Determination of Obesity Indices Cut-Off Points for Predicting Metabolic Syndrome in Inactive College Students

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Abstract

Objective: The present this study aimed to determine the proper cut-off points for waist circumference (WC), Waist to height ratio (WHtR) and body mass index (BMI) for early predicting of metabolic syndrome among inactive college students.

Materials and Methods: In this cross-sectional study, 126 males (age 20.33±1.71) and 63 females (age 20.36±1.72) with inactive lifestyle participated. Based on the metabolic risk factors, the participants were assigned to group 1 (one risk factor and less) or group 2 (two risk factors and more) separately. Data were obtained using a questionnaire, anthropometric and physical fitness (VO_2max) measurements and blood sampling. Independent t-tests was used to show between-group differences according to the numbers of risk factors, Pearson correlation coefficient was used to determine the relationship between obesity indices and metabolic risk factors, and the ROC curves was used to estimate the power of predicting and to determine the cut-off points for metabolic syndrome's risk factors.

Results: Significant correlation between obesity indices and metabolic risk factors (Except blood glucose and systolic blood pressure in males) were observed. As the number of metabolic risk factors increased, the significant elevation of obesity indices in both genders were observed. All obesity indices were within normal range except fat percentage. Cut-off points for BMI, WC and the WHtR, were 21.19, 20.84 and 77.75, 0.46 and 75.50, 0.48 for males and females respectively.

Discussion: The best predictive indices and cutoff points for susceptibility to metabolic syndrome were: in males, 77.75 for WC and in females, 21.19 for BMI. It should be noted that in the present study, two or more factors were considered to determine the cut-off points to diagnose susceptible individuals.

Keywords: Metabolic syndrome, Sedentary lifestyle, Obesity indices

Introduction

The metabolic syndrome is a combination of 5 risk factors including obesity, insulin resistance /impaired glucose uptake and metabolism, dyslipidemia (high triglycerides, low HDL-C) and hypertension (1). Any of these risk factors

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may increase the risk of serious disease such as cardiovascular disease and diabetes. If there are at least 3 of these factors, the person is diagnosed with metabolic syndrome (2). According to the Adult Treatment Panel (ATP III), similar to America, the prevalence of metabolic syndrome in Iran is about 25 to 40 percent (3). Also in recent years, the more prevalence of metabolic syndrome in Iranian teenage between 10-19 years old was reported (4). New statistical data showed that students (18-24 years old) are exposed to chronic diseases. At least % 45.7 of Iranian students (5) and 43% of American students suffer from one condition of metabolic syndrome (6). Unhealthy diet and lack of exercise are the characteristics of the students' lifestyle which may lead to obesity and metabolic syndrome (7). Physical inactivity affects body composition by reducing muscle mass and increasing body fat percentage (8). Overweight and obesity are considered as a disease and may develop metabolic syndrome (9). Obesity can be assessed by various anthropometric measurements, including Body Mass Index (BMI), and abdominal obesity indices such as waist circumference (WC), Waist to height ratio (WHtR) (10). Many studies have reported, compared to Europeans, Asians have more body fat percentage (11). According to that, the incidence of metabolic risk factors was observed in lower cut-off points for BMI and WC in Asians. For example, for prediction of metabolic disorders, the cut-off points of BMI in China, Indonesia and Vietnam are 22.5, 21.5, and 20.5 in, respectively, and cut-off points for WC are 90 and 80 cm for Asian men and women, respectively (12).

Early detection of metabolic syndrome risk factors in student population would be possible by determination of appropriate cut-off points for obesity indices. In the next step, these cut-off points may be used in primary screening to prevent the spreading of metabolic syndrome risk factors in that population (9). According to this point of view that obesity cut-off points are depended on race, geographic region and gender, determining the appropriate cut-off points for detection of metabolic syndrome risk factors in student population may be helpful (13). This study aimed to assess the cut-off points for obesity indices which can be measured by easy and simple methods and tools (e.g. Questionnaires and some tests), instead of blood sampling. Thereby, the students at risk are detected to provide appropriate mechanisms to prevent the prevalence of the metabolic syndrome for health promotion at the university.

Materials and Methods

This cross-sectional study was carried out on Sharif University students. The volunteers filled out a checklist including demographic and physical activity information (14). Totally, 126 males (age 20.33±1.71) and 63 females (age 20.36±1.72) were selected and in regard of ethical research, they were informed about detailed information of methodology and then signed the informed consent for participation in this study. Based on the numbers of metabolic syndrome components, each participant was assigned to group 1 (lower risk subjects with 1 risk factor and less) or group 2 (at risk subjects with 2 risk factors and more). After 12 hours of fasting, blood samples were drawn. Then, separated serums were stored at -20°C for measuring plasma glucose (Bio system, England), high-density lipoprotein (HDL-C) and triglycerides (Kit Company test Pars, Iran) concentrations later, using photometric enzyme assay. Height and weight were measured in the fasting state, with light clothes and barefooted (Seca, Germany). BMI was calculated by dividing weight in kilogram by the square of height in meters. WC was measured in the area between the lowest rib and the top of the hip bone (Iliac crest) at the navel level. Also, for calculating WHtR, waist circumference was divided by hip circumferences. Body density was calculated by measuring the skinfold thickness at three sites: triceps, suprailiac and thigh for females, and chest, abdomen and thigh for males

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(15,16) on the right-hand side of the body using Caliper (harpenden CE 1020, England) to estimate body fat percentage. To ensure the inactivity of students the VO_2max was estimated by Cooper test (17,18). The cut-off points were estimated using data form group 2.

Statistical Methods

Independent T-test was used to find the between group differences in physical fitness and obesity indices, the Pearson correlation coefficient was used to examine the relationships between obesity and metabolic risk factors. ROC was used to estimate power of prediction for obesity indices and also determines the cut-off points based on the sensitivity and specificity. SPSS software version 16 was used for statistical analysis and values equal or less than %5 were considered significant.

Results

Based on the metabolic syndrome components, 126 males (age 20.33±1.71) and 63 females (age 20.36±1.72) were selected and based on the metabolic risk factors, each participated were assigned to group 1 (lower risk subjects with 1 risk factor and less, 99 males and 55 females) or group 2 (at risk subjects with 2 risk factors and more, 27 males and 8 females), and separate data from each sex were analyzed.

The Vo_2max of female was 20.84± 3.2 $ml/kg/min^{-1}$ and 34.47± 4.39 $ml/kg/min^{-1}$ in males.

The Vo_2max was 20.84± 3.2 $ml/kg/min^{-1}$ and 34.47± 4.39 $ml/kg/min^{-1}$ for females and males respectively. Also, based on their Vo_2max, they were allocated in 2 classes, very poor and poor (17,18).

According to table 1, Fasting blood glucose levels had no correlation with any of obesity indices and triglyceride levels had a strong relationship with all indicators in both genders. HDL in males and systolic blood pressure in females had significant relationship with obesity indices.

In table 2, cut-off points and area under the curve (AUC) for obesity Indices is shown for group 2 (more than one risk factor) in both genders. All of the AUCs were statistically significant and BMI in Females and WC in males had the most extensive AUC.

Table 3 shows that the AUCs for HDL and triglyceride were significant, and blood pressure's AUC was not significant.

Characteristics of 2 groups which separated by sex are presented in Table 4. Compared to

Table 1. Correlation of the variables between the obesity indices and metabolic disorders (N= 126 males and 63 females)

Risk factors / Obesity indices	Sex	Systolic pressure (mmHg)	Diastolic pressure (mmHg)	HDL-C (mg/dl)	Triglyseride (mg/dl)	Fasting Glucose (mg/dl)
BMI (kg/m2)	Males	r = 0.042	r = 0.124	r = -0.187*	r = 0.277**	r = 0.042
	Females	r = 0.421 **	r = 0.223	r = -0.259*	r = 0.265*	r = 0.148
WC (cm)	Males	r = 0.98	r = 0.159	r = -0.211*	r = 0.266**	r = 0.088
	Females	r = 0.346**	r = 0.122	r = -0.194	r = 0.427**	r = 0.158
WHtR (cm/cm)	Males	r = 0.113	r = 0.181*	r = -0.209*	r = 0.259**	r = 0.070
	Females	r = 0.322**	r = 0.099	r = -0.247	r = 0.358**	r = 0.152
Fat pecent	Males	r = 0.152	r = 0.173	r = -0.190*	r = 0.296**	r = 0.029
	Females	r = 0.502**	r = 0.378**	r = -0.185	r = 0.352**	r = 0.141

* $P<0.05$, ** $P<0.01$

Table 2. The Cut-Off Points and AUCs for obesity indices for group 2 in both genders

Sex	Obesity Indices	AUC	Cut-off Point	Sensitivity	Specificity	Upper-Bound	Lower-Bound	*P*
Females N=63	BMI	0.898	21.19	1.00	0.8	0.990	0.805	0.000
	WC	0.818	75.50	0.88	0.65	0.939	0.698	0.004
	WHtR	0.836	0.48	1.00	0.72	0.964	0.709	0.002
Males N=126	BMI	0.702	20.84	0.89	0.44	0.816	0.589	0.001
	WC	0.741	77.75	0.93	0.48	0.842	0.641	0.000
	WHtR	0.729	0.46	0.85	0.53	0.843	0.615	0.000

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group 1, a significant increase in obesity indices and a decrease in VO_2max which was significant in males, was observed in group 2.

Discussion

The aim of this study was to determine the proper cut-off points of obesity indices for early detection of metabolic syndrome in inactive students. Considering the age of our subjects (18-24 years old), and the necessity of the early predicting the risk of metabolic syndrome, so the cut-off points of obesity indices were estimated for group 2. In females, the most extensive AUC was related to BMI (0.898) and WHtR (0.836), and in males was related to WC (0.741), and WHtR (0.729), respectively.

Many studies showed that despite lower BMI, Asians have more fat percentages compare to Caucasians (3,11,19,20). Given the fact that there is a relationship between abdominal fat and health, the lower cut-off points must be considered for these populations (19). Also, the existence of at least one metabolic risk factor in %41 to %81 of all races was reported (even in low values of WC females: 75-80 cm and males: 80-85 cm) (20). In our study, the most extensive AUC in males belonged to WC, and this index has a strong correlation with HDL and triglyceride. The WC cut-off points in group 2 were 75.5 for females and 77.8 for males. Also, the cut-off points for HDL, triglycerides and hypertension in both genders were 78.9, 77.65 and 75.75 respectively, which were lower than other Iranian results. For example, in one study, WC cut-off point was estimated 94.5 for subjects with more than one risk factor (21) and in another study were suggested 94 and 80 for males and females respectively (22). The Cut-off points in Southeast Asia are nearly similar to our study, so that WC cut-off points for both genders were estimated 80 in Cambodia and China (11). In Korea and India 78, 80, and 83, 78 were reported for males and females respectively (23). In another study, the Cut-off points of 78 and 72 were estimated for Indian men and women over 20 years old. One reason for difference between the results of the present study with others can be related to diversity in method and site of the WC measurement. But the important reason should be referred to the participants' age differences. Compare to elderly, the lower cut-off points for young people was reported (24). An increase in WC cut-0ff point was observed with increasing the age. For example, in subjects with more than one risk factor, the cut-off points for WC were suggested 83 for young (18-24 years old) and 95 for elderly

Table 3. The Cut-Off Points and AUCs for obesity indices for detecting HDL, BP, Triglyceride abnormalities in all subjects.

Metabolic risk factors	Obesity Indices	AUC	Cut-off Point	Sensitivity	Specificity	Upper-Bound	Lower-Bound	*P*
HDL	BMI	0.624	21.11	0.71	0.58	0.705	0.543	0.003
	WC	0.610	78.9	0.63	0.62	0.692	0.529	0.009
	WHtR	0.627	0.46	0.69	0.56	0.708	0.547	0.003
Hypertension	BMI	0.575	20.50	0.73	0.91	0.670	0.480	0.112
	WC	0.585	75.75	0.75	0.45	0.676	0.493	0.073
	WHtR	0.584	0.46	0.63	0.52	0.676	0.491	0.075
Triglyceride	BMI	0.695	21.11	0.84	0.49	0.798	0.591	0.002
	WC	0.747	77.65	0.88	0.54	0.837	0.658	0.000
	WHtR	0.672	0.50	0.52	0.78	0.780	0.564	0.006

Table 4. Between-group differences of obesity indices in both genders

Sex	Group	Number of risk factors	BMI	WC	WHtR	Fat percentage	VO_2max
Females N=63	1	1≥	20.33	73.92	0.46	21.45	21.02
	2	2≤	24.85**	85.56*	0.52*	30.41**	19.63
Males N=126	1	1≥	22.05	80.63	0.46	15.03	34.99
	2	2≤	24.81**	88.90**	0.51**	19.58**	32.53*

* P<0.05, ** P<0.01 differed from group 1

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(45-54 years old) people (25).

In the present study, the AUC of WHR in both males and females was in second place, and had a correlation with more risk factors in the males. Shao et al. suggested that WHR is the best predictor for metabolic syndrome in Chinese race and 0.50 as a proper Cut-off point for both genders. Iranian suggestions for WHR cut-off points were 0.59, 0.57 (21,24) and Korean reported 0.49, 0.5124 for males and females respectively, and also they confirmed that WHR is a suitable predictors for metabolic syndrome as much as WC19, (26). In the present study, the cut-off points of WHR for detection of metabolic syndrome were 0.48 and 0.46 for females and males students respectively, and for detection of hypertension and HDL-C was 0.46 and for triglycerides was 0.50. Kuo et al. (2012) proposed the cut-off points 0.49 and 0.51 for Korean male and female respectively (26). The cut-off points of WHR in our subjects were lower than other studies. Similar to WC, the reason may be related to the age of the subjects. Since the many cross-sectional studies have shown that there is a correlation between physical inactivity and more abdominal fat or less muscle mass (27), the lower cut-off points for abdominal obesity indices for incidence of metabolic syndrome in inactive students can be expected.

Although some studies stated BMI is not suitable for estimating the body fat percentage in a certain population such as college students (8), our finding showed that BMI has a strong correlation with risk factors and had the most extensive AUC for predicting metabolic syndrome in females. In addition, existence of at least one metabolic risk factor for normal level of BMI (between 22-24 kg/m^2) in all race was reported (20). In the present study, the BMI cut-off points in group 2 were 21.19 and 20.84 for males and females respectively. According to WHO, the cut-off point of BMI for Asians is 23. In Iranian studies, 28.87 (24) and 26.65 (21) were reported, but the cut-off points for existence one factor and more in Indian males and females is 21 and in Taiwanese is 22.7 (23). At a certain level of BMI, some Asian ethnicities have more body fat percentage than others which may be due to prenatal inappropriate nutrition, sedentary lifestyle, fiber deficiency diet and genetic differences (3). The low cut-off points for BMI in our inactivate students showed that the incidence of the metabolic syndrome risk factors in lower range of BMI should be expected. Also low BMI solely is not a determinant for the amount of body fat and being healthy. Regarding to the body fat percentage, 29% of lean subjects with BMI <25 kg/m^2 are in obese level with dyslipidemia, diabetes and hypertension (28). The age of our subjects was differed from the other studies and based on the findings, because the percentage of body fat increases with age, so using the unique cut-off point is not appropriate for different ages. Unlike females, BMI had the lowest extensive AUC in males which can be explained as follows: females have more body fat than males which may not be distinguished by BMI (8). Therefore, it is necessary to determine two different cut-off points for female and male. Additionally, the relationship between fat percentage and BMI depends on many factors such as race, body structure and level of physical activity (8,20).

Table 4 shows, the average of all obesity indices increased significantly in group 2 (increasing the risk factors). However, according to WHO and ATP III, all variables in this group were within normal range, except body fat percentages of females and males which were in obese and overweight level, respectively. This emphasizes that the current BMI and WC cut-off points are not appropriate for predicting the incidence of metabolic syndrome in our subjects and new cut-off points with lower limits should be determined for this population.

Conclusions

The findings of the present study showed that lower obesity indices should be considered for

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early predicting metabolic syndrome in inactive college students.

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References

1. Grundy SM, Brewer HB, Cleeman JI, Smith SC, Lenfant C. Definition of metabolic syndrome report of the National Heart, Lung, and Blood Institute/American Heart Association Conference on scientific issues related to definition. Circulation. 2004;109(3):433-8.
2. Dugdale DC. Metabolic syndrome. U.S. National library of medicine. [Updated: 2 June 2012]; Available from: http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0004546.
3. Pan WH, Yeh WT, Weng LC. Epidemiology of metabolic syndrome in Asia. Asia Pac J Clin Nutr 2008;17(1):37-42.
4. Mehrkash M, Mohammadian S, Qorbani M. Eshghinia S, Shafa N. Prevalency of metabolic syndrome among adolescents aged 15 to 17 years in Gorgan, Northern Iran. Journal of Gorgan University of Medical Sciences 2011;13(2):93-9.
5. Rashidi AA, Parastouei K, Aarabi MH, Taghadosi M, Khandan A. Prevalence of metabolic syndrome in students of Kashan University of Medical Sciences in 2008. Feyz 2010;13(4):307-12.
6. Keown TL, Smith CB, Harris MS. Metabolic syndrome among college students. J Nurse Prac 2009;5(10):754-9.
7. Mackie BD, Zafari AM. Physical activity and the metabolic syndrome. Hospital Physician. 2006;29.
8. Zanovec M, Lakkakula AP, Johnson LG, Turri G. Physical activity is associated with percent body fat and body composition but not body mass index in white and black college students. International journal of exercise science. 2009;2(3):175.
9. Fernandes J, Lofgren IE. Prevalence of metabolic syndrome and individual criteria in college students. J Am Coll Health 2011;59(4):313-21.
10. Browning LM, Hsieh SD, Ashwell M. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0·5 could be a suitable global boundary value. Nutrition Research Reviews 2010;23:247-69.
11. Wildman RP, Gu D, Reynolds K, Duan X, He J. Appropriate body mass index and waist circumference cutoffs for categorization of overweight and central adiposity among Chinese adults. The American journal of clinical nutrition. 2004;1;80(5):1129-36.
12. An Y, Yi S, Fitzpatrick A, Gupta V, Prak PR, Oum S, et al. Appropriate Body Mass Index and Waist Circumference Cutoff for Overweight and Central Obesity among Adults in Cambodia. PloS one. 2013;8(10):77897.
13. Bovet P, Arlabosse T, Viswanathan B, Myers G. Association between obesity indices and cardiovascular risk factors in late adolescence in the Seychelles. BMC pediatrics. 2012;12(1):1.
14. Maud PJ, Foster C. Physiological Assessment of Human Fitness. Human Kinetics 2006.
15. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. British journal of nutrition. 1978 Nov;40(3):497-504.
16. Jackson AS, Pollock ML, Ward AN. Generalized equations for predicting body density of women. Medicine and science in sports and exercise. 1980;12(3):175-81.
17. Heywood V. The Physical Fitness Specialist Manual, The Cooper Institute for Aerobics Research, Dallas TX, revised 2005.
18. Heyward VH. Advanced Fitness Assessment and Exercise Prescription, 2006. Champaign, IL: Human Kinetics.;5.
19. Consultation WE. Waist circumference and waist-hip ratio. Report of a WHO Expert Consultation. Geneva: World Health Organization. 2008: 8-11.
20. Deurenberg P, Deurenberg-Yap M, Guricci S. Asians are different from Caucasians and from each other in their body mass index/body fat per cent relationship. Obesity reviews. 2002;3(3):141-6.
21. Gharipour M, Sadeghi M, Dianatkhah M, Bidmeshgi S, Ahmadi A, Tahri M, et al. The cut-off values of anthropometric indices for identifying subjects at risk for metabolic syndrome in Iranian elderly men. Journal of obesity. 2014;23:2014.
22. Fereidoun Azizi M, Davood Khalili M, Hassan Aghajani M, Alireza Esteghamati M, Farhad Hosseinpanah M, Alireza Delavari M, et al. Appropriate waist circumference cut-off points among Iranian adults: the first report of the Iranian National Committee of Obesity. Archives of Iranian medicine. 2010;13(3):243.
23. Misra A, Vikram NK, Gupta R, Pandey RM, Wasir JS, Gupta VP. Waist circumference cutoff points and action levels for Asian Indians for identification of abdominal obesity. International journal of obesity. 2006;30(1):106-11.
24. Arjmand G, Shidfar F, Nojoomi MM, Amirfarhangi A. Anthropometric Indices and Their Relationship With Coronary Artery Diseases. Health Scope. 2015;4(3).

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25. Dobbelstey CJ, Joffres MR, MacLean DR, Flowerdew GA. comparative evaluation of waist circumference, waist-to-hip ratio and body mass index as indicators of cardiovascular risk factors. The Canadian Heart Health Surveys. International Journal of Obesity & Related Metabolic Disorders, 2001;25(5).
26. Ko KP, Oh DK, Min H, Kim CS, Park JK, Kim Y, et al. Prospective study of optimal obesity index cutoffs for predicting development of multiple metabolic risk factors: the Korean genome and epidemiology study. Journal of Epidemiology. 2012;22(5):433-9.
27. Sternfeld B, Wang H, Quesenberry CP, Abrams B, Everson-Rose SA, Greendale GA, et al. Physical activity and changes in weight and waist circumference in midlife women: findings from the Study of Women's Health Across the Nation. American Journal of Epidemiology. 2004;160(9):912-22.
28. Gómez-Ambrosi J, Silva C, Galofré JC, Escalada J, Santos S, Millán D, et al. Body mass index classification misses subjects with increased cardiometabolic risk factors related to elevated adiposity. International Journal of Obesity. 2012;36(2):286-94.
1.

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