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Finding an Appropriate Cut-off Point for Neck Circumference to Determine Overweight and Obesity in a Large Sample of Iranian Adults

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Abstract

Objective: Obesity is a major public health concern and there are different ways to detect it in population. The aim of the present study is to evaluate the neck circumference (NC) in a simple and practical way.

Materials and Methods: This cross-sectional survey utilized data from the Yazd Health Study (YaHS) which is a population-based cohort study. In brief, 9962 individuals aged 20-70 years with measurement of body weight, height, waist circumference (WC) and NC were available for analysis. To determine the relationship between NC and other anthropometric measurement, we utilized of Pearson's correlation coefficient. Receiver operator characteristic (ROC) curve analysis was used to find out an optimal cut off value for detecting general and central obesity as well as to determine the sensitivity and specificity of NC in predicting general and central obesity. The whole analysis was performed using SPSS version 22.

Results: NC correlated positively with body mass index (BMI) (r= 0.608, *P*< 0.001 in men and r= 0.541, *P*< 0.001 in women) and WC (r= 0.662, *P*< 0.001 in men and r= 0.542, *P*< 0.001 in women). The best cut-off point for NC to determine people with general obesity was 40.25 cm for men and 35.75 cm for women.

Conclusion: The NC has an acceptable correlation with BMI and WC. In addition, NC is a simple free measurement which may be utilized in various health-care settings. These properties make the NC as the best anthropometrics to determine overweight and obesity and it can be used as an appropriate predictor for overweight and obesity in population-based screening programs.

Keywords: Neck circumference, Overweight, Obesity, Area under curve

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Introduction

Obesity is a major public health concern in developed and developing countries (1,2) and it is a serious risk factor for cardio-metabolic diseases such as diabetes, hypertension, coronary heart disease and dyslipidemia (3).

Current studies were shown about 69% of adults in United States (US) are either overweight or obese (4). According to World Health Organization (WHO), a worrying increase in obesity in Asian countries including Iran was observed (5). Based on several studies, the prevalence of obesity in Iran is reported to be around 21.7% (6). The suggestion of US preventive service task force is that all adults must be screened for obesity to decrease complications of it (5).

Obesity and overweight are used for people whose weight is too high for age and gender (7). There are many methods for detection of overweight and obese people including body mass index (BMI), waist circumference (WC), waist/hip ratio, mid upper arm circumference, sub scapular/triceps ratio and neck circumference (NC) (8). However, choosing the best and easiest screening tool for identifying obese population is essential (9). BMI is a traditional measure of obesity and is widely used to evaluate obesity in practice (10). According to the WHO, overweight is considered as BMI between 25 and 29.9 and obesity is considered as BMI of 30 or higher (11). Despite its benefits including simplicity of measurement and explanation, BMI cannot show the body fat distribution. Among other techniques, the measurement of WC is simple and easy (10), but it has some limitation such as presence of multiple anatomical landmarks, daytime variation, insufficiency in cold areas and in women the difficulty of measuring is due to cultural inhibitions (5,10-12).

Recently measurement of NC has been used to detect overweight and obesity in men, because it is a simple and quick method which can demonstrate distribution of upper-body subcutaneous adipose tissue and central obesity (4). In addition NC can be a useful and practical tool to evaluate obesity in bedridden patients and pregnant women (3). A number of studies in different gender-age groups have showed a high correlation between NC, WC and BMI (10,13). The Framingham heart study revealed that NC can be considered as an index of central obesity as it has an independent relationship with visceral fat and BMI (14). In various studies, different cut-off points have been reported for the evaluation of obesity (9).

In a study by Lindarto et al. in Indonesia in 2016, the best cut-off point that represented overweight/obesity was ≥37cm for men and ≥33.5cm for women (4). Another study from northern of Iran, showed that optimal NC cut-off point for general overweight/obesity in men was 38.75cm and in women was 34.2cm, while according to Iranian obesity committee appropriate NC cut-off points for central obesity was 39.3cm in men and 34.5cm in women (9).

Concerning the recent use of NC to evaluate obesity and absence standard cut-off point for it, the first aim of this study was to assess correlation between NC with WC and BMI. The second aim was to determine an optimal cut-off point of NC to detect general and visceral obesity and define sensitivity and specificity of this method.

Materials and Methods

Study population

This cross-sectional survey utilized data from the Yazd Health Study (YaHS) which is a population-based cohort study. Details of YaHS have been reported previously (15). In brief, 9962 individuals aged 20-70 years with measurement of body weight, height, WC and NC were available for analysis.

Anthropometry

All anthropometrics were measured in standing position. Height was measured using a wall-mounted tape measure to the nearest

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centimeter while the participants were without shoes. Body weight was measured with a portable digital scale (Model BF511, Omron Inc. Nagoya, Japan) with an accuracy of 100 gr while the subjects were barefoot with light clothes. BMI (kg/m²) was calculated according to this formula (weight (kg)/height squared (m²)). The WC was measured at the midpoint between iliac crest and lowest rib using a non-stretch tape. The NC was measured by placing a tape measure around the base of neck just below the laryngeal prominence (Adam's apple).

Definition of measurement cutoffs

Based on WHO guidelines, overweight and obesity (general obesity) were defined as 25≤ BMI ≤ 29.9 and BMI≥ 30 respectively (16). According to the ATP 3 definitions, central (abdominal) obesity was defined as WC≥102 cm in men and WC≥88 cm in women (17).

Statistical analysis

All statistical analysis was performed using SPSS version 22. The anthropometric variables were presented as mean ± standard deviation. To determine the relationship between NC and other anthropometric measurement, we utilized Pearson's correlation coefficient. Receiver operator characteristic (ROC) curve analysis was used to find out an optimal cutoff value for detecting general and central obesity as well as to determine sensitivity and specificity of NC in predicting general and central obesity. *P* less than 0.05 was considered as significant level.

Ethical considerations

This study was approved by the research ethics committee of Shahid Sadoughi University of Medical Sciences (ethical code: IR.SSU.MEDICINE.REC.1396.9).

Results

The study sample consisted of 9962 subjects, 4921 (49.4%) men and 4989 (50.1%) women (0.6% missing data). The mean BMI was 27.2 (± 5.2) kg/m² (men: 26.2 (± 4.6), women: 28.1 (± 5.6)). Also the mean WC was 94.1 (± 13.3) cm (men: 94.2 (±12.7cm), women: 93.9 (±13.5cm)) and the mean NC was 37.6 (± 3.7) cm (men: 39.3(± 3.4cm), women: 35.9 (± 3.2cm)). NC correlated positivity with BMI (r= 0.608, *P*< 0.001 in men and r= 0.541, *P*< 0.001 in women). In addition NC correlated positivity with WC (r= 0.662, *P*< 0.001 in men and r= 0.542, *P*< 0.001 in women). All subjects were divided into three categories based on BMI. BMI ranges were as follows: BMI<25, 25≤BMI≤29.9 (overweight), and BMI≥30 (obesity). NC was positively correlated with BMI and WC in every three categories (Table 1). Table 2 shows the relationship between NC with WC and BMI in all age groups.

The proportion of overweight was 38.3 %. The mean NC in the BMI< 25 group was 35.7 (± 3.1) cm and in the overweight group was 38.1 (± 3.3) cm. The area under the curve (AUC) was 0.723 (sensitivity: 0.601, specificity: 0.709) and cut-off point of NC for overweight was 37.25 cm.

Table 1. Relationship of NC with BMI and WC in three BMI categories among Yazd health study participants

Variable	BMI<25.0		25.0≤BMI≤29.9		BMI≥30.0	
	r	*P*	r	*P*	r	*P*
BMI	0.331	<0.001	0.137	<0.001	0.137	<0.001
WC	0.446	<0.001	0.377	<0.001	0.405	<0.001

Table 2. Relationship between NC and BMI/WC by age

Age group	BMI		WC	
	r	*P*	r	*P*
20 – 29	0.487	<0.001	0.570	<0.001
30 - 39	0.450	<0.001	0.544	<0.001
40 - 49	0.342	<0.001	0.530	<0.001
50 - 59	0.327	<0.001	0.467	<0.001
60 - 69	0.318	<0.001	0.450	<0.001

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The prevalence of general obesity and central obesity were 26.4% and 47.2%, respectively. Based on ROC analysis, AUC for NC and general obesity was 0.798 in men and 0.761 in women. Moreover AUC for NC and central obesity was 0.845 in men and 0.782 in women (Figure 1 and 2). The best cut-off point for NC to determine people with general obesity was 40.25 cm for men and 35.75 cm for women. Table 3 presents cut-off points of NC, sensitivity and specificity for general/central obesity.

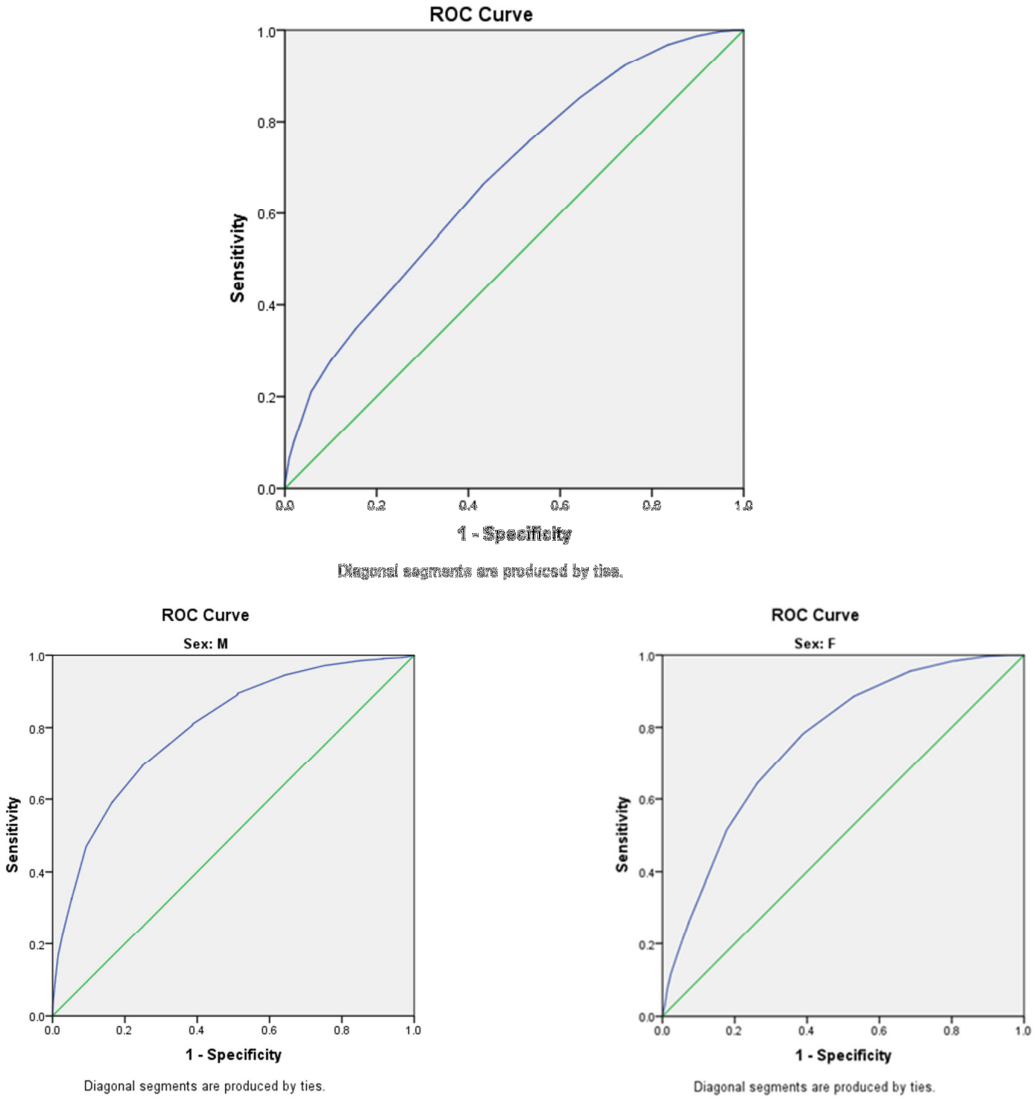

Figure 1. Receiver operating characteristic (ROC) curves related to neck circumference and general obesity.

Table 3. Cut-off points, sensitivity and specificity of NC for detecting general/central obesity

Variable	Men			Women		
	NC(cm)	sensitivity	specificity	NC(cm)	sensitivity	specificity
General obesity (BMI≥ 30)	40.25	69.3%	75.2%	35.75	78.2%	61.1%
Central obesity [men: WC >102 Women: WC >88]	40.25	71.8 %	81.1%	34.65	77.8%	62.7%

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Discussion

According to our analysis, NC was positively correlated with WC. NC was also in correlation with BMI in its three subgroups including BMI< 25, 25≤ BMI≤ 29.9 (overweight), and BMI≥30 (obesity). This significant relationship between NC with WC and BMI was reported in all age groups. These results were observed in other similar studies (18-20), the cut-off point of NC was calculated 37.25 in overweight subgroup. The sensitivity and specificity of this value was 60.1% and 70.9%, respectively, while the cutoff for general obesity was 40.25 cm for men and

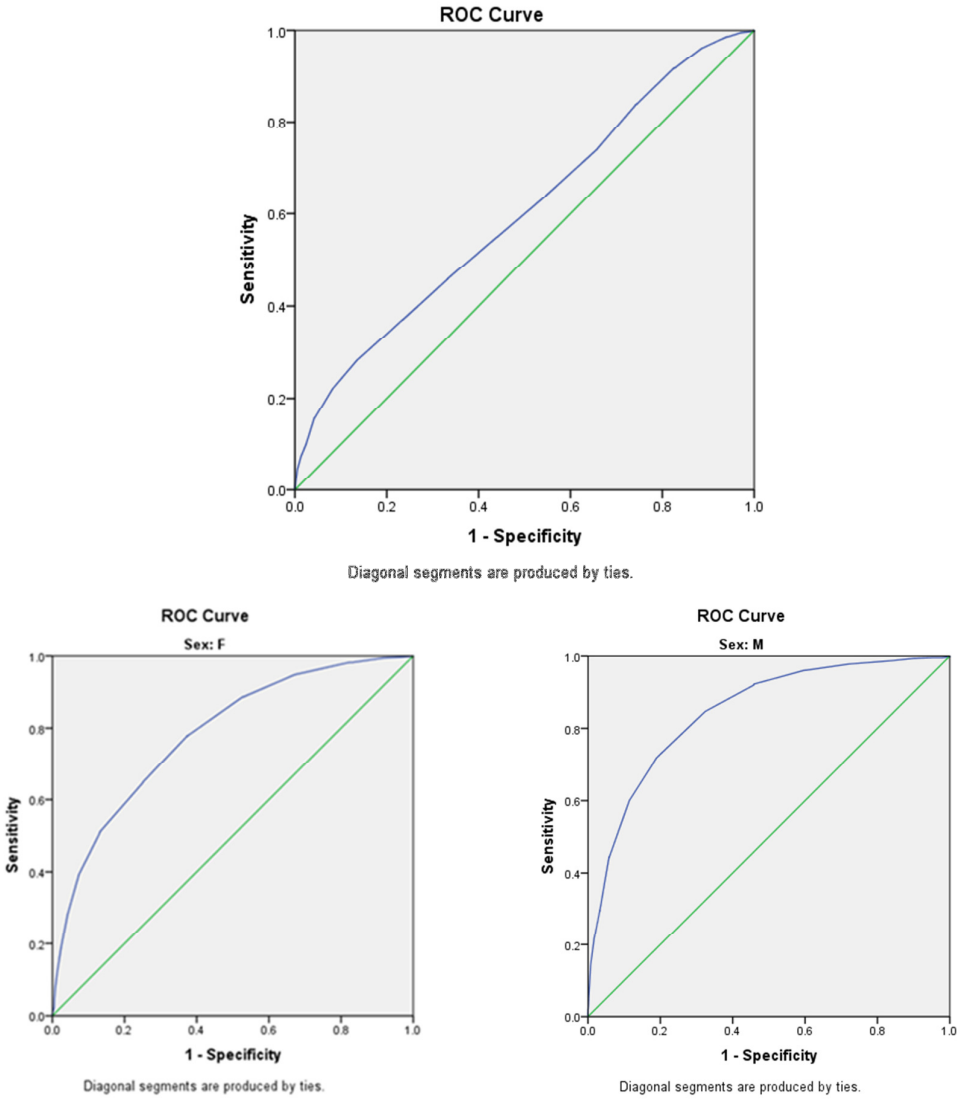

Figure 2. Receiver operating characteristic curves related to neck circumference and central obesity.

Table 4. Cut-off point of NC (cm) to define general/central obesity in previous studies

Year	Study	Central obesity		General obesity	
		Men	Women	Men	Women
2011	Pakistan (REF)	-	-	35.5	32
2015	China	38.5	34.5	-	-
2016	Iran	39.25	34.5	38.75	34.2
2016	Indonesia	-	-	37	33.5
2014-2015	Current study	40.25	34.65	40.25	35.75

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35.75 cm for women.

Wang et al. (13) evaluated 3307 persons to evaluate the efficacy of NC as a predictor of general obesity and insulin resistance. They reported that NC had positive correlation with BMI and WC in both genders. In diagnosis of general obesity, the best cut-off point for NC was determined more than 38.5 and 34.5 cm for men and women, respectively. The accuracy of this value was 82.9% for men and 79.9% for women. These cutoff points were less than our values which can be related to the differences of Persian and Chinese races.

Yang et al. (21) has reported the results of their investigation to definite the relationship between NC and general obesity in Chinese people with diabetes mellitus. They stated that the NC more than 38 cm and 35 cm for men and women was the best cutoff for diagnosis of overweight, respectively. These values were more similar to our study population. They also reported NC more than 39 cm for men and 35 cm for women as the most accurate cutoff point to determine metabolic syndrome. This hypothesis was not evaluated in our study and the authors assumed that it is better to use NC as a predictor of metabolic disorder like Yang study.

Kelishadi et al. (10) designed a study to declare the most correlated cut-off point for NC in diagnosis of according to different gender and age groups in an Iranian population based study. This national investigation was accomplished among 23043 school students with a mean age of 12.55 years. According to their results, NC had significant positive correlation with overweight and general obesity. They stated that NC can be mentioned as a simple clinical evaluation for obesity diagnosis in pediatrics. They also recommended using this value for adults and our study is a similar investigation in the same race but in adult persons. The authors suppose this study as a complementary one for a national population-based survey.

Hingorjo et al. (7) evaluated 150 students aged 18-20 years by anthropometric values of obesity including BMI, WC, and hip circumference and compared them with NC. Overweight and obesity were determined in their study by BMI more than 23 and 25, respectively. The results stated a significant positive association of NC with BMI and WC in both genders. They also declared that NC can be a cost effective, useful primary screening measurement for detecting overweight and obesity. The NC more than 35.5 cm in men and 32 cm in women was confirmed as the optimal cutoff overweight. This value was different from our value probably due to the differences between Pakistani and Iranian ethnicity. Another bright point about the differences between Mozaffer et al. and our study was the definition of overweight; they defined overweight by the BMI more than 23 (up to 29.9) while we determined it by 25≤BMI≤29.9.

Mondal and et al. (22) evaluated 1169 Karbi adults in northeast of India to determine the correlation between NC and overweight as a simple initial screening measurement among Indian adults. The ROC analysis confirmed a significant association between BMI, WC and HC and NC for overweight.

Our research setup was very similar to the Moazezi et al. (9) investigation, they mentioned the NC as a parameter of obesity. They declared that NC can be a fast and acceptable screening test for determining overweight and obesity. They evaluated anthropometric values including BMI, WC, and NC among 8387 adults. NC more than 38.75 cm for men had 83.5% sensitivity to have correlation with BMI more than 25 kg/m2, and a specificity of 77.8%, while NC more than 34.2 cm had sensitivity and specificity 79.4% and 80.2%, respectively. The best cutoff for NC in diagnosis of general obesity was 39.25 in men and 34.5 in women. This NC cutoff was correlated to WC more than 95 cm. The cutoff points of Moazezi and et al. was obviously similar to ours. Probably this similarity is because of the same age group, race and geographical status in both investigations.

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Conclusions

The results of our study demonstrated that the NC has an acceptable correlation with BMI and WC. In addition, NC is a simple free-of-charge measure which may be utilized in various health-care settings without dependency to any laboratory or radiographic facilities. These properties make the NC as the best anthropometrics to determine overweight and obesity and it can be used as an appropriate predictor for overweight and obesity in population-based screening programs

Strengths and limitation

This research was a population-based study with a large sample size. Therefore the results could be generalized to the Yazdi adult population. However, due to the limitation that this study was carried out in the population of 20 years and over, it needs to be performed in children and adolescents as well.

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Conflict of Interest

There is no conflict of interest to declare.

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