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Abstract

Background: Various indices have been used to estimate overweight and obesity; all have limitations and strengths. The prevalence of overweight and obesity may differ by ethnicity.

Aims: This study evaluated waist circumference (WC), waist-to-hip ratio (WHpR), waist-to-height ratio (WHtR) and neck circumference (NC) as reliable alternatives to body mass index for screening for overweight and obesity, and determined their optimum cut-off values in different ethnic groups.

Methods: The study was conducted from November 2015 to February 2016 among adolescents aged 12–14 years from five ethnicities in the Islamic Republic of Iran: Arab, Kurdish, Sistani and Baluchi, Turkish and Turkman. Stratified multistage sampling was used to select 2444 students. Receiver operating characteristic curves were constructed to evaluate WC, WHpR, WHtR and NC as screening indices for overweight and obesity as categorized by body mass index centiles.

Results: The prevalence of overweight and obesity in the total sample were 15.3% and 9.2% respectively, with higher rates in students of Arab, Kurdish and Turkish ethnicity. The areas under curve ranged from 0.8 to 0.9 for WC, WHtR and NC. The mean optimum values with the highest sensitivity and specificity to identify overweight were: 72.3 cm (sensitivity 0.80, specificity 0.75) for WC, 0.46 (0.85, 0.70) for WHtR and 31 cm (0.76, 0.76) for NC. For obesity mean optimum values were: 77 cm (0.84, 0.81) for WC, 0.50 (0.84, 0.84) for WHtR and 31.5 cm (0.88, 0.71) for NC.

Conclusions: WC, WHtR and NC may be useful tools to screen for adiposity using their optimum values for sex and ethnicity.

Keywords: overweight, obesity, anthropometric indices, adolescent, ethnicity, Iran

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Introduction

The increasing trend of overweight and obesity is a critical public health problem worldwide (1). Obesity in children and adolescents increases the risk of metabolic syndrome conditions. Furthermore, it can cause chronic disease in adulthood, such as hyperlipidaemia, diabetes, metabolic syndrome, muscle-skeletal disorders, asthma and apnoea (2). Fat distribution and type of obesity are the main predictors of metabolic disorders (3). Despite the serious health

risks of obesity in all age groups, no exact index to determine body fat percentage is available (4). Various indices have been used to estimate overweight and obesity with varying limitations and strengths. However, body mass index (BMI) is the most appropriate method for screening of weight status in all age groups (5).

Two popular indices for abdominal obesity are waist circumference (WC) and waist-to-hip ratio (WHpR) (6). Waist-to-height ratio (WHtR) is another index to estimate waist girth. WHtR adjusted for height is a new predictor of obesity and cardio/metabolic risks (7). In addition, neck circumference (NC) has recently been used as a new measure of fat deposition and cardio/metabolic disease (8–10). Studies have shown that abdominal obesity better predicts major causes of death—cancer and cardiovascular disease—compared with BMI (11,12). Similarly, NC can accurately predict metabolic syndrome and blood pressure differences as it measures upper body adiposity (13). Therefore, the limitations of BMI in detecting fat distribution and differentiating between fat and muscle deposition can be overcome using WC and NC.

 Anthropometric indices are affected by demographic factors such as age, sex, race or ethnicity, and geographical location because of different characteristics of populations in body size and composition (14). Thus, the cut-off points of these indices differ in various regions. Consequently, the levels of obesity and obesity-related health risks may differ by ethnicity at the same level of BMI. For instance, health risks at lower levels of BMI among Asian populations have been reported (15).

This study aimed to evaluate the use of WC, WHpR, WHtR and NC as a reliable alternative to BMI and determine the optimal cut-off values for identification of overweight and obesity.

Methods

Study design and sample

This community-based cross-sectional survey was carried out from November 2015 to February 2016. The sample included adolescents aged 12–14 years from 5 different ethnic groups in 5 geographical regions of the Islamic Republic of Iran where each ethnic group is concentrated. The study participants were categorized into the following 5 ethnic groups according to both their parents' ethnicity and their place of residence.

Arab ethnicity: inhabitants in some parts of Khozestan province

Kurdish: mostly from western Islamic Republic of Iran (Kurdistan province)

Sistani and Baluchi: ethnic group in Sistan and Bluchestan province in the east of the country

Turkish ethnicity: mostly living in the north-east of the country, especially in Azerbaijan, Ardabil and Zanjan provinces

Turkman: a branch of Turkmen in northern and north-eastern Islamic Republic of Iran (Golestan and Khorasan provinces).

The sample size was estimated as 504 for each ethnic group based on 30% predicted prevalence of obesity (16), 95% confidence interval and a precision level of 5% (total of 2 520). The participants were selected using stratified multistage sampling according to socioeconomic status and geographical location. In the first stage, 125 junior high schools (25 schools from each ethnic region) were selected by random sampling, out of a total of 674 schools in all 5 provinces. Then, 20 adolescents were selected in each school by simple random sampling (Figure 1). After drop-outs, the final sample was 2 444 students.

Inclusion criteria were students between 12 and 14 years of age from the selected ethnicities. Exclusion criteria were other ethnic origins and students with developmental and intellectual disabilities, which was assessed by asking the student's teacher.

Verbal consent was obtained from all participants and their parents or legal caregivers after explaining the aim of the study.

Data collection

Demographic variables and anthropometric measures were obtained for all participants, including age, sex, ethnicity, residence area, weight, height, waist circumference, hip circumference and neck circumference.

Weight and height measures were taken by trained health staff. Weight was recorded in light clothing by a digital weighing scale (Beurer, Germany) to the nearest 0.1 kg. Weight scale accuracy was checked against standard scales, twice a day. Height was measured barefoot using a non-stretch tape measure (Seca, Japan) to the nearest 0.5 cm. WC was measured at the midway between the lowest rib margin and the iliac crest while the student was standing, and hip circumference was measured at the maximum extension of the buttock using a non-stretch measuring tape, to the nearest 0.1 cm. NC was measured at the midway of the neck, between mid-cervical spine and mid anterior neck using a non-stretch measuring tape, to the nearest 0.1 cm.

WHpR was the ratio of the waist to hip circumferences and WHtR was calculated by dividing the waist circumference by height. BMI was calculated as weight divided by height squared (kg/m2). The students were categorized as underweight (BMI lower than 5th age- and sex- specific centiles), normal weight (BMI between 5th and 85th age- and sex-specific centiles), overweight (BMI between 85th and 95th age- and sex-specific centiles), and obese (BMI greater than 95th age- and sex-specific centiles) based on NCHS/CDC cut-off points (17).

Data analysis

Statistical analyses were performed using SPSS, version 18. Anthropometric indices and demographic characteristics of the participants were reported as mean and standard deviation (SD) and frequency. Normal distribution of the data was checked using histogram and Q-Q plots. We assessed between-group comparisons using the independent samples t-test and one-way ANOVA; post-hoc tests were used for further analysis.

Receiver operating characteristic (ROC) curves were used to determine the usefulness of WC, WHpR, WHtR and NC as screening tools of overweight and obesity, and to estimate appropriate cut-off values by the Youden index. The area under the curve (AUC) and 95% confidence interval (CI) were calculated from the ROC analysis to determine the overall accuracy of the anthropometric indices in screening for overweight and obesity.

Sensitivity and specificity values, and true-positive and true-negative rates were calculated to construct the ROC curves. Sensitivity was defined as the probability that obesity or overweight would correctly classify subjects who were test-positive for each method (WC, WHpR, WHtR and NC). Specificity was defined as the probability of correctly classifying the subjects who were test-negative for each method (WC, WHpR, WHtR and NC).

A P-values less than 0.05 was considered statistically significant.

Ethical considerations

The study was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Science, Ahvaz, Islamic Republic of Iran.

Results

A total of 2 444 students, aged 12–14 years, participated in the study, 48% of whom were boys. Demographic characteristics and anthropometric data of the students according to sex and ethnic group are summarized in Table 1. Girls had a significantly higher mean BMI than boys (P

The prevalence of underweight, overweight and obesity in the total sample was 6.7%, 15.3% and 9.2% respectively using BMI centiles. Table 2 shows the prevalence of underweight, overweight and obesity according to sex and ethnicity. The lowest prevalence of both overweight (8.8%) and obesity (3.1%) was seen in Sistani and Baluchi students. The highest prevalence of overweight was seen in female Kurdish students (21.6%) and male Turkish students (21.8%). The highest prevalence of obesity was seen in both girls and boys of Arab ethnicity.

Table 3 shows the relationship between anthropometric indices and underweight, overweight and obesity (as categorized by BMI). A significant increasing trend was seen in all anthropometric indices with increasing BMI score.

The AUC of anthropometric indices assuming BMI overweight and obesity categories as standard criteria are shown in Table 4 . The AUC of WC, WHtR and NC showed very good accuracy to identify overweight and obesity, as indicated by AUCs greater than 0.8. The AUC of WHpR showed sufficient accuracy, as indicated by AUCs greater than 0.6 (
Table 4
and
Figure 2
).

Tables **5** and **6** show the optimal cut-off points to identify overweight and obesity, as

determined by the highest sensitivity and specificity, according to sex and ethnic group. In the total male population, the optimal cut-off values of WC to identify overweight and obesity were respectively 72.75 cm and 77.55 cm; WHpR were 0.88 and 0.88; WHtR were 0.46 and 0.49, and NC were 30.95 cm and 31.55 cm. These values in females to identify overweight and obesity were respectively: WC: 72.75 cm and 77.70 cm; WHpR: 0.84 and 0.84; WHtR: 0.47 and 0.50; and NC: 30.9 cm and 31.60 cm.

Discussion

Our findings indicate that 15.3% of the participants were overweight and 9.2% were obese. The anthropometric indices WC, WHtR and NC identified overweight and obesity accurately, as categorized by BMI centiles. Furthermore, the optimum values of WC, WHtR and NC were 72.3 cm, 0.46 and 31 cm respectively to identify overweight, and 77 cm, 0.50 and 31.5 cm respectively to identify obesity, based on the maximum sensitivities and specificities.

Recent studies have reported similar though slightly lower rates of overweight and obesity in Iranian school-aged children (18–23). This may be a consequence of the nutrition transition that is occurring in developing countries (24). In our study, students of Arab ethnicity had the highest BMI values and those of Sistani and Baluchi ethnicity had the lowest. Moreover, we observed a higher prevalence of obesity in students of Arab ethnicity compared with other ethnic groups. The main causes of higher obesity in Arab ethnicity may be different dietary habits, inactivity due to the hotter and more humid climate conditions in Khozestan and genetic factors (25). On the other hand, the prevalence of overweight and obesity were lowest in the Sistani and Baluchi ethnic group and a high prevalence of underweight was observed in this group. In this regard, Mirmohammadi et al. also reported low prevalence rates of overweight and obesity in Baluchi ethnic groups (20). The lower socioeconomic development in this region and lower availability of food might be the reason. Our study found that girls had significantly higher BMI values than boys. The higher BMI in girls may be due to less physical activity, as was shown in the CASPIAN study conducted in the Iranian population (23). In addition, we found boys had a higher prevalence of obesity and lower prevalence of overweight than girls. Other studies have reported similar results (18,26,27). However, different results have been reported by other studies. For instance, 2 studies in Iranian children and/or adolescents reported a higher prevalence of both overweight and obesity in boys (19,28). These differences may be due to differences in mean age of the participants and residence.

The second part of our study demonstrated the suitability of WC, WHpR, WHtR and NC to screen for overweight and obesity, as an alternative to BMI centiles. The BMI index does not determine fat content and distribution in overweight individuals which is a limitation, particularly as central fat and upper adiposity are reliable indicators of cardio/metabolic disorders (13,14).

A higher AUC for WHtR was found compared to WC, NC, and WHpR. This concurs with previous studies that showed a higher AUC for WHtR compared to WC to screen for obesity (29–31). Moreover, WHtR was a good predictor of body fat percentage and, in particular, it was more sensitive than BMI in identifying body fat, measured by skinfold methods (32,33). Furthermore, a systematic review and meta-analysis reported WHtR was a stronger predictor of cardiovascular disease risk factors compared with WC in different age and ethnic groups (34). The greater AUC for WHtR in different population groups supports its use as a reliable screening tool for adiposity. Furthermore, the WHtR index overcomes some of the limitations of WC as it is adjusted for height. Because WHtR removes the height variation effect, it can be a determinant of body fat distribution. Moreover, WHtR does not need age- and sex-specific references and so it is easier to interpret. In our study, the optimal cut-off points of WHtR to define overweight and obesity were respectively 0.46 and 0.49 in male students and 0.47 and 0.50 in female students. Similar studies used WHtR thresholds to identify adiposity in children, also showing nearly consistent results (30,32,33).

We found a suitable area under the ROC curve for WC. The optimal accuracy of WC to detect overweight and excess fat was consistent with recent findings (30,33,35–37). WC is known to be a practical tool for screening of over-nutrition. Because of the appropriate accuracy and ease of measuring and interpreting WC, it can be used alone or with BMI to satisfactorily screen for overweight and obesity, and could overcome the BMI limitations. Fujita et al., using a DEXA technique, showed a direct relationship between body fat and BMI, WC and WHtR (30). WC has also been reported to be a more sensitive index for detecting body fat percentage compared with BMI (38), and can predict cardio/metabolic disorders and metabolic syndrome conditions (39,40).

We estimated that the optimal cut-off points of WC were 73 cm to identify overweight and 77 cm for obesity, in both sexes. These values concur with recent studies which used BMI centiles as the reference (29,35). Mazıcıoğlu et al. determined overweight in 13-year-old Turkish children and reported WC cut-off points of 72.5 in males and 67.5 in females (35). On the other hand, based on percentage of body fat, WC cut-off points in other studies showed lower values; this might be because of the younger age groups and also different socioeconomic status of the sample which affected the health status of children (31,33).

The Kurdish ethnic group in our study had significantly higher WC, WHtR and WHpR values compared with other ethnic groups. The high prevalence of abdominal obesity in Kurdish adolescents supports the use of WC and/or WHtR in screening for over-nutrition. Although the BMI values were significantly higher in students of Arab ethnicity, the central obesity measures in the Arab group were similar to other ethnicities. Therefore, the use of BMI centiles may be more appropriate in those of Arab ethnicity together with WC.

The area under the ROC curve for WHpR was not in a suitable range. WHpR is a less accurate anthropometric measurement tool, especially in obese subjects, as it will underestimate the obesity and central body fat because both waist and hip circumferences increase similarly in overweight or obese people. Therefore, it may not be a useful predictive index of metabolic disease. In other studies, WHpR was also reported to be a less accurate index than WC and WHtR (41,42).

In our study, NC showed an adequate accuracy to identify overweight and obesity. The AUC of NC was lower than WHtR and WC but higher than WHpR. In this regard, Coutinho et al. reported a direct relationship between NC and BMI, WC, and body fat%. Hatipoglu et al. also reported NC to be an easy and accurate method to diagnose children with higher BMI levels (41,43); however they concluded WC was superior to NC for identifying overweight and obesity (41). The optimal cut-off points for NC in our study were 30.9 cm and 31.6 cm for overweight and obesity respectively in both sexes. Hatipoglu et al. reported similar NC values of 32.5 cm (males) and 31 cm (females) in post-pubertal subjects (41). We observed significantly higher NC values in Kurdish and Turkish ethnic groups and significantly lower values in Arab and Sistani and Baluchi participants. This is in line with our results for the central adiposity indices that showed higher upper fat content in the Kurdish adolescents and relatively lower fat content in students of Arab ethnicity.

The main limitation of our study was the lack of body composition analysis and skinfold thickness values to measure adiposity. Furthermore, because we sampled just 5 ethnic groups, the overall prevalence of overweight and obesity and also the optimal cut-off points cannot be generalized to the Iranian student population. Therefore, in accordance with our objective, the results are presented separately by ethnic groups. Moreover, Fars ethnicity, which is a major ethnic group of the Islamic Republic of Iran, was not included in our study, although it would be an appropriate comparison group.

Conclusion

The prevalence of overweight and obesity is of concern and needs to be considered in health programmes. The rates were different in various ethnic groups. WC, WHtR and NC successfully identified overweight and obesity in Iranian adolescents. Ethnic differences need to be considered to estimate optimal cut-off points of anthropometric indices.

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Competing interests: None declared.

Évaluation de la surcharge pondérale et de l'obésité chez les adolescents iraniens : valeurs seuils optimales pour les indices anthropométriques

Résumé

Contexte : Divers indices sont utilisés pour estimer la surcharge pondérale et l'obésité ; ils présentent tous des avantages et des inconvénients. La prévalence de la surcharge pondérale et de l'obésité peut varier en fonction de l'origine ethnique.

Objectifs : La présente étude a évalué le tour de taille, le rapport tour de taille/tour de hanches, le rapport tour de taille/taille et la circonférence du cou en les considérant comme des alternatives fiables à l'indice de masse corporelle pour dépister la surcharge pondérale et l'obésité. Elle a ensuite déterminé leurs valeurs seuils optimales pour différents groupes ethniques.

Méthodes : L'étude a été réalisée en République islamique d'Iran entre novembre 2015 et février 2016 auprès d'adolescents âgés de 12 à 14 ans et issus de 5 groupes ethniques différents : arabe ; kurde ; sistani et baloutche ; turc et turkmène. Une méthode d'échantillonnage stratifié à plusieurs degrés a été utilisée pour sélectionner 2444 étudiants. Des courbes ROC (fonction d'efficacité du récepteur) ont été tracées pour évaluer le tour de taille, le rapport tour de taille/tour de hanches, le rapport tour de taille/taille et la circonférence du cou en tant qu'indices de dépistage de la surcharge pondérale et de l'obésité telles que catégorisées par les percentiles d'indice de masse corporelle.

Résultats : La prévalence de la surcharge pondérale et de l'obésité dans l'échantillon total était, respectivement, de 15,3 % et 9,2 %. Des taux plus élevés ont été observés chez les

étudiants d'origine arabe, kurde et turque. Les aires sous la courbe oscillaient entre 0,8 et 0,9 pour le tour de taille, le rapport tour de taille/taille et la circonférence du cou. Les valeurs optimales moyennes ayant la sensibilité et la spécificité la plus élevée pour dépister la surcharge pondérale étaient : 72,3 cm (sensibilité 0,80 ; spécificité 0,75) pour le tour de taille, 0,46 (0,85 ; 0,70) pour le rapport tour de taille/taille et 31 cm (0,76 ; 0,76) pour la circonférence du cou. Pour l'obésité, les valeurs optimales moyennes étaient : 77 cm (0,84 ; 0,81) pour le tour de taille, 0,50 (0,84 ; 0,84) pour le rapport tour de taille/taille et 31,5 cm (0,88 ; 0,71) pour la circonférence du cou.

Conclusions : Les valeurs optimales du tour de taille, du rapport tour de taille/taille et de la circonférence du cou selon le sexe et le groupe ethnique peuvent s'avérer utiles pour dépister l'adiposité.

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