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Full Length Research paper

Inter-relationship of waist-to-hip ratio (WHR), body mass index (BMI) and subcutaneous fat with blood pressure among university-going Punjabi Sikh and Hindu females

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Different anthropometric measurements such as body mass index (BMI), waist to hip ratio (WHR), waist and hip circumferences (WC and HC) and skin fold thickness are the important indicator to investigate the risk factors for cardiovascular diseases. Therefore, this cross-sectional study was undertaken to assess the interrelationship between blood pressures with body mass index (BMI), waist to hip ratio (WHR) and subcutaneous fat. Three hundred university-going Punjabi Sikh and Hindu females were surveyed for blood pressures, pulse rate, height, weight, waist and hip circumferences, four skin folds (biceps, triceps, subscapular and suprailiac). All these measurements were taken from each subject using standard procedure. The relation between blood pressure and different anthropometric variables were assessed in multiple regression models. No significant differences of all the measured mean values of the traits have found between these two groups. However, further analysis of the data showed that BMI, WHR and skin folds measurements have significant ($p < 0.05$) effect on blood pressure phenotypes. The results of the present cross-sectional study indicated that BMI and WHR would be the good predictors for the chronic disease like hypertension. Primarily among female WHR should be used as a good predictor for elevated blood pressure.

Key words: Waist and hip circumferences, body mass index, blood pressure, Punjabi female.

INTRODUCTION

Waist-to-hip ratio, body mass index and subcutaneous fat are the important indicator of obesity, cardiovascular disease and hypertension. This relationship is documented from many studies (Gerber and Stern, 1999; Ghosh et al., 2000; Livshits and Gerber, 2001; Mueller et al., 2001; Badaruddoza, 2004; Bose et al., 2005; Ghosh, 2007; Badaruddoza and Kumar, 2009). Despite the modern technique, anthropometric measurements such as height, weight, BMI and WHR etc. are traditionally important method to study the genetic structure and prediction of risk factors of many complex diseases in human health (Seidell et al., 1989, 2001). Seidell et al. (1989) have suggested from the multicenter study of women that BMI was thebest overall predictor for both systolic and diastolic blood pressure. However many epidemiological studies (Folsom et al., 1993; Rimm et al., 1995; Schreiner et al., 1996; Silventoinen et al., 2003; Yalcin et al., 2005) have suggested that waist-to-hip ratio is also independent risk factor of cardiovascular disease for both sexes especially in female. Although importance of blood pressure as a risk factor in cardiovascular disease is well established (Gardner and Poehlman, 1995; Badaruddoza and Afzal, 1999, 2000; Gerber and Stern, 1999; Merio et al., 2004), however, how blood pressure is influenced by different factors such as WHR, BMI, adiposity and environmental factors is the key for the understanding of coronary diseases. The people of South Asian origin have increased cardiovascular risk due to more centralized deposition of body fat with higher mean of WC and WHR compared to Europians (McKeigue et al., 1991; Enas, 2000; Ghose et al., 2000). Therefore, one basic question raises that which one of the anthropometric measurements

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ments may be appropriate to track the elevated blood pressure in general population. Hence, the purpose of the present study is to establish the relationship of BMI, WHR and adiposity of skinfold with blood pressures (SBP and DBP) and to identify their effectiveness to screen the women with higher blood pressure among university-going two Punjabi female groups.

MATERIALS AND METHODS

The study population

This cross-sectional descriptive study was conducted on the Punjabi female students of the Guru Nanak Dev University, Amritsar, Punjab (North India). Measurements were made on 300 university-studying Punjabi females aged 20 - 26 years during the period of January - June, 2008. Out of 300 females, 150 were of Sikh religion and 150 were of Hindu religion. A simple random sampling procedure was followed to choose the subjects. All the participants were subjected to sign the consent form and asked some specific questions for age and ethnicity. None of the selected subjects refused the study. The study was approved by the universitys' appropriate research ethics committee in 2007. Data collection was carried out by face to face interviews at the hostels and inside the respective department in the University campus. The information regarding demographic features, food habits, family history about hypertension, physical activity and religion were recorded using a questionnaire. According to the religion basis the subjects were divided into two groups and recognized as Punjabi Sikh and Punjabi Hindu. Any comprehensive study dealing with anthropometric characteristics and blood pressure between Punjabi Sikh and Hindu females of 20 - 26 years of age group in the region of Punjab, India have not been available. Therefore, based on very limited information regarding the association of elevated blood pressure with BMI and WHR, these two specific religious sects (Punjabi Sikh and Hindu) have been chosen for the present study due to their similar ethnicity, considerable amount of admixture, same environment and food habit. The subjects between the age group 20 - 26 years were given the opportunity to participate in the present study because it was assumed that overall response would be 100% and this age group is more sensitive for tracking the obesity in females.

Anthropometric measurements

Different anthropometric measurements such as BMI, WHR, WC and HC are the part of index for investing of cardiovascular risk factors (Yalcin et al., 2005). Therefore, the reliability and validity of anthropometric measurements for the use of index of cardiovascular risk factors are well established (Dalton et al., 2003; Yalcin et al., 2005; Khan et al., 2008). Height (in cm) and weight (in kilogram) were measured to the nearest 0.1 cm and 0.5 kg respectively. The measurements were taken from the participant without shoes and with light clothed. The body mass index was calculated using the formula, BMI = weight (kg) / height (m^2). Waist circumference was measured at the midpoint between the inferior margin of the last rib and the top of the iliac crest. Hip circumference was measured at the largest posterior extension of the buttocks. Waist and hip circumferences were measured to the nearest 0.1 cm. The waist-to-hip ratio was calculated using the formula, WHR = waist circumference (cm) /hip circumference (cm). Biceps, triceps, subscapular and suprailiac skinfolds were measured to the nearest 0.2 mm on the left side of the body using Lange skinfold caliper. All anthropometric measurements were taken an each individual using standard anthropometric techniques (Singh and Bhasin, 1968; Weiner and Lourie, 1981). The measurements were taken by second female author using standard anthropometric tools. The age of the individuals was determined directly from their reported date of birth.

Measurements of physiometric variables

The physiometric variables included measurement of systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse rate. Two consecutive readings were recorded for each of SBP and DBP and the averages were used. The measurements were taken with the help of mercury sphygmomanometer in a sitting position with the right forearm placed horizontal on the table. The recordings were taken as recommended by the American Heart Association (1981). An appropriate sized cuff was fitted on the arm of the subject and was inflated to about 20 mm Hg above the point at which the radial pulse disappeared. The pressure within the cuff was then released at a rate of approximately 2 mm Hg/second, while osculating with a stethoscope placed over the brachial artery. The onset of sound (Korotkoff-phase I) was taken as indicative of systolic blood pressure and the disappearance of sound (korotkoff-phase V) was taken as indicative of diastolic blood pressure. Korotkoff phase was taken as recommended by the American Heart Association and others (Londe and Goldring, 1976). All efforts were made to minimize the factors which affect blood pressure like anxiety, fear, stress, laughing and recent activity (Badaruddoza and Afzal, 1999). Mean arterial blood pressure (MBP) was calculated for each of the two readings taken for SBP and DBP by using the formula:

MBP = DBP + (SBP-DBP)/3 (Pérusse et al., 1989)

The radial artery at the wrist was used to count the pulse. It was counted over one minute.

Statistical analyses

All data were analyzed by SPSS (Statistical Package for social sciences, Version 17, SPSS Inc, USA). Mean, standard deviation, independent samples t-test, Karl Pearson's correlation test, regression analysis (univariate and multivariate) and ANOVA were used to investigate the relationship between the anthropometric measurements and blood pressure phenotypes among both groups. The probability values less than or equal 0.05 (two tailed) were considered to be significant.

RESULTS

Table 1 presents the means and standard deviations and the comparison of different means with t and p values with respect to all measured variables between Punjabi Sikh and Hindu female students. The Sikh females have greater mean for waist and hip circumferences, suprailiac skinfold, MBP and pulse rate as compared with the Hindu female students. Whereas, the Hindu female students have greater mean for height, weight, BMI, WHR, three skinfolds (biceps, triceps and subcsapular) SBP and DBP as compared with Sikh female students. However, it has been found that the differences of all measured variables except age ($p < 0.001$), triceps skinfold ($p < 0.001$) and pulse rate ($p < 0.024$) have not been statistically significant at least at 5% level ($p < 0.05$) between these two categories of female subjects. Table 2 depicts the

Table 1. Differences of means (Sikh - Hindu) and Comparison of means through 't' test with significance value among university-going Punjabi Sikh and Hindu females students.

Variables	Mean ± SD		Mean differences	t	P
	Sikh (n = 150)	Hindu (n = 150)			
Age (years)	22.57 ± 2.18	21.74 ± 1.94	-0.83	3.47	< 0.001
Height (cm)	157.48 ± 5.63	157.72 ± 5.61	-0.24	0.37	NS
Weight (kg)	50.58 ± 8.30	50.66 ± 9.24	-0.08	0.08	NS
BMI (Kg/m^2)	20.37 ± 3.05	20.42 ± 3.49	-0.05	0.13	NS
Waist circumference (cm)	71.11 ± 8.06	70.95 ± 7.70	0.16	0.17	NS
Hip circumference (cm)	92.82 ± 7.10	92.73 ± 7.08	0.09	0.11	NS
WHR	0.76 ± 0.05	0.763 ± 0.05	-0.003	0.50	NS
Biceps skinfold (mm)	11.60 ± 3.31	12.24 ± 3.42	-0.64	1.65	NS
Triceps skinfold (mm)	19.17 ± 4.94	21.09 ± 5.30	-1.92	3.25	< 0.001
Subscapular skinfold (mm)	20.98 ± 6.03	22.27 ± 5.73	-1.29	1.90	NS
Suprailiac skinfold (mm)	20.80 ± 6.48	20.05 ± 9.36	0.75	0.80	NS
SBP (mm Hg)	116.89 ± 9.64	117.56 ± 9.00	-0.67	0.67	NS
DBP (mm Hg)	76.05 ± 7.61	76.13 ± 7.00	-0.08	0.09	NS
MBP (mm Hg)	89.90 ± 8.26	89.89 ± 6.80	0.01	0.32	NS
Pulse rate	83.22 ± 10.70	80.39 ± 10.85	2.83	2.27	<0.024

NS: Non significant.

Table 2. Comparison of correlation coefficients for blood pressure with other metric variables among university-going Punjabi Sikh and Hindu female students.

Variables	Sikh			Hindu		
	SBP	DBP	MBP	SBP	DBP	MBP
Age (years)	0.04	0.09	0.005	0.13	0.012	0.012
Height (cm)	0.09	0.05	0.07	0.004	0.04	0.03
Weight (kg)	0.48**	0.32**	0.39	0.30**	0.21**	0.28**
BMI (Kg/m^2)	0.48**	0.33**	0.39**	0.32**	0.23**	0.30**
Waist circumference (cm)	0.50**	0.32**	0.41**	0.36**	0.24**	0.33**
Hip circumference (cm)	0.47**	0.31**	0.37**	0.25**	0.18*	0.26**
WHR	0.27**	0.15*	0.22**	0.31**	0.18*	0.26**
Biceps skinfold (mm)	0.39**	0.35**	0.38**	0.22**	0.24**	0.26**
Triceps skinfold (mm)	0.35**	0.26**	0.31**	0.301**	0.17*	0.25**
Subscapular skinfold (mm)	0.46**	0.28**	0.38**	0.32**	0.25**	0.32**
Suprailiac skinfold (mm)	0.39**	0.32**	0.37**	0.17*	0.13	0.17*
Pulse rate	0.15*	0.195*	0.173*	0.07	0.003	0.025

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

comparison of correlation coefficients for blood pressure phenotypes with other metric variables between Punjabi Sikh and Hindu female subjects. As shown in the Table 2, weight, BMI, waist and hip circumferences, WHR, biceps, triceps and suprailiac skinfolds have shown significant correlation with SBP, DBP and MBP among both groups. It has been observed that waist circumference is highly correlated with SBP and MBP whereas, BMI has been found highly correlated with only DBP among both groups. In multiple regression models, the standardized regression coefficient with standard error (SE) and percent variance (R^2) accounted by regression for blood pressure phenotypes are given in Tables 3 and 4. All regression coefficients except age, height and pulse rate are highly significant ($p < 0.001$) for SBP among Punjabi Sikh female students. Almost the same trend for DBP has been noticed, except age, height, WHR and pulse rate (Table 3). Among Punjabi Hindu female students (Table 4), all regression coefficient except age, height and pulse rate for SBP; age, height, suprailiac skinfold and pulse rate for DBP; age, height and pulse rate for MBP have been found to be significant ($p < 0.001$). Almost negligible percent

Table 3. Standardized regression coefficient and standard error (SE) with significant level and percent of variance (R^2) for different variables in multiple regression model with blood pressure phenotypes among university-going Punjabi Sikh female students.

Variables	SBP		DBP		MBP	
	β ± SE	R^2	β ± SE	R^2	β ± SE	R^2
Age (years)	0.17 ± 0.36	0.002	0.35±0.29	0.009	90.37±7.06**	0.000
Height (cm)	0.17 ± 0.14	0.009	0.07 ± 0.11	0.003	0.11 ± 0.12	0.005
Weight (kg)	0.55 ± 0.08**	0.227	0.29 ± 0.07**	0.102	0.39 ± 0.08**	0.154
BMI (Kg/m^2)	1.51 ± 0.23**	0.227	0.81 ± 0.19**	0.106	1.07 ± 0.20**	0.156
Waist circumference (cm)	0.60 ± 0.09**	0.250	0.31 ± 0.07**	0.105	0.42 ± 0.08**	0.166
Hip circumference (cm)	0.64 ± 0.10**	0.219	0.33 ± 0.08**	0.095	0.44 ± 0.10**	0.140
WHR	50.10 ± 14.51**	0.075	22.08 ± 11.71	0.023	50.10 ± 14.51**	0.075
Biceps skinfold (mm)	1.13 ± 0.22**	0.152	0.81 ± 0.18**	0.125	34.21 ± 12.56**	0.050
Triceps skinfold (mm)	0.68 ± 0.15**	0.122	0.40 ± 0.12**	0.067	0.95 ± 0.19**	0.140
Subscapular skinfold (mm)	0.73 ± 0.12**	0.208	0.36 ± 0.09**	0.079	0.47 ± 0.04**	2.360
Suprailiac skinfold (mm)	0.59 ± 0.11**	0.158	0.38 ± 0.09**	0.104	0.38 ± 0.09**	0.194
Pulse rate	0.13 ± 0.07	0.022	0.06 ± 0.60	0.002	0.03 ± 0.06	0.002

**Regression coefficient is significant at the 0.01 level (2-tailed). * Regression coefficient is significant at the 0.05 level (2-tailed)

Table 4. Standardized regression coefficient and standard error (SE) with significant level and percent of variance (R^2) for different variables in multiple regression model with blood pressure phenotypes among university-going Punjabi Hindu female students.

Variables	SBP		DBP		MBP	
	β ± SE	R^2	β ± SE	R^2	β ± SE	R^2
Age (years)	-0.60 ± 0.38	0.020	-0.04 ± 0.29	0.000	-0.19 ± 0.29	0.003
Height (cm)	-0.08 ± 0.13	0.000	-0.05 ± 0.10	0.002	-0.05 ± 0.10	0.002
Weight (kg)	0.29 ± 0.08**	0.090	0.16 ± 0.06**	0.042	0.20 ± 0.06**	0.080
BMI (Kg/m^2)	0.82 ± 0.20**	0.101	0.46 ± 0.16**	0.050	0.59 ± 0.15**	0.090
Waist circumference (cm)	0.42 ± 0.09**	0.130	0.22 ± 0.07**	0.060	0.29 ± 0.07**	0.110
Hip circumference (cm)	0.32 ± 0.10**	0.060	0.18 ± 0.08**	0.030	0.23 ± 0.08**	0.060
WHR	55.01 ± 13.83**	0.098	24.75 ± 11.13**	0.030	34.34 ± 10.57**	0.070
Biceps skinfold (mm)	0.57 ± 0.21**	0.050	0.48 ± 0.16**	0.050	0.52 ± 0.16**	0.070
Triceps skinfold (mm)	0.51 ± 0.13**	0.090	0.22 ± 0.18**	0.030	0.32 ± 0.10**	0.060
Subscapular skinfold (mm)	0.51 ± 0.12**	0.104	0.30 ± 0.09**	0.060	0.38 ± 0.09**	0.101
Suprailiac skinfold (mm)	0.16 ± 0.08**	0.030	0.09 ± 0.06	0.020	0.12 ± 0.06**	0.030
Pulse rate	0.06 ± 0.07	0.01	0.02 ± 0.05	0.00	0.02 ± 0.05	0.006

**Regression coefficient is significant at the 0.01 level (2-tailed). * Regression coefficient is significant at the 0.05 level (2-tailed).

cent of variance (R^2) for all anthropometric variables have been seen in both the groups except waist circumference for SBP (25% among Punjabi Sikh females, Table 3). Significant relationship of blood pressure phenotypes along with other metric variables has been analyzed by the test of ANOVA (Univariate and multivariate, Table 5). Almost all variables except age, height and pulse rate have shown significant association and impact on blood pressure phenotypes (SBP, DBP and MBP) among Punjabi Sikh and Hindu female students (Table 5). Therefore, the strong association and impact ($p < 0.001$) between blood pressure phenotypes (SBP and DBP) and all measured variables (weight, waist and hip circumferences, and skinfolds) except age, height and pulse rate were corroborated by the results of regression and ANOVA analysis. We continued the analysis by calculation of significant predictors of SBP, DBP and MBP with respect to other measured variables through multivariate regression analysis (Table 6). The results revealed that age, weight, BMI, waist and hip circumferences, WHR and pulse rate have significant ($p < 0.001$) impact and strong predictors of SBP, DBP and MBP among both the groups. It is interesting to note that from multivariate regession analysis that none of the skinfolds measurement has shown significant predictor status for SBP, DBP and MBP. Therefore, the dependent variables (SBP, DBP and

Table 5. Comparison of analysis of variance (ANOVA, univariate analysis) of SBP, DBP and MBP with respect to other variables among university-going Punjabi Sikh and Hindu female students.

Variables	SBP		DBP		MBP	
	Sikh	Hindu	Sikh	Hindu	Sikh	Hindu
	F	F	F	F	F	F
Age (years)	0.23	2.51	1.49	0.021	0.0043	0.47
Height (cm)	1.39	0.003	0.39	0.22	0.80	0.22
Weight (kg)	43.19*	14.50*	16.88*	6.53*	26.98*	12.22*
BMI (Kg/m^2)	43.28*	16.44*	17.61*	8.14*	27.44*	14.82*
Waist circumference (cm)	48.88*	21.88*	17.35*	9.08*	29.37*	17.36*
Hip circumference (cm)	41.24*	10.08*	15.69*	4.85*	24.05*	8.77*
WHR	11.93*	15.80*	3.56*	4.94*	7.42*	10.55*
Biceps skinfold (mm)	26.25*	7.36*	21.16*	8.69*	24.83*	11.02*
Triceps skinfold (mm)	20.47*	14.63*	10.72*	4.32*	15.25*	9.79*
Subscapular skinfold (mm)	38.57*	17.05*	12.83*	9.53*	25.73*	16.54*
Suprailiac skinfold (mm)	27.57*	4.29*	17.23*	2.61	17.23*	4.38*
Pulse rate	3.26	0.788	0.36	0.002	0.24	0.09

*F is significant at 0.001 levels (2-tailed).

Table 6. Calculation of significant predictors of SBP, DBP and MBP with respect to other variables through multivariate regression analysis among university-going Punjabi Sikh and Hindu female students.

Variables	SBP		DBP		MBP	
	Sikh	Hindu	Sikh	Hindu	Sikh	Hindu
	F	F	F	F	F	F
Age (years)	0.22*	0.18*	0.32*	0.24*	0.17*	0.29*
Height (cm)	0.02	0.04	0.07	0.02	0.03	0.01
Weight (kg)	0.15*	0.16*	0.29*	0.23*	0.22*	0.22*
BMI (Kg/m^2)	0.13*	0.27*	0.21*	0.24*	0.23*	0.85*
Waist circumference (cm)	1.35*	0.88*	1.55*	1.40*	1.12*	1.25*
Hip circumference (cm)	0.93*	0.95*	0.99*	0.93*	0.98*	0.97*
WHR	17.64*	11.86*	12.02*	10.06*	10.01*	11.21*
Biceps skinfold (mm)	0.09	0.03	0.06	0.005	0.11	0.015
Triceps skinfold (mm)	0.04	0.07	-0.06	0.006	0.03	0.006
Subscapular skinfold (mm)	0.05	0.03	0.05	0.015	0.10	0.011
Suprailiac skinfold (mm)	0.03	0.01	0.09	0.006	0.05	0.004
Pulse rate	3.26*	2.79*	2.36*	2.08*	2.24*	2.09*

*F is significant at 0.001 levels (2-tailed).

MBP) can only be predicted from a linear combination of the present independent variables such as age, weight, BMI waist and hip circumferences, WHR and pulse rate.

DISCUSSION

In general, the results of the present study support the hypothesis that BMI, WHR, skinfolds adiposity and pulse rate have some independent effect on the risk of elevated blood pressures (SBP and DBP) among females. WHR and BMI have found equally important indicator to predict the risk of cardiovascular diseases. However, WHR has shown better prediction power for cardiovascular disease among women. Similar observations have been documented from other studies (Lean et al., 1995; Rexorde et al., 2001; Janssen et al., 2002; Yalcin et al., 2005). Yalcin et al. (2005) have reported that WC in men and BMI in women are the most important predictors for the elevation in SBP and DBP. Many investigators (Pouliot et al., 1994; Dalton et al., 2003; Esmaillzadeh et al., 2004; Khan et al., 2008) advocated that WC as well as WHR have strongest relationship with the elevation of blood pressures especially in females although age and menopause have significant effect on cardiovascular parameters. This hypothesis have also supported by many authors (Spencer et al., 1997; Rheeder et al., 2002; Badaruddoza and Hundal, 2009; Badaruddoza et al., 2009). Therefore, the elevation of SBP and DBP among women can be correlated with anthropometric variables. Waist and hip circumferences are most important variables in women for obesity and blood pressures. It has been shown that the mean values of all the traits have not shown any statistical significant differences ($p < 0.05$) among Punjabi Sikh and Hindu university-going females. With respect to BMI, WHR and blood pressures, the present results are largely consistent with insignificance deviation from each other. However, Punjabi Hindu females showed a marginal increase of BMI, WHR and blood pressures as compared to Punjabi Sikh females. Furthermore, from correlation, regression and multivariate analysis it have been seen that age, BMI, and pulse rate are equally and significantly associate with SBP and DBP among Punjabi Sikh and Hindu females. It is due to the fact that similar ethnic, genetic and environmental background of these two groups. Therefore, it appears that the BMI, WHR and adiposity are ethnic and genetic with environmental specific to population. However, further comparative study among different ethnic and same ethnic with different caste would require to investigate whether ethnicity have effects on body structure and adiposity in the population. The present study has shown similar effect to many previous studies (Folson et al., 1993, Rimm et al., 1995; Schreiner et al., 1996; Mukhopadhyay et al., 2005). After analysis of the present data it has been shown that BMI, WHR, height, weight, many skinfolds and Pulse rate have some independent effect on the risk of Cardiovascular disease among Punjabi Sikh and Hindu females. A significant association of BMI, WHR and skinfolds with blood pressure phenotypes has noticed among both the groups. All the positive correlation and regression coefficients suggested that both the groups have same ethnic origin and have sufficient amount of admixture. Finally, it has been suggested from the present study that beyond genetic and environment components ethnic differences have also significant impact on the variation of BMI, WHR and blood pressures. At the same time significant interactions between all these variables have seen among both the groups. Again, it has been suggested that similar effects among both groups could be the reason of same ethnic origin and cultural homogeneity. Therefore, no ethnic difference has been noticed on the variation between two populations.

Therefore, the present study indicated that BMI, WHR and skinfolds measurements can be used as significant predictor to predict or understanding etiology of the chronic diseases like hypertension and obesity/ diabetes regardless the background of the ethnic and genetic composition. The weakness of the present data is that the analysis does not include male data. However, this is a problem for female investigator in Indian society because opposite sex contact in adult in general is not allowed (Arya et al., 2002). However, it may be concluded that high BMI and WHR are better predictor for the incidences of cardiovascular diseases among women. Therefore, present authors suggested that WHR would be a simple and significant indicator for the management of moderate or high risk of cardiovascular disease and regular health care system in women.

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