Original Article

Correlation of anthropometric indices with common cardiovascular risk factors in an urban adult population of Iran: data from Zanjan Healthy Heart Study

Ali Awsat Mellati PhD[1], Seyed Nouraddin Mousavinasab PhD[1], Sepide Sokhanvar MD[1], Seyed Ali Naghi Kazemi MD[1], Mohammad Hossain Esmailli PhD[2], Hossain Dinmohamadi MD[3]

[1]*Zanjan Metabolic Disease Research Center, Zanjan University of Medical Sciences, Zanjan, Iran*
[2]*Physiology Department, Qazvin University of Medical Sciences, Qazvin, Iran*
[3]*Health and Prevention, Zanjan University of Medical Sciences, Zanjan, Iran*

The purpose of this study was to determine the anthropometric index that best predicts common cardiovascular risk factors. A total of 2768 individuals (1310 men and 1458 women) aged 21-75 years with full relevant data from the Zanjan Healthy Heart Study (a prospective study in Zanjan and Abhar, two main cities of Zanjan Province, Iran) were recruited. Common cardiovascular risk factors (TG, TC, HDL-c, LDL-c, fast blood sugar, blood pressure), anthropometric indices (BMI, WC, WHR, WHtR) were measured using standard process, and their correlated classification was evaluated by partial correlation and Receiver Operator Characteristic (ROC) curve analysis. Area under curve (AUC) of WHtR was the largest for most (6 of 7) of the common cardiovascular risk factors in both men and women; followed by WC (4 of the 7 including ties) in men, while AUCs of three anthropometric indices (WC, BMI, WHR) were the same with the largest for 1 of 7 risk factors in women. These results show that the high prevalence of lipid profiles, as cardiovascular risk factors, need special attention, intervention and appropriate treatment. Consistence with other reports, WHtR is a better discriminator of cardiovascular risk factors compared with the other three indices (BMI, WC, and WHR). We determined its optimal cut-off point of 0.5 for both genders. However, due to differences in reported cut-off values across different ethnic groups, future research and longitudinal data is needed before reaching an internationally accepted simple and appropriate measure that could be effectively used in the clinical and epidemiological fields.

Key Words: WHtR, anthropometric indices, cardiovascular risk factors, obesity, ROC analysis

INTRODUCTION

In many developing countries, changes in diet and life style have led to the increase in the prevalence of obesity,[1,2] which is one of the major risk factors of cardiovascular and other chronic diseases.[3,4] From various anthropometric indices only four of these, include body mass index (BMI), waist circumference (WC), waist to hip ratio (WHR), waist to height ratio (WHtR), are the most commonly used predictors of cardiovascular risk factors in clinical practice and large scale epidemiological studies. BMI is an index of overweight and obesity which is used by the World Health Organization as an international standard for identifying adiposity in adult populations.[5] BMI is not a measure of fat distribution, and can not distinguish central from peripheral adiposity, which is the principal limitation of this index.[6,7] However, increased risk of cardiovascular disease in individuals is associated with excess fat in the central (abdominal) region,[8,9] which leads to metabolic disorders and other obesity related morbidity.[10-12] Other three anthropometric indices (WC, WHR, WHtR) are indicators of central fat distribution,[13-15] which are going to replace BMI in several definitions for clinical diagnosis of metabolic syndrome.[16]

The attention of majority of current studies is over which of the four anthropometric indices exhibit the stronger correlation with common cardiovascular risk factors, and their superiority in regard with simplicity, public acceptance and could be performed uniformly well across diverse populations. In addition attempts have been made to determine and compare ethnic-specific anthropometric index cut-off points for obesity.[17-20] In a study conducted among Hong Kong Chinese, Ho et al[17] found that WHtR might be the best anthropometric index in relation with cardiovascular risk factors, and the cut-off value of 0.48 was determined for both Chinese men and women. More recently a meta-analysis of ten cross-sectional and longitudinal study, most based upon receiver-operating characteristic (ROC) curve analysis,

Corresponding Author: Dr Ali Awsat Mellati, Zanjan metabolic disease research center; Zanjan University of Medical Sciences, P.O. Box 45157778, Zanjan, Iran
Tel / Fax:00982414249553
Email: mellati3000@yahoo.com
Manuscript received 5 December 2008. Initial review completed 8 March 2009. Revision accepted 18 March 2009.

from different regions (Asia, Africa, Caucasian populations) with a 88000 sample size, Lee et al[20] have proved that among four anthropometric indices WHtR is the best discriminator of cardiovascular risk factor, and found great disparity in optimal cut-off points for the indices in different population.

Most studies reported are from European or white-Caucasoid population[18,19,21,22] and little data are available about Asian-Pacific region and Middle East population.[23,24] The Obesity in Asia Collaboration (OAC) have been initiated with the aims of detecting which anthropometric index exhibits the strongest correlation with cardiovascular disease risk factors, examining any heterogeneity in the strength and nature of these associations among study populations. To determine whether ethnic differences exist, they sought data from eligible studies. To date, 12 countries and regions from the Asia-Pacific region with information on nearly 800000 individuals have participated in the OAC.[25]

Considering ethnic variability and population dependence of predictive power of anthropometric indices for risk factors[26,27] and availability of limited data about Iranian population as one of developing countries, in the present study we have investigated the most suitable anthropometric index for predicting common cardiovascular risk factors in participants of the Zanjan Health Heart Study project, a representative adult population in Zanjan province, Iran.

MATERIAL AND METHODS

Subjects

This cross-sectional study was conducted using the Zanjan Healthy Heart Study data (2002-2003). It is a prospective study performed on residents of Zanjan and Abhar, two main cities of Zanjan province, Iran, with the aim of determining the relevance of cardiovascular disease risk factors, obesity, and developing a healthy life style to improve their risk profile. The population (n=3277) were selected by multistage cluster random sampling. A questionnaire was given to obtain the subjects' information on age, sex, history of cardiovascular diseases and diabetes mellitus, family history, life style factors (smoking, physical activity, dietary habits) under direction of clinicians. After excluding subjects with missed information and obvious diseases (i.e., hypertension and diabetes mellitus), weight loss more than 10% during the last six months determined by history taking and physical examination, and those taking medication that would affect serum lipoprotein; 2768 individuals (1310 men and 1458 women) aged 21-75 years were recruited. The protocol was approved by the ethical committee of the Zanjan University of Medical Sciences and informed consent was obtained from all participants.

Anthropometric measurements

Weight and height were measured according to standards established by Jellife.[28] Body weight measurements were conducted with participants in light clothes and without shoes, to the nearest 0.1 kg using a digital scale. Height was measured with participants in a standing position, without shoes, using stadiometer to the nearest 0.5 cm while the shoulders were in a normal position. WC was measured at the narrowest level from the front after exhalation and that of the hip circumference (HC) at the maximum level from the lateral aspect over light clothing, using an unstretched tape meter[29] and the measurements were recorded to the nearest 0.1 cm. All measurements were taken by the same person. WHR and WHtR were calculated as WC divided by hip circumference and height, respectively. BMI was calculated as weight in kg divided by height in metric square.

Assessments and Measurements

A qualified physician measured blood pressure two times in a seated position after 15 min of rest using a standard mercury sphygmomanometer, and the mean of the two measurements was considered as the participant's blood pressure.

Biochemical analyses

The measurements were done by medical personnel in the health center belonging to Zanjan University of Medical Sciences, all of whom were trained and supervised by preventive medicine physician. A blood sample was drawn from all study participants between 7:0 and 9:0 a.m. in to vacutainer tubes after 12-14 h overnight fasting. Blood samples were taken in a sitting position according to the standard protocol and centrifuged within 30-45 min of collection. All blood lipid analyses were done at the research laboratory of Valieasr Hospital belonging to Zanjan University of Medical Sciences on the day of blood collection. The analysis of samples was performed using Selectra 2 autoanalyzer (vital scientific, spankeren, Netherlands). Total cholesterol (TC) and triglycerides (TG) levels were assayed with a sensitivity of 5 mg/dl using enzymatic colorimetric tests with cholesterol esterase and cholesterol oxidase and glycerol phosphate oxidase respectively (ParsAzmon kits, Iran). High-density lipoprotein cholesterol (HDL-c) was measured after precipitation of the apolipoproteins with phosphotungistic acid. Low density lipoprotein cholesterol (LDL-c) was calculated from serum TC, TG and HDL-c using Friedwald formula.[30] It was not calculated when TG concentrations were more than 400 mg/dl. Lipid standard (c.f.a.s./Boehringer Mannheim, cat. no. 759350) was used to calibrate the selectra 2 autoanalyzer for each day of the experiment. Assay performance was checked in one out of 20 test intervals using the lipid control serum perineum (normal range) and percipath (pathologic range) wherever applicable. Inter- and intra assay coefficients of variation (CV) for the assay (TC or TG) were 1.1% and 1.6% in lower limit, 0.9% and 0.6% for upper limit.

Fasting blood sugar (FBS) was measured on the day of blood collection by enzymatic colorimetric method using glucose oxidase.

High triglyceride, high total cholesterol, high low-density lipoprotein cholesterol, low high-density lipoprotein cholesterol, high fast blood glucose, high systolic blood pressure (SBP) and high diastolic blood pressure (DBP), were defined as TG≥150 mg/dL, TC≥200 mg/dL, LDL-C≥130 mg/dL, HDL-C≤40 mg/dL for men and ≤50 mg/dL for women, FBG≥110 mg/dL, SBP≥130 mmHg and DBP≥85 mmHg[31,32] which were used as cut-off criteria for cardiovascular risk factors. The ratio of TC to

Table 1. Means and median of anthropometric indices and common cardiovascular risk factors of 2768 study subjects

Variables	Male (n=1310)		Female (n=1458)		*p*
	Mean±SD	Median	Mean±SD	Median	
Age (years)	40.5±14.6	38	39.1±14.2	36	<0.015
TG (mg/dL)	171.6±118.9	137	154.2±108.7	127	<0.001
TC (mg/dL)	182.1±39.4	181	190.5±43.9	185	<0.001
HDL-c (mg/dL)	38.0±6.4	38	39.9±6.9	39	<0.001
LDL-c (mg/dL)	112.2±36.7	109	121.2±39.8	116	<0.001
TC/HDL-c	4.9±1.6	4.7	4.9±1.7	4.6	<0.531
FBG (mg/dL)	90.0±28.9	87	93.8±35.2	88	<0.002
SBP(mmHg)	124.6±19.1	120	120.4±21.5	120	<0.001
DBP (mmHg)	79.3±11.7	80	77.7±12.6	80	<0.001
Height (cm)	169.6±7.9	170	156.6±7.2	156	<0.001
Weight (kg)	70.5±12.9	70	63.8±12.4	63	<0.001
BMI (kg /cm2)	24.5±4.2	24.3	26.1±5.0	26	<0.001
WC (cm)	87.8±11.7	88	85.0±12.9	85	<0.001
WHR	0.90±0.08	0.9	0.83±0.08	0.83	<0.001
WHtR	0.52±0.07	0.51	0.54±0.09	0.54	<0.001

*$p<0.05$

HDL (TC/HDL) was calculated and a value of ≥5 for men and ≥4 for women were used for dislipidemia classifation.[33]

Statistical analysis

All calculations and statistics were done with SPSS 11.5 (SPSS, Inc.Chicago.IL, USA). Results were expressed as means ± SD for normally distributed data and as median for data that are not normally distributed. The Student's t-test or Mann-Whitney U test was used for variables displaying both normal and non-normal distribution. Pearson correlation coefficient was used to explore the relationship between quantitative data when the two variables had a normal distribution and Spearman's correlation was employed when at least one of the variables had a non-normal distribution.

Partial correlation and ROC curve were used for selecting the best anthropometric index as a screening tool for cardiovascular risk factors. First, partial correlation was performed between cardiovascular risk factors and anthropometric indices after adjusting for age. Then, ROC curve analysis was used to calculate the area under ROC curves between each cardiovascular risk factor and anthropometric index. Each value of an anthropometric index was used as a cut-off value to calculate its sensitivity and specificity in classifying a cardiovascular risk factor. The ROC curve is a plot of the sensitivity (true positive rates) against 1–specificity (false positive rate) for each cut-off value, and the area under curve (AUC) is an indicator of how good the anthropometric indices can distinguish a positive test outcome. AUC value can be between 0 and 1, with 0.5 (chance or diagonal line) indicating that the anthropometric index has no predictive performance and 1 indicating perfect performance. After determining which was the best anthropometric index, the optimal cut-off value for each anthropometric index (BMI, WC, WHR, WHtR) was determined by the point of convergence of sensitivity and specificity, i.e., by the value that had the largest sum of sensitivity and specificity.[34,35] $p<0.05$ was considered statistically significant.

Table 2. Prevalence of common cardiovascular risk factors according to the gender of study subjects

Risk Factors	Male (n=1310)		Female (n=1458)		*p*
	n	%	n	%	
High TG (mg/dL)	576	44.1	566	39	0.006
High TC (mg/dL)	408	31.3	577	40	<0.001
Low HDL-c (mg/dL)	837	63.9	1357	93.1	< 0.001
High LDL-c (mg/dL)	638	49.7	811	56.6	<0.001
High TC/HDL-c	550	42.2	962	66.7	< 0.001
High FBG (mg/dL)	100	7.7	149	10.3	0.018
High SBP (mmHg)	476	36.3	432	29.6	<0.001
High DBP (mmHg)	396	30.2	366	25.1	0.003

$p<0.05$ according to genders

RESULTS

Table1 presents medians or means of common cardiovascular risk factors and anthropometric indices of 2768 study individuals according to gender. The subjects studied included 1310 (47.3%) men and 1458 (52.7%) women, ages ranging from 21 to 75, with medians 38 and 36 for men and women, respectively. Women had the highest levels of all lipid variables except TG which was higher in men. The levels of FBG, SBP and DBP were approximately similar for men and women. The values of anthropometric measurements including WC and WHR were higher for men, while the means of BMI and WHtR were higher for women. The prevalence of lipid profiles was abnormally very high (Table 2). Dislipidemia, low levels of HDL-c, and hypercholesterolemia were more prevalent in women than men. The prevalence of high SBP and DBP were higher for men than women. Except for the weak correlation between BMI and WHR with r of 0.4 in men and 0.38 for women, there was significant correla-

Table 3. Pearson correlation coefficients anthropometric indices

	BMI	WC	WHR	WHtR
Male				
BMI	1	0.78*	0.40*	0.80*
WC	0.78*	1	0.66*	0.94*
WHR	0.40*	0.66*	1	0.65*
WHtR	0.80*	0.94*	0.65*	1
Female				
BMI	1	0.79*	0.38*	0.81*
WC	0.79*	1	0.76*	0.96*
WHR	0.38*	0.76*	1	0.75*
WHtR	0.81*	0.96*	0.75*	1

* *p* =0.01

tion among the four anthropometric indices with r ranging from 0.65 to 0.96 (Table 3). Table 4 gives the age adjusted partial correlation coefficients between anthropometric indices and common cardiovascular risk factors. In both genders, WHtR had the highest coefficient in 6 (for men) and 7 (for women) of 7 risk factors, followed by WC with 4 (for men) and 6 (for women) risk factors including ties. Table 5 displays the AUCs with 95% confidence intervals overlap, for anthropometric indices according to genders. In men, WHtR was the best in distinguishing an abnormality in 6 of 7 cardiovascular risk factors, followed by WC (4 of the 7 including ties). In women AUC of WHtR was the most distinctive for most (6 of the 7 including ties) of the risk factors followed by the other three anthropometric indices (WC, WHR and BMI) which have the largest AUC for only one risk factor (FBS, HDL-C and DBP), respectively. Figure1 shows ROC curves, for comparison, of the four anthropometric indices in relation to one or more risk factors according to gender. Table 6 shows optimal cut-off points for BMI, WC, and WHtR where sensitivity approximates specificity for each risk factor. The cut-off values over various risk factors in men ranged between 21.6 and 26.2 for BMI, 84.9 and 92.0 for WC, 0.88 and 0.93 for WHR, 0.49 and 0.56 for WHtR; and in women ranged between 22.9 and 26.3 for BMI, 80.5 and 93.4 for WC, 0.76 and 0.84 for WHR and 0.50 and 0.56 for WHtR.

DISCUSSION

Since the cut-off values for the various indices of obesity and fat distribution differ in different countries and seems race and ethnic dependent,[3,20,27,33,36,37] there is no global standard. It is important to develop simple and effective anthropometric indexes for the screening of higher metabolic risk subjects in different populations until reaching

Table 4. Age adjusted partial correlation coefficients between anthropometric indices and common cardiovascular risk factors

	Male				Female			
	BMI	WC	WHR	WHtR	BMI	WC	WHR	WHtR
TG (mg/dL)	0.26**	0.30**	0.23**	0.28**	0.21**	0.24**	0.19**	0.24**
TC (mg/dL)	0.24**	0.26**	0.15**	0.26**	0.23**	0.22**	0.12**	0.23**
HDL-c (mg/dL)	-0.15**	-0.17**	-0.17**	-0.17**	-0.08*	-0.10**	-0.09*	-0.09**
LDL-c (mg/dL)	0.12**	0.14**	0.06*	0.15**	0.14**	0.14**	0.06*	0.14**
TC/HDL-c	0.25**	0.26**	0.19**	0.26**	0.17**	0.19**	0.14**	0.19**
FBS (mg/dL)	0.10*	0.13**	0.09**	0.16**	0.08**	0.10**	0.10**	0.10**
SBP (mmHg)	0.20**	0.17**	0.07**	0.19**	0.17**	0.16**	0.15**	0.18**
DBP (mmHg)	0.16**	0.15**	0.06**	0.17**	0.16**	0.16**	0.14**	0.16**

Pearson partial correlation; *$p<0.05$, **$p<0.0001$

Table 5. Area under the receiver-operating characteristic (ROC) curves for four anthropometric indices in predicting cardiovascular risk factors in men and women

Cardiovascular Risk factors	Area under the ROC curve (95% CI)			
	BMI	WC	WHR	WHtR
Men				
TG (mg/dL)	0.67(0.64-0.70)	0.69(0.66-0.72)	0.67(0.64-0.70)	0.67(0.64-0.70)
TC (mg/dL)	0.64(0.60-0.67)	0.66(0.62-0.69)	0.64(0.61-0.68)	0.66(0.63-0.69)
HDL-c (mg/dL)	0.56(0.53-0.60)	0.59(0.55-0.62)	0.59(0.56-0.62)	0.58(0.55-0.61)
LDL-c (mg/dL)	0.58(0.54-0.61)	0.60(0.56-0.63)	0.59(0.55-0.62)	0.61(0.58-0.64)
TC/HDL-c	0.63(0.60-0.66)	0.65(0.62-0.68)	0.63(0.60-0.66)	0.65(0.62-0.68)
FBS (mg/dL)	0.63(0.57-0.68)	0.69(0.64-0.74)	0.69(0.63-0.74)	0.70(0.64-0.75)
SBP (mmHg)	0.64(0.61-0.67)	0.65(0.62-0.68)	0.63(0.60-0.66)	0.67(0.64-0.70)
DBP (mmHg)	0.61(0.58-0.65)	0.62(0.58-0.65)	0.59(0.56-0.62)	0.63(0.60-0.66)
Women				
TG (mg/dL)	0.68(0.65-0.70)	0.69(0.67-0.72)	0.68(0.65-0.70)	0.70(0.67-0.72)
TC (mg/dL)	0.69(0.67-0.72)	0.71(0.68-0.74)	0.66(0.63-0.69)	0.72(0.69-0.74)
HDL-c (mg/dL)	0.54(0.48-0.59)	0.54(0.48-0.60)	0.55(0.49-0.60)	0.54(0.48-0.59)
LDL-c (mg/dL)	0.65(0.62-0.68)	0.67(0.64-0.69)	0.63(0.60-0.66)	0.68(0.65-0.70)
TC/HDL-c	0.66(0.63-0.69)	0.68(0.65-0.71)	0.65(0.62-0.68)	0.69(0.66-0.72)
FBS (mg/dl)	0.70(0.66-0.74)	0.76(0.72-0.79)	0.73(0.69-0.77)	0.76(0.73-0.80)
SBP (mmHg)	0.69(0.66-0.72)	0.73(0.70-0.75)	0.72(0.70-0.75)	0.75(0.72-0.77)
DBP (mmHg)	0.87(0.64-0.70)	0.69(0.66-0.72)	0.68(0.65-0.71)	0.71(0.68-0.74)

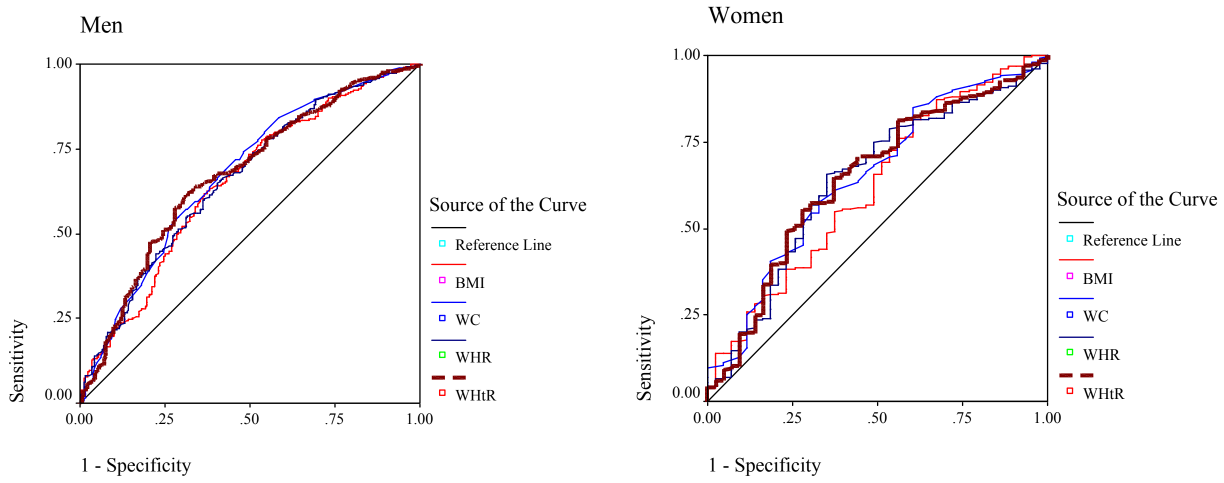

Figure1. Receiver operating characteristic (ROC) curves for one or more risk factors in men and women. BMI: body mass index, WC: waist circumference, WHR: waist-to-hip ratio, WHtR: waist to height ratio.

internationally-accepted measures. This is the first such study in Iran, as a developing country, and probably in the Middle East region that attempted to evaluate comparatively four anthropometric indices (BMI, WC, WHR, and WHtR) in an attempt to find the most distinctive index to be used as an indicator of cardiovascular risk factor for an urban adult population, based on ROC curve analysis. Although some studies have been performed in this region, they have been done without using ROC curve analysis and unfortunately with lack of data on at least one of the four indices.

The results of the present study indicate that WHtR was a better indicator of cardiovascular risk factor in both men and women in comparison with the other three anthropometric indices, as reflected in the calculated area under the ROC curve (Table 5) as well as in partial correlation analysis (Table 4), that shows higher correlation coefficient existing between WHtR and the sum of cardiovascular risk factors than other anthropometric indices. Although from the results we see that BMI clearly has higher sensitivity but lower specificity than WHtR and other indices (Table 6). The largest AUC for most risk factors and high enough sensitivity suggest that WHtR performs well in women but has lower specificity. Our finding is consistent with several studies in south Asia,[15,17,38] Western countries[18,21] and Iran.[23] However it is contrary to other reports that show that other anthropometric indices have better correlation with cardiovascular risk

Table 6. Optimal cut-off value†, sensitivity, specificity and likelihood ratios of anthropometric indices for common cardiovascular risk factors in men and women

	BMI				WC				WHR				WHtR			
	Cut-off	Se	Sp	LR	Cut-off	Se	Sp	LR	Cut-off	Se	Sp	LR	Cut-off	Se	Sp	LR
Men																
TG	24.3	56.6	69.5	1.85	86.5	69.6	58.9	1.69	0.91	70.7	56	1.6	0.51	59.7	68.5	1.89
TC	24	66.2	57	1.54	84.9	72.5	51.5	1.49	0.88	69.9	51.7	1.45	0.53	55.9	67.3	1.71
HDL-c	21.6	68.8	42.3	1.19	86.5	53.2	60.7	1.35	0.91	60.9	53.3	1.3	0.49	59.4	53.5	1.27
LDL-c	24	59.5	55	1.32	84.9	66.9	49.7	1.33	0.88	64.1	49.7	1.27	0.5	66.4	50.7	1.35
TC/HDL	24.6	55.8	62.8	1.5	86.5	63.8	58.1	1.52	0.91	51.8	69	1.67	0.54	48.2	74.5	1.89
FBS	26.2	49	71.6	1.72	92	64	72.4	2.31	0.93	59	72.4	2.13	0.56	54	77.3	2.37
SBP	24.5	49.2	69.9	1.63	92	53.8	68.9	1.72	0.93	54.4	65.2	1.56	0.53	50.2	76.9	2.17
DBP	22.8	63.9	51.1	1.3	90.4	58.1	59.4	1.43	0.9	76	37.1	1.2	0.51	58.1	62.1	1.53
Any condition above	21.7	73.4	55.2	1.64	86.5	54.9	77.9	2.48	0.88	58.7	72.1	2.1	0.5	58.8	73.4	2.21
Women																
TG	26.3	67.3	57.5	1.58	82.5	69.8	61.7	1.82	0.77	73.9	55.4	1.65	0.55	70	60.9	1.79
TC	25.1	72.8	56.6	1.68	80.5	80.8	53.6	1.74	0.82	65.9	60.2	1.66	0.51	80.9	53.6	1.74
HDL-c	22.9	75.2	32.7	1.11	93.4	22.3	86.1	1.6	0.76	62.6	46.5	1.17	0.5	69.9	38.6	1.13
LDL-c	23.7	70.6	45	1.28	80.5	77.1	51.4	1.59	0.82	63.1	58.9	1.53	0.51	77.1	51.4	1.58
TC/HDL	23.7	73.4	51.2	1.5	78.4	74.9	53.1	1.6	0.82	58.2	65.8	1.7	0.5	75.1	54.8	1.66
FBS	24.5	88.6	43.3	1.56	84	86.6	55.3	1.93	0.84	73.2	63.7	2.01	0.52	79.9	64.5	2.25
SBP	25.1	76.6	54.1	1.66	84	75.5	59.8	1.87	0.83	70.8	65.8	2.07	0.52	81.7	56.2	1.86
DBP	25.1	71.9	57.3	1.68	87.4	62	67.6	1.91	0.82	71.9	57.3	1.68	0.56	78.7	52.9	1.67
Any condition above	22.9	70.8	57.1	1.65	84	51.5	78.6	2.41	0.8	56.1	81	2.95	0.5	66	71.4	2.31

†optimal cut-off value is the largest sum of sensitivity and specificity

factors.[19,24,36] Lee et al[20] support previous claims that measures of central obesity, in particular the WHtR, are better discriminators of cardiovascular disease risk factors compared with BMI. They also rejected the previous suggestion that combining BMI with WC increases the cardiovascular risk prediction more than either measure alone[39] and supported the use of WHtR as the sole measure of obesity. Current reports emphasize the distribution of adipose tissue in the evaluation of the risks of obesity because central fat is not only metabolically more active in comparison with peripheral fat but also contains large insulin-resistant adipocytes.[40,41] There is strong association between visceral fat and cardiovascular risk factors.[16,42-44] BMI which is by far the most widely used indicator of total adiposity, can not distinguish fat from muscle mass or peripheral from central fat, also its limitations are recognized by its change according to age[45-47] and its dependency on race, with Asian populations predisposed to visceral or abdominal fat at low BMI values.[48,49] WHR, one of the abdominal obesity measures, is more susceptible to measurement errors. This index remains the same even when there is a change in body size.[20] Our data in line with the result of other studies,[50-52] show that it is less dependent on fatness, as demonstrated by a correlation of almost 0.38 with BMI, whereas the correlation of WC reached 0.78 (Table 3). In addition, people usually know their waist circumference but are often ignorant about their hip circumference. These drawbacks make WHR of little value as a simple indicator of cardiovascular risks for the public.

There is a new tendency to use WC[45,53] or WHtR[20,54] as an indicator of cardiovascular risk factors rather than other mentioned indices. Although WC has been shown to be highly correlated with the amount of visceral body fat measured by computer tomography[20,55] and the majority of current studies suggest that WC is a better indicator of cardiovascular risk factor than BMI or WHR.[56,58] Moreover the World Health Organization (WHO)[45] has stated that WC is the easiest and most efficient anthropometric index to be used in population based studies, because it measures fatness and fat location. However, there is no global standard for it. Some studies measure WC at the level of the umbilicus and some at the WHO standard definition which is halfway between the iliac crest and the lower rib. The WC cut-off values differ between genders, different races and ethnic groups.[15,27,48] The percentage of body fat is higher for short stature individuals, compared with taller individuals. Thus, the assumption that people with the same WC would have the same cardiovascular disease risk, without considering their height, is invalid, while WHtR is the measurement of the distribution of body fat in the abdominal region with regard to differences in height. In adults, as height is approximately constant, WHtR changes only when there is change in waist, therefore individuals with different heights have their own cut-off waist circumference. Also WHtR offers several other potential advantages over other mentioned anthropometric indices. First, WHtR is the most significant predictor of cardiovascular risk factors, probably due to better measurement of the relative fat distribution among subjects of different age and height. Second, this index does not require percentile table, because of its independency on age and gender. Since this value does not require reference tables it may be accepted for clinical application. Third, it is a parameter that is less influenced by height, which is a particular advantage of WHtR. Fourth, unlike BMI, WHtR, it has the advantage of only requiring a tape measurement rather than both a weighing scale and tape measure. Practically, it can be easily calculated, no matter what unit of measurement was used, also people usually know their waist circumference and height. It may be clinically useful to use this simple and inexpensive anthropometric index for primary health care setting in the routine physical examinations of adults.

The results of the analysis of our data suggest a WHtR optimal cut-off point of 0.5 for both men and women, which correspond to a sensitivity of 58.8% and 66.0%, specificity of 73.4% and 71.4% and likelihood ratio of 2.21 and 2.31, in the prediction of one or more cardiovascular risk factors. The best cut-off point is the criterion value with the highest accuracy that maximizes the sum of sensitivity and specificity. The determined cut-offs (Table 6) including 0.5 for WHtR correspond to best trade off which is the result of an optimal balance between sensitivity and specificity using ROC curve analysis. If we adopt lower cut-off, specificity will be reduced with enhancement of sensitivity, which leads to misclassification of subjects and number of individuals who will be erroneously classified as at risk. In considering determined median for WHtR (0.51 for men and 0.54 for women), about half of the population in the present sample is above the proposed cut-off of this study. Approximately, the 0.5 optimal cut-off value have been determined by some researchers in East Asian countries.[59, 60] However the marked difference in optimal cut-off values is observed in different ethnic populations, ranging from 0.46 to 0.62.[20] Ho et al[17] and Lemieux et al[61] demonstrated that one's waist measurement should not exceed half of the body height which means every one will have an individual cut-off waist measurement. This should be more acceptable to the public than a single waist measurement for all. Ashwell and Hsieh[62] have suggested a cut-off value of 0.5 for action level one, WHtR close to 0.5 in East Asia, and 0.6 for action level two in some ethnic populations. More studies and conversation is required to determine ethnic-specific cut-off values for WHtR as a best measure of central obesity. The positive feature of our study is our sample size which is relatively large and is from a homogeneous population, and its other strength is the use of the ROC curve analysis model. The limitation of the present study is its cross-sectional data. Future studies using longitudinal data will provide stronger evidence of this correlation.

In conclusion, although several studies have analyzed the association between cardiovascular risk factors and four anthropometric indices based upon ROC analysis, most, including the present one, support the idea that WHtR, as a measure of central obesity, is a better anthropometric index of cardiovascular risk factors compared with other indices. We determined a WHtR optimal cut-off point of 0.5 for both men and women. However due to different reported cut-off values across different ethnic groups, future research and study is needed until reaching an internationally-accepted simple and appropriate measure that could be efficiently used in the clinical and epidemiological fields.

ACKNOWLEDGEMENT
The study was financially supported by Zanjan University of Medical Sciences. The authors express appreciation to the staff of the Zanjan Metabolic Research Center, Associated Prof. Dr Sharifi, Dr Anjomshoaa, Miss Arteashdar, and Mr. Zabihian for their valuable help in conducting this study.

AUTHOR DISCLOSURES
All authors declared that there is no financial interest and received no funding for the work presented in this paper and/or APJCN which would create a conflict of interest.

REFERENCES
1. (WHO) WHO: Obesity: Preventing and managing the global epidemic. Report of WHO consultation on obesity. 3-5 June 1997. Geneva: WHO, 1998. Edited by: WHO, Geneva:2006
2. Hossain P, Kawar B, El Nahas M. Obesity and diabetes in the developing world-a growing challenge. N Eng J Med. 2007; 353:213-5.
3. Doll S, Paccaud F, Bovel P, Burnier M, Wietlisbach V. Body mass index, abdominal adiposity and blood pressure: consistency of their association across developing and developed countries. Int J Obes Relat Metab Disord. 2002; 26: 48-57.
4. Seidell JC, Kahn HS, Williamson DF, Lissner L, Valdez R. Report from centers for disease control and prevention workshop on use of adult anthropometry for public health and primary health care. Am J Clin Nutr. 2001; 73:123-6.
5. WHO expert consultation. Appropriate body-mass index for Asian populations and its implication for policy and intervenes strategies. Lancet. 2004; 363: 157-63
6. Field AE, Coakley EH, Must A, Spadano JL, Laird N, Dietz WH, Rimm E, Colditz GA. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. Arch Int Med. 2001; 161: 1581-6
7. Willett WC, Dietz WH, Colditz GA, Guidelines for healthy weight. N Engl J Med. 1999; 341: 427-34
8. Larsson B, Svardsudd K, Welin L, Wilhelmsen L, Bjorntorp P, Tibblin G. Abdominal adipose tissue distribution, obesity and risk of cardiovascular disease and death: 13 year follow up of participants in the study of the men born in 1913. Br Med J. 1984; 288: 1401-1404
9. Lapidus L, Bengtsson C, Larsson B, Pennert K, Rybo E, Sjestrom L. Distribution of adipose tissue and risk of cardiovascular disease and death: a 12-y follow-up of participants in the population study of women in Gothenburg, Sweden. Br Med J. 1984; 289: 1257-1260
10. Fujioka S, Matsuzawa Y, Tokunaga K, Tarui S. Contribution of intra-abdominal fat accumulation to the impairment of glucose and lipid metabolism in human obesity. Metabolism. 1987; 36: 54-59
11. Williams SR, Jones E, Bell W, Davies B, Bourne MW. Body habitus and coronary heart disease in men. A review with reference to methods of body habits assessment. Eur Heart J. 1997; 18: 376-93
12. Visscher TL, Kromhout D, Seidell JC. Long-term and recent time trends in the prevalence of obesity among Dutch men and women. Int J Obes Relat Metab Disord. 2002; 26: 1218-24
13. Okasun IS, Liao Y, Ratimi CN, Chai S, Cooper RS. Predictive values of waist circumference for dyslipidemia, type 2 diabets and hypertention in overweight white, black, and Hispanic American adults. J Clin Epidemiol. 2000; 53: 401-8
14. Lemos-Santos MG, Valente JG, Goncalves-Silva RM. Sichieri R. Waist circumference and waist-to- hip ratio as predictors of serum concentration of lipids in Brazilian men. Nutrition. 2004; 20: 857-62
15. Hsieh SD, Muto T. Metabolic syndrome in Japanese men and women with special reference to the anthropometric criteria for the assessment of obesity: proposal to use the waist-to height ratio. Prev Med. 2006; 42: 135-9
16. Zimmet P, Magliano D, Matsuzawa Y, Alberti G, Shaw J. The metabolic syndrome: a global public health problem and a new definition. J Atheroscler Thromb. 2005; 12: 295-300
17. Ho S, Lam T, Janus ED; The Hong Kong Cardiovascular Risk Factor Prevalence Study steering committee. Waist to stature ratio is more strongly associated with cardiovascular risk factors than other simple anthropometric indices. Ann Epidemiol. 2003; 13: 683-691
18. Dalton M, Cameron AJ, Zimmet PZ, Shaw JE, Jolley D, Dunstan DW, Welborn TA. Waist circumference, waist-hip ratio and body mass index and their correlation with cardiovascular disease risk factors in Australian adults. J of International Medicine. 2005; 254: 555-563
19. Dobbelsteyn CJ, Joffres MR, MacLean DR, Flowerdew G. A 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 Obes Relat Metab Disord. 2001; 25: 652-661
20. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. J Clin Epidemiol. 2008; 61: 646-653
21. Schneider HJ, Glaesmer H, Klotsche J, Bohler S, Lehnert H, Zeiher AM, Marz W, Pittrow D, Stalla GK, Wittchen HU;DETECT Study Group. Accuracy of anthropometric indicators of obesity to predict cardiovascular risk. J Clin Endocrinol Metab. 2007;92: 589-94
22. Flegal KM, Carroll MD, Ogden CL. Prevalence and trends in obesity among US adults, 1999-2000. JAMA. 2002; 288: 1723-7
23. Chehrei A, Sadrina S, Hasanzadeh Kashteli A, Doneshmand MA, Rezaei J. Correlation of dislipidemia with waist to height ratio, waist circumference, and body mass index in Iranian adults. Asia Pac J Clin Nutr. 2007; 16: 248-253
24. Esmaillzadeh A, Mirmiran P, Azizi F. Comparative evaluation of anthropometric measures to predict cardiovascular risk factors in Tehrania adult women. Public Health Nutrition. 2005;9: 61-69
25. Huxley R, Barzi F, Stolk R, Caterson I, Gill T, Lam TH, Omari A, Woodward M. Obesity in Asia Collaboration (OAC). Ethnic comparisons of obesity in the Asia pacific region: protocol for a collaborative overview of cross-sectional studies. Obes Rev. 2005; 6: 193-8
26. Gallagher D, Visser M, Sepulueda D, Pierson RN, Harris T, Heymsfield SB. How useful in body mass index for comparisons of body fatness across age, sex and ethnic groups. Am J Epidemiol. 1996; 143: 228-39
27. Molanus A, Seidell JC. Selection of anthropometric indicators for classification of abdominal fatness- a critical review. Int J Obes Relat Metab Disord. 1998; 22: 719-27
28. Jellife DB. The assessment of the nutritional ststus of the community Genneva: WHO: 1966
29. Jellife DB, Jellife EFP. Community nutritional assessment. Oxford unv. Press: 1989. p.56-110

30. Fridwald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem. 1972; 18: 499-502
31. Expert Panel on Detection, Evaluation, and treatment of high blood cholesterol in adults. 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 Panel III). JAMA. 2001; 285: 2486-97
32. Joint National Committee on prevention, detection, evaluation and treatment of high blood pressure. The sixth report of the joint national commitee on prevention, detection, evaluation, and treatment of high blood pressure. Arch Intern Med. 1997; 157: 2413-46
33. WHO Expert Committee on physical status. The use of interpretation of anthropometry. Peport of a WHO Expert Committee World Health Organization: Geneva; 1995
34. Van Der Schouw YT, Verbeek AL, Ruijs JH. ROC curves for the initial assessment of new diagnostic tests. From Pract. 1992; 9: 506-11
35. Forr BM, Shapiro DE. Diagnostic tests: Distinguishing good tests from bad and even ugly ones. Infect Cont Hosp EP. 2000; 21: 278-284
36. Zhu S, Heymsfield SB, Toyashima H, Wang Z, Pietobelli A, Heshka S. Race-ethnicity –specific waist circumference cutoffs for identifying cardiovascular disease risk factors. Am J Clin Nutr. 2005; 81: 409-15
37. Mirmiran P, Esmaillzadeh A, Azizi F. Detection of cardiovascular risk factors by anthropometric measures in Tehranian adults: receiver operating characteristic (ROC) curve analysis. Eur J Clin Nutr. 2004; 58: 1110-18
38. Aekplakorn W, Losulwat V, Suriyawongpasial P. Obesity indices and cardiovascular risk factors in Thai adults. Int J Obs. 2006; 30: 1782-90
39. Zhu S, Heshka S, Wang Z, Shen W, Allison DB, Ross R, Heymsfield SB. Combination of BMI and waist circumference for identifying cardiovascular risk factors in whites. Obes Res. 2004; 12: 633-45
40. Bjorntorp P. Abdominal fat distribution and the metabolic syndrome. J Cardiovasc Pharmacol 1992; 20: 526
41. Bjorntorp P. Metabolic difference between visceral fat and subcutaneous abdominal fat. Diabetes Metab. 2000; 26 (suppl 3): 10
42. Seidell JC, Bouchard C. Abdominal adiposity and risk of heart disease. JAMA 1999; 281: 2284-2285
43. Williams SR, Jones E, Bell W, Davies B, Bourne MW. Body habitus and coronary heart disease in men. A review with reference to methods of body habitus assessment. Eur Heart J. 1997; 18: 378-93
44. Kaplan NM. The deadly quartet: upper-body obesity, glucose intolerance, hypertriglyceridemia. Arch Intern Med.1989; 149: 1514-20
45. World Health Organization physical status: the use and interpretation of anthropometry. WHO Technical report Series 854. Genva: World Healt Organization, 1995
46. Baumgarther RN, Heymsfield SB, Roche AF. Human body composition and the epidemiology of chronic disease. Obes Res. 1995; 3: 73
47. Grinker JA, Tucker KL, Vokonas PS, Rush D. Changes in patterns of fatness in adult men in relation to serum indices of cardiovascular risk: Normative Aging study. Int J Obes. 2000; 24: 1369
48. Steering Committee. The Asia-Pacific perspective: Rededining obesity and its treatment Australia: Health communication Australia Pty Limited 2000.
49. Hsieh SD, Yoshinaga H, Muto T, Sakurai Y. Anthropometric obesity indices in relation to age and gender in Japanese adults. Toboku J Exp Med. 2000; 191: 79-84
50. Onat A, Sansey V, Uysal O. Waist circumference and waist-to-hip ratio in Turkish adult: interrelation with other risk factors and association with cardiovascular disease. Int J Cardiol. 1999; 70: 43
51. Ho SC, Chen YM, Woo JLF, Leung SSF, Lam TH, Janus ED. Association between simple anthropometric indices and cardiovascular risk factors. Int J Obes. 2001; 25: 1689-97
52. Oliveria CL, Veiga GV, Sichieri R. Anthropometric markers for cardiovascular disease risk factors among overweight adolescents. Nutr Res. 2001;21:1335
53. Lemos-Santos MG, Valente JG, Goncalves-Siva RM, Sichieri R. Waist circumference and waist-to-hip ratio as predictors of serum concentration of lipid, in Brazilian men. Nutrition. 2004; 20: 857-62
54. Ashwell M, Lejeune S, McPherson K. Ratio of waist circumference to height may be better indicator of need for weight management. BMJ. 1996; 312: 377
55. 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 Obs. 1999; 23: 801-809
56. Ledoux M, Lambert J, Reader BA, Despres JP. A comparative analysis of weight to height and waist to hip circumference indices as indicators of the presence of cardiovascular disease risk factors. Canadian Heart Health surveys Research Group. Can Med Assoc J. 1997; 157(suppl 12): S32-S38
57. Seidell JC, Cigalini M, Charzewska J, Ellsinger BM, Deslypere JP, Cruz A. Fat distribution in European mens: a comparison of anthropometric measurements in relation to cardiovascular risk factors. Int J Obes Relat Metab Disord. 1992; 16: 17-22
58. Ledoux M, Lambert J, Reader BA, Despres JP. Correlation between cardiovascular disease risk factors and simple anthropometric measures. Canadian Heart Health Surveys Research Group. Can Med Assoc J. 1997; 157(suppl 1): S46-S53
59. 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: 1147-1152
60. Hsieh SD, Yoshinago H. Abdominal fat distribution and coronary heart disease risk factors in men. Waist/height ratio as a simple and useful predictor. Int J Obes. 1995; 19: 585-589
61. Lemieux S, Prudhomme D, Bouchard C. Trembley 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: 685-693
62. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005; 56: 303-7

Original Article

Correlation of anthropometric indices with common cardiovascular risk factors in an urban adult population of Iran: data from Zanjan Healthy Heart Study

Ali Awsat Mellati PhD[1], Seyed Nouraddin Mousavinasab PhD[1], Sepide Sokhanvar MD[1], Seyed Ali Naghi Kazemi MD[1], Mohammad Hossain Esmailli PhD[2], Hossain Dinmohamadi MD[3]

[1]*Zanjan metabolic disease research center, Zanjan university of medical sciences, Zanjan, Iran*
[2]*Physiology department, Qazvin university of medical sciences, Qazvin, Iran*
[3]*Health and Prevention, Zanjan university of medical sciences, Zanjan, Iran*

伊朗城市成人的體位測量指數與心血管疾病危險因子之相關性：Zanjan 健康心臟研究資料

本研究目的，為找出預測心血管疾病危險因子的最佳體位測量指數。由 Zanjan 健康心臟研究中（一前瞻性研究，於伊朗 Zanjan 省的 Zanjan 及 Abhar 兩大城市進行），找出 2768 位有完整資料的受試者，包括 1310 位男性及 1458 女性，年齡介於 21-75 歲。常見的心血管疾病危險因子(三酸甘油酯、總膽固醇、高密度脂蛋白膽固醇、低密度脂蛋白膽固醇、空腹血糖及血壓)及體位測量指數(身體質量指數、腰圍、腰臀比及腰圍身高比)，皆使用標準流程量測。將心血管疾病危險因子及體位測量指數，使用淨相關及接收器運作特性(ROC)曲線分析。ROC 曲線分析結果，在男性與女性，共有 6 項心血管危險因子，都以腰圍身高比的曲線下面積（AUC）最大。在男性，其次為 4 項心血管危險因子，以腰圍 AUC 較大；女性受試者，三種體位測量指數（腰圍、身體質量指數及腰臀比）各在 1 項心血管危險因子中，有最大的 AUC。由結果顯示，高盛行率的血脂異常，即心血管疾病之高風險，需特別注意、介入並使用適當方式治療。腰圍身高比，比起其他三種體位測量指數（身體質量指數、腰圍、腰臀比），為心血管危險因子之較好預測因子，與其他研究報告結果相符合。在男性及女性中，決定的最佳切點為 0.5。然而因種族不同，其切點也與之前研究不同，需要未來研究及縱貫性資料，以訂定出國際公認簡單、適宜之測量，可有效在臨床及流行病學領域上使用。

關鍵字：腰圍身高比、體位測量指數、心血管危險因子、肥胖、ROC 分析