**Biosight 2024; 05(2,3,4): 17-25**

# Correlation of Anthropometric Indices with Metabolic Syndrome and Its Components in Young Adults.

Bhanwrio Menghwar[1*], Zulfiqar Ali Laghari[2], Jamshed Warsi[3], Ayaz Ali Samo[4]

*Department of Physiology, Faculty of Natural Sciences, University of Sindh, Jamshoro.*

**Abstract: Introduction:** Syndrome X is also called insulin resistance, now a days it is termed as metabolic syndrome (MetS), metabolic syndrome (MetS) is a group of different components and these components are categorized as raised blood pressure, increased waist circumference, insulin resistance or raised fasting blood sugar and lipid dysregulation. Metabolic syndrome is the leading cause of type II diabetes and cardiovascular diseases (CVDs) and in young adults it is increasing with rapidity. **Methodology:** This cross-sectional study was conducted in the healthy young adults at the community level, age of the participants was 18-25 years, living in Qasimabad. Data was collected through self-designed questionnaire. T-test, chi square and bivariate tests were used to analyze the data for MetS. **Results:** The overall number of subjects were 336 out of these 202(60.1) were females and 134(39.9) were males. In this study the overall prevalence of MetS among healthy young adults was 7.4%, prevalence of MetS in males 15(11.2%) that was higher than females 10(5%) according to the NECP ATP-III diagnostic criteria for MetS, statistically significant Chi square= 4.56, p=value 0.033. BMI showed slightly higher correlation with SBP (r=0.601, p<0.01), FBS (r=0.481, p<0.01, TG (r=0.506, p<0.01) and HDL (r= -0.359, p<0.01). Whereas WC showed higher correlation with SBP (r=0.578 p<0.01). **Conclusion:** The prevalence of MetS components were higher in males than females. The correlation of BMI with the individual components of MetS was found better than other anthropometric indices.

**Keywords:** Syndrome X, Metabolic syndrome, Waist Circumference, Young Adults.

Received: March 07, 2024
Accepted: September 30, 2024
DOI: 10.46568/bios.v5i2-3-4.194

**Correspondence**: Name Bhanwrio Menghwar, Ph.D Student, Department of Physiology, Faculty of Natural Sciences, University of Sindh, Jamshoro, Pakistan. Tel: +92 3463607350. Email: bhanwarlal.849@gmail.com

## Introduction

Syndrome X is also called insulin resistance, now a days it is termed as metabolic syndrome (MetS), metabolic syndrome (MetS) is a group of different components and these components are categorized as raised blood pressure, increased waist circumference, insulin resistance or raised fasting blood sugar and lipid dysregulation[1, 2]. The term of metabolic syndrome (MetS) was first coined by Kylin in 1920, according to Kylin MetS is the collection of disturbances in metabolism [3]. Metabolic syndrome is the leading cause of type II diabetes and cardiovascular diseases (CVDs) and in young adults it is increasing with rapidity [4]. In the 21st century MetS is considered as the main health problem [5]. Metabolic syndrome (MetS) is also considered as a worldwide public health problem in all age groups including adults, teenagers and in children, in these age groups diabetes and CVDs develops [6]. Those individuals suffering with MetS develops two folds risk of CVD within a duration of 5 to 10 years and five folds are at a risk to develop diabetes in comparison to MetS absent individuals [7]. Recently various organizations have identified MetS by the presence of any three or more components including hyperglycemia,

low plasma level of HDL, increased triglycerides, raised blood pressure and increased waist circumference [7].

The prevalence of type II diabetes, hypertension and dyslipidemia is elevated in Asians population than the non-Asians [8]. Metabolic syndrome is foremost public health issue around the globe including Pakistan. According to the Adult Treatment Panel (ATP III) criteria one fourth of the South Asians has highest burden of cardiovascular diseases in comparison with other population around the globe [9]. In South Asians the mortality rates due to CVD are greater than Eastern and Western countries of Asia [10]. Worldwide one fourth population is suffering from metabolic syndrome [11] . According to a systematic review the pooled prevalence of MetS in Pakistan was 28.8% among 16-75 years [12].

These studies suggest MetS prevalence is higher, which could mainly be attribute to increase in urbanization, eating junk food and having no or less physical activity, all of these are causing the increase in obesity, which is major factor of MetS. The data on association of MetS with anthropometric indices is scanty and least studied in Pakistan. We have therefore setup this study to explore the evaluation of MetS using different anthropometric indicators.

In developing countries such as in Asia-Pacific regions, the prevalence of obesity increases by 2% per year [13, 14]. As a consequence of rising in obesity, several cardiovascular risk factors are also increasing, followed by increasing the metabolic syndrome [15, 16]. Abdominal obesity is one of the prime independent predictor among others risk factors of MetS [17]. To prevent the individuals from occurrence of MetS it is essential to identify its risk factors as early as possible [18, 19].

Anthropometric indices are the measurement of different areas of the body and used as a proxy indicators for whole body or central obesity. For the measurement of general obesity body mass index (BMI) is used [20]. For the assessment of central obesity the measurement of waist circumference (WC) is recommended [8, 21]. Relative fat distribution in terms of waist to hip ratio (WHR) of the body has been calculated by dividing the WC with HC [22, 23]. This study was aimed to find out the prevalence MetS components and its correlation with anthropometric indices.

## Methodology

### Study setting and study design

**Study design:** This cross-sectional study was conducted in the healthy young adults at the community level, age of the participants was 18-25 years, living in Qasimabad. Data was conducted from August 2021- July 2022 after the registration of topic.

**Sampling:** The standard formula was used to calculate the sample size for this study. The overall number of subjects were 336 out of these 202(60.1) were females and 134(39.9) were males.

### Inclusion and Exclusion Criteria.

All the healthy young adults of both genders 18-25 years of age were included in this study, those suffering from any ailments or taking any medicine and pregnant females were excluded.

### Collection of data

After taking written consent, data was collected by filling self-designed interview based questionnaire from the randomly selected participants by using convenience technique of sampling. Anthropometric indices such as height, weight, WC and HC were measured by using standardized protocol. Measurement of weight was done with bare foot and light clothing by using weight scale. Measurement of height was done with bare foot stranded on the flat surface by using stadiometer mounted on the wall [24]. Measurement of waist circumference was done after normal expiration at midpoint between the iliac crest and the lowest rib by using a tape [8]. The measurement of hip circumference was done at the most protuberant part of the buttocks [25].

Waist-to-Hip ratio was calculated by dividing waist with hip, cutoff of WHR are used as per WHO guidelines, for females 0.85 and for males 0.90 [25]. Body mass index (BMI) was calculated by dividing the weight in kilogram with height in meter square and South Asian cutoff values were used [26].

The blood pressure was measured by using digital automatic Omron monitor, systolic blood pressure (SBP) and diastolic blood pressure (DBP) was measured twice in seated position and mean of two measurements were used [27, 28].

Before the collection of blood samples in the next day morning, the participants were informed to remain fasted for at least 10 hours [29]. Fasting Blood Sugar was measured by using ACCU-CHEK Active Roche Glucometer after 10 hours overnight fasting and Blood samples for lipid profile were collected and transported to the laboratory and analyzed by using Biochemistry auto-analyzer. Ethical consideration was obtained from the department of Physiology, University of Sindh Jamshoro. To analyze the data SPSS Version 23 was used, Mean values, T-test and Bivariate correlation tests were carried out. P=value <0.01 and <0.05 were used as statistically significant.

Several diagnostic criteria are used for the diagnosis of MetS. For this study most broadly applied definition: the revised NCEP ATP III was used [30]. National Cholesterol Education Program Adult Treatment Panel III NCEP ATP III defines that MetS is positive if any three of the five components are present, 1.fasting blood sugar is greater than 110 mg/dl, 2.fasting HDL cholesterol level <40 mg/dl (men) or <50 mg/dl (women), 3.fasting triglyceride level over 150 mg/dl, 4.blood pressure over 130/85 mmHg, and 5.waist circumference over 102 cm (men) or 88 cm (women) [31-33]

## Results

The overall mean age of the participants was 20.97 years, males 21.84 and females 20.4 years, others basic demographics of the participants which includes the Mean values, t-test and p-values. Mean values of all characteristics are significant except BMI, HC, FBS, TG and HDL are shown in Table 1.

**Table 1** Basic characteristics of the participants.

| **Variables** | **All Participants** | | **Male** | | **Female** | | **t-test** | **p=value** |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | | |
| **Age years** | 20.97 | 2.27 | 21.84 | 2.55 | 20.40 | 1.86 | 5.97 | 0.000 |
| **Weight Kg** | 58.01 | 10.52 | 61.23 | 11.26 | 55.87 | 9.43 | 4.71 | 0.000 |
| **Height cm** | 159.82 | 7.27 | 163.76 | 6.07 | 157.21 | 6.83 | 8.99 | 0.000 |
| **BMI Kgm$^{-2}$** | 22.63 | 3.58 | 22.81 | 3.90 | 22.51 | 3.35 | 0.75 | 0.453 |
| **WC cm** | 74.24 | 10.94 | 80.80 | 10.57 | 69.89 | 8.81 | 10.24 | 0.000 |
| **HC cm** | 88.74 | 8.08 | 89.72 | 8.37 | 88.09 | 7.83 | 1.82 | 0.070 |
| **WHR** | 0.83 | 0.07 | 0.89 | 0.05 | 0.79 | 0.06 | 15.67 | 0.000 |
| **WHtR** | 0.46 | 0.06 | 0.49 | 0.06 | 0.43 | 0.05 | 7.47 | 0.000 |
| **SBP mmHg** | 114.69 | 10.43 | 117.90 | 9.01 | 112.57 | 10.64 | 4.77 | 0.000 |
| **DBP mmHg** | 76.52 | 7.54 | 79.48 | 6.22 | 74.55 | 7.71 | 6.17 | 0.000 |
| **FBS mg/dl** | 87.54 | 10.95 | 88.74 | 11.02 | 86.75 | 10.85 | 1.63 | 0.102 |
| **Trig mg/dl** | 116.65 | 53.24 | 120.33 | 50.61 | 114.21 | 55.19 | 1.02 | 0.304 |
| **HDL mg/dl** | 38.09 | 6.67 | 37.70 | 6.75 | 38.35 | 6.96 | -0.85 | 0.393 |

Table 2 shows the frequencies and percentages of MetS absent and MetS present, according to ATP-III Diagnostic Criteria. Overall prevalence is 25(7.4%), in which prevalence of MetS among

male participants is 15(11.2%) and female participants is 10(5%), statistically significant Chi square= 4.56, p=value 0.033.

**Table 2** Prevalence of Metabolic Syndrome ATP-III Criteria.

| Gender | MetS Abesent | MetS Present | Total |
|---|---|---|---|
| **Male** | 119(88.8) | 15(11.2) | 134(39.9) |
| **Female** | 192(95.00) | 10(5.00) | 202(60.1) |
| **All Participants** | 311(92.6) | 25(7.4) | 336 (100) |
| Chi square= 4.56, p=value 0.033 | | | |

According to NCEP ATP-III diagnostic criteria MetS is defined as, if someone has three out of five MetS components, table 3 shows the frequencies and percentages of MetS components in the studied participants, 44(13.1%) were normal with zero MetS component, 214(63.7%) have one component, 53(15.8%) have two components, 19(5.7%) have three components, 05(1.5%) have four components and only one female participant has five components 1(0.3). The overall prevalence of three components were 19(5.7), higher in males 12(9%) than in females 07(3.5%) and it is statistically significant Chi square= 70.63, p=value 0.000.

**Table 3** Distribution of the components of Metabolic Syndrome

| Gender | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| **Male** | 41(30.6) | 63(47.0) | 15(11.2) | 12(9.0) | 02(1.5) | 00(0.0) |
| **Female** | 03 (1.5) | 151(74.8) | 38(18.8) | 07(3.5) | 03(1.5) | 01(0.7) |
| **All Participants** | 44(13.1) | 214(63.7) | 53(15.8) | 19(5.7) | 05(1.5) | 01(0.3) |
| Chi square= 70.63, p=value 0.000 | | | | | | |

Note: These numbers, 0 indicates not any MetS component and 1-5 indicates that some participants have 1,2,3,4 or 5 components respectively.

Table. 4 shows the overall and gender wise correlation of anthropometric indices with blood pressure (BP). Overall weight is significantly correlated with SBP and DBP, in males systolic blood pressure (SBP) is highly significantly correlated with BMI (r= 0.656) then females. Diastolic Blood Pressure (DBP) is highly significantly correlated the weight (r= 0.571) in females than males.

**Table 4** Overall and gender-wise Correlation of Anthropometric Indices with the Blood Pressure.

| Variables | All Participants | | Male | | Female | |
|---|---|---|---|---|---|---|
| | SBP mmHg | DBP mmHg | SBP mmHg | DBP mmHg | SBP mmHg | DBP mmHg |
| **Age in (Years)** | $0.309^{**}$ | $0.276^{**}$ | $0.264^{**}$ | $0.172^{**}$ | $0.253^{**}$ | $0.226^{**}$ |
| **Weight (Kg)** | $0.616^{**}$ | $0.566^{**}$ | $0.640^{**}$ | $0.502^{**}$ | $0.571^{**}$ | $0.563^{**}$ |
| **Height (cm)** | $0.174^{**}$ | $0.266^{**}$ | $0.118^{NS}$ | $0.063^{NS}$ | $0.049^{NS}$ | $0.116^{NS}$ |
| **BMI (Kg/m$^{2)}$** | $0.601^{**}$ | $0.527^{**}$ | $0.656^{**}$ | $0.544^{**}$ | $0.593^{**}$ | $0.556^{**}$ |
| **WC (cm)** | $0.578^{**}$ | $0.546^{**}$ | $0.541^{**}$ | $0.429^{**}$ | $0.549^{**}$ | $0.513^{**}$ |
| **HC (cm)** | $0.530^{**}$ | $0.473^{**}$ | $0.558^{**}$ | $0.433^{**}$ | $0.510^{**}$ | $0.495^{**}$ |
| **WHR** | $0.384^{**}$ | $0.390^{**}$ | $0.243^{**}$ | $0.207^{*}$ | $0.326^{**}$ | $0.273^{**}$ |
| **WHtR** | $0.557^{**}$ | $0.508^{**}$ | $0.493^{**}$ | $0.403^{**}$ | $0.541^{**}$ | $0.478^{**}$ |

*p<0.05, **p<0.001 and NS is non-significant

Table. 5 shows the overall and gender-wise correlation of anthropometric indices with fating blood sugar (FBS). Among these anthropometric indices (AI), BMI is highly correlated with FBS (r=0.599) in females then males (r=0.330).

**Table. 5** Overall and gender-wise Correlation of Anthropometric Indices with the Fasting Blood Sugar.

| Variables | FBS in All Participants | FBS in Male | FBS in Female |
|---|---|---|---|
| **Age in (Years)** | $0.197^{**}$ | $0.240^{**}$ | $0.127^{NS}$ |
| **Weight (Kg)** | $0.449^{**}$ | $0.277^{**}$ | $0.578^{**}$ |
| **Height (cm)** | $0.093^{NS}$ | $0.014^{NS}$ | $0.088^{NS}$ |
| **BMI (Kg/m$^{2)}$** | $0.481^{**}$ | $0.330^{**}$ | $0.599^{**}$ |
| **WC (cm)** | $0.387^{**}$ | $0.271^{**}$ | $0.497^{**}$ |
| **HC (cm)** | $0.431^{**}$ | $0.277^{**}$ | $0.534^{**}$ |
| **WHR** | $0.192^{**}$ | $0.124^{NS}$ | $0.209^{**}$ |
| **WHtR** | $0.379^{**}$ | $0.246^{**}$ | $0.477^{**}$ |

.

Table. 6 shows the overall and gender-wise correlation of AI with Triglycerides (TGs). Overall BMI (r=506) and gender-wise in males (r=0.431) and in (r=0.563), BMI is significantly correlated with TG.

**Table. 6** Overall and gender-wise Correlation of Anthropometric Indices with the Triglycerides

| Variables | TG in All Participants | TG in Male | TG in Female |
|---|---|---|---|
| **Age in (Years)** | $0.245^{**}$ | $0.324^{**}$ | $0.178^{**}$ |
| **Weight (Kg)** | $0.481^{**}$ | $0.421^{**}$ | $0.535^{**}$ |
| **Height (cm)** | $0.054^{NS}$ | $0.066^{NS}$ | $0.015^{NS}$ |
| **BMI (Kg/m$^{2)}$** | $0.506^{**}$ | $0.431^{**}$ | $0.563^{**}$ |
| **WC (cm)** | $0.398^{**}$ | $0.314^{**}$ | $0.513^{**}$ |
| **HC (cm)** | $0.442^{**}$ | $0.359^{**}$ | $0.493^{**}$ |
| **WHR** | $0.195^{**}$ | $0.104^{NS}$ | $0.264^{**}$ |
| **WHtR** | $0.398^{**}$ | $0.269^{**}$ | $0.512^{**}$ |

Table. 7 Shows the overall and gender-wise correlation of anthropometric indices with high density lipoprotein (HDL). Overall and gender-wise in females BMI is negatively correlated with HDL but in males weight is negatively correlated with HDL, p=value is <0.01.

**Table. 7** Gender-wise Correlation of Anthropometric Indices with the High Density Lipoprotein (HDL).

| Variables | HDL in All Participants | HDL in Male | HDL in Female |
|---|---|---|---|
| **Age in (Years)** | $-0.143^{**}$ | $-0.043^{NS}$ | $-0.221^{**}$ |
| **Weight (Kg)** | $-0.329^{**}$ | $-0.302^{**}$ | $-0.352^{**}$ |
| **Height (cm)** | $0.000^{NS}$ | $0.038^{NS}$ | $0.058^{NS}$ |
| **BMI (Kg/m$^{2)}$** | $-0.359^{**}$ | $-0.293^{**}$ | $-0.408^{**}$ |
| **WC (cm)** | $-0.267^{**}$ | $-0.201^{*}$ | $-0.345^{**}$ |
| **HC (cm)** | $-0.233^{**}$ | $-0.169^{NS}$ | $-0.271^{**}$ |
| **WHR** | $-0.179^{**}$ | $-0.122^{NS}$ | $-0.237^{**}$ |
| **WHtR** | $-0.284^{**}$ | $-0.186^{*}$ | $-0.367^{**}$ |

## Discussion

Various studies in this age (18-25 years) group have been conducted only in the universities and colleges [27, 34-39]. So that this study was designed to find out the prevalence of MetS components and their correlation with anthropometric indices among young adults at community level. Overall mean values of anthropometric indices, blood pressure, TG, HDL and FBS of this study are consistent with a study conducted in the Lahore and other study also [34, 37, 39]. The mean values of FBS, TGs and HDL were nonsignificant in my study than a study conducted by Majat Yahia [39] Mean age of the participants was 20.97 years, males 21.84 and females 20.4 years it was consistent with[39], because the number of females are greater than males in both studies.

Overall the prevalence of metabolic syndrome among young adults in this study was 7.4%, the prevalence of MetS was more in males 15(11.2%) than in females 10(5%) according to the NECP ATPIII diagnostic criteria for MetS, statistically significant Chi square= 4.56, p=value 0.033. A study conducted in Lahore among the undergraduate students where the overall prevalence of MetS was 31(6.1%) in male 24(9.8%) and in females 7(2.6%) [34]. This study is also consistent with other studies, in a Colombian study where the overall prevalence of MetS was 6%, in males 9% and in females 3% [40], in a Korean study overall 5.3%, male 6.3% and females 4.1% [35], in American study overall 3.7% males 4.7% and females 1.6% [36], in Kenya overall prevalence of MetS is 1.9%, [41], in UAE prevalence of MetS was 6.8% [42]. In all these studies MetS was higher in males except in UAE because it was conducted among only in females.

The distribution of individual MetS components in which 44(13.1%) were normal with not a single MetS component, 214(63.7%) have one component, 53(15.8%) have two components, 19(5.7%) have three components, 05(1.5%) have four components and only one female participant has five components. The prevalence of three components was higher in males 12(9%) than in females 07(3.5%) and it is statistically significant Chi square= 70.63, p=value 0.000. An study conducted in USA among college students, the prevalence of MetS components was 63% females and 73% males have none components, 25% males, 30% females have one component, 3% males and 7% females have two components and 0.4% only female has three components[39], other study conducted in USA among college students the frequency of MetS components was 0(37%),1(42.5%), 2(13%), 3(5%) and 4(1.9%)[37] also consistent with[40].

Correlation is the most widely used statistical measure to assess relationships among variables that suggest that how two variable are correlated, such as, if one variable goes up and other variable either goes up or down depending on type of correlation as negative or positive. Most of the anthropometric indices (AI) are correlated with all the components of MetS, whereas height is not correlated with FBS, TGs and HDL.

The correlation of anthropometric indices with blood pressure (BP) is shown in the table 4, overall weight is significantly correlated with SBP and DBP, in male participant's systolic blood pressure (SBP) is highly significantly correlated with BMI then females. Diastolic Blood Pressure (DBP) is highly significantly correlated the weight in females than males. This type of study is conducted in Karachi among healthy participants age >25 years, in which DBP is correlated with WC in females than males [43]. According to Dieny WC is correlated with SBP in females, this study was conducted only in females[44].

The overall and gender-wise correlation of anthropometric indices with fating blood sugar (FBS) is shown in table 5. Among these anthropometric indices, Overall and gender-wise BMI is highly correlated with FBS in females and in males. Correlation of BMI with FBS in females of this study is comparable with[44].

The overall and gender-wise correlation of anthropometric indices with high density lipoprotein (HDL). Overall and gender-wise in females BMI is negatively correlated with HDL but in males weight is negatively correlated with HDL, p=value is <0.01. In other study HDL is also negatively correlated with BMI only in males but not correlated with WC and WHtR in both

genders [43]. According to Dieny a study conducted in Indonesia, BMI is also negatively correlated with HDL significantly[44].
The correlation of anthropometric indices with Triglycerides (TGs), overall the correlation of BMI and gender-wise in males is and in females is, BMI is significantly correlated with TG. whereas TG is positively correlated with WHtR in males only [43]. The correlation of BMI with TG in females is also consistent with[44].

**Conclusion:** The prevalence of MetS and its components was higher in males than females. The correlation of BMI with the individual components of MetS was found better than other anthropometric indices.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

## HUMAN AND ANIMAL RIGHTS

No animals were used in this study. The study on humans was conducted in accordance with the ethical rules of the Helsinki Declaration and Good Clinical Practice.

## CONSENT FOR PUBLICATION

Not applicable.

## AVAILABILITY OF DATA AND MATERIALS

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

## FUNDING

None.

## CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

## ACKNOWLEDGEMENTS

None.

## REFERENCES

1. Samson, S.L. and A.J. Garber, Metabolic syndrome. Endocrinology and Metabolism Clinics, 2014. 43(1): p. 1-23.
2. Valerio, A., et al., Obesity and Higher Risk for Severe Complications of Covid-19: What to do when the two pandemics meet. Journal of Population Therapeutics and Clinical Pharmacology, 2020. 27(SP1): p. e31-e36.
3. Alberti, K.G.M., P. Zimmet, and J. Shaw, The metabolic syndrome—a new worldwide definition. The Lancet, 2005. 366(9491): p. 1059-1062.
4. Graybeal, A.J., et al., Associations between eating behaviors and metabolic syndrome severity in young adults. Eating Behaviors, 2023: p. 101821.
5. Ramírez-Manent, J.I., et al., Waist Circumference Is an Essential Factor in Predicting Insulin Resistance and Early Detection of Metabolic Syndrome in Adults. Nutrients, 2023. 15(2): p. 257.
6. DeBoer, M.D., Assessing and managing the metabolic syndrome in children and adolescents. Nutrients, 2019. 11(8): p. 1788.

7. Alberti, K.G., et al., Harmonizing the metabolic syndrome: a joint interim statement of the international diabetes federation task force on epidemiology and prevention; national heart, lung, and blood institute; American heart association; world heart federation; international atherosclerosis society; and international association for the study of obesity. Circulation, 2009. 120(16): p. 1640-1645.
8. Organization, W.H., Waist circumference and waist-hip ratio: report of a WHO expert consultation, Geneva, 8-11 December 2008. 2011.
9. Moran, A. and R. Vedanthan, Cardiovascular disease prevention in South Asia gathering the evidence. Global heart, 2013. 8(2): p. 139.
10. Turin, T.C., et al., Burden of cardio-and cerebro-vascular diseases and the conventional risk factors in South Asian population. Global heart, 2013. 8(2): p. 121-130.
11. Mente, A., et al., Metabolic syndrome and risk of acute myocardial infarction: a case-control study of 26,903 subjects from 52 countries. Journal of the American College of Cardiology, 2010. 55(21): p. 2390-2398.
12. Adil, S.O., et al. Prevalence of Metabolic Syndrome among Apparently Healthy Adult Population in Pakistan: A Systematic Review and Meta-Analysis. in Healthcare. 2023. MDPI.
13. Gortmaker, S.L., et al., Social and economic consequences of overweight in adolescence and young adulthood. New England journal of medicine, 1993. 329(14): p. 1008-1012.
14. Organization, W.H., The Asia-Pacific perspective: redefining obesity and its treatment. 2000.
15. Duncan, G.E., S.M. Li, and X.-H. Zhou, Prevalence and trends of a metabolic syndrome phenotype among US adolescents, 1999–2000. Diabetes care, 2004. 27(10): p. 2438-2443.
16. Ford, E.S., W.H. Giles, and A.H. Mokdad, Increasing prevalence of the metabolic syndrome among US adults. Diabetes care, 2004. 27(10): p. 2444-2449.
17. Wander, P.L., et al., Change in visceral adiposity independently predicts a greater risk of developing type 2 diabetes over 10 years in Japanese Americans. Diabetes care, 2013. 36(2): p. 289-293.
18. Ferreira, A.P., et al., Prediction of metabolic syndrome in children through anthropometric indicators. Arquivos brasileiros de cardiologia, 2011. 96: p. 121-125.
19. Seo, J.-Y. and J.H. Kim, Validation of surrogate markers for metabolic syndrome and cardiometabolic risk factor clustering in children and adolescents: a nationwide population-based study. PLoS One, 2017. 12(10): p. e0186050.
20. Shah, N.R. and E.R. Braverman, Measuring adiposity in patients: the utility of body mass index (BMI), percent body fat, and leptin. PloS one, 2012. 7(4): p. e33308.
21. O'Donnell, C.M., C.M. Tarnay, and A.J. Rapkin. Waist circumference, not BMI, is a positive predictive factor in women who suffer from chronic abdominal and pelvic. in Reproductive Sciences. 2008. SAGE PUBLICATIONS INC 2455 TELLER RD, THOUSAND OAKS, CA 91320 USA.
22. Croft, J.B., et al., Waist-to-hip ratio in a biracial population: measurement, implications, and cautions for using guidelines to define high risk for cardiovascular disease. Journal of the American Dietetic Association, 1995. 95(1): p. 60-64.
23. Lear, S., et al., Appropriateness of waist circumference and waist-to-hip ratio cutoffs for different ethnic groups. European journal of clinical nutrition, 2010. 64(1): p. 42-61.
24. Shahzad, F. and A. Ishaque, Frequency and predictors of metabolic syndrome in adolescents/first year medical students of a public sector medical college Quetta, Pakistan. JPMA. The Journal of the Pakistan Medical Association, 2017. 67(5): p. 752-755.
25. BaiSakhiya, S., S. Singh, and P. Manjhi, Correlation between age, gender, waist-hip ratio and intra ocular pressure in adult north indian population. Journal of clinical and diagnostic research: JCDR, 2016. 10(12): p. CC05.

26. Misra, A. and U. Shrivastava, Obesity and dyslipidemia in South Asians. Nutrients, 2013. 5(7): p. 2708-2733.
27. Amirabdollahian, F. and F. Haghighatdoost, Anthropometric indicators of adiposity related to body weight and body shape as cardiometabolic risk predictors in British young adults: superiority of waist-to-height ratio. Journal of obesity, 2018. 2018.
28. Suliga, E., et al., The usefulness of anthropometric indices to identify the risk of metabolic syndrome. Nutrients, 2019. 11(11): p. 2598.
29. Jain, J., et al., Prevalence and correlates of metabolic syndrome in young population: a cross sectional study. J Diabetes Metab, 2015. 6(503): p. 2.
30. Grundy, S.M., et al., Diagnosis and management of the metabolic syndrome: an American Heart Association/National Heart, Lung, and Blood Institute scientific statement. Circulation, 2005. 112(17): p. 2735-2752.
31. Ahmad, M., et al., Prevalence of various components of metabolic syndrome in our younger population. Pakistan Journal of Physiology, 2011. 7(2): p. 46-48.
32. Krakauer, N.Y. and J.C. Krakauer, Anthropometrics, metabolic syndrome, and mortality hazard. Journal of obesity, 2018. 2018.
33. Ranasinghe, P., et al., Prevalence and trends of metabolic syndrome among adults in the asia-pacific region: a systematic review. BMC public health, 2017. 17(1): p. 1-9.
34. Malik, M.S., et al., Dietary patterns, exercise, and the metabolic syndrome among young people in Urban Pakistan (Lahore). Metabolic Syndrome and Related Disorders, 2020. 18(1): p. 56-64.
35. Jang, I. and J.-S. Kim, Risk of cardiovascular disease related to metabolic syndrome in college students: A cross-sectional secondary data analysis. International journal of environmental research and public health, 2019. 16(19): p. 3708.
36. Fernandes, J. and I.E. Lofgren, Prevalence of metabolic syndrome and individual criteria in college students. Journal of American College Health, 2011. 59(4): p. 313-321.
37. Dalleck, L.C. and E.M. Kjelland, The prevalence of metabolic syndrome and metabolic syndrome risk factors in college-aged students. American Journal of Health Promotion, 2012. 27(1): p. 37-42.
38. Widjaja, N.A., R. Arifani, and R. Irawan, Cut-off value of waist-to-hip ratio as a predictor of metabolic syndrome in adolescents with obesity. Acta Bio Medica: Atenei Parmensis, 2023. 94(3).
39. Yahia, N., et al., Prevalence of metabolic syndrome and its individual components among midwestern university students. Journal of community health, 2017. 42: p. 674-687.
40. Martínez-Torres, J., et al., A Cross-sectional study of the prevalence of metabolic syndrome and associated factors in colombian collegiate students: the FUPRECOL-adults study. International journal of environmental research and public health, 2017. 14(3): p. 233.
41. Mbugua, S.M., S.T. Kimani, and G. Munyoki, Metabolic syndrome and its components among university students in Kenya. BMC Public Health, 2017. 17(1): p. 1-8.
42. Al Dhaheri, A.S., et al., A cross-sectional study of the prevalence of metabolic syndrome among young female Emirati adults. PLoS One, 2016. 11(7): p. e0159378.
43. Adil, S.O., et al., Role of anthropometric indices as a screening tool for predicting metabolic syndrome among apparently healthy individuals of Karachi, Pakistan. Frontiers in endocrinology, 2023. 14: p. 1223424.
44. Tsani, F.A., FAT_Anthropometry indicators that are most related to metabolic profiles in female college students.