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A Comparative Analysis of Obesity Indices as Potential Predictors of Prehypertension and Prediabetes in Young Saudi Female University Students

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Abstract

Background: The prevalence of obesity is leading to alarming rise in development of prehypertension and prediabetes, which are major risk factors for cardiovascular disease and metabolic syndrome. This study compared the performance of four anthropometric indices and their correlation with prehypertension and prediabetes among young Saudi female university students. The main objective is to identify these conditions earlier so as to modify the risk factors and to help ameliorate these conditions.

Methods: A cross-sectional study with convenient sampling was conducted on 184 apparently healthy female students belonging to all colleges of Princess Nourahbint Abdulrahman University, Riyadh, KSA during health awareness week. Weight, height, waist, and hip circumference were measured to the nearest correct value and body mass index (BMI), waist to hip ratio (WHpR) and waist to height ratio (WHtR) were calculated. Systolic and diastolic blood pressures were recorded by mercury sphygmomanometer and blood glucose level was measured by glucometer.

The data was analyzed by SPSS version 20. Chi-square test was applied for categorical variables. For blood pressure Man-Whitney test was applied. Anthropometric indices were compared by univariate logistic regression.

Results: Of 184 participants, 25.5 % and 14.6% were found to have prehypertension (PHTN) and prediabetes, respectively. The total percentage of obese students was 31.5% identified mainly based on BMI. Overweight and obese subjects as indicated by BMI were likely to have PHTN as compared to those with normal weight. Moreover, obese subjects were more likely to have prediabetesas well (OR: 1.78, 95% CI: 0.61,5.22). Waist circumference (WC)>88 cm was 4.11 times more likely to predict prediabetes than WC <88and waist height ratio was also more likely to predict prediabetes in this age group.

Conclusion: Increased BMI is a strong predictor for prehypertension whereas WC and WHtR were found to have significant correlation with prediabetes.

Key words: prehypertension, prediabetes, obesity, BMI, waist circumference

Introduction

Overweight and obesity in adolescents and young adult age groups have become anepidemic globally as well as in Saudi Arabia, especially in females. According to a National Epidemiological Health Survey done in KSA, prevalence of overweight and obesity equals 36.9% and 35.5% respectively.[1] The rising level of obesity is associated with increased risk of developing prehypertension (PHTN), prediabetes (PreDM) and their coexistence in disease free healthy adults ultimately leading to hypertension (HTN), type 2 diabetes mellitus (DM), and cardiovascular disease (CVD) risks.[2]

The term PHTN was first defined in the 7th JNC report and replaced the previously used term of high normal blood pressure (BP).[3]PHTN, per se is not a disease with an immediate high risk and the clinical value of its identification is the potential detection of early stage of risk of HTN and CVD over an individual's life span. [4]

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It develops gradually over many years usually without a specific identifiable cause, influenced by multiple interactions between various risk factors. A primary risk factor for PHTN is being overweight, whereas a family history of HTN, a sedentary lifestyle, high calorie intake, alcohol, and smoking, are among other risk factors. [5,6] The Framingham Heart Study reported that conversion rate of PHTN to HTN over 4-years was 30%. A prehypertensive person is more than three times more likely to have a heart attack and 1.7 times more likely to have heart disease than a person with normal BP. [7] Moreover San Antonio Heart Study documented that PHTN is associated with DMand much of this risk is associated with insulin resistance syndrome.[8]

PreDM is defined as impaired fasting blood glucose level (100 to 125 mg/dL or 5.6 - 6.9 mmol/L) according to American Diabetic Association and is likely to develop into type 2 diabetes in 10 years or less,if left untreated.[9] The exact cause of preDM is unknown, although family history and genetics appear to play an important role. Excess fat especially abdominal fat and physical inactivity also seem to be important factors in the development of preDM. [10] Intra-abdominal obesity and visceral fat deposition is strongly associated with increased risk and higher magnitude of developing insulin resistance and its concomitant metabolic disorders including atherogenic dyslipidemia and overt diabetes mellitus. [11]

Simple anthropometric measurements are the most commonly used tools for assessing body composition. Body Mass Index (BMI) and waist hip ratio (WHpR) are indicators of central obesity and have been traditionally used to assess body weight.[12] Waist circumference (WC) is a simple measure of obesity and an efficient predictor of total fat content and visceral fat accumulation. Waist height ratio (WHtR) is the ratio between waist girth and height and indicates the degree to which fat has accumulated around the waist. Studies have reported sensitivity of these indices for different diseases.[13] The BMI is a common mean of identifying obesity but may not reflect body fat in all individuals. Compared with BMI, WC is a better index to investigate metabolic abnormalities. [14]

The direct association between preHTN, preDM and anthropometric indices of obesity has been studied in many countries and ethnic groups but the best index to predict these diseases remains controversial. The aim of the paper is to highlight the increased frequency of preHTN, preDM and to predict a sensitive obesity indicator for predicting these diseases in Saudi population.

This study is expected to raise the awareness about the avoidable risk factors by implementing screening programs and lifestyle modifications to reduce the incidence of these diseases and its complications.

Materials and Methods:

This cross-sectional study was conducted at Princes Nourahbint Abdulrahman University during "Health awareness week" with convenient sampling.184 Young Saudi female students belonging to different colleges participated in the study.

Inclusion criteria: All healthy (disease free) students between ages 18-25 years included.

Exclusion criteria: students with pregnancy or any other disease or diagnosed cases of diabetes and HTN.

The study was approved by Research and Ethical Committee of Princess Nourah University. Verbal consent was taken from each participant.

Measurement of Blood Pressure (BP): BP was measured by mercury sphygmomanometer in sitting position with back supported and arm resting at the level of heart. Two readings were taken and averaged.
PHTN was defined as systolic BP between 121-139 mmHg and diastolic BP between 81-89 mmHg.[3]

Measurement of Blood glucose: Random blood glucose level is determined by Glucometer (ACCU-CHEK, Roche Diagnostic GmbH))

BMI: Weight is measured on a calibrated scale recorded to nearest 0.1 kg, while height was measured via a stadiometer and recorded to nearest centimeter. BMI was calculated by formula: Weight kg/height m^2.
BMI is classified according to WHO international classification for Asian population as follows:
Underweight: < 18.49 kg/m2 Normal weight: 18.5 – 24.9 kg/m2
Overweight: 25 – 27.9 kg/m2 Obese: >28 kg/m2

Waist circumference: was measured in the middle between 12^{th} rib and iliac crest at the level of umbilicus with the belly relaxed. The subject is asked to stand with feet together and arms at sides. Scores are recorded to nearest millimeter.
Normal value for females: < 88

Waist-hip ratio: hip circumference was measured at the fullest point around the buttocks and ratio is calculated by dividing it with waist circumference.
Normal: < 0.85High risk: > 0.85

Waist-height ratio: the ratio was calculated by dividing waist circumference with height.
Underweight:<46 Normal: 46 –52.9 Overweight:53–57.9 Obese: ≥ 58

Statistical analysis was performed using SPSS version 20. Descriptive statistics were presented as mean ±SD. The Chi-square test was applied for categorical variables and expressed as frequencies and percentage. For systolic, diastolic blood pressure and blood glucose level (continuous data) Mann Whitney U-test was applied. Continuous variables are expressed as Median (interquartile range). Each proportion of anthropometric indices was then individually compared with prehypertensive and prediabetic subjects by univariate logistic regression. A P value <0.5 was used to establish statistical significance.

Results

A total of 184 female students (age: 18-25 years) belonging to all colleges of Princes Nourahbint Abdulrahman University participated in this study. Table 1 shows characteristics of study population. The mean BMI was 23.23±4.95, mean WC was 75.6±15.3 cm, mean WHpR was 0.78±0.12, whereas WHtR was 47.8±9.5. The mean systolic and diastolic BP were 113.4±12.9 mmHg and 74.7±11 mmHg, respectively. The family history of diabetes was positive in 51% and that ofPHTN in 45% participants. 24% students have family history of both diseases.

Table 2 shows the comparison of proportion of different anthropometric indices among normal,preDMand PHTN groups. Out of 184participants27 (14.6%) were found to have prediabetes; among them 12 (44.4%) were overweight and obese based on BMI, 9 (33.3%) based on WC, 6 (22%) on the basis of WHpR and 13 (48%) based on WHtR. WC and WHtR were found to be significantly increased in preDMgroup (P<0.05).

Table 2 also shows that47 (25.5%) students were categorized as prehypertensive;among them 17 (36%) were overweight and obesebased on BMI, 7 (14%) on the basis of WC, 5 (10.6%) on the basis of WHpR, and 9 (19%) on the basis of WHtR. Thus, overweight, and obese categories of BMI were more likely to have PHTN as compared to normal group (P<0.05)

Table 3 showed Spearman's correlation coefficient between different anthropometric indices and systolic and diastolic BP. BMI has significant moderate correlation with WC, WHtR and diastolic BP (r_s=.61, r_s= .62;p<0.001). Whereas WC and WHtR were strongly correlated to systolic BP.

Table 4 showed univariate regression analysis of anthropometric indices with PHTN. Among obesity indices, in PHTN group WC, WHpR and WHtR were not significant predictors; however, BMI in overweight and obese range was found to have significant predictive value as compared to normal and underweight categories. Moreover, BMI >29 was more likely to predict pre-diabetes as well (OR: 2.08, 95% CI: 0.46-9.34). Among preDM group, WC (≥ 88 cm) was 4.11 times more likely to be a strong predictor than WC (< 88 cm). Moreover, model also explained that the WHtR of obese tended to be more significant in pre-diabetes as compared to underweight (OR: 5.33, 95% CI: 1.78, 15.9).

Discussion

The study reported the frequency of PHTN and preDMin young female university students and their correlationwith obesity indices and family history of HTN and diabetes. Identification of high normal BP, impaired glucose level and assessment of comorbidities such as obesity and family history ofHTN and diabetes may improve the accuracy of predicting HTN later in life.[15]

Our data showed that overall, 31.5% participants were overweight and obese based on BMI. This is consistent with a study done previously in the same university in 2010 reporting 47.9% participants to be overweight and obese.[16]Excess weight and obesity, is an established risk factor for HTN as reported by a meta-analysis of 24 case-control studies in China.[17]Other studies have documented that high fructose and sugar consumption along with radical changes in diet with high intake of processed and fast food rich in calories during past two decades, has increased the prevalence of obesity, HTN and metabolic syndrome in developing countries.[18]

A majority of subjects in our study were normotensive, however, 25.1%participants had PHTN and 55% of them have positive family history of HTN. Among normotensive subjects 29 % participants were overweight and obese based on BMI; however, among PHTN group a majority of subjects have normal weight. A study done in Dammam revealed that 13.5% of female university students had PHTN; the most prevalent risk factor was physical inactivity followed by overweight/obesity and family history of HTN.[19] Maintaining a normal BMI has been shown to reduce systolic BP by 20 mmHg for each 10 kg reduction in weight.[20]

While comparing the different indices among PHTN group, it was evident that higher BMI is a significant predictor of PHTN in this age group. Previous studies in adolescents and young adults have consistently demonstrated an association between BMI and HTN.[21]

Although many studies have suggested that WC is easy to perform and more sensitive index than BMI in predicting PHTN in young adults; [22,23]our study did not show significant correlation of PHTN with any other anthropometric indicators in this age group.

Although a majority of participants in this study had normal blood glucose level, however 14.4% were found to have impaired levels; out of them 66% had positive family history of DM Epidemiological studies have clearly shown that offspring of patients with type 2 DM are at increased risk of developing the disease because they share the same genetic predisposition and have similar lifestyle habits as their parents.[24]Among this group, WC and WHtR were more likely indicators to predict association of obesity with prediabetes as compared to BMI and WHpR ($P<0.001$). A study in India documented association of intra-abdominal and truncal subcutaneous adiposity with higher magnitude of insulin resistance and metabolic disorders.[25]Among U.S. adolescents aged 12-19 years, the overall prevalence of PHTN/HTN was 14% and for preDM /DM was 15% as reported by NHANES during survey period from 1999-2008.[26] Also a study in Spain reported that excess of central fat based on WC is associated not only with an increase in BP but also with an unhealthy lipid profile and insulin resistance. [27]

In recent years there has been a greater concern about presence of obesity and metabolic syndrome in this age group. It is emphasized that each component of metabolic syndrome (HTN, diabetes, obesity, and dyslipidemia) must be identified as early as possible to prevent definitive lesions. Further, combined presence of preHTN and preDM have more serious outcomes than expected with either preHTN or preDM alone. Our study showed that 3.2 % participants had both PHTN and preDM as well as they were also overweight or obese. This is in consistence with a study in USA that documented that one in four disease free US adults has preDM, one in three has PHTN and one in ten has coexisting PHTN and preDM.[28]

To lower the risk of progression of PHTN to HTN, and preDM to overt DM, maintaining BMI between 18.5 and 24.9kg/m2 is a necessary modification of lifestyle behaviors. Screening of modifiable risk factors such as elevated fasting blood glucose, BP, BMI and WC and evaluation of eating habits and physical activity has a relatively low cost and could be performed in a health center facility. Regular observation of subjects especially with high-risk family history is needed, emphasizing weight control and physical activity. [29] It has been documented by many studies that consuming a diet rich in fruits and vegetables as well as low-fat dairy products reduce BP by 8-14 mmHg, restricting Na in diet is expected to reduce BP by 2-8 mmHg while walking briskly at least for 30 minutes daily reduces BP by 4-9 mmHg.[30]

Conclusion:

This study presents evidence of an alarming rise in the frequency of obesity, prehypertension, and prediabetes in Saudi females at a young age, and that BMI and WC are strong and potential predictors of risk of developing hypertension and diabetes in this age group. Awareness of these diseases and preventive measures is mandatory through educational campaigns, pamphlets, print and electronic media and other resources to avoid the disease burden on government.

Future healthcare directions and policy:

Clinicians and public health practitioners must address the growing need to emphasize and support lifestyle approaches to the prevention and control of PHTN and preDM including a healthy diet and avoidance of excessive weight gain that remains the cornerstone of prevention in a young adult population. Moreover, this is imperative for health professionals to educate and inform people at high risk of HTN and diabetes about their risk status as recommended by NICE guidelines i.e., identifying people at risk followed by effective intervention if necessary.

Limitations of study:

The study included only female students as it is a woman only university.

It was a cross sectional study; a longitudinal study is required in future to further probe the risk factors and dietary modifications.

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Table 1: Study population characteristic measurements.

Characteristics	**Mean**	**Standard deviation**	**Minimum**	**Maximum**
Weight (kg)	57.8799	13.065	36	135
Height (m)	1.5792	0.061	1.43	1.77
BMI (kg/m²)	23.2394	4.953	15	48.5
Waist Circumference (cm)	75.6122	15.332	30	140
Hip Circumference (cm)	95.5848	13.098	42.5	151
Waist-to-Hip ratio	0.7847	0.121	0.58	1.32
Waist-to- Height ratio	47.8467	9.504	18.29	86.9
Systolic Blood Pressure (mmHg)	113.42	12.927	80	180
Diastolic Blood Pressure (mmHg)	74.71	11.095	40	100
Blood glucose	99.26	29.324	64	447

Table 2: Comparison of proportion of different anthropometric indices among normal, prediabetic and prehypertensive subjects.

Variables	Normal n=157 (%)	Prediabetes n=27 (%)	P value	Normal n=137 (%)	Prehypertension n=47 (%)	P value
BMI (Kg/m²) Normal (18.5-24.9) Underweight (<18.5) Overweight (25-27.9) Obese (>28)	89 (56.7) 22 (14.1) 23 (14.6) 23 (14.6)	13 (48.1) 6 (22.2) 6 (22.2) 6 (22.2)	0.432	82 (59.9) 14 (10.2) 22 (16.1) 19 (13.8)	20 (42.5) 10 (21.2) 7 (14.8) 10 (21.2)	0.043**
Waist-circumference (cm) < 88 >88	140 (89.2) 17 (10.8)	18 (66.6) 9 (33.3)	0.002**	118 (86.1) 19 (13.8)	40 (85.1) 7 (14.8)	0.862
Waist-to-hip ratio < 0.85 >0.85	134 (85.3) 23 (14.6)	21 (77.7) 6 (22.2)	0.319	113 (82.4) 24 (17.5)	42 (89.3) 5 (10.6)	0.264
Waist-to-height ratio Normal (46-52.9) Underweight (<46) Overweight (53-57.9) Obese (>58)	45 (28.1) 87 (55.4) 13 (8.3) 12 (&.6)	3 (11.1) 11 (40.7) 5 (18.5) 8 (29.6)	0.001**	36 (26.3) 72 (52.6) 15 (10.9) 14 (10.2)	12 (25.5) 26 (55.3) 3 (6.2) 6 (12.8)	0.789

Systolic BP (mmHg)	110(106-120)	115 (100-120	0.968	110(100-118	125 (121-130)	<0.001**
Diastolic BP (mmHg)	79 (70-80)	80 (60-81)	0.498	70 (66-80)	90 (81-90)	<0.001**
Blood glucose level¥	96 (89-104)	99 (91-105)	0.525	94 (88-103)	98 (93-107)	0.028

**Significant p-value.

*P-value is calculated by chi-square test. Categorical variables are expressed as Frequencies and Percentages.

¥P-value is calculated by Mann Whitney U-test. Continuous variables are expressed as Median (Inter-quartile

Table 3. Spearman's rank correlation (r2) among all the variables in prediabetic & prehypertension group

	BMI	WC	WHpR	WHtR	SBP	DBP	FBG
BMI	1.000	.611**	.143	.617**	.068	.141**	-.007
WC	.611**	1.000	.574**	.944**	.128**	.009	-.084
WHpR	.143	.574**	1.000	.596**	.016	-.049**	-.081
WHtR	.617**	.944**	.596**	1.000	.077**	-.020**	-.066
SBP	.068	.128	.016	.077	1.000	.467	.108
DBP	.141	.009	-.049	-.020	.467	1.000	.106
FBG	-.007	-.084	-.081	-.066	.108	.106	1.000

Table 4: Univariate regression analysis of anthropometric indices with prediabetes and prehypertension

Variables	**Prediabetes**			**Prehypertension**		
	Odds ratio	**95% CI**	**p-value**	**Odds ratio**	**95% CI**	**p-value**
BMI: Normal (18.5 - 24.9)	1*	-	-	1*	-	-
BMI: Underweight (< 18.5)	0.62	0.13 – 2.96	0.55	1.89	0.51 – 7.14	0.34
BMI: Overweight (25 - 27.9)	1.78	0.61 – 5.21	0.28	5.76	1.22 – 27.42	0.02**
BMI: Obesity (≥ 28)	1.78	0.61 – 5.22	0.29	10.1	2.29 – 43.57	0.03**
WC: (< 88 cm)	1*	-	-	1*	-	-
WC: (≥ 88 cm)	4.11	1.60 – 10.5	0.003**	1.08	0.42 - 2.78	0.86
WHR: (< 0.85)	1*	-	-	1	-	-
WHR: (≥ 0.85)	1.66	0.61 – 4.56	0.32	0.61	0.21 – 1.56	0.26
WHtR: Normal (46 – 52.9)	1*	-	-	1*	-	-
WHtR: Underweight (< 46)	2.92	1.13 - 7.55	0.02**	1.01	0.49 – 2.39	0.84
WHtR: Overweight (53 – 57.9)	1.31	0.48 – 3.79	0.59	0.61	0.14 – 2.43	0.47
WHtR: Obese (≥ 58)	2.15	0.87 – 5.35	0.09	1.21	0.41 – 4.09	0.67

*1: Reference category. **Significant p-value.

BMI: body mass index, WC: waist circumference, WHR: waist-to-hips ratio, WHtR: waist-to-height ratio