

## Screening of cardiometabolic risks clustering in young Pakistani adults classified by anthropometric traits

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### Abstract

**Objective:** To estimate frequencies of metabolic risk phenotypes and their associations in body mass index and waist circumference-based obesity categories.

**Methods:** The cross-sectional study was conducted at Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan, from August 2014 to March 2016. Anthropometric and clinical data of young adults was collected. All subjects were categorised into body mass index, waist circumference-based obesity categories and common metabolic risk phenotypes (hypertension, hyperglycaemia, dyslipidaemia) frequencies and their associations were estimated in age and gender adjusted models. Data was analysed using SPSS 21.

**Results:** Of the 2,000 participants, 800(40%) were females and 1,200(60%) were males. There were 500(25%) participants in each group, i.e. underweight, normal weight, overweight and obese. The overall mean age was 23.68±4.33 years (range: 16-30 years). All clinical parameters were significantly raised in general and abdominally obese class ( $p < 0.05$ ). Based on body mass index and waist circumference, the frequency of general obesity was 324(16.2%) and abdominal obesity was 994(49.7%). Co-morbid metabolic risk phenotypes were as follows: hypertension 1,098(54.9%) and 924(46.2%); hyperglycaemia 1,116(55.8%) and 550(27.5%); dyslipidaemia 300(15%) and 194(9.7%), respectively. The strongest associations of body mass index and waist circumference alone categorised obesity were found with hyperglycaemia, (Odds ratio: 7.23, 6.49) followed by dyslipidemia (Odds ratio: 5.60, 5.67) and hypertension (Odds ratio: 3.28, 3.02).

**Conclusion:** Body mass index and waist circumference were found to be powerful, discriminating predictors of co-morbidities linked with general and abdominal obesity.

**Keywords:** T2D, Obesity, Diabetes, Waist circumference. (JPMA 67: 1825; 2017)

### Introduction

Cardiometabolic risks, especially hyperglycaemia, hypertension and dyslipidaemia, are on the rise globally<sup>1</sup> in parallel with type 2 diabetes (T2D), cardiovascular diseases (CVDs) and non-alcoholic fatty liver disease (NAFLD), with high disability and mortality rates.<sup>2</sup> At the same time, overweight and obesity have also become serious issues across all developing and developed world nations.<sup>3</sup> According to World Health Organisation's (WHO) reports, more than 1.9 billion adults were overweight and over 600 million obese while 41 million children under the age of 5 were either overweight or obese.<sup>4</sup> As for gender trends, over-weight/obesity seems to be gradually increasing in women compared to men. However, the alarming situation yet to be realized in various parts of the world is clustering of cardiometabolic risks within an individual regardless of ethnicity, gender and age.<sup>5</sup>

Therefore, continuous efforts are being made globally to identify the risk factors that might be increasing the susceptibility of world populations towards excess weight gain and associated metabolic health disturbances.<sup>5</sup> The common quantifiable risk markers of human obesity and health complications are body mass index (BMI) and waist circumference (WC).<sup>6</sup> BMI takes into account the weight to height ratios with international and Asia-specific age based cut-off values while WC mainly focuses on gender-specific central/abdominal region measurements.<sup>7</sup> The role of BMI has long been studied as an informative disease risk marker of obesity, associated health complications and mortality.<sup>8</sup> However, raised waist sizes have been shown to increase the risk of cardiometabolic risks despite normal ranges of BMI.<sup>9</sup> Keeping with the importance of BMI and WC as obesity risk markers, studies have used both weight to height ratios and waist circumference measurements to identify their ill effects.<sup>10</sup> However, roles of BMI and WC as risk markers of metabolic dysregulations and mortality are contrasting and debatable in different world populations.<sup>9</sup> Due to strong correlations of central obesity with cardiometabolic risks, WC is given priority as critical marker of abdominal

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adiposity over BMI.<sup>9</sup> Based on these reservations many researchers recommend combinations of BMI and WC to access commonly prevailing metabolic risks.<sup>11</sup> Pakistan is considered to be the 9th most obese country in the world.<sup>12</sup> According to 2014 WHO estimates, 5.4% people in Pakistan are obese, of which 3.7% are male and 7.3% females,<sup>13</sup> whereas almost 23% (18.6-27.2) population >18 years of age was found overweight.<sup>12</sup> Despite introduction of new adiposity indices and their role as strong markers of disease risk, simple yet affordable measurements of BMI and WC still have high risk predictive scores. Due to their simplicity and affordability, measurements of height, weight and WC are quite common when collecting population data on a large scale, both in hospital-based settings or when performing an epidemiological study. In addition, numerous past and present studies have reported reliable and accurate associations of raised BMI, WC and health complications. In Pakistan, several studies have conducted health surveys while taking into account obesity parameters and their ill health effects on age- and gender-stratified population groups. But complete information regarding obesity-associated metabolic dysregulations in rather healthy young individuals is scarce.<sup>14</sup>

The present study was planned to assess the cardiometabolic risks in BMI- and WC-categorised individual groups as well as in combined groups. Due to their ease of measurement and affordability, we expect that the combination of BMI and WC will prove to be a reliable and accurate marker of identifying those at higher risk of cardiometabolic health complications.

## Subjects and Methods

The cross-sectional study was conducted at Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan, from August 2014 to March 2016 after approval was obtained from the institutional ethics committee. All participants were informed of the study objectives and signed a written informed consent before questionnaire-based interview and blood sampling. Subjects diagnosed with advanced stage health complications and on specific medications were excluded from the study. The sample size was calculated using the following formula:

$$n = 2(Z_{\alpha} + Z_{1-\beta})^2 \sigma^2 / \Delta^2$$

- ◆ where n= required sample size.
- ◆  $Z_{\alpha}$ ,  $Z$  = constant (set by convention according to the accepted  $\alpha$  error and whether it is a one-sided or two-sided effect) value of  $\alpha$ - error was considered 1.96 at 5%
- ◆ For  $Z_{1-\beta}$ ,  $Z$  = constant set by convention according to

power of the study that was calculated at 80% and 0.84 value was used.

- ◆ In the above-mentioned formula,  $\sigma$  is the standard deviation (estimated) and  $\Delta$  is the difference in estimated effect size from previous data. This gives the number of sample per group and was calculated as follows

$$n = 2(1.96 + 0.84)^2 (0.9)^2 / (0.3)^2 = 423$$

*round off 500 in each group*

The subjects were selected randomly from different schools, colleges and universities of Pakistan

The anthropometric data including height, body weight, WC, and blood pressure of the subjects were recorded. The weight of study subjects was recorded while standing on an electronic balance without heavy clothing and shoes. For accurate height records, a wall-mounted measuring tape was used to measure length in standing position and feet together. A non-stretchable measuring tape was used to record WC from the narrowest part of torso (the region between the lowest rib and level of iliac crests at end expiration) in standing position.<sup>15</sup> The mercury sphygmomanometer was employed for systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings while subjects were in a sitting position. For frequency estimation of general and abdominal obesity, study subjects were grouped on the basis of BMI and WC using international criterion.<sup>16</sup> The BMI ( $\text{kg}/\text{m}^2$ ) was calculated by dividing body weight (kg) by meter square of height and categorised into four groups: lean (BMI <18.5  $\text{kg}/\text{m}^2$ ), normal weight (BMI = 18.5-22.9  $\text{kg}/\text{m}^2$ ), overweight (BMI = 23-27.4  $\text{kg}/\text{m}^2$ ), and obese (BMI >27.5  $\text{kg}/\text{m}^2$ ). Likewise, international gender-based cut-off values of WC (i.e.  $\geq 80$  cm in women and  $\geq 94$  cm in men) were used to quantify abdominal obesity among study population.<sup>17</sup>

For biochemical assays, venous blood samples (4.0mL) were withdrawn from cubital vein using sterile syringes and collected in evacuated gel tubes and transferred to the institution's biochemistry laboratory. Samples were centrifuged at 3,500 revolutions per minute (rpm) for 30 minutes within 2 hours of sampling and serum aliquots stored at  $-20^{\circ}\text{C}$  until analysis. The anthropometric readings and blood samples were withdrawn by an experienced medical staff. Biochemical analysis including total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, very low-density lipoprotein (vLDL) cholesterol and fasting blood sugar (FBS) was performed using commercially available kits (Roche Diagnostics, United States) on the spectrophotometer (Roche Hitachi

912 Chemistry Analyser, Roche Diagnostics, United States). The metabolic risk phenotypes cutoff values were set for hyperglycaemia (fasting blood glucose [FBG]  $\geq 100$ mg/dL, or  $\geq 6$ mmol/L), dyslipidaemia (TC  $> 200$ mg/dl or  $> 5.18$ mmol/L, TG  $\geq 150$ mg/dL or  $\geq 1.7$ mmol/L, HDL  $< 40$ mg/dL or  $1.0-1.3$ mmol/L, LDL  $> 100$ mg/dL or  $> 2.59$ mmol/L, vLDL  $> 32$ mg/dL or  $> 0.77$  mmol/L), hypertension (SBP  $\geq 130$  mmHg or DBP  $\geq 85$  mmHg), and abdominal obesity (WC  $> 94$ cm in men and  $> 80$ cm in women).

Collected samples were categorised on the basis of BMI classes following South Asian criteria.<sup>16</sup> Within the BMI classes we also categorised the data into subgroups on the basis of sex. The data was analysed using SPSS 21. Descriptive statistics were used to compute means and standard deviations (SD) of all the study parameters. Frequency estimation for prevalence of subjects in four BMI categories and metabolic risk phenotypes were estimated. Data was also compared on the basis of gender and BMI categories. The means and SD among male and female and BMI groups were compared using analysis of variance (ANOVA) followed by least significant difference (LSD) to find out the differences among groups. The association analysis of metabolic risk phenotypes with BMI and WC was also computed by applying multinomial logistic regression.

For risk score calculation, lean, normal, overweight and obese BMI categories was given values 1,2,3 and 4, respectively, and normal and increased WC was given values 0 and 1. For combined risk score these values were summed up and regression analysis was done for association analysis with risk phenotypes. The significance of all statistical analysis was set at  $p \leq 0.05$ .

## Results

Of the 2,000 participants, 800(40%) were females and 1,200(60%) were males. There were 500(25%) subjects in each group, i.e. underweight, normal weight, overweight and obese. The overall mean age was  $23.68 \pm 4.33$  years (range: 16-30 years), body weight  $64.0 \pm 17.2$ , BMI  $23.77 \pm 6.88$  kg/m<sup>2</sup>, and WC value  $86.09 \pm 16.88$  cm. The mean values for SBP and DBP were  $128.80 \pm 18.29$  and  $80.92 \pm 10.55$  mmHg, respectively. The overall mean TC was  $163.95 \pm 1.20$  mg/dl, HDL was  $52.6 \pm 0.47$  mg/dl, LDL was  $101.31 \pm 1.29$  mg/dl, vLDL was  $26.75 \pm 0.40$  mg/dl, TG was  $133.74 \pm 0.88$  mg/dl and FBG was  $98.5 \pm 1.72$  mg/dl.

The age of male and female subjects was  $23.68 \pm 4.29$  and  $23.62 \pm 4.39$  years, respectively, with no statistical difference ( $p=0.789$ ). The mean body weights ( $66.50 \pm 16.72$  kg) and WC ( $87.62 \pm 17.19$  cm) of male subjects were significantly higher ( $p=0.0001$ ) compared to female counterparts whose mean body weight was  $57.43 \pm 18.06$  kg and WC was  $82.73 \pm 17.18$  cm. No

**Table-1:** Baseline characteristics of total study population with gender based comparison.

Study Parameters	(Mean $\pm$ SD)			P-value*
	Total	Male (n=1200)	Female (n=800)	
Age (Years)	23.68 $\pm$ 4.33	23.68 $\pm$ 4.29	23.62 $\pm$ 4.39	0.789
Weight (Kg)	64.0 $\pm$ 17.2	66.50 $\pm$ 16.72	57.43 $\pm$ 18.06	0.0001
BMI (Kg/m <sup>2</sup> )	23.77 $\pm$ 6.88	23.93 $\pm$ 6.74	23.41 $\pm$ 7.77	0.187
WC (cm)	86.09 $\pm$ 16.88	87.62 $\pm$ 17.19	82.73 $\pm$ 17.18	0.001
SBP (mmHg)	128.80 $\pm$ 18.29	129.36 $\pm$ 18.56	129.01 $\pm$ 18.52	0.73
DBP (mmHg)	80.92 $\pm$ 10.55	81.49 $\pm$ 11.16	80.26 $\pm$ 9.60	0.041
TC (mg/dl)	163.95 $\pm$ 1.20	163.18 $\pm$ 1.22	167.05 $\pm$ 1.25	0.163
HDL (mg/dl)	52.6 $\pm$ 0.47	54.52 $\pm$ 0.49	47.95 $\pm$ 0.45	0.001
LDL (mg/dl)	101.31 $\pm$ 1.29	97.06 $\pm$ 1.3	110.20 $\pm$ 1.3	0.0001
vLDL (mg/dl)	26.75 $\pm$ 0.40	28.17 $\pm$ 0.4	25.15 $\pm$ 0.43	0.001
TG (mg/dl)	133.74 $\pm$ 0.88	140.83 $\pm$ 0.87	125.77 $\pm$ 0.95	0.001
FBG (mg/dl)	98.5 $\pm$ 1.72	101.2 $\pm$ 1.87	94.5 $\pm$ 1.46	0.001

P values were calculated using t test

BMI: Body mass index

WC: Waist circumference

SBP: Systolic blood pressure

DBP: Diastolic blood pressure

TC: Total cholesterol

HDL: High-density lipoprotein

LDL: Low-density lipoprotein

vLDL: Very low-density lipoprotein

TG: Triglycerides

FBG: Fasting blood glucose.

**Table-2:** Comparison of study parameters based on BMI and WC.

Study Parameters	BMI Classes (Kg/m <sup>2</sup> )				WC Categories (cm)		p-value
	Underweight N=500 <18.5 Kg/m <sup>2</sup> (Mean± SD)	Normal weight N=500 18.5-22.9 Kg/m <sup>2</sup> (Mean± SD)	Overweight N=500 23-27.4 Kg/m <sup>2</sup> (Mean± SD)	Obese N=500 >27.5 Kg/m <sup>2</sup> (Mean± SD)	Normal N=900 (Mean± SD)	Abdominal Obesity N=1100 (Mean± SD)	
Age(Years)	22.88±11.13a	23.29±13.05a	22.43±12.19a	22.89±12.05a	23.29 ±13.05	22.43±12.19	0.06
Weight(Kg)	45.97±8.71 a	61.01±9.10 b	67.57±8.53 c	82.03±15.32 d	54.35±11.28	74.69±14.56	0.0001
BMI(Kg/m <sup>2</sup> )	-	-	-	-	19.38±4.03	28.611±5.95	0.001
WC (cm)	69.65±11.01 a	83.96±12.54b	95.58±3.9 c	108.09±16.88d	-	-	-
SBP(mmHg)	121.0±12.27 a	120.2±14.12a	136.4±17.07b	147.3±19.28 c	121.06±12.56	137.62±20.18	0.001
DBP(mmHg)	75.26±11.12 a	81.31±7.84 b	81.00±9.83 b	87.07±10.39 c	79.14±10.06	83.55±11.23	0.003
TC(mg/dl)	139.2 ±0.65 a	158.5±0.88 b	166.3±3.69 b	193.3±1.52 c	151.2±0.82	179.81±1.46	0.001
HDL(mg/dl)	61.87±0.46 c	61.87±0.40 c	52.97±0.39 b	37.9±0.31 a	60.71±0.43	44.86±0.43	0.002
LDL(mg/dl)	69.6±0.86 a	88.9±0.97 b	104.4±3.66 c	135.34±1.41 c	82.36±0.96	122.58±1.40	0.0001
vLDL(mg/dl)	20.19±0.09 a	23.03±0.14 b	24.8±0.21 c	37.20±0.26 d	22.14±0.26	32.4±0.48	0.0004
TG (mg/dl)	100.97±0.41 a	115.2±0.67 b	124.±1.05 c	186.0±1.32 d	110.7±0.57	162.09±1.06	0.0001
FBG (mg/dl)	86.4±0.71 a	99.0±1.65b	100.8±3.41 b	126.2±2.31 c	92.5±1.27	108.9±2.206	0.0001

LSD indicated by a, b, c, d superscripts at p<0.05 For abdominal Obesity: WC male >90cm, WC female >80cm

BMI: Body mass index

WC: Waist circumference

SBP: Systolic blood pressure

DBP: Diastolic blood pressure

TC: Total cholesterol

HDL: High-density lipoprotein

LDL: Low-density lipoprotein

vLDL: Very low-density lipoprotein

TG: Triglycerides

FBG: Fasting blood glucose.

**Table-3:** Association of metabolic risk phenotypes with anthropometric indices.

Cardiometabolic Risk Phenotypes	Odds Ratios (95% Confidence Intervals)		
	BMI	WC	BMI WC Combined Risk Score
Hypertension	3.28 (2.02-5.33)	3.02 (2.3-3.98)	1.56 (1.44-1.69)
Hyperglycaemia	7.23 (4.41-12.03)	6.49 (4.38-9.64)	1.79 (1.59-2.04)
Dyslipidaemia	5.60 (2.61-12.08)	5.67 (2.54-12.66)	1.88 (1.57- 2.24)

BMI: Body mass index

WC: Waist circumference.

significant difference ( $p=0.187$ ) was found in the BMI of males ( $23.93\pm 6.74$  kg/m<sup>2</sup>) and females ( $23.41\pm 7.77$  kg/m<sup>2</sup>). Moreover, the mean SBP of males was  $129.36\pm 18.56$  mmHg and DBP  $81.49\pm 11.16$  mmHg, compared to  $129.01\pm 18.52$  mmHg and  $80.26\pm 9.60$  mmHg, respectively, in females, with no statistical difference in SBP ( $p=0.73$ ) but with slight yet significantly raised DBP in males ( $p=0.041$ ). With regards to the biochemical assay profiles, vLDL, TG and FBS were all significantly raised in male subjects compared to females ( $p=0.001$ ), except for TC. HDL was significantly lowered ( $p=0.001$ ) and LDL raised ( $p=0.0001$ ) in females. All anthropometric and biochemical parameters were within normal ranges except LDL that was slightly raised

( $>100.15$  mg/dl) in the studied population and more so in female subjects ( $110.20\pm 1.3$  mg/dl) (Table-1). The body weight significantly increased ( $p\leq 0.05$ ) from underweight ( $45.97\pm 8.71$  Kg) to obese BMI ( $82.03\pm 15.32$  kg/m<sup>2</sup>) class. The WC also increased significantly ( $p\leq 0.05$ ) and linearly from underweight ( $69.65\pm 11.01$ cm) to obese ( $108.09\pm 16.88$  cm) BMI class. No significant difference was observed in SBP of underweight and normal weight subjects ( $p>0.05$ ). But in comparison, overweight and obese subjects had significantly ( $p\leq 0.05$ ) raised SBP ( $136.4\pm 17.07$  mmHg,  $147.3\pm 19.28$  mmHg). The DBP of obese subjects ( $87.07\pm 10.39$  mmHg) was significantly ( $p\leq 0.05$ ) raised as compared to underweight subjects ( $75.26\pm 11.12$  mmHg), normal weight subjects ( $82.31\pm 7.84$

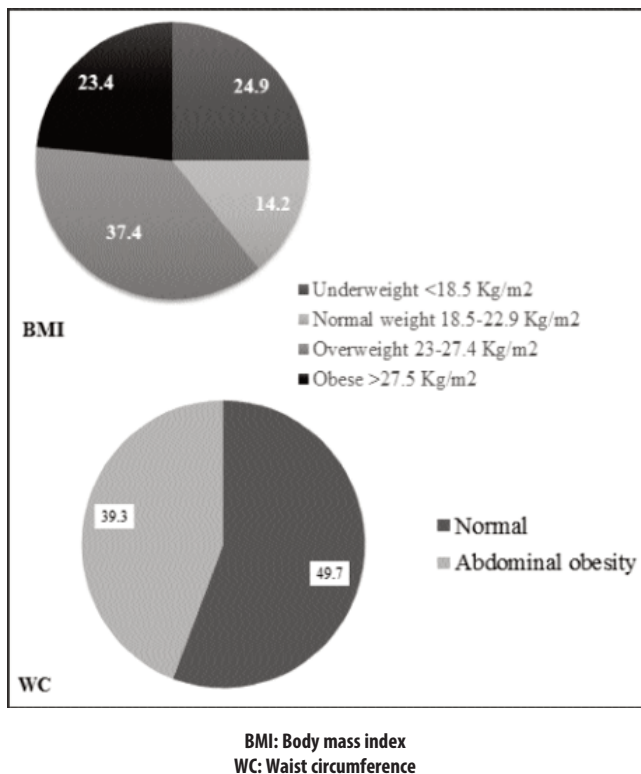


Figure-1: Frequency estimation of subjects in BMI and WC categories.

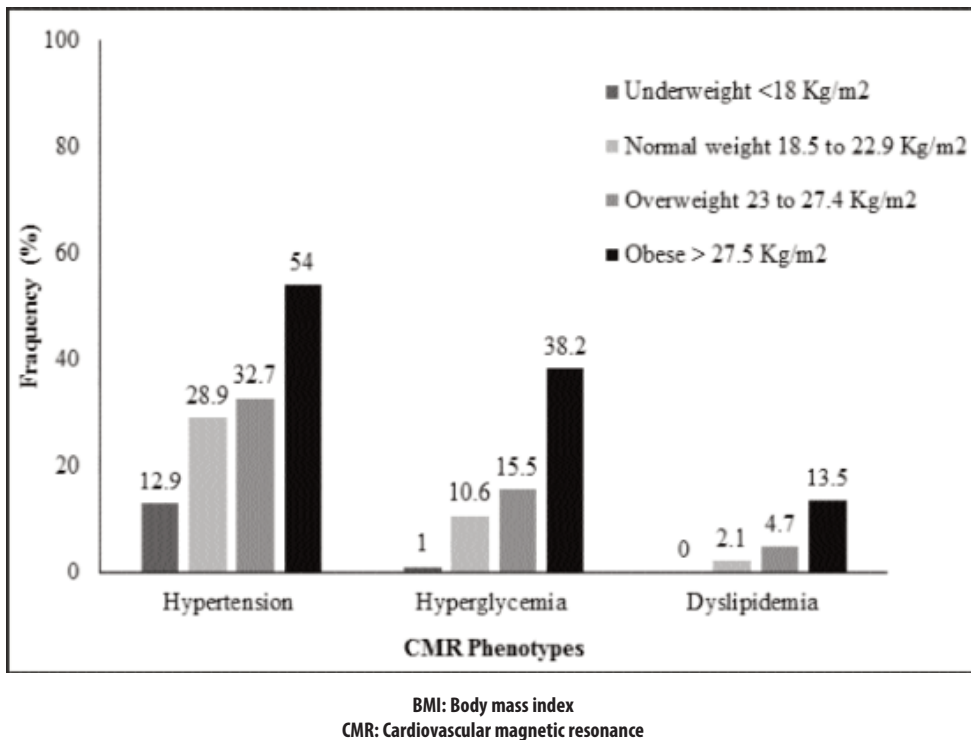
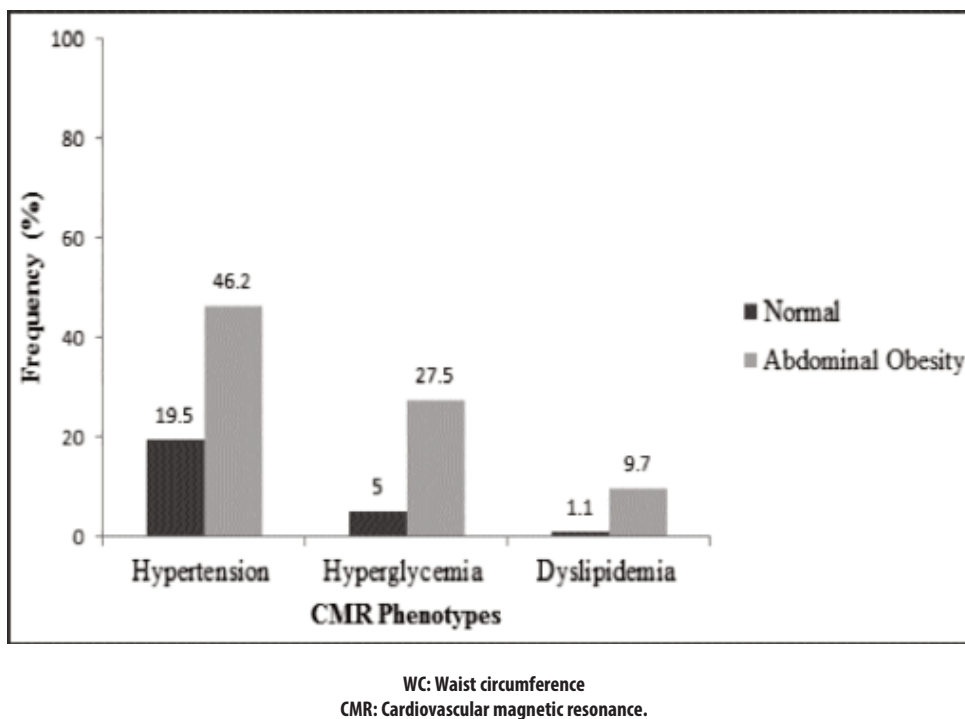


Figure-2: Frequencies of Cardiometabolic Metabolic Risk Phenotypes among BMI Categories.

mmHg) and overweight subjects (85.00±9.83 mmHg). With regards to biochemical assays profiles, TC, LDL, vLDL, TG and FBG were all significantly ( $p \leq 0.05$ ) raised in obese BMI class while HDL was significantly ( $p \leq 0.05$ ) lowered as compared to the underweight and normal weight subjects. The WC categories (normal vs abdominal obesity) based comparison of studied parameters were arranged using international cut-off ranges for males (>90cm) and females (>80cm). All studied parameters, including anthropometric and biochemical assays profiles, were significantly raised ( $p \leq 0.05$ ) in abdominally obese category as compared to the normal ones except HDL that was significantly lowered in raised WC group (Table-2).

Based on BMI categories, 71(14.2%) participants were in normal weight range, 125(24.9%) underweight, 187(37.4%) overweight and 117(23.4%) were obese. In WC categories, 249(49.7%) participants were obese and 197(39.3%) were in normal weight category (Figure-1). Moreover, the frequency of hypertension among four BMI categories were as follows: underweight 65(12.9%), normal weight 145(28.9%), overweight 164(32.7%), and obese 270(54%). In case of hyperglycaemia, the frequencies were: underweight 5(1%), normal weight 53(10.6%), overweight 78(15.5%), obese 191(38.2%), and dyslipidemia rates were: underweight 0(0%), normal weight 10.5(2.1%), overweight 23.5(4.7%), and obese 68(13.5%) (Figure-2). The metabolic risk phenotypes frequencies verses WC-based abdominal obesity categories were as follows: for hypertension, normal weight 98(19.5%), and obese 231(46.2%); for hyperglycaemia, normal weight 25(5%), and obese 138(27.5%), or dyslipidaemia, normal weight 6(1.1%) and obese 49(9.7%) (Figure-3).

In case of BMI alone, the strongest association of raised BMI/general obesity was found with hyperglycaemia (Odds ratio [OR] 7.23, confidence interval (CI): 4.41-12.03), followed by dyslipidaemia (OR 5.60, CI 2.61-12.08) and hypertension (OR 3.28, CI 2.02-5.33). In case



**Figure-3:** Frequencies of Cardiometabolic Metabolic Risk Phenotypes among WC Categories.

of WC alone, statistically strong association of raised WC/abdominal obesity was also found with hyperglycaemia (OR 6.49, CI 4.38-9.64) followed by dyslipidaemia (OR 5.67, CI 2.54-12.66) and hypertension (OR 3.02, CI 2.3-3.98). The significant associations with metabolic risk phenotypes were maintained when BMI and WC were combined. However, the highest association was with dyslipidaemia (OR 1.88, CI 1.57-2.24), followed by hyperglycaemia (OR 1.79, CI 1.59-2.04) and hypertension (OR 1.56, CI 1.44-1.69) (Table-3).

## Discussion

In the present study, we reported significant discriminating roles of BMI and WC as strong markers of co-morbid health complications under obese status. Generalised and abdominal obesity were both highly prevalent in young Pakistani adults with raised levels of blood pressure, lipid profile and fasting blood sugar. All three common metabolic risk phenotypes, i.e. hyperglycaemia, hypertension, and dyslipidaemia, were not only prevalent in young obese adults but also showed strong associations with upper obese ranges of either BMI or WC alone or BMI and WC combined but with varying trends. The BMI and WC alone categories had higher risk of hyperglycaemia followed by dyslipidaemia and hypertension, whereas for BMI and

WC combination trends were as follows: dyslipidaemia (OR=1.88) > hyperglycaemia (OR=1.79) > hypertension (OR=1.56). Thus, simple yet affordable anthropometric indices, BMI and WC offer high predictive value markers of obesity and its associated cardiometabolic dysregulations.

Human obesity and co-morbid metabolic health dysregulations are on the rise worldwide regardless of ethnicity, gender and age. Though once thought of as the health issues of older age, younger adults are equally at a higher risk of excess weight gain and related health complications. Due to burgeoning worldwide health issues of obesity, populations are at an

increasing risk of developing metabolic complications and thus need for regular health monitoring and control becomes a necessity. Though excess body weight and related health issues need to be monitored under the supervision of trained medical staff, there is a need for easy to measure yet affordable methods to be used personally on a regular basis. The simplest and most commonly used scales of human obesity are BMI and WC with set international criterion.<sup>18</sup> Both obesity scales are easily measurable without the need of sophisticated, expensive machines or trained medical staff.<sup>19</sup> Moreover, different international health organisations also offer free online calculators for obesity indices and expected health outcomes.<sup>20</sup> This clearly highlights the necessity for easily accessible health monitoring of large populations at individual levels regardless of the geographical location and financial status of a person. Although large variations exist, some of the obvious risk factors of rise in obesity are sedentary lifestyle and over-consumption of high energy dense foods under genetic influences.<sup>21</sup> Among total obese subjects, >50% belong to ten countries including the United States, China, India, Russia, Brazil, Mexico, Egypt, Germany, Pakistan and Indonesia, with increased female sex-specific trends.<sup>12,22</sup> The alarming facts highlighted by our study are rapid rise on overweight and obesity among young adults. Based on BMI and WC

obesity categories, we report 16.2% general obesity and 49.7% abdominal obesity in young Pakistani adults. Some of the significant contributing co-factors of obesity are ethnicity, age and gender. According to world obesity facts, females are at an increased risk of excess weight gain as compared to males.<sup>12,22,23</sup> In contrast, the young rather healthy study cohort of our study categorised BMI obese lacked any gender difference ( $p=0.187$ ) which was significantly highlighted in WC obese category ( $p=0.001$ ). However, failure to accurately measure weight-to-height ratios and waist circumference could mislead their ill effects on human health.<sup>18</sup>

Some of the obvious global serious health consequences of overweight and obesity are T2D, hypertension and CVDs.<sup>24</sup> The significantly ( $p<0.05$ ) elevated levels of SBP, DBP TC, LDL, vLDL, TG, FBG and lowered HDL in general and abdominally obesity groups of our study clearly indicate our young adult population being at an early risk of the development of advanced diseases. The frequencies of cardiometabolic risk phenotypes including hyperglycaemia, dyslipidaemia and hypertension were also computed among BMI and WC alone and combined obesity categories. Though frequencies of all three common metabolic risk phenotypes were significantly raised in BMI and WC classified obese classes results were contrasting. In BMI-based obesity category, the highest frequencies were found for hyperglycaemia (55.8%) and hypertension (54.9%) as compared to dyslipidaemia (15%). In contrast, hypertension seemed highly frequent metabolic risk (46.2%) in WC-based obesity category followed by hyperglycaemia (27.5%) and dyslipidaemia (9.7%). We have previously reported significantly high frequencies and associations of cardiometabolic risk phenotypes with metabolic syndrome (MetS) and non-alcoholic fatty liver disease (NAFLD) in Pakistani populations characterised on the basis of International Diabetes Federation (IDF) criterion.<sup>25,26</sup> Thus, general Pakistani populations seem to be at an increasing risk of co-morbid metabolic risks that raises the need of screening those at an early risk of advanced health complications. In addition to their elevated frequencies, cardiometabolic risk phenotypes also showed statistically significant associations with BMI and WC-based obesity categories in young adult Pakistani population cohort. In case of BMI and WC alone categories, the strongest associations were in the order hyperglycaemia > hypertension > dyslipidaemia. In BMI and WC combined category of general and abdominal obesity, the cardiometabolic risk phenotypes associations trend changed to dyslipidaemia > hyperglycaemia > hypertension irrespective of age and gender.

Our study results emphasise the combined use of BMI and WC as adiposity indices in order to predict those at high risk of obesity-related health complications. Since both markers are easy to measure using in-expensive simple devices, it is convenient to screen large population cohorts, especially young adults in their personal settings for regular health monitoring. Though imaging techniques especially MRI and DEXA as well as skin folds are considered best for accurate quantification of fat mass, their unavailability for a large scale population cohort was the biggest limitation of our study. In addition, HOMA-IR test records, if available, could have provided the accurate status of insulin resistance among obese subjects.

## Conclusion

BMI and WC were important markers of obesity-associated cardiometabolic risks development in young adults. The rise in general and abdominal obesity also led to an elevation in levels of blood pressure, fasting glucose and lipid profiles along with significantly high rates of hyperglycaemia, hypertension and dyslipidaemia. However, the use of combined risk scores of BMI and WC verses BMI or WC alone led to contrasting associations with common metabolic risk phenotypes. The study signifies discriminating powers of both adiposity indices when identifying large population cohorts at risk of developing specific obesity-associated health complications on a regular basis.

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