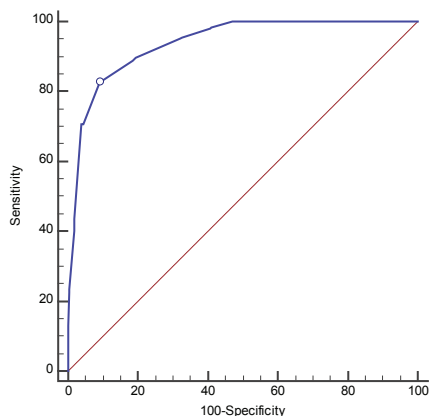


Figure 3. Receiver operating characteristic curves related to obesity and neck circumference in men

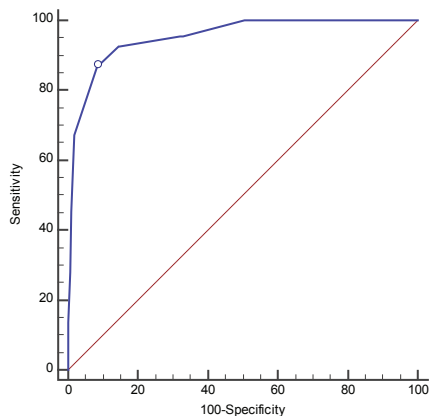


Figure 4. Receiver operating characteristic curves related to obesity and neck circumference in women

were found the best cut-off points(14) . Yang G et al. (15) determined the NC cut off values for overweight non diabetic Chinese (20-80 years old) as ≥ 38 cm for men and ≥ 35 cm for women . Similarly, according to Noun et al (16); NC ≥ 37 cm for man and NC, ≥ 34 cm for woman are considered overweight cut off points. Our study resulted with > 37 cm for man and > 32.5 cm for woman cut off points.

In a over 30 years old community-based cross-sectional study by Aswathappa et al (18) was conducted in 700 subjects, which included age-matched 350 type 2 diabetics and 350 non-diabetics, the best cut off value to determine subjects with central obesity was found NC >36 cm for diabetics and >37 cm for non-diabetics. And ≥ 38.5 cm for men and ≥ 34.5 cm for women cut of points has been established by Wang et al (19) in 3307 adults aged 20-65. Yang G et al. (15) determined the NC cut off values for central obesity in 20-80 years old non diabetic Chinese as >37 cm for men and >34 cm for women.

Onat et al (5) found that the NC cutoff value for central obesity was ≥ 38.5 cm for men and ≥ 34.5 cm for woman in 1912 men and women by in a total age of 55.1 ± 12 . Our data are similar or slightly below than other studies in adult male cut off points (14-19). However, our female NC cut off values are lower than other studies which performed on adults. This might be related to our low average age or nation.

Lower cut off values were found in lower age groups. Lou et al (20) researched in 2847 Han children aged 7-12 years and found NC was significantly correlated with age and NC cut-off values for elevated BMI were between 27.4-31.3 cm in boys and 26.3-31.4 cm in girls. The CASPIAN-IV (21) study was investigated in 23043 students, who were 7-18 years old. According to CASPIAN-IV study cut off points were between 26.4-36.1 cm for boys and 25.9-32.2 cm for girls and NC was significantly correlated with age.

Qureshi et al (22) performed a study, conducted among Bangladeshi national participants, and suggested that men with NC ≥ 34.75 cm and women with NC ≥ 31.75 cm are to be considered overweight while men with NC ≥ 35.25 cm and women with NC ≥ 34.25 cm are to be considered obese. NC ≥ 35.25 cm in male and NC ≥ 31.25 cm in women were the best cutoff value for abdominal obesity. According to Thai People study NC of 33 cm in women and 39 cm in men are

Table 2. Cut off values for determining the overweight and centrally obese students according to ROC analysis

	Men					Women				
	Cut off	Sensitivity	(95% CI)	Specificity	(95% CI)	Cut off	Sensitivity	(95% CI)	Specificity	(95% CI)
Overweight	>37	87.84	83.2-91.6	79.96	76.2-83.4	>32.5	83.43	77.0-88.7	87.40	85.7-89.0
Central obesity	>38.5	82.54	77.3-87.0	91.04	88.2-93.4	>33.5	87.27	79.6-92.9	91.51	90.1-92.8

recommended as the optimal cutoff points to indicate abdominal obesity (23). By Monadal et al (24) the cut-offs of NC were observed to be 36.0 cm and 38.0 cm (in males) and 30.9 cm and 33.0 cm (in females) for Asian Indian adults with BMI ≥ 25.00 kg m⁻² and BMI 30 kg m², respectively.

This results showed that the NC cutoff value for overweight and central obesity are variable by age and nation and in males and females

In 2017 a systematic review and meta-analysis performed with 38 assesment in 11 articles according to age, sex and weight status. Using sensitivity and specificity, 27 assessments (71.0%) considered NC an accurate measure to diagnose overweight and obesity. The best sensitivity and specificity were found for the age >19 years (82.0%, 82.0%), female (80.0%, 73.0%), and obese (80.0%, 85.0%) categories. It is also believed that more studies will permit the creation of a reference dataset of NC cut-off values for differrent conditions and world populations. (25)

WC is quite useful measurement for determining central obesity. However, WC measurement may be affected by cultural and environmental factors. The room temperature, clothes worn, sociocultural and religious hindrances for undressing may prevent the performance of an accurate measurement. Besides, dyspepsia may also cause the measurement to result wrongly high. (26)

NC is a good indicator for metabolic health status to. Even by He et al (27) neck circumference might be a viable tool to screen for gestational diabetes mellitus and for pregnant Han Chinese women, a neck circumference of ≥ 35.15 cm was a predictor of gestational diabetes mellitus.

Although this study quite informative, it has certain limitations. First of all, this study was just performed in one centre and they have not the same socioeconomic status, food access or physical activity neither in their region nor outside regions young adult population. Therefore, it may not reflect the entire population. Secondly, it may not represent other communities and ethnic groups since it was exclusively performed on Turks. Thirdly, evaluation of NC based on single measurements might be considered a minor limitation. However, this study is the first one for determining NC cut off points for

overweight and abdominal obesity in 18-25 years old Turks.

Conclusion

In conclusion, this study demonstrated that NC was associated with overweight and central obesity. This study among Turkish university students showed that an NC >37 cm for men and >32.5 cm for women was the best cut off point to determine subjects with overweight and a NC >38.5 cm for men and >33.5cm for women was the best cut off point to determine subjects with central obesity.

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