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Optimal Anthropometric Cutoff Points to Predict Overweight and Obesity: A Cross-Sectional Survey in Iranian Females

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Abstract

Background: Body mass index (BMI) is the most applicable measure to screen overweight and obesity. However, individual and demographic factors affect the BMI cutoff values.
Objectives: The current study aimed to determine the cutoff points for waist circumference (WC), waist-to-hip ratio (WHpR), waist-to-height ratio (WHtR) and neck circumference (NC) as indicators of overweight and obesity in Iranian females.
Methods: This cross-sectional survey was conducted on 2466 females, aged 30 - 59 years, recruited from five ethnic groups; Arab, Kurd, Sistani and Baluchi, Turk and Turkmen in Iran, from Nov 2015 to Feb 2016. The subjects were selected by cluster multistage random sampling through five provinces. Receiver operating characteristics (ROC) analyses and Youden index were used to estimate the optimal anthropometric cutoff points.
Results: Overall, 38.1% of females were overweight and 38.0% were obese. Significant differences of nutritional status were observed among different ethnic groups ($P < 0.001$). The higher rates of overweight were observed in Kurd and Turk subject. Furthermore, the obesity was more common among Arab and Kurd subjects. Sistani and Baluchi showed the lowest rate of obesity and highest underweight. ROC analysis showed the highest area under curve (AUC) for WHtR and WC, followed by NC and WHpR was in the lowest area. The optimal cutoff points to diagnose overweight and obesity were WC, 90.25 and 95 cm, WHtR, 0.57 and 0.62, NC, 33 and 34 cm, and WHpR, 0.90 and 0.93 in total population, respectively.
Conclusions: Higher cutoff values were proposed for anthropometric parameters in different ethnic groups of Iranian females compared to international cutoff points to predict overweight and obesity.

Keywords: Obesity, Overweight, Prevalence, Females, ROC Curve, Sensitivity, Specificity

1. Background

Overweight and obesity are considered as the fifth cause of death worldwide, as a result of metabolic disease. The rate of overweight is anticipated about 35 billion by 2030, and obesity will be 537 million (1). Obesity is an important risk factor of cardiovascular disease. Also, it worsens the glycemic and lipid profile and increases the risk of diabetes, hypertension and hyperlipidemia (2). The incidence of overweight and obesity is dependent on excessive fat storage in different parts of the body. Body fat distribution results different degrees of severity and risk of metabolic diseases and other chronic disorders (3). Despite the serious health threatening effects of obesity in various population groups, there is no agreement on the amount of fat content and body fat percentage as the criteria to diagnose obesity (4). Several indices are suggested in different demographic groups with specific advantages and limitations. Body mass index (BMI) is the most common tool in screening obesity in adult population (5).

Some other anthropometric parameters were also used to define overweight and obesity. Waist circumference (WC) is a reliable indicator which determines abdominal obesity more accurately than other indices, especially in adult subjects. Besides, waist-to-hip ratio (WHpR) is used as an anthropometric measurement to predict obesity and metabolic diseases (6). Furthermore, waist-to-height ratio (WHtR) is a relatively new index to measure obesity and predict metabolic risks that modulate the height effect to determine central obesity which is affected by genetic variation (7). On the other hand, neck circumference (NC) was also used as a simple and valid method to predict cardio-

vascular disease, insulin resistance, dyslipidemia and hypertension risks (8-10).

Although each of the indices measures obesity with different errors, the best way to assess obesity-related metabolic diseases using anthropometric indices still remains controversial. Anthropometric parameters depend on gender, age, race/ethnicity and geographical areas. Therefore, body weight and body composition vary in different populations and ethnic groups (11). World health organization (WHO) reported that the association of BMI, percentage of body fat and health risks in Asian and European populations were different. Furthermore, it is suggested that a clear BMI cutoff point could not determine overweight or obesity for all Asian populations (12). Therefore, ethnic diversity in the Asian population should be considered to identify BMI cutoff point for health risks. To the authors' best knowledge; there is no finding on anthropometric cutoff points in different ethnic groups of Iranian females.

2. Objectives

The current study aimed to compare specificity and sensitivity of WC, WHpR, WHtR and NC compared to BMI, to define overweight and obesity in females, aged 30-59 years, from five large ethnic groups of Iran.

3. Methods

3.1. Study Population and Sampling

In this cross-sectional survey, 2750 females were selected from five ethnic groups; Arab, Kurd, Sistani and Baluchi, Turk and Turkmen are distributed in various regions of Iran. The survey was performed from Nov 2015 to Feb 2016.

The sample size was estimated 504 cases, according to Z = 95%, P = 0.3, d = 4%, and power of 0.8 (13). Subjects were selected among families covered by health system using cluster and multi-stage sampling. The sampling was conducted in urban and rural areas of five provinces with the most original population of intended ethnic groups. In each distinct, the cluster distributions were stratified according to place (urban/rural) and socioeconomic status of regions and in each cluster, 22 subjects were randomly selected by systematic random sampling from the list of inhabitants as sampling frame of each health center.

The inclusion criteria were middle-aged female (30 - 59 years), females who were originally from one of the five intended ethnicities. The exclusion criteria were pregnancy, lactating, less than one year interval to previous delivery and subjects with chronic disease such as cancer, thyroid disorders, muscle-skeletal malfunction and other diseases that affect nutritional status. The clinical information was obtained from the participants or the health records.

The study subjects in the age range of 30 - 59 years were considered as middle-aged. This group was selected due to high risk of chronic diseases in this age category and the necessity to prevent diseases and slow their progression that provide a healthier aging in later years.

The study was approved by the ethics committee of Jundishapur University of Medical Science, Ahvaz, Iran (No. AJUMS.REC.1393.119). The verbal consent was also obtained from all participants after explaining the goals of the study.

3.2. Data Collection and Measurements

Demographic and anthropometric characteristics, including age, type of ethnicity, resident area, weight, height, waist circumference, hip circumference and neck circumference were gathered for all participants. Body weight was measured using a digital scale (beurer, Germany) while subjects were lightly clothed and barefoot, to the nearest 0.10 kg error. The place of measurement was on the ground floor with no slope. Moreover, all weighing scales were calibrated during the study by a 2 kg weight control. Height was measured by Seca height scale while subjects were in a standing position and barefoot, to the nearest 1 cm error. BMI was expressed as body weight (kg) divided by squared body height (m^2). The study used WHO cutoff points to determine overweight and obesity. The BMI values greater than 25 kg/m^2 was defined as overweight and BMI $\geq$ 30 kg/m^2 as obesity.

WC was measured at the midpoint between the lowest rib margin and the iliac crest that surrounded the abdomen parallel to the floor, and at the end of normal expiration and hip circumference was measured at the maximum extension of the buttock using a non-stretch measuring tape, to the nearest 0.1 cm. WHpR was calculated as WC divided by HC and WHtR was calculated as WC divided by height. NC was measured using a non-stretch measuring tape in the midway of the neck, between mid-cervical spine and mid anterior neck to the nearest 0.1 cm. All measures were quantified by a trained health professional. Interviewers were trained to measure anthropometric indices by a standard protocol and their performances were evaluated by an observer, several times during the study.

3.3. Statistical Analysis

Analyses were conducted by statistical package for social sciences (SPSS) version 18 (SPSS Inc., Chicago). Kolmogorov-Smirnov test was used to check normality of data. Then the parametric tests were used for all analyses due to normal distribution of data. The intergroup comparisons were measured by one-way ANOVA followed by

post hoc testes and descriptive data were reported as mean ± standard deviation or frequency and percent. Receiver operating characteristic (ROC) curve was constructed to assess the accuracy of WC, WHpR, WHtR and NC to diagnose overweight and obesity, by measuring area under the curve (AUC). The optimal cutoff points of anthropometric parameters were estimated as the maximum sensitivity and specificity. The $P < 0.05$ were considered significant.

4. Results

A number of 2750 females were selected according to inclusion criteria, of which 284 were excluded due to chronic diseases and metabolic disorders and 2466 subjects were assessed in the study. The prevalence of underweight, overweight and obesity were respectively 1.5%, 38.1% and 38.0% in the study population. The rate of both overweight and obesity in Kurd group were in higher levels. Although obesity was more common among Arab females, their overweight prevalence was the lowest. Sistani and Baluchi ethnic was the weakest group with the lowest mean BMI (Table 1).

Anthropometric parameters according to ethnic groups are presented in Table 1. The mean BMI was 28.6 kg/m^2 in a range of 27.0 ± 5.3 to 29.6 ± 43. The mean WC, WHpR and WHtR indices were significantly higher in Kurd and lower in Sistani and Baluchi and also Turk females. NC was significantly higher in Turk and Kurd females and lower in Sistani. Table 2 shows the significantly positive relationship between BMI and each anthropometric index.

The areas under the ROC curves (AUCs) of anthropometric parameters based on BMI ≥ 25 and BMI ≥ 30 as standard criteria for overweight and obesity are presented in Table 3. WC and WHtR were categorized in very good areas of accuracy (AUCs greater than 0.8), followed by NC in good area (AUCs > 0.7) and WHpR in sufficient area (AUCs > 0.6) to identify overweight and obesity. Table 3 shows the optimal cutoff points of overweight and obesity diagnosis considering the highest sensitivity and specificity, according to ethnic groups.

5. Discussion

The current study showed that 76.1% of females were overweight and obese (BMI ≥ 25), and reported WHtR and WC as the most accurate anthropometric parameters which had the highest AUC value (more than 0.85) compared to NC and WHpR.

The study found overall prevalence of overweight and obesity 38.1% and 38.0% respectively. In comparison, former studies showed a wide range of overweight and obesity. A systematic review conducted by Jafari-Adli et al. (14) reported that 27.0% - 38.5% of adults were overweight and 12.6% - 25.9% were obese. Moreover, a report revealed that 63.3% of Iranian females, aged more than 20 years, had BMI value ≥ 25 (15). The differences observed in comparison of obesity prevalence in the current study compared to previous literatures may be due to ethnic variations that affect body composition; since the current study also showed significant differences between measured ethnic groups. Furthermore, there is an increasing trend of overweight and obesity prevalence in all age groups, genders, race/ethnic and developing status over the years, therefore, the higher rate of obesity in the current study may be attributed to the global nutrition transition (16).

The current study showed WHtR in a very good range of accuracy to define overweight and obesity. Similarly, Ahmad et al. (17) found higher AUC level for WHtR in adult females. Consequently, WHtR may be a more reliable index to estimate body fat. Since WHtR is adjusted for height, it can remove ethnic differences and demographic variations and become a unique index to predict the risk of cardiovascular diseases at national level. Furthermore, a systematic review and meta-analysis introduced WHtR as a stronger predictor of cardiovascular diseases compared to WC, in different ethnicities and age groups (18). Similarly, Khader et al. (19) reported WHtR with the strongest association with metabolic disease in 3462 females in Jordan. The current study found optimal WHtR as 0.57 and 0.62 to identify overweight and obesity, respectively. Inconsistently, recent literatures showed different results (19, 20) that may be due to demographic variety.

WC was recognized as another most reliable index to define overweight and obesity. This was in accordance with previous literatures in Germany and Australia (21, 22) Yang et al. (23) showed the priority of BMI and WC to estimate body fat percentage which was detected by dual-energy x-ray absorptiometry (DEXA). Recently, researchers proposed using WC to screen overweight and obesity in community based programs, due to high reliability of WC and its easy usage and interpretation (24). However, this optimal value varied in different studies (20, 25). Ren Q et al. (25) identified the values of WC as 79.9 cm among Chinese females to detect hypertension that was lower than that of the current study findings.

In the current study, NC was categorized in the second level of accuracy, after WHtR and WC, to define overweight and obesity. Although, recent studies reported NC higher than 37 cm as the cutoff value of cardiovascular disease risk factors, it cannot be a proper cutoff to predict overweight and obesity in all populations (10). The current study found NC ≥ 37 cm in lower than 20% of females, although more than three-quarters of them were overweight based on BMI definition. In accordance with the current

Table 1. Demographic and Anthropometric Characteristics of Study Subjects, According to Ethnic Groups[a]

Anthropometric Measure	Arab	Kurd	Sistani and Baluchi	Turk	Turkmen	Total	P Value[b]
Age, y	40.58 ± 6.04	39.00 ± 5.62	39.35 ± 6.10	38.89 ± 5.50	40.45 ± 5.42	39.67 ± 5.79	< 0.001
BMI, Kg/m^2	29.50 ± 5.53	29.56 ± 4.30	27.05 ± 5.32	28.17 ± 4.71	28.89 ± 5.29	28.64 ± 5.11	< 0.001
Waist circumference, cm	95.79 ± 12.92	103.48± 10.07	91.21 ± 12.58	90.39 ± 12.14	97.91 ± 13.33	95.75±75	< 0.001
Waist to hip ratio	0.93 ± 0.08	0.97 ± 0.06	0.89 ± 0.08	0.86 ± 0.07	0.93 ± 0.08	0.91 ± 0.08	< 0.001
Waist-to-height ratio	0.61 ± 0.08	0.66 ± 0.06	0.58 ± 0.08	0.56 ± 0.07	0.61 ± 0.08	0.60 ± 0.08	< 0.001
Neck circumference, cm	34.66 ± 3.03	35.43 ± 2.39	33.86 ± 2.63	35.60 ± 3.28	34.64 ± 2.57	34.83 ± 2.86	< 0.001
Underweight	2 (0.4)	2 (0.4)	24 (4.9)	1 (0.2)	8 (1.6)	37 (1.5)	< 0.001
Normal	106 (20.4)	67 (14.1)	149 (30.2)	122 (25.6)	108 (21.5)	552 (22.4)	
Overweight	185 (35.6)	188 (39.5)	190 (38.5)	189 (39.7)	187 (37.3)	939 (38.1)	
Obesity	226 (43.5)	219 (46.0)	130 (26.4)	164 (34.5)	199 (39.6)	938 (38.0)	

Abbreviation: BMI, body mass index.
[a] Data are presented as mean ± SD or No. (%).
[b] P values are calculated by one way ANOVA; Different superscript letters in each row indicate significant differences.

Table 2. The AUC for Anthropometric Parameters to Identify Overweight and Obesity in the Study Subjects

			Arab	Kurd	Sistani and Baluchi	Turk	Turkmen	Total
WC	BMI ≥ 25	AUC	0.88	0.92	0.90	0.82	0.91	0.88
		95% CI	0.85 - 0.91	0.89 - 0.95	0.87 - 0.92	0.78 - 0.86	0.88 - 0.94	0.87 - 0.90
	BMI ≥ 30	AUC	0.87	0.09	0.91	0.86	0.90	0.88
		95% CI	0.84 - 0.90	0.87 - 0.93	0.88 - 0.94	0.83 - 0.90	0.88 - 0.93	0.86 - 0.89
WHpR	BMI ≥ 25	AUC	0.68	0.72	0.69	0.65	0.73	0.71
		95% CI	0.62 - 0.91	0.66 - 0.79	0.64 - 0.74	0.59 - 0.70	0.68 - 0.78	0.68 - 0.73
	BMI ≥ 30	AUC	0.63	0.66	0.69	0.65	0.67	0.67
		95% CI	0.58 - 0.68	0.61 - 0.71	0.63 - 0.74	0.60 - 0.70	0.62 - 0.72	0.65 - 0.69
WHtR	BMI ≥ 25	AUC	0.90	0.94	0.90	0.85	0.92	0.89
		95% CI	0.87 - 0.93	0.92 - 0.96	0.87 - 0.92	0.81 - 0.88	0.89 - 0.94	0.88 - 0.90
	BMI ≥ 30	AUC	0.88	0.91	0.92	0.86	0.92	0.88
		95% CI	0.85 - 0.91	0.88 - 0.94	0.89 - 0.94	0.83 - 0.90	0.89 - 0.94	0.87 - 0.90
NC	BMI ≥ 25	AUC	0.83	0.85	0.88	0.74	0.88	0.83
		95% CI	0.79 - 0.87	0.80 - 0.89	0.85 - 0.91	0.68 - 0.79	0.85 - 0.91	0.81 - 0.85
	BMI ≥ 30	AUC	0.80	0.76	0.83	0.79	0.85	0.80
		95% CI	0.76 - 0.84	0.71 - 0.80	0.79 - 0.87	0.75 - 0.83	0.82 - 0.88	0.79 - 0.82

Abbreviations: AUC, area under curve; ROC, receiver operating characteristic; CI, confidence interval; WC, waist circumference; WHpR, waist-to-hip ratio; WHtR, waist-to-height ratio; NC, neck circumference.

study results, Hingorjo et al. (26) introduced NC as an appropriate screening tool of obesity and showed NC ≥ 32 cm to diagnose overweight and obesity. However, NC cut-off point to detect central obesity was reported ≥ 37 cm (27). This higher value may be due to the type of obesity. NC is a marker of upper-body adipose tissue that may reveal metabolic risk factors over central adiposity and it can predict the obstructive sleep apnea more precisely than WC and BMI (28). The appropriate threshold level of NC to predict obstructive sleep apnea was considered ≥ 36 cm and metabolic syndrome, ≥ 33 cm (28, 29).

The current study found WHpR in a sufficient area of ac-

Table 3. Optimal Cutoff Points of Anthropometric Indices to Identify Overweight and Obesity in the Study Subjects

	WC			WHtR			WHpR			NC		
	Optimal Threshold	Sensitivities	Specificities	Optimal Threshold	Sensitivities	Specificities	Optimal Threshold	Sensitivities	Specificities	Optimal Threshold	Sensitivities	Specificities
Arab												
Overweight	90.25	0.81	0.82	0.910	0.69	0.60	0.570	0.85	0.82	33.25	0.76	0.72
Obesity	95.25	0.86	0.82	0.930	0.63	0.57	0.603	0.89	0.70	34.25	0.78	0.68
Kurd												
Overweight	94.25	0.92	0.72	0.951	0.74	0.70	0.608	0.90	0.81	33.75	0.87	0.67
Obesity	103.50	0.87	0.79	0.974	0.61	0.60	0.656	0.90	0.80	35.25	0.71	0.69
Sistani and Baluchi												
Overweight	87.25	0.84	0.80	0.878	0.68	0.63	0.550	0.87	0.79	32.85	0.90	0.72
Obesity	95.50	0.87	0.82	0.900	0.67	0.61	0.610	0.87	0.82	34.55	0.79	0.74
Turk												
Overweight	86.50	0.78	0.78	0.852	0.64	0.61	0.531	0.83	0.79	34.25	0.70	0.67
Obesity	90.50	0.88	0.71	0.873	0.62	0.61	0.586	0.81	0.79	35.75	0.77	0.69
Turkmen												
Overweight	90.25	0.87	0.79	0.912	0.71	0.64	0.578	0.87	0.83	33.25	0.81	0.81
Obesity	99.25	0.83	0.80	0.940	0.63	0.61	0.621	0.87	0.80	34.10	0.86	0.70
Total population												
Overweight	90.25	0.83	0.81	0.901	0.69	0.62	0.571	0.83	0.81	33.25	0.82	0.71
Obesity	95.25	0.89	0.70	0.930	0.63	0.62	0.623	0.83	0.78	34.25	0.85	0.62

Abbreviations: WC, waist circumference; WHpR, waist-to-hip ratio; WHtR, waist-to-height ratio; NC, neck circumference.

curacy, less accurate than other anthropometric measures. Although, the most recent studies reported same results (30, 31), Al-Odat et al. (32) reported that WHpR was superior to WC and WHtR to predict metabolic syndrome. Another study in Iran also introduced higher AUC level for WHpR and WHtR compared to WC and BMI (33). The overall cutoff point for WHpR in the current study was nearly the same as former researches in Iranian population; however, it was different from other countries. For instance, the WHpR optimal cutoff value among Chinese females was 0.85, which was lower than this value in the current study subjects (25). The dissimilar results also reported in other studies (20). The ethnic differences in optimal cutoff value for all anthropometric parameters should be considered. The current study proposed that demographic factors affect the values including age, ethnicity, race, marital status and pregnancy history.

5.1. Limitation

The current study aimed to assess optimal anthropometric cutoff points in just five ethnic groups of Iran. So, the current study didn't evaluate the Fars population as the major ethnicity. Therefore, the total results cannot be the representative of national Iranian population and should be reported separately by ethnic groups.

5.2. Strength

The main strength of the current study was the assessment of optimal anthropometric cutoff points among five

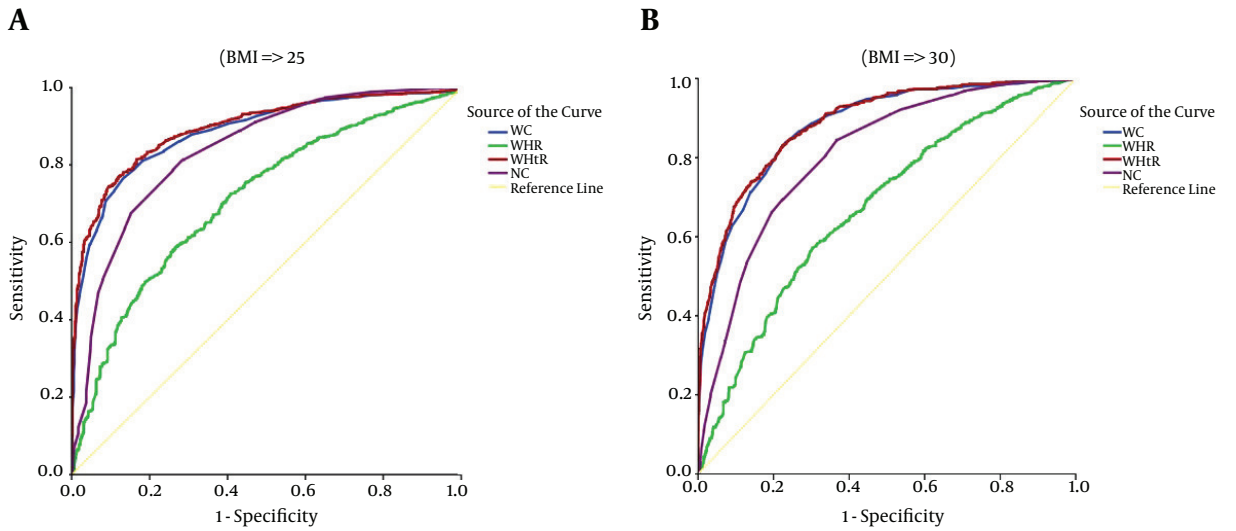

Figure 1. The Area Under Curve for Waist Circumference, Waist-to-Hip Ratio, Waist-to-Height Ratio and Neck Circumference to Define Overweight (BMI $\geq$ 25) (A) and Obesity (BMI $\geq$ 30) (B) in the Study Subjects

predominant ethnic groups that removed the effect of ethnic diversity to predict health risks.

5.3. Conclusion

In conclusion, overweight and obesity prevalence in Iranian females reached a critical level that need to be considered in health political programs. Although some ethnic groups such as Arab and Kurd were in high level of overweight or obesity, the rate of underweight in Sistani and Baluchi ethnic group was noticeable. The study concluded WC, WHtR and NC can be successfully identified overweight and obesity alternative to BMI categorization. The optimal anthropometric cutoff points were different by ethnic groups.

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