# Association of body mass index, waist-to-hip ratio and waist circumference with cardiovascular risk factors: Isfahan Healthy Heart Program

**Babak Sabet[(1)], Roya Derakhshan[(2)], Fatemeh Derakhshan[(3)], Roya Kelishadi[(4)], Alireza Khosravi[(5)]**

## Abstract

**BACKGROUND:** Investigating association of obesity indexes with other risk factors of cardiovascular diseases can help finding the best index in clinic for each sex. In this study, relationship of obesity based on body mass index (BMI), waist circumference, and waist-to-hip ratio with cardiovascular disease risk factors was investigated.

**METHODS:** Participants of the first phase of Isfahan Healthy Heart Program (IHHP) in 2000-2001, including 12800 healthy people aged over 19 years from Isfahan, Najafabad and Arak (Iran), were studied. Anthropometric indexes and cardiovascular risk factors were collected using conventional definitions and standard questionnaires. Kappa coefficient of agreement between calculated risk factors with definition of obesity based on anthropometric indexes was calculated using SPSS software.

**RESULTS:** Waist circumference showed the highest correlation with cardiovascular risk factors in men and women. Obesity based on BMI and waist-to-hip ratio in both sexes showed the same correlation with cardiovascular risk factors. In the correlation study matched for age, it was shown that the highest correlation was seen between waist circumference and two other indexes. Correlation coefficient over 60% showed the strongest agreement between obesity indexes and metabolic syndrome.

**CONCLUSION:** In Iranian population, waist circumference as a simple measure with a higher agreement with cardiovascular risk factors can be used in clinical settings and epidemiological studies.

**Keywords:** Obesity Indexes, Obesity, Cardiovascular Risk Factors, Isfahan.

***ARYA Atherosclerosis Journal 2012, 7(Suppl): S47-S50***

***Date of submission:*** 2 Jan 2012, ***Date of acceptance:*** 18 Feb 2012

## Introduction

Although obesity as a global health problem is increasing,[1] no acceptable index has been introduced to show its accurate intensity.[2,3]Nowadays, using body mass index (BMI), waist-to-hip ratio (WHR) and waist circumference (WC) is a common practice in clinical settings for measuring obesity.[2-5]Despite this fact, making a decision about the relationship between other cardiovascular risk factors such as diabetes and hypertension based on proxy indexes of obesity seems difficult in both sexes. Although BMI is currently used in diagnosis and treatment of obesity, it is not a good index alone.[6,7] In epidemiological studies, each index has a different value.[8-13] Because cardiovascular risk factors such as diabetes, hypertension and metabolic syndrome which are closely related with obesity are more prevalent,[14] determining agreement of each anthropometricfactor with other cardiovascular risk factors in men and women can affect clinical decision making.

## Materials and Methods

In a cross-sectional study in Isfahan, Najafabad and Arak (Iran), as the first phase of a 5-year community-based interventional clinical trial (Isfahan Healthy Heart Project, IHHP), 6400 participants from Isfahan and Najafabad and 6400 subjects from Arak were investigated.

Data of 12514 people were collected and studied.[13] In this study, sampling was conducted in a multistage

1- Research Member, Isfahan Cardiovascular Research Center, Isfahan, Iran And Assistant Professor, Department of Surgery, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
2- Gynecologist, Shahid Beheshti University of Medical Sciences, Tehran, Iran.
3- General Practitioner, Department of Clinical Neurosciences, University of Calgary, Calgary, Canada.
4- Professor, Isfahan Cardiovascular Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
5- Associate Professor, Hypertension Research Center, Isfahan Cardiovascular Research Institute, Isfahan University of Medical Sciences, Isfahan, Iran.
Correspondence To: Alireza Khosravi, Email: alikh108@yahoo.com

manner and according to urban-rural ratio. Data collecting tools was designed based on standardized final section of surveillance unit of WHO for non-contagious diseases. It was translated and then standardized again before use. Hypertensive patients in this study were defined as people who had taken antihypertensive medicine in the past 7 days, or those who had mean systolic and diastolic pressure of over 140/90 mmHg, in three measurements with 5 minutes intervals, two times with one-week interval. Blood pressure was measured a standardized sphygmomanometer. WC and hip circumference were measured using identical tape measures. Participant's weight was measured by a standardized scale while they were wearing light clothes. Lab tests were done after scheduling it with the participant and after 12-hour fasting, under standard conditions in the laboratory of Isfahan Cardiovascular Research Center. This laboratory was regularly surveyed by Belgian WHO reference laboratory of Levin. Fasting blood sugar (FBS), triglyceride (TG), and high-density lipoprotein cholesterol (HDL-C) were measured and reported under standard conditions.

Metabolic syndrome was defined as simultaneous occurrence of the three of the following criteria: FBS ≥110 mg/dl, TG ≥150 mg/dl, systolic blood pressure ≥135 mmHg or diastolic blood pressure ≥85 mmHg, WC≥102 cm in men and ≥88 cm in women, HDL-C lower than 35 mg/dl in men and 40 mg/dl in women.[15]Diabetes was defined as FBS ≥126 mg/dl, or taking antidiabetic medication.[16] Furthermore, appropriate physical activity was defined as at least 3 hours of regular exercise.[14] Dyslipidemia was defined as HDL-C lower than 40 mg/dl, or cholesterol equal ≥240 mg/dl, LDL-C≥40 mg/dl, TG ≥200 mg/dl, or taking hypolipidemic medications.[14] WHR over 0.85 in women and over 1 in men, BMI over 30 in both sexes, and WC equal to or more than 102 cm in men and 88 cm in women was considered as obesity.[17] Data were analyzed using SPSS software and kappa coefficient of agreement between obesity indexes and cardiovascular risk factors was reported.

## Results

In this study, data of 6391 women (out of 6400 women) and 6123 men (out of 6400 men), all aged over 19-year-old, were complete and were entered in the analyses. Mean and standard deviation of BMI for men and women was 24.5 ± 4.8 and 26.7 ± 5.9, respectively. Mean and standard deviation of WC for men and women was 88 ± 12 and 82 ± 14 cm, respectively. Mean and standard deviation of WHR for men and women was 0.89 ± 0.08 and 0.9 ± 0.09, respectively. Furthermore, in women population, 15.4% had hypertension, 28.1% hadmetabolic syndrome, 5.4% had diabetes, 48.5% had dyslipidemia, and 88.2% had inappropriate (less than 3 hours per week) exercise. In men, 12.2% had hypertension, 8.1% had metabolic syndrome, 4.2% had diabetes, 54.8% had dyslipidemia, and 78% had inappropriate exercise. Adjusted correlation of obesity indexes for age in both sexes, and correlation degree of each index with cardiovascular disease risk factors are shown in table 1 to 4.

**Table 1.** Age adjusted correlation of obesity indexes in both sexes

| | | BMI | WC | WHR |
|---|---|---|---|---|
| Men | BMI | 1 | 0.64 $ | 0.34 |
| | WC | 0.64 | 1 | 0.61 |
| Women | BMI | 1 | 0.6 | 0.19 |
| | WC | 0.6 | 1 | 0.63 |

## Discussion

This study was conducted to investigate the anthropometric indexes of obesity as one of the risk factors of cardiovascular diseases in relation with other obesity-related risk factors in an Iranian population. It aimed to determine the index with higher degree of agreement to use it in clinical settings and epidemiological studies. The results showed

**Table 2.** Degree of correlation between high waist-to-hip ratio and cardiovascular disease risk factors

| Group | Kappa coefficient* | SE of Kappa | Degree of agreement** |
|---|---|---|---|
| Hypertensive men | 0.170 | 0.017 | Little |
| Hypertensive women | 0.078 | 0.005 | Little |
| Diabetic men | 0.119 | 0.018 | Little |
| Diabetic women | 0.020 | 0.003 | Little |
| Dyslipidemic men | 0.049 | 0.006 | Little |
| Dyslipidemic women | 0.131 | 0.011 | Little |
| Men with metabolic syndrome | 0.242 | 0.020 | Relatively good |
| Women with metabolic syndrome | 0.169 | 0.007 | Relatively good |
| Men without efficient physical activity | 0.014 | 0.004 | Little |
| Women without efficient physical activity | 0.032 | 0.120 | Little |

Obesity based on waist-to-hip ratio (WHR) ≥ 0.8 in women and WHR ≥ 1 in men
* Kappa coefficient of agreement shows the degree of agreement between two dependent variables and ranges from -1 to 1.
** Little agreement was defined as Kappa between 0 and 0.2, relatively good 0.21-0.4, good 0.41-0.6, relatively perfect 0.61-0.8 and perfect 0.81-1

**Table 3.** Degree of correlation of obesity based on body mass index over 30 and cardiovascular risk factors

| Group | Kappa coefficient* | SE of Kappa | Degree of agreement** |
|---|---|---|---|
| Hypertensive men | 0.128 | 0.016 | Little |
| Hypertensive women | 0.136 | 0.014 | Little |
| Diabetic men | 0.093 | 0.017 | Little |
| Diabetic women | 0.056 | 0.010 | Little |
| Dyslipidemic men | 0.065 | 0.007 | Little |
| Dyslipidemic women | 0.157 | 0.011 | Little |
| Men with metabolic syndrome | 0.313 | 0.020 | Relatively good |
| Women with metabolic syndrome | 0.278 | 0.013 | Relatively good |
| Men without efficient physical activity | 0.005 | 0.004 | Little |
| Women without efficient physical activity | 0.005 | 0.005 | Little |

Obesity based on body mass index (BMI) ≥ 30

* Kappa coefficient of agreement shows the degree of agreement between two dependent variables and ranges from -1 to 1.

** Little agreement was defined as Kappa between 0 and 0.2, relatively good 0.21-0.4, good 0.41-0.6, relatively perfect 0.61-0.8 and perfect 0.81-1

**Table 4.** Degree of correlation of obesity based on waist circumference and cardiovascular risk factors

| Group | Kappa coefficient* | SE of Kappa | Degree of agreement** |
|---|---|---|---|
| Hypertensive men | 0.215 | 0.016 | Relatively good |
| Hypertensive women | 0.116 | 0.006 | Little |
| Diabetic men | 0.113 | 0.015 | Little |
| Diabetic women | 0.04 | 0.004 | Little |
| Dyslipidemic men | 0.105 | 0.008 | Little |
| Dyslipidemic women | 0.215 | 0.012 | Relatively good |
| Men with metabolic syndrome | 0.484 | 0.017 | Good |
| women with metabolic syndrome | 0.329 | 0.008 | Relatively good |
| Men without efficient physical activity | 0.008 | 0.005 | Little |
| Women without efficient physical activity | 0.016 | 0.010 | Little |

Obesity based on waist circumference ≥ 88 cm in women and ≥102 in men

* Kappa coefficient of agreement shows the degree of agreement between two dependent variables and ranges from -1 to 1.

** Little agreement was defined as Kappa between 0 and 0.2, relatively good 0.21-0.4, good 0.41-0.6, relatively perfect 0.61-0.8 and perfect 0.81-1

that despite the common use of BMI and the higher certainty of WHR in other studies[7,9] WC had a higher degree of agreement with other cardiovascular risk factors in this study for both men and women. Han et al. found a higher agreement between WC and other cardiovascular risk factors as compared with waist to height ratio.[18] The findings of Ashwell et al. emphasized the higher predictive value of WC for cardiovascular risk factors.[13] WHO studies confirmed the high predictive value of WC as a simple index that can be obtained by one-time measurement.[19] Although Han et al. confirmed the better rate of WC alone as compared to waist to height ratio with regard to cardiovascular risk factors,[20] recent studies haveemphasized the higher sensitivity and specificity of modified WC based on weight (WSR).[21,22]The findings of the present study show a weak relationship between BMI and WHR and cardiovascular risk factors. Although based on current protocols, using WHR is considered beneficial in women,[22] the need to measure hip and WC twice increases the measurement error. Furthermore, the increase of weight as much as two times may not dramatically change WHR.[20] Various studies had controversial findings about the higher value of WSR as compared to WC.[13,18,20]In the present study, we did not discuss the agreement of WSR with cardiovascular risk factors because there was no standard index based on the current protocols. In general, various studies have confirmed the value of WHR for women but BMI is more used in applied studies. In line with other studies,[22] the findings of the present study confirms the higher agreement of WHR in women, but they show the higher agreement between WC and other cardiovascular risk factors. It reveals the predictive importance of this simple index in calculating obesity in clinical and epidemiological decision making. The high correlation of this index with metabolic syndrome, which is emphasized as a strong predictor of cardiovascular diseases[23] clarifies the superiority of WC to other indexes.

## Acknowledgments

The Persian version of this article has been previously published in Journal of Isfahan Medical School: 2003, No: 71; 15-19.

## Conflict of Interests

Authors have no conflict of interests.

## References


1. Puoane T, Steyn K, Bradshaw D, Laubscher R, Fourie J, Lambert V, et al. Obesity in South Africa: the South African demographic and health survey. Obes Res 2002; 10(10): 1038-48.
2. Han TS, van Leer EM, Seidell JC, Lean ME. Waist circumference action levels in the identification of cardiovascular risk factors: prevalence study in a random sample. BMJ 1995; 311(7017): 1401-5.
3. Folsom AR, Stevens J, Schreiner PJ, McGovern PG. Body mass index, waist/hip ratio, and coronary heart disease incidence in African Americans and whites. Atherosclerosis Risk in Communities Study Investigators. Am J Epidemiol 1998; 148(12): 1187-94.
4. Lemieux S, Prud'homme D, Bouchard C, Tremblay A, Despres JP. A single threshold value of waist girth identifies normal-weight and overweight subjects with excess visceral adipose tissue. Am J Clin Nutr 1996; 64(5): 685-93.
5. Hu FB, Wang B, Chen C, Jin Y, Yang J, Stampfer MJ, et al. Body mass index and cardiovascular risk factors in a rural Chinese population. Am J Epidemiol 2000; 151(1): 88-97.
6. Valdez R. A simple model-based index of abdominal adiposity. J Clin Epidemiol 1991; 44(9): 955-6.
7. Taylor RW, Keil D, Gold EJ, Williams SM, Goulding A. Body mass index, waist girth, and waist-to-hip ratio as indexesof total and regional adiposity in women: evaluation using receiver operating characteristic curves. Am J Clin Nutr 1998; 67(1): 44-9.
8. Rankinen T, Kim SY, Perusse L, Despres JP, Bouchard C. The prediction of abdominal visceral fat level from body composition and anthropometry: ROC analysis. Int J Obes Relat Metab Disord 1999; 23(8): 801-9.
9. Hsieh SD, Yoshinaga H. Waist/height ratio as a simple and useful predictor of coronary heart disease risk factors in women. Intern Med 1995; 34(12): 1147-52.
10. Gustat J, Elkasabany A, Srinivasan S, Berenson GS. Relation of abdominal height to cardiovascular risk factors in young adults: the Bogalusa heart study. Am J Epidemiol 2000; 151(9): 885-91.
11. Ko GT, Chan JC, Woo J, Cockram CS. Waist circumference as a screening measurement for overweight or centrally obese Chinese. Int J Obes Relat Metab Disord 1996; 20(8): 791-2.
12. Ko GT, Chan JC, Cockram CS, Woo J. Prediction of hypertension, diabetes, dyslipidaemia or albuminuria using simple anthropometric indexes in Hong Kong Chinese. Int J Obes Relat Metab Disord 1999; 23(11): 1136-42.
13. Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. BMJ 1996; 312(7027): 377.
14. Sarraf-Zadegan N, Sadri G, Malek AH, Baghaei M, Mohammadi FN, Shahrokhi S, et al. Isfahan Healthy Heart Programme: a comprehensive integrated community-based programme for cardiovascular disease prevention and control. Design, methods and initial experience. Acta Cardiol 2003; 58(4): 309-20.
15. Executive Summary of The Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, And Treatment of High Blood Cholesterol In Adults (Adult Treatment PanelIII). JAMA 2001; 285(19): 2486-97.
16. American Diabetes Association. Diabetic Retinopathy. Diabetes Care 2002; 25(suppl 1): 590-3.
17. Kelishadi R, Sabet B, Khosravi A. Anticardiolipin antibody of adolescents and age of myocardial infarction in parents. Med Sci Monit 2003; 9(12): CR515-CR518.
18. Han TS, Lean ME, Seidell JC. Waist circumference remains useful predictor of coronary heart disease. BMJ 1996; 312(7040): 1227-8.
19. Asia-Pacific Steering Committee, World Health Organization, Regional Office for the Western Pacific, International Association for the Study of Obesity, International Obesity Task Force. The Asia-Pacific perspective: Redefining obesity and its treatment. Australia: Health Communications Australia; 2000.
20. Ho SY, Lam TH, Janus ED. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann Epidemiol 2003; 13(10): 683-91.
21. Cox BD, Whichelow M. Ratio of waist circumference to height is betterpredictor of death than body mass index. BMJ 1996; 313(7070): 1487.
22. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. N Engl J Med 1999; 341(6): 427-34.
23. Onat A, Ceyhan K, Basar O, Erer B, Toprak S, Sansoy V. Metabolic syndrome: major impact on coronary risk in a population with low cholesterol levels-a prospective and cross-sectional evaluation. Atherosclerosis 2002; 165(2): 285-92.