 Original Research

The Association of Metabolic Syndrome Components with Anthropometric Measurements

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ABSTRACT

Aim: This study aims to research the association of metabolic syndrome components with anthropometric measurements like arm circumference, neck circumference, hip circumference, waist-hip ratio, and waist-to-height ratio, which are applied rarely.

Methods: This cross-sectional study was conducted with 292 patients in November-December 2019. The arm circumference, neck circumference, waist circumference, hip circumference, waist-hip ratio, waist-to-height ratio, and body mass index measurements of the patients were made. Glucose, high-density lipoprotein, low-density lipoprotein, systolic, and diastolic blood pressure measurements were also recorded. The association between metabolic syndrome components and anthropometric measurements was analyzed.

Results: Metabolic syndrome is diagnosed in 32.8% of the participants. According to body mass index, 18.6% of the patients were normal, 34.2% were overweight, and 47.2% were obese. There was a significant difference between the patients with and without metabolic syndrome in terms of laboratory parameters, blood pressure values, and anthropometric measurements. In the diagnosis of metabolic syndrome, optimal cut-off values for arm circumference, neck circumference, hip circumference, waist-hip ratio, and waist-to-height ratio were determined as 31.75 (AUC=0.703), 34.85 (AUC=0.763), 113.75 (AUC=0.757), 0.90 (AUC=0.701), 0.61 (AUC=0.769) for females while they were 35.75 (AUC=0.573), 39.75 (AUC=0.795), 111.5 (AUC=0.607), 0.96 (AUC=0.888), 0.61 (AUC=0.888) for males respectively.

Conclusion: A significant correlation was detected between arm circumference, neck circumference, hip circumference, waist-hip ratio, and waist-to-height ratio, and metabolic syndrome components. However, low-density lipoprotein was not correlated with neck circumference and high-density lipoprotein with waist-to-height ratio.

Keywords: metabolic syndrome, anthropometric measurement, body mass index, obesity, lipid profile

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Introduction

Metabolic syndrome (MS) is a disease characterized by abdominal obesity, insulin resistance, hypertension, and hyperlipidemia by World Health Organisation (WHO). It is known that MS and obesity are associated with cardiovascular diseases, insulin resistance, some cancer types, and psychiatric diseases (1-3).

Determining some strategies to predict MS risk in adults and prevent its occurrence from the basics of preventive health care. For this reason, it is important to make an early diagnosis in high-risk individuals (4,5). There are several criteria for the evaluation of individuals in terms of obesity. The most common ones are the body mass index (BMI) and waist circumference (WC) measurement, however, it is not possible to receive more accurate information about body composition. WC measurement is not sufficient for bed-ridden patients, pregnant, and other patients having several diseases like liver diseases and so on. In such cases, other anthropometric measurements become important (6).

Fatty acid release from visceral adipose tissue is different from subcutaneous adipose tissue. Fatty acid release from visceral adipose tissue causes a mild inflammation whereas fatty acid release from subcutaneous adipose tissue leads to a decrease in insulin sensitivity (7). This situation explains the association between anthropometric measurements and cardiometabolic parameters. Free fatty acid release from subcutaneous adipose tissue increases the risk independently of visceral adiposity (8,9).

The more recent studies are deeply focused on body composition and cardiovascular disease risk. Neck circumference (NC), an indicator of upper body fat tissue, increases cardiovascular disease risk independently of visceral fat accumulation (9).

Circumferential measurements may give information on the evaluation of fat localization (6,10,11). To the best of our knowledge, there is no study focusing on all the anthropometric measurements such as arm circumference (AC), NC, hip circumference (HC), waist-hip ratio (WHR), and waist-to-height ratio (WHtR) in our country. We aim to detect the association between the anthropometric measurements applied rarely like AC, NC, HC, WC, WHR, and WHtR and MS components and also to contribute to the literature.

Methods

This cross-sectional study was conducted with individuals between the ages of 18 and 69 who have applied to Ankara Dışkapı Yıldırım Beyazıt Training and Research Hospital Family Practice Policlinics in November-December 2019.

Our study was approved by the Ethics Committee of Ankara Dışkapı Yıldırım Beyazıt Training and Research Hospital (Decree No: 72/08). This study was conducted with 292 volunteer participants who have maintained their weight for the last three months or not having been in the lactation period, and not having received an antihyperlipidemic treatment.

Age, gender, educational levels, menopausal status, socio-demographic features examining the situation of present illness and drug utilization, high-density lipoprotein (HDL), low-density lipoprotein (LDL), glucose, and triglyceride levels of these patients were recorded. Biochemical parameters were studied using P800 Roche Hitachi and Olympus AU 5200. WC, HC, AC, and NC values of the patients were measured using an inelastic tape measure.

The height and bodyweight of the patients were also measured and BMI was calculated by dividing patients' body weight by the square of their height. Horizontal size between the largest parts of the hip was measured for the HC. While WC was measured midway between the iliac crest and the last rib (12), AC was measured midway between the shoulder and the elbow (13).

According to the World Health Organization (WHO) classification, participants were categorized as normal, overweight, and obese. The participants were evaluated considering metabolic syndrome diagnostic criteria of the National Cholesterol Education Program (NCEP) Adult Treatment Panel III (ATP III) and were split into groups as being with or without metabolic syndrome. Metabolic syndrome diagnosis was made in the presence of at least three of NCEP ATP III criteria mentioned below:

- Abdominal obesity (waist circumference >102 cm in males, >88 cm in females)
- Hypertriglyceridaemia (≥150 mg/dl)
- Low HDL (<40 mg/dl in males, <50 mg/dl in females)
- Hypertension (blood pressure ≥ 130/85)
- Hyperglycemia (fasting glucose ≥ 110 mg/dl)

Statistical analyses were performed using SPSS version 21.0 (IBM®, Chicago, The USA) packaged software. The convenience of variables to the normal distribution was analyzed through visual (histogram and probability graphics) and analytical (Shapiro-Wilk test) methods. Descriptive statistics were expressed as mean and standard deviation in normally distributed numeric data and as number and percentage in nominal data. Normally distributed numeric variables were analyzed through "Independent Samples T-Test" between two groups, "One-way Anova Test" among three groups, and "Paired T-Test" within the group. Non-normally distributed numeric variables were compared through the "Mann-Whitney U Test" between two groups and of the "Kruskal-Wallis Test" among three groups. Nominal data were evaluated between two groups by using the "Chi-square Test". P values below 0.05 in statistical analyses were accepted as statistically significant.

Results

Metabolic syndrome was present in 97 participants in our study. Mean ages of the females with MS were 47±14.9 years and without MS were 38.9±13.5 years (p<0.001); mean ages of the males with MS were 50.3±14.2 years and without MS 35.9±11.2 years (p<0.001). 78.8% of the participants were female (p<0.001). 47.7% of all the participants had an educational background shorter than 12 years about the presence of MS (p<0.001).

Table 1. The distribution of socio-demographic features, metabolic parameters, and of anthropometric measurements according to gender differences and the presence of MS

		Female (n=230)			Male (n=62)		
		MS (+) (N=60)	MS (-) (N=170)	p	MS (+) (N=37)	MS (-) (N=25)	p
Age (years)	Mean ± SD	47±14.9	38.9±13.5	**<0.001**	50.3±14.2	35.9±11.2	**<0.001**
Glucose (mg/dL)	Med (min-max)	101 (66-232)	83 (60-266)	**<0.001**	89 (67-256)	80 (48-115)	**0.001**
SBP (mmHg)	Med (min-max)	130 (100-180)	110 (75-160)	**<0.001**	137 (90-155)	110 (90-140)	**<0.001**
DBP(mmHg)	Med (min-max)	85 (65-120)	78 (50-110)	**<0.001**	90 (60-110)	80 (60-90)	**<0.001**
Triglyceride (mg/dL)	Med (min-max)	177 (48-422)	102 (32-404)	**<0.001**	172 (48-501)	114 (50-342)	**<0.001**
HDL(mg/dL)	Med (min-max)	42 (26-69)	51 (28-84)	**<0.001**	38 (25-69)	44 (25-74)	**0.036**
LDL (mg/dL)	Mean ± SD	135.5±33.3	124.3±29	**0.016**	137.2±32.8	134±29.9	0.698
BMI	Mean ± SD	32.6±4	27.9±5.4	**<0.001**	32.4±4.5	28.5±3.8	**0.001**
NC (cm)	Med (min-max)	37.5 (32-48)	34 (29-44)	**<0.001**	43 (38-51)	39.5 (32-47)	**<0.001**
AC (cm)	Med (min-max)	33 (28-44)	31 (20.5-46)	**<0.001**	33 (27.5-43)	32.5 (26-42)	0.246
HC (cm)	Med (min-max)	115 (98-149)	108 (31-135)	**<0.001**	112 (99-135)	108.5 (101-127)	0.220
WHR	Med (min-max)	0.9 (0.6-1.1)	0.8 (0.6-2.9)	**<0.001**	1 (0.8-1.1)	0.9 (0-0.9)	**<0.001**
WHtT	Med (min-max)	0.6 (0.5-0.9)	0.5 (0.3-0.8)	**<0.001**	0.6 (0.5-0.7)	0.5 (0-0.7)	**<0.001**

HDL: High-Density Lipo-protein; LDL: Low-Density Lipo-protein; BMI: Body Mass Index; NC: Neck Circumference; AC: Arm Circumference; WC: Waist Circumference; HC: Hip Circumference; WHR: Waist- Hip Ratio; WHtR: Waist-To-Height Ratio; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; MS: Metabolic Syndrome

There was a significant difference between the females with and without MS in terms of laboratory parameters, tension values, and anthropometric measurements (p<0.001). All the metabolic parameters and measurements except HDL-cholesterol level were higher within the group consisting of females with MS whereas HDL-cholesterol levels were found out to be lower.

There was also a significant difference between the males with and without MS in terms of laboratory parameters, blood pressure measurements, and anthropometric measurements such as NC, WHR, and WHtR apart from LDL-cholesterol levels (p<0.001). No significant difference was also detected among AC, HC, and HDL-cholesterol levels (p>0.05).

The distribution of socio-demographic features, metabolic parameters, and anthropometric measurements according to gender differences and the presence of MS was summarized in Table 1.

A significant positive correlation was observed among glucose, triglyceride, LDL-cholesterol, systolic blood pressure (SBP), diastolic blood pressure (DBP) and arm circumference (AC), waist circumference (WC), hip circumference (HC), and BMI when all the patients within the groups were evaluated together (p<0.05). However, a significant negative correlation was observed with HDL level (p<0.05). The association between metabolic parameters and anthropometric measurements was summarized in Table 2.

Table 2. The association between metabolic parameters and anthropometric measurements

		Glucose**	TRG**	HDL**	HDL**	SBP**	DBP**
NC	Rho	0.264	0.398	-0.331	0.056	0.502	0.452
	p	**<0.001**	**<0.001**	**<0.001**	0.393	**<0.001**	**<0.001**
AC	Rho	0.272	0.347	-0.232	0.251	0.423	0.485
	p	**<0.001**	**<0.001**	**<0.001**	**0.015**	**<0.001**	**<0.001**
WC	Rho	0.385	0.317	-0.180	0.177	0.533	0.490
	p	**<0.001**	**<0.001**	**0.002**	**0.003**	**<0.001**	**<0.001**
HC	r	0.288	0.243	-0.155	0.191	0.425	0.402
	p	**<0.001**	**<0.001**	**0.009**	**0.001**	**<0.001**	**<0.001**
BMI	Rho	0.411	0.322	-0.189	0.197	0.487	0.436
	p	**<0.001**	**<0.001**	**0.001**	**0.001**	**<0.001**	**<0.001**
WHR	Rho	0.327	0.283	-0.152	0.134	0.432	0.391
	p	**<0.001**	**<0.001**	**0.011**	**0.025**	**<0.001**	**<0.001**
WHtT	Rho	0.429	0.304	-0.077	0.191	0.522	0.452
	p	**<0.001**	**<0.001**	0.203	**0.001**	**<0.001**	**<0.001**

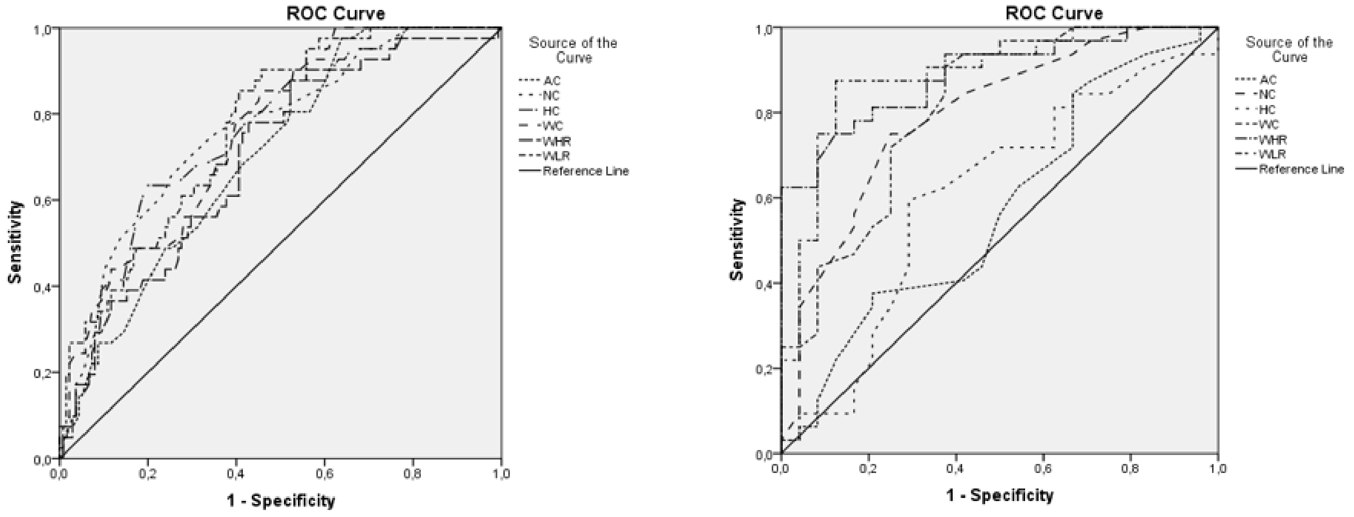
**Pearson Correlation Test; **Spearman Correlation Test; HDL: High-Density Lipo-protein; LDL: Low-Density Lipo-protein; TRG: Triglyceride; BMI: Body Mass Index; NC: Neck Circumference; AC: Arm Circumference; WC: Waist Circumference; WHR: Waist-Hip Ratio; WHtR: Waist-To-Height Ratio; HC: Hip Circumference; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure*

It was observed in the correlation analysis between BMI and anthropometric measurements that BMI was positively correlated with AC (Rho: 0.817), NC (Rho: 0.666), HC (Rho: 0.819), WC (Rho: 0.820), WHR (Rho: 0.535), and WHtR (Rho: 0.850) (p<0.05)

In Figure 1, the anthropometric measurements' accuracy for diagnosing MS was compared using plots of the ROC curves.

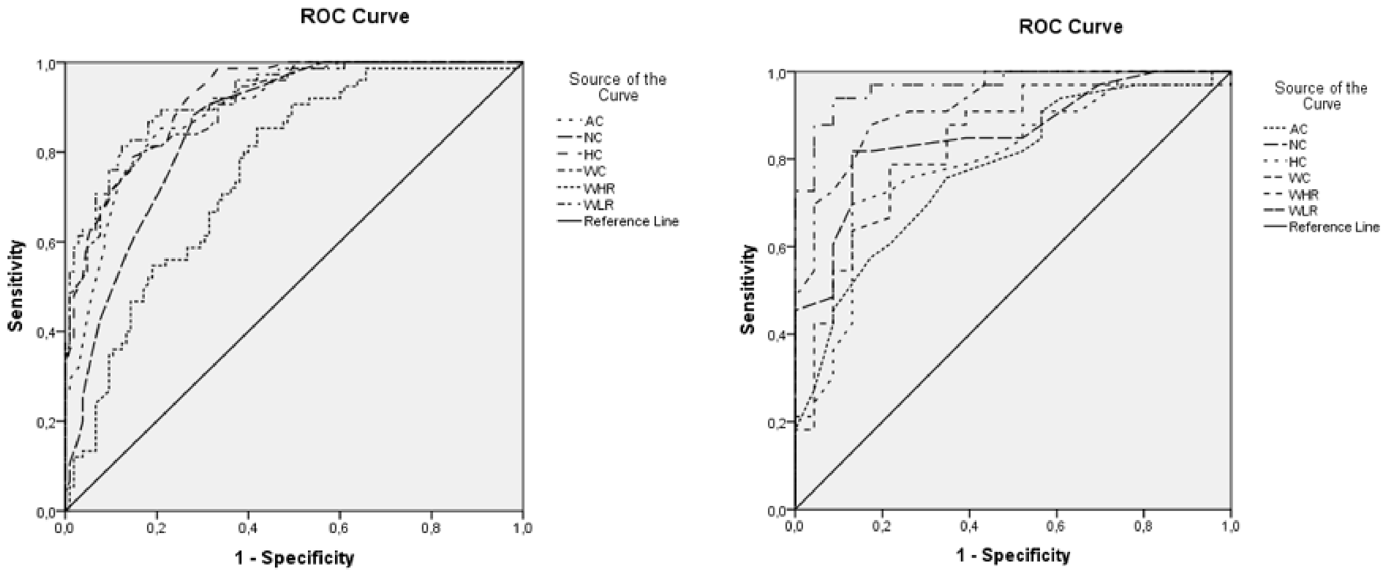
In Figure 2, the anthropometric measurements' accuracy for diagnosing obesity was compared using plots of the ROC curves.

AUC, sensitivity, specificity, and cut-off values of anthropometric measurements for MS and obesity were demonstrated in Table 3.



FEMALE **MALE**

Figure 1. The anthropometric measurements' accuracy for diagnosing MetS was compared using plots of the ROC curves. WC: Waist Circumference; HC: Hip Circumference; AC: Arm circumference; NC: Neck circumference; WHR: Waist-Hip Ratio; WHtR: Waist-To-Height Ratio.



FEMALE **MALE**

Figure 2. The anthropometric measurements' accuracy for diagnosing obesity was compared using plots of the ROC curves. WC: Waist Circumference; HC: Hip Circumference; AC: Arm circumference; NC: Neck circumference; WHR: Waist-Hip Ratio; WHtR: Waist-To-Height Ratio.

Table 3. Cut-off values of anthropometric measurements for metabolic syndrome and obesity

	AUC	Cut-off value	Sensitivity	Specificity	95%CI
Females with metabolic syndrome					
AC	0.703	31.75	68	58	0.621-0.785
NC	0.763	34.85	80	56	0.682-0.844
HC	0.757	113.75	63	80	0.677-0.836
WHR	0.701	0.90	78	57	0.614-0.787
WHtT	0.769	0.61	85	59	0.695-0.843
Males with metabolic syndrome					
AC	0.573	35.75	34	79	0.419-0.727
NC	0.795	39.75	84	58	0.675-0.915
HC	0.607	111.5	59	70	0.452-0.761
WHR	0.888	0.96	75	87	0.805-0.971
WHtT	0.888	0.61	84	87	0.797-0.979
Females with obesity					
AC	0.892	32.25	74	87	0.847-0.938
NC	0.857	34.6	88	72	0.803-0.910
HC	0.919	110.75	81	80	0.882-0.956
WC	0.903	102.50	81	81	0.861-0.945
WHR	0.756	0.92	60	70	0.686-0.826
WHtT	0.922	0.61	89	77	0.884-0.959
Males with obesity					
AC	0.775	33.5	60	78	0.653-0.897
NC	0.857	40.25	81	82	0.759-0.955
HC	0.791	110.50	72	78	0.669-0.913
WC	0.926	105.50	87	82	0.861-0.991
WHR	0.838	0.95	78	78	0.731-0.945
WHtT	0.968	0.61	93	91	0.929-1.000

WC: Waist Circumference; HC: Hip Circumference; AC: Arm circumference; NC: Neck circumference; WHR: Waist-Hip Ratio; WHtR: Waist-To-Height Ratio. AUC: Area Under The Curve

Discussion

A significant correlation of MS components with anthropometric measurements has been detected in our study. There is also a significant correlation between anthropometric measurements with NC and AC. It turns out that NC is associated with a variety of cardiovascular diseases and impaired lipid metabolism. It is thought that it may be used as an indicator in many fatal or non-fatal cardiovascular cases (5,14-17). NC has been detected to be higher in individuals with obesity. Similarly, NC values are significantly found out to be higher in obese participants in our study. NC cut-off values for metabolic syndrome were determined as 39.75 for males (84% sensitivity, 58% specificity) and 34.85 for females (80% sensitivity, 56% specificity). However, they were determined for obesity as 40.25 for males (81% sensitivity, 82% specificity) and as 34.6 for females (88% sensitivity, 72% specificity). In two different studies conducted by Luo et al. (5) and Dai et al. (14) to determine the correlation with visceral obesity, NC cut-off values have been detected as 38.5 in males and 34.5 in females similar to our study. Also, that NC is associated with cardiometabolic risk factors, and increases prospective cardiovascular case incidence has been reported in this study. That there is a significant correlation between NC and glucose, triglyceride, HDL-cholesterol, SBP, and DBP in our study promotes this finding. Similarly, Ozkaya et al (16) revealed in their study including 264 participants that NC is significantly associated with SBP, DBP, HDL-cholesterol, and triglyceride. NC has also been found out to be associated with the whole cardiometabolic risk factor in a study conducted by Preis et al (17), however, there has not been a significant detected correlation with LDL-cholesterol in males and there has been a low correlation in females. In our study, similarly, no correlation has been detected between LDL-cholesterol and neck circumference.

WHR, WHtR, WC, and HC have been associated with cardiovascular risk factors in several studies (18-20). However, there are a limited number of studies related to AC. Several studies have revealed that AC may be an alternative measurement in cases like pregnancy in which measuring waist circumference is not possible (21,22). Fakier et al. (23) have detected a high correlation between BMI and arm circumference in pregnancy up to 30th weeks in their study. The cut-off value has been determined as 30.57. That AC is associated with obesity has been detected in another study conducted by Okereke et al. (20) with 578 pregnant and the cut-off value has been determined as 33. Similarly, the cut-off value for obesity has been detected as 32.25 in our study. AC, WC, HC, WHtR, and WHR have been detected to be higher significantly in patients with metabolic syndrome in the study of Sagun et al. (24). The association among glucose, triglyceride, HDL-cholesterol, SBP, and DBP and these anthropometric measurements have been found out significantly similar to our study.

In a prospective cohort study on abdominal obesity, cardiovascular diseases, and cancer-related deaths, 44.636 females have been followed up for 16 years and obesity has been found out to be associated with cardiovascular diseases. Our study has revealed that WHR and WHtR are associated with hypertension and hypercholesterolemia. Higher WC or WHR has been associated with an increased cardiovascular risk even in females with normal weight (18). It is known that WC is the main measurement for the risk estimation compared to the other anthropometric measurements because it reveals a high correlation with visceral fat accumulation. The status of WHR in risk estimation differs. Some studies are revealing that a large waist circumference and a narrow hip circumference reflect the cardiovascular risk more accurately. There are also studies showing that a narrow waist circumference and a wide hip circumference ratio are protective (21). According to some studies in literature, WHR is considered to be more effective than WC in risk estimation (22). American Heart Association recommends the ultimate value for WHR is 0.95 for males and 0.88 for females (25). Cut-off values for obesity have been determined as 0.95 for males and 0.92 for females in our study. WHtR can be an alternative to WHR because it indicates body frame size more accurately lately. This situation has been supported by some studies in the literature. Patel et al. (26) express that WC and WHtR are more associated with metabolic syndrome components compared to WHR. Our study has been supporting this finding. Also, the correlation between BMI and metabolic syndrome components is stronger than WHR.

There are some limitations of our study. Body compositions have been estimated through anthropometric measurements. Notwithstanding, some methods such as CT, MRI, and BEI have importance in the determination of body composition (27). Manuel anthropometric measurements have been preferred due to their practicality. MS frequency has been found out as 61% in females and 59% in males in our study. Compared to the other studies conducted in our country, MS frequency is higher because the participants have been chosen from the applicants to family medicine policlinics consecutively. For this reason, it is not possible to say that MS frequency represents the general population.

Conclusion

BMI may be a simple and adequate measurement for the early diagnosis of obesity. Some measurements like waist circumference, waist-to-height ratio, and waist-hip ratio may also be used to measure the abdominal fat distribution and to determine body frame size. However, considering neck or arm circumference may be a good alternative when waist circumference cannot be measured in patients with pregnancy, cirrhosis, acid, or bedridden patients.

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