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Neck Circumference as a Novel Anthropometric Value for Diagnosis of Metabolic Syndrome and Obesity in Patients with Diabetes

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Authors' contributions

This work was carried out in collaboration between all authors. Author ZM designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author HM managed the literature searches, analyses of the study performed the spectroscopy analysis and authors AP and ZM managed the data collection. All authors read and approved the final manuscript.

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ABSTRACT

Background and Objective: Metabolic syndrome and obesity are known as important risk factors for cardiovascular disease which have a high frequency among diabetic patients. Central obesity in metabolic syndrome diagnostic criteria was determined as high waist circumference. But it is not always applicable. So introducing novel anthropometrics is crucial to accurate diagnosis of metabolic syndrome. This study was designed to evaluate diagnostic accuracy of neck circumference in central obesity and metabolic syndrome in a diabetic population of north of Iran.
Materials and Methods: In this diagnostic study adult patients with previous diagnosis of diabetes mellitus was evaluated. Metabolic syndrome was diagnosed based on Iranian National Committee of Obesity. Anthropometrics and lab data was collected during 4 years of study period and data

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was analyzed by Spearman correlation, Man-Whitney U test, and Chi Square test. Diagnostic accuracy was evaluated by drawing ROC curve.
Results: 2942 patients was included in the study. 794 patients (27%) were diagnosed with metabolic syndrome. Neck circumference was significantly higher in patients with metabolic syndrome and obesity (BMI≥30). It has also a positive correlation with waist circumference (r=0.656 in men and r=0.681 in women) and obesity (r=0.632 in men and r=0.661 in women) in all patients. Area under ROC curve for metabolic syndrome was 0.624 for men (95% CI= 0.576-0.672) and 0.663 for women (95% CI= 0.635-0.691).
Conclusion: Neck circumference can be introduced as a novel anthropometric value for diagnosis of metabolic syndrome.

Keywords: Metabolic syndrome; central obesity; neck circumference; waist circumference; body mass index; diagnostic accuracy.

1. INTRODUCTION

Metabolic syndrome is an energy storage and usage disorder that strongly related to cardiovascular diseases [1]. The best known of its components are dyslipidemia, elevation of arterial blood pressure (BP), deregulated glucose homeostasis and abdominal obesity [2]. There are diverse criteria which published by different groups or associations for cutoff point of each component, but the most widely used are the United States Adult Treatment Panel III (ATP III) criteria, International Diabetes Federation (IDF) criteria, and World Health Organization (WHO) criteria [3,4]. Iran National Committee of Obesity (INCO) also provided its' own criteria for diagnosis of metabolic syndrome based on performed studies in Iran population [5]. This criteria seems had better adjustment for Iranian peoples for diagnosis of metabolic syndrome rather than other criteria [6].

Obesity specifically central obesity has known as an strong risk factor for cardiovascular diseases from many years ago [7,8]. Calculating Body Mass Index (BMI) for total obesity and waist circumference for central obesity is the simplest way to evaluate a person. Patients with diabetes usually suffer from obesity and metabolic syndrome, so they are in high risk of cardiovascular diseases. Also researches in recent years in Iran indicated that prevalence of diabetes, metabolic syndrome, and obesity is increasing [4] and young population of Iran are in a high level of risk [9]. So study on this issue is very important to provide proper policy for amending life style in Iranian people.

Waist circumference is used as only anthropometric value for diagnosis metabolic syndrome and the most widely used value for assessment of central obesity. But this value measurement may face with obstacles. For instance in case of pregnancy waist circumference is not a valid tool for diagnosis of metabolic syndrome and obesity. Another obstacle occur in winter which patients' clothes may interrupt accurate measurement of waist circumference. Also in Islamic populations including Iran it would not be pleasured for patients to show their abdominal region naked to an opposite gender examiner. So identification of novel values would help clinicians to evaluate anthropometrics of their patients more concise [10]. Neck circumference has shown in recent years that has potential to introduce as an novel anthropometric value [11]. Previous studies indicated that neck circumference had significant relation to insulin resistance [12] and cardiovascular diseases risk factors [13], And has a positive correlation with BMI and waste circumference [11]. Also Chinese [14], Brazilian [15], and South African [16] experiences indicated that neck circumference can be used as an anthropometric value for diagnosis of metabolic syndrome. But there is no study in Iran for this issue. So in this study we aimed to determine diagnostic validity of neck circumference for metabolic syndrome and obesity in Iranian diabetic patients for the first time.

2. MATERIALS AND METHODS

2.1 Study Design and Patients

This cross sectional diagnostic accuracy study was performed on every adult patient with previous diagnosis of diabetes mellitus (based on WHO criteria) [17], who referred to an endocrinology clinic in Babol city, north of Iran, from April 2009 to March 2012. Demographic information including age and gender was recorded in first patient visit. Anthropometric

values including weight (Kg) and height (meter) and BMI (Kg/m^2) and waist circumference (cm) and neck circumference (cm), also blood pressure (systolic and diastolic, mmHg) was measured in any patient referral by an educated nurse. Same measurement devises was used for all patients. Biochemical markers data including fasting blood sugar (FBS, mg/dl), triglyceride (TG, mg/dl), and high density lipoprotein (HDL) cholesterol (mg/dl) was collected from patients' laboratory sheets which had ordered by endocrinologist according to clinical indications for each patients. All patients was suggested to do their biochemical tests in a unique lab. Pregnant patients and whom with thyroid nodule or goiter was excluded from the study.

After data collection, metabolic syndrome suffering was evaluated in patients based on Iranian National Committee of Obesity (INCO) criteria. This criteria state that patients suffer from metabolic syndrome if they have three from five following components: waist circumference more than 95 cm in both gender, systolic blood pressure above 130 mmHg or diastolic blood pressure above 85 mmHg, FBS more than 100 mg/dl, serum TG level more than 150 mg/dl, and serum HDL level less than 40 mg/dl in men and less than 50 mg/dl in women. Obesity was defined as BMI ≥30 kg/m^2 [18].

2.2 Anthropometric Values Measurement

Anthropometric values were performed using standard methods [19]. Weight was measured while wearing light clothing and without shoes, using a digital scale to the nearest 100 g. Height was measured without shoes, with stadiometer to the nearest 0.5 cm. Neck circumference was measured while the patient was sitting, at the middle of the neck between mid-cervical spine and mid- anterior neck to 0.5 cm just below the Adam's apple using plastic tape measure. Waist circumference was measured with the patient standing with minimal wear at midpoint between the lower ribs and the iliac crest. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2).

2.3 Statistical Analysis

Correlation of neck circumference with BMI and waist circumference was evaluated in both genders separately by Spearman correlation test. Recessive Operation Curve (ROC) was drawn to assess diagnostic validity of neck circumference on metabolic syndrome and obesity. Best cutoff point was calculated in both genders separately. Also Mann-Whitney U test was used for comparison of neck circumference and age between patients with and without metabolic syndrome and Chi square was used for gender frequency analysis. Statistical analysis was done by SPSS software version 18 (Chicago) and P-value less than 0.05 was considered as significant.

3. RESULTS

In period of 4 years 3157 adult patients with diabetes mellitus referred to the endocrinology clinic. 215 patients was excluded because of pregnancy, thyroid nodule, or goiter and data of 2942 participants was evaluated. Mean age of all patients was 49.56±14.30. 827 participants (28.1%) were men and 2116 of them (71.9%) were women. Baseline characteristics of patients according to gender were described in Table 1.

From 2942 patients with diabetes, 794 participants (27%) diagnosed with metabolic syndrome based on INCO criteria. 213 of them (26.8%) were men and 581 of them (73.2%) were women. Gender was not significantly associated with metabolic syndrome but age, BMI, and obesity was significantly associated (Table 2). Neck circumference was significantly higher in patients with metabolic syndrome and obesity in comparison with patients without metabolic syndrome and obesity in both genders (Table 3). There was a significant positive correlation between neck circumference and waist circumference in diabetic patients (men, $r = 0.656$; women, $r = 0.681$; each $P< 0.001$, Fig 1A). Also for BMI a significant positive correlation with neck circumference was observed (men, $r = 0.632$; women, $r = 0.661$; each $P< 0.001$, Fig. 1B).

In assessment of diagnosis validity of neck circumference for metabolic syndrome by drawing ROC curve it has been found that area under curve for men was 0.624 (95% CI=0.576 – 0.672, Fig. 2A) and for women was 0.663 (95% CI=0.635 – 0.691, Fig. 2B). Best cutoff point for men was 39.75 with sensitivity of 70.7% and specificity of 50.1%. For women best cutoff point was 36.75 with sensitivity of 57.1% and specificity of 68.4%.

ROC curve was also drawn for evaluation of diagnostic validity of neck circumference for obesity. Area under curve for men was 0.800 with 95% confidence interval of 0.754 – 0.845 (Fig. 3A) and for women was 0.825 with 95%

confidence interval of 0.804 – 0.846 (Fig. 3B). Best cutoff point for men was 40.75 with sensitivity of 77.4% and specificity of 67.7%, and for women best cutoff point was 35.75 with sensitivity of 80.4% and specificity of 69.2%.

4. DISCUSSION

The results of our study indicated that neck circumference is significantly higher in patients with metabolic syndrome and obesity rather than patients without in a diabetic population of north of Iran. Neck circumference also positively correlated with waist circumference and BMI in men and women. Diagnostic accuracy evaluation showed that neck circumference has an acceptable validity for metabolic syndrome and obesity in both gender, but estimated cut off points don't have high sensitivity or specificity. Neck circumference in issue of diagnosis of obesity is more accurate rather than metabolic syndrome.

Table 1. Baseline characteristics of patients in different gender

Characteristics	Gender		
	Men (N=827)	Women (N=2116)	P-value
Age median (min-max)	51 (18-85)	50 (18-89)	0.008
Weight median (min-max)	77 (42-138)	72 (39-135)	< 0.001
Height median (min-max)	1.68 (1.46-1.91)	1.55 (1.20-1.80)	< 0.001
BMI median (min-max)	27.3 (16.6-45.9)	29.9 (16.6-49.3)	< 0.001
Obesity (BMI ≥ 30) N (%)	166 (26.3%)	829 (49.7%)	< 0.001
Systolic blood pressure median (min-max)	120 (80-180)	120 (80-190)	< 0.001*
Diastolic blood pressure median (min-max)	80 (50-110)	80 (50-110)	< 0.001**
FBS median (min-max)	152 (62-469)	142 (52-468)	0.008
TG median (min-max)	143 (25-498)	146 (19-520)	0.909
HDL median (min-max)	42.5 (16-95)	45 (22-93)	0.001
Waist circumference median (min-max)	98 (66-139)	99 (64-140)	0.019
Neck circumference median (min-max)	40 (32-47.5)	36 (29-44)	< 0.001

** Mean rank of men was 1357.03 and for women were 1152.56,*
*** Mean rank of men was 1299.94 and for women were 1171.86*

Table 2. Association of gender, age, BMI, and obesity with metabolic syndrome

Variable		Metabolic syndrome		
		Positive (N=794)	Negative (N=2148)	P-value
Gender N (%)	Men	213 (25.8%)	614 (74.2%)	0.350
	Women	581 (27.5%)	1535 (72.5%)	
Age median (min-max)		54 (18-86)	49 (18-89)	< 0.001
BMI median (min-max)		30.7 (19.5-49.3)	28 (16.6-49.1)	< 0.001
Obesity N (%)		442 (58.1%)	553 (36%)	< 0.001

Table 3. Neck circumference association with metabolic syndrome and obesity

Value disorder			Mean	Standard deviation	Median	Minimum	Maximum	P-value
Metabolic syndrome	Men	Positive	40.95	2.54	41	34.5	47.5	< 0.001
		Negative	39.74	2.83	39.5	32	47.5	
	Women	Positive	37.02	2.42	37	30.5	44	< 0.001
		Negative	35.55	2.07	35	29	44	
	Total	Positive	38.09	3.01	38	30	47.5	< 0.001
		Negative	36.66	3.29	36	29	47.5	
Obesity	Men	Positive	42.38	2.63	42.5	35	47.5	< 0.001
		Negative	39.38	2.39	39.5	32	45	
	Women	Positive	37.53	2.28	37.3	31	44	< 0.001
		Negative	34.61	2.18	34.5	29	44	
	Total	Positive	38.31	2.94	38	31	47.5	< 0.001
		Negative	36.28	3.20	36	29	45	

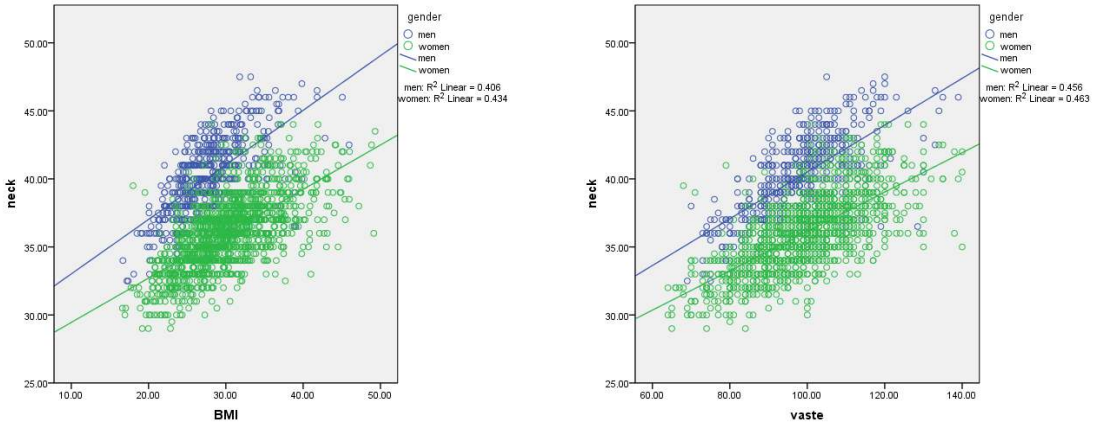

Fig. 1. Correlation of neck circumference with waist circumference (A) and BMI (B)

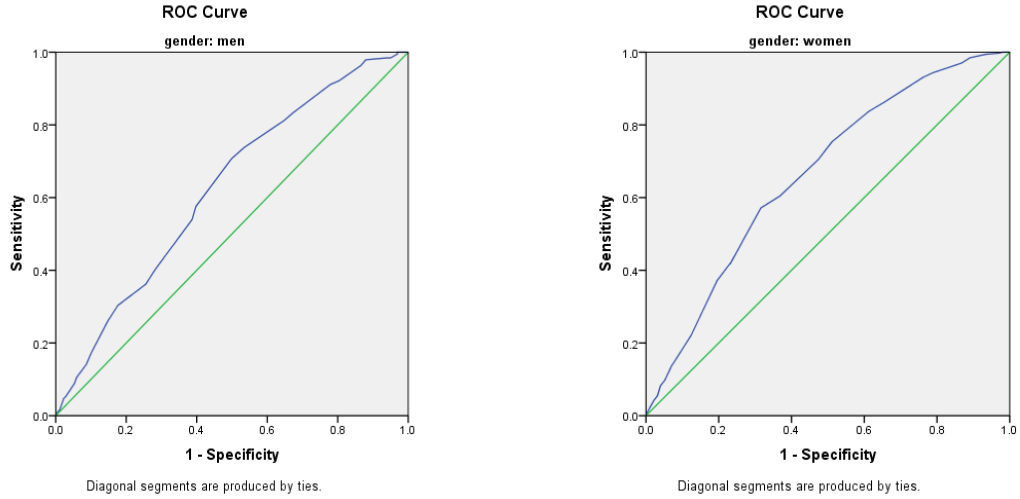

Fig. 2. Diagnostic accuracy of neck circumference for metabolic syndrome in men (A) and women (B) was evaluated by drawing ROC curve

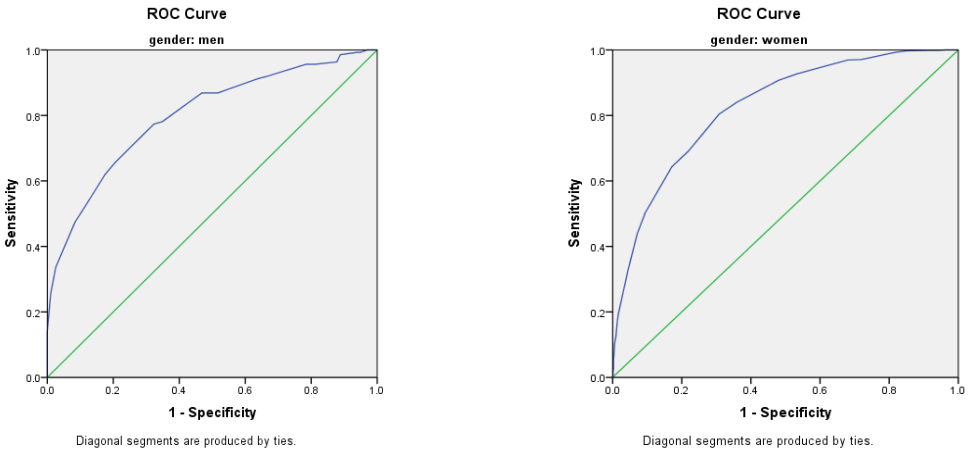

Fig. 3. Diagnostic accuracy of neck circumference for obesity in men (A) and women (B) was evaluated by drawing ROC curve

Correlation of neck circumference with other anthropometrics is essential for introducing it as a novel value. In our study neck circumference had a positive correlation with waist circumference and BMI (Fig. 1) with a correlation coefficient more than 0.6 which indicate a strong correlation. These findings are same with other studies [10,11,16,20,21]. In all of these studies a strong positive correlation were found between neck circumference and BMI and waist circumference. Yang et al. [14] study in China also indicated a significant positive correlation between these anthropometrics but this correlation was not strong like our study and the other studies. Otherwise based on our results and other studies it seems that neck circumference can be used as a central obesity value.

To evaluate obesity with neck circumference a reliable cut-off point should be determined for men and women discretely. In our study best cut-off point for obesity (BMI≥30) was 40.75 in men and 35.75 in women but estimated sensitivity and specificity for these points were not so high. Ben-Noun and et al in Israel [10] found a cut-off point of 39.5 for men and 36.5 for women but compare to our study calculated sensitivity and specificity were above 95% in both genders. Onta et al. [21] in Turkey also estimated cut-off points for abdominal obesity (waist circumference ≥95.88) and found that neck circumference of 38.5 cm in men and 34.5 cm in women were the best cut-off points for central obesity but sensitivity and specificity were not so high (between 65% to 85%). Chinese study by Yang et al. [14] also found the best cut-off point of neck circumference for central obesity in men equal to 37 cm and in women equal to 35 cm and calculated sensitivity and specificity was near our and Onta study. It can be concluded that neck circumference had diagnostic validity for obesity specifically central obesity but cut-off points with high sensitivity and specificity for both genders were not determined in the most of studies yet.

Results of our study indicated that neck circumference is significantly greater in diabetic patients with metabolic syndrome in comparison to diabetic patients without metabolic syndrome. Also ROC curve analysis showed that this anthropometric value had acceptable diagnostic accuracy for metabolic syndrome although sensitivity and specificity of estimated cut-off points for men and women were not so high. Our finding is just like Yang and et al study in China (14) which performed on 31282 patients with diabetes. Area under curve (AUC) of ROC curve and 95% confidence interval of AUC in this study was near our results and best cut off point for men was 39 cm and for women was 35 cm. But sensitivity of our men's cut-off point was greater. Other studies were not done in diabetic patients, whatever assessed diagnostic accuracy of neck circumference in metabolic syndrome. Arnold et al. [20] estimated neck circumference accuracy for metabolic syndrome in college students and found that the sensitivity of best cut-off points is low. But Hoebel et al. study in South Africa [16] revealed that neck circumference is a reliable anthropometrics for diagnosis of metabolic syndrome in African and Caucasian men and women with a AUC greater than 0.7 in overall. The estimated cut-off points

for African and Caucasian men was 39 cm and 40 cm in order and for African and Caucasian women was 32 cm and 34 cm in order. Altogether it seems that there is not a world consensus for diagnostic accuracy of neck circumference for metabolic syndrome yet and further studies in other countries and ethnics are needed to clarify this hypothesis. But if neck circumference wants to be used for diagnosis of metabolic syndrome best cut-off point for men should be around 40 cm and for women should be around 35 cm.

5. CONCLUSION

In conclusion, our study in a population of diabetic patients in north of Iran indicated that neck circumference can be introduced as a novel anthropometric value which has strong positive correlation with waste circumference and BMI. Also neck circumference is an acceptable and reliable tool for diagnosis of central obesity but in case of metabolic syndrome there is less confidentiality and further studies is required in this issue.

CONSENT

It is not applicable.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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