Original Article

Correlation of dyslipidemia with waist to height ratio, waist circumference, and body mass index in Iranian adults

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Overweight and obesity are increasing problems in many countries and are related to multiple cardiovascular risk factors. Although imaging techniques can determine total body fat and its distribution reliably, anthropometric measurements remain important in clinical practice. The purpose of this study was to determine the association between some anthropometric measurements and dyslipidemia as an important cardiovascular risk factor in Iranian population. A total of 750 subjects (580 females and 170 males) were selected by multistage random sampling from residents of Arak (Iran) and related villages in 2005. None of them had any significant past medical history. Body mass index(BMI), waist circumference(WC), and waist to height ratio(W/Ht) of subjects were measured to identify their relationship with their lipid profile including total cholesterol(TC), triglyceride(TG), high density lipoprotein cholesterol(HDL-C), low density lipoprotein cholesterol(LDL-C), and the ratio of total cholesterol to high density lipoprotein cholesterol(TC/HDL-C). Fasting blood sugar (FBS) was also measured. WC and W/Ht showed greater correlation with TC, TG, LDL-C, TC/HDL-C level than did BMI. Among lipid profile, TG showed the closest correlation with W/Ht (r=0.309, p<0.001) and WC (r=0.308, p<0.001). HDL-C level did not show any statistical relationship with W/Ht, but it was weakly correlated with WC (r=-0.088, p<0.05). None of the indices showed any association with FBS level. It can be concluded that W/Ht and WC can best predict dyslipidemia in an Iranian adult population. We suggest using both W/Ht and WC as inexpensive and easy methods in clinical and epidemiological fields.

Key Words: obesity, dyslipidemia, waist to height ratio, waist circumference, body mass index

Introduction

Obesity is associated with an adverse cardiovascular risk profile and consequently with excess cardiovascular morbidity and mortality.[1,2] The prevalence of obesity has increased dramatically in industrialized and developing countries.[3,4] The world Health Organization (WHO) has recently defined obesity as a disease.[5]

Abdominal or central adiposity is considered the most important determinant of cardiovascular disease (CVD) and type 2 diabetes mellitus (DM) .[6,7] While precise, sophisticated techniques for measuring body fat distribution and body composition are available,[8,9] they are generally not appropriate outside specific research settings.[10] The use of simple anthropometric measurements seems to diagnose obesity in early stages. As a result, many attempts have been made to find out the most appropriate anthropometric index in different studies.

Body mass index (BMI), which relates weight to height, is the most widely used and simple measure of body size, and is frequently used to estimate the prevalence of obesity within a population.[11,12] A BMI $\geq$ 25 Kg/m^2 is associated with increased morbidity, primarily from DM and CVD, while a BMI >30 Kg/m^2 is associated with increased risk for both morbidity and mortality, the latter mainly from diabetes, coronary heart disease (CHD), and stroke.[2,13] BMI does not reflect body fat distribution, whereas the intra-abdominal deposition of adipose tissue is a major contributor to the development of hypertension, insulin resistance, DM and dyslipidemia.[14] Thus, other anthropometric indices such as waist circumference (WC), waist-to-height ratio (W/Ht), and waist-to-hip ratio (WHR) have been used as alternatives to BMI. Waist circumference is increasingly being accepted as the best anthropometric indicator of abdominal adiposity and metabolic risk.[15-17]

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Manuscript received 22 June 2006. Initial review completed 16 July 2006. Revision accepted 23 August 2006.

On the other hand, some studies have proved that waist-to-height ratio (W/Ht) might be more closely associated with cardiovascular risks than other anthropometric indices.[18-20] Until now, few studies have been conducted in order to determine the correlation of cardiovascular risk factors with simple anthropometric measurements in Iranian population.

In the present study, we compared some anthropometric indices (BMI, WC, and W/Ht) to determine their relationship to dyslipidemia as an important cardiovascular risk factor,[21] in Iranian adult population.

Materials and methods

In this cross sectional population based study, 810 individuals were selected by multistage random-sampling. First, people were divided in two stratums (residents of city or villages), and then participants were selected by cluster random sampling in each stratum. Subjects were excluded from the study for any obvious disease (i.e. hypertension and diabetes mellitus) and weight loss more than 10% during the last six months, by history taking and physical examination. 750 eligible subjects with a mean age of 41.11±16.06 years were included. There were 580 women (mean age of 40.41±15.44 years) and 170 men (mean age of 43.57±17.88 years). All subjects were residents of Arak (Iran) and related villages.

Weight was then measured, while subjects were minimally clothed without shoes, using digital scales and was recorded to the accuracy of 100g. Height was measured in standing position without shoes using tape meter while the shoulder was in a normal position. BMI was calculated as weight in kilograms divided by height in meters squared. Those with a BMI of 25.0-29.9 Kg/m^2 were classified as overweight, whilst those with a BMI $\geq$30 Kg/m^2 were defined as obese. Subjects with BMI greater than 45 Kg/m^2 were considered very obese.[5]

Waist circumference was measured at the point halfway between the lower border of ribs and the iliac crest in a horizontal plane.[10] Waist to height ratio was calculated by dividing waist circumference by height. All anthropometric parameters were measured by a trained nurse.

Blood pressure was measured on the right arm, with the subject in the sitting position, using a standard mercury manometer after at least 5 min of rest. The appearance of first sound (Phase I of Korotkoff's sounds) and disappearance of sound (phase V of Korotkoff's sounds) were used to determine systolic and diastolic blood pressure. Two readings at 5 min intervals were taken from each participant. The lower of the two readings was recorded as subject's blood pressure. Hypertension was defined as a systolic blood pressure (SBP) of 140 mmHg or greater, and/or a diastolic blood pressure (DBP) of 90 mmHg or greater.[22] Blood pressure was measured by a general physician.

A blood sample was drawn by a trained staff member from a regional laboratory between 07:00 and 09:00 AM from all study participants after 12-14h overnight fasting. Blood samples were taken in a sitting position according to the standard protocol and were centrifuged within 30-45 minutes of collection. All blood lipid analyses were done on the days of blood collection using auto analyser (Hitachi 902, Roche, Germany). Total cholesterol (TC) and triglyceride (TG) was assayed using enzymatic calorimetric test with cholesterol esterase, cholesterol oxidase, and glycerol phosphate oxidase respectively. High density lipoprotein cholesterol (HDL-C) was measured after precipitation of apolipoprotein B containing lipoproteins with phosphotangistic acid. Low density lipoprotein cholesterol (LDL-C) was calculated from serum TG, TC, and HDL-C.[23] LDL-C was not calculated when serum TG concentration was greater than 400 mg/dL. High total cholesterol, high triglyceride, high low-density lipoprotein cholesterol, and low high-density lipoprotein cholesterol were defined as TC $\geq$ 200mg/dL, TG $\geq$150mg/dL, LDL-C $\geq$130mg/dL, and HDL-C <40mg/dL according to the criteria of APT III.[24]

Fasting blood glucose (FBS) was assayed using kinetic calorimetric test with hexokinase. Assay performance was monitored in one out of 20 tests interval using the control serum, percinorm (normal range) and percipath (pathologic range). All samples were analysed when internal quality control met the acceptable criteria.

All data were analysed by SPSS (SPSS Inc, Chicago IL, USA, version 11). Simple descriptive techniques were used to describe the variables among the participants. The K-S test and levene were applied to verify normal distribution and the quality of variances. Pearson correlation coefficient test was used to explore the relationship between quantitative data. Independent sample t-test and Mann-Whitney U test were used to compare between BMI variable groups. Chi square test was used to find the relationship between qualitative data. The study was approved by the local ethics research committee.

Results

Among the 750 subjects, 388(51.7%) had BMI greater than 25 Kg/m^2 and were therefore considered overweight. Percentage of overweight was 55.1% and 43.7% in females and males respectively (p<0.01). BMI was greater than or equal to 30 Kg/m^2 in 16.4% of all subjects, including 18.6% of all females and 9% of all males(p<0.01). Among obese subjects 5.78% were very obese.

Table 1 shows anthropometric and biomedical data including total cholesterol, triglyceride, HDL-C, LDL-C, TC/HDL-C, LDL-C/HDL-C, and fasting blood glucose according to sex groups.

Table 2 shows anthropometric and biomedical data including total cholesterol, triglyceride, HDL-C, LDL-C, TC/HDL-C, LDL-C/HDL-C, and fasting blood glucose according to BMI.

In this analysis overweight subjects presented higher total cholesterol, higher triglyceride, lower HDL-C, higher LDL-C, higher TC/HDL-C, higher LDL-C/HDL-C and higher fasting blood glucose than normal weight subjects.

High total cholesterol was found in 28.5% of subjects (30.2% of men and 22.9% of women (p>0.05)).

Triglyceride was more than or equal to 150mg/dL in 29.3% of subjects. Percentage of hypertriglyceridemia was 28.9% and 30.7% among women and men respectively (p>0.05).

Elevated low-density lipoprotein (LDL-C$\geq$130 mg/dL) was found in 25.5% of subjects. 19.9% of men and 27.3% of women showed LDL-C level above the normal range

Table 3. Correlation of TC, TG, LDL-C, LDL-C, HDL-C, TC/HDL-C, LDL-C/HDL-C, and FBS with anthropometric measurements and age in normotensive subjects of Arak (Iran) in 2005

		BMI	WC	Age	W/Ht
TC (mg/dL)	r	0.131*	0.241*	0.271*	0.269*
TG (mg/dL)	r	0.112*	0.308*	0.172*	0.309*
LDL-C (mg/dL)	r	0.111*	0.213*	0.235*	0.242*
HDL-C (mg/dL)	r	-0.04***	-0.088**	-0.02***	-0.07***
TC/HDL-C	r	0.111**	0.248*	0.195*	0.255*
LDL-C/HDL-C	r	0.099*	0.229*	0.174*	0.240*
FBS (mg/dL)	r	0.003***	0.057***	0.134*	0.03***

* $p<0.001$, ** $p<0.05$, *** no significant

Table 1. The anthropometric and biochemical characteristics of normotensive, non-diabetic subjects of Arak (Iran) in 2005 by gender

	Female		Male		
Index	mean	S.D	mean	S.D	*p*
Age (years)	40.4	15.4	43.6	17.4	*
BMI (kg/m^2)	26.6	14.8	26.1	17.6	***
WC (cm)	84.8	15.2	84.9	45.6	***
W/Ht	0.53	0.10	0.50	0.25	**
FBS (mg/dL)	83.4	25.8	85.1	47.4	***
TC (mg/dL)	180.9	45.9	170.2	45.3	**
LDL-C (mg/dL)	110	43.0	98.3	40.7	**
HDL-C (mg/dL)	47.7	12.5	44.3	11.4	**
TG (mg/dL)	134.0	86.9	141.6	99.7	***
TC/HDL-C	4.01	1.40	4.07	1.50	***
LDL-C/HDL-C	2.46	1.16	2.38	1.2	***

* $p<0.05$, ** $p<0.01$, *** no significant

Table 2. The biochemical parameters of normotensive non-diabetic subjects of Arak (Iran) in 2005 by BMI

	BMI<25kg/m^2		BMI≥25kg/m^2		*p*
	Mean	S.D.	Mean	S.D.	
TC (mg/dL)	164.9	40.3	191.5	47.4	<0.001
TG (mg/dL)	109.1	63.6	161.3	103.2	<0.001
LDL-C (mg/dL)	96	40	118.1	42.7	<0.001
HDL-C (mg/dL)	48.1	12.3	45.8	12.3	<0.01
TC/HDL-C	3.62	1.30	4.40	1.43	<0.001
LDL-C/HDL-C	2.13	1.06	2.73	1.2	<0.001
FBS(mg/dL)	79.5	20.6	87.9	39.4	<0.001

*$p<0.01$, **$p<0.001$

($p<0.05$).

Low high-density lipoprotein (HDL-C <40 mg/dL was found in 31.7% of subjects. Among study participants 41.6% of men and 29.4% of women had HDL-C level below the normal range ($p<0.01$).

Abnormal total cholesterol, LDL-C, and HDL-C was variable in different age groups. By age groups, subjects in the 51-60 age group had highest abnormal levels of total cholesterol and LDL-C. On the other hand lowest HDL-C level was seen among the individuals who were older than 70 years. LDL-C level was more markedly abnormal than total cholesterol and HDL-C level for all age groups.

Table 3 shows correlation of total cholesterol, triglyceride, LDL-C, HDL-C, TC/HDL-C, LDL-C/HDL-C, FBS with different anthropometric parameters.

Discussion

Obesity is associated with many metabolic risks; however, far fewer studies of obesity-related disorders have been performed in Asia compared with western countries.[19] Studies in Iran have shown an increasing prevalence of obesity, which is expected to rise in the future due to increasing urbanization.[25] Here we presented the high prevalence of obesity among Iranian adults. In our study half of subjects were overweight. The prevalence of obese and very obese subjects was 16.4% and 5.78% respectively. These rates are lower than that reported by Azizi *et al*. in Tehran, Iran.[26] Lin *et al*. reported lower prevalence of overweight adults (37.8%) and obese subjects (6.8%)

in Taiwan.[27] Our findings are consistence with the report of Dalton *et al*. in Australian population.[10]

In this study, hypercholesterolemia (29.5%), hypertriglyceridemia (29.3%), abnormally low HDL-C (31.7%), and elevated LDL-C (25.5%) were the common findings. These ratios are higher than reported in Japanese,[19] but are lower than what was observed among Tehranian [26] and Taiwanian [27] participants, except for HDL-C and TG which were lower among Taiwanian subjects. This difference may be explained by different ethnicity, different nutritional status and lower level of urbanization of Arak population in comparison with Tehranian and Taiwanian subjects. The present study was performed on normotensive subjects. It has been shown that hypertensive patients demonstrate higher levels of lipid profile than does the general population,[28] and lower level of lipid profile in our study may be explained by this fact that according to eligibility criteria, we could not include hypertensive patients in the study. Inclusion of these subjects in our study we would probably have shown more lipid abnormalities.

In our study men had a higher prevalence in all metabolic abnormalities except for high LDL-C, which had higher prevalence among women.

Anthropometric measurements are associated with various health conditions,[15] and BMI is by far the most widely used measurement to reflect general obesity. BMI, however, does not take into account the proportion of weight related to increased muscle or the distribution of excess fat within the body, both of which affect the health risks associated with obesity.[10] Individuals with a similar BMI can vary considerably in their abdominal fat mass, with premenopausal women typically having half the abdominal fat mass of men.[29]Also its limitations are recognized by its dependency on race, with Asians having large percentages of body fat at low BMI values[30] and its change according to age.[15] For these reasons, a measure of obesity that takes into account the increased risk of obesity related illnesses because of the accumulation of abdominal fat is desirable. There is a new tendency to use waist circumference[15-17] or waist to height ratio[18-20] rather than waist to hip ratio, because studies with computed tomography have disclosed them to have closer relationship with intra-abdominal fat [31, 32] and with changes in intra-abdominal fat. [33] An increased waist circumference is most likely associated with elevated risk factors because of its relation with visceral fat accumulation, and the mechanism may involve excess exposure of the liver to fatty acids.[34] The combination of WC and height that is W/Ht could manifest better the morphology of an enlarged abdomen with inappropriate short stature.[35]

In our study we investigated the relationships between some anthropometric indices (BMI, WC, and W/Ht) and dyslipidemia in Iranian adult population. Our result showed that there is correlation between these indices and dyslipidemia. Among the anthropometric indices, just waist circumference had a correlation with HDL-C level. None of the indices showed any relation to FBS levels. Our data showed that WC and W/Ht are good predictors of abnormalities in lipid profile. Among lipid profile, triglyceride level showed the closest relationship with WC and W/Ht.

Since the TC to HDL-C ratio is considered the best predictor of coronary artery disease in comparison with triglyceride level,[36] a good anthropometric predictor of cardiovascular disease should be related to the TC / HDL-C.[17] In the present study WC and W/Ht were also strongly correlated with TC / HDL-C.

The greatest limitation to our study was the lack of hip circumference measurement, which could help us more to choose the best anthropometric indices between BMI, WC, W/Ht, and WHR.

Our study proved that waist to height ratio (W/Ht) and waist circumference (WC) could be used as simple and non-invasive methods for detection of dyslipidemia as an important cardiovascular risk factor, in Iranian adult population and we suggest using these indices as simple and inexpensive methods in clinical and epidemiological fields.

Acknowledgments

This study was conducted by financial support of "Management and Planning Organization" of Islamic republic of Iran. We wish to thank Drs. Mohammad Reza Hassanjani Roushan, Iman Fani, Saeid Heydari, Samar Sayyed Yahossein, Diyana Taheri, and Noushin Afsharmoghaddam for their appreciable help to review the manuscript before submission.

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Original Article

Correlation of dyslipidemia with waist to height ratio, waist circumference, and body mass index in Iranian adults

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伊朗成人血脂異常與腰圍身高比、腰圍及身體質量指數的相關

過重與肥胖是很多國家日漸增加的問題，與多種心血管疾病危險因子有關。雖然影像技術可以可靠的評估總體脂肪量及其分布，體位測量在臨床的應用仍然相當重要。本研究目的為評估在伊朗族群的一些體位測量值，與以血脂異常當作重要的心血管危險因子之相關。750 名研究對象(580 名女性及 170 名男性)，以多步驟隨機抽樣選自 2005 年伊朗 Arak 及其相關村莊居民。他們沒有任何病史。測量研究對象的身體質量指數(BMI)、腰圍(WC)及腰圍身高比(W/Ht)，以確認與他們的血脂的相關性，包括總膽固醇(TC)、三酸甘油酯(TG)、高密度脂蛋白膽固醇(HDL-C)、低密度脂蛋白膽固醇(LDL-C)及總膽固醇與高密度脂蛋白膽固醇比值(TC/HDL-C)。同時測量空腹血糖值(FBS)。結果顯示 WC 及 W/Ht 與 TC、TG、LDL-C、TC/HDL-C 的相關性較 BMI 高。在血脂方面，TG 顯示與 W/Ht(r=0.309, p<0.001)及 WC(r=0.308, p<0.001)相關最高。 HDL-C 值與 W/Ht 沒有任何統計相關，但與 WC 為弱相關(r=-0.088, p<0.05)。沒有任何指標與 FBS 值具有相關性。綜合上述，在伊朗的成人族群 W/Ht 和 WC 可以最佳預測血脂異常。我們建議在臨床及流行病學，同時使用 W/Ht 和 WC 這兩個便宜又簡單的方法。

關鍵字：肥胖、血脂異常、腰圍身高比、腰圍、身體質量指數。