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Correlation and optimal cut-off determination of waist-hip circumference and ratio among health science students

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Abstract

Introduction: Body mass index (BMI), waist circumference (WC), hip circumference (HC), and waist-hip ratio (WHR) are commonly used anthropometric indices to define obesity. This study aims to find the correlation between anthropometric parameters and corresponding cut-off point of WC, HC, and WHR related to BMI.

Method: A cross-sectional study was conducted among undergraduate students in Punjab University College of Pharmacy, Pakistan, from Jan to Jun 2021. The cut-off of WC, HC, and WHR with BMI (for obese ≥25 kg/m^2 for Asia-Pacific population) was calculated using the receiver operating characteristic curve (ROC). Ethics approval was obtained. A sample size was calculated using Cochrane's formula. Normality of data distribution was checked. Pearson correlation coefficient was applied for correlation between variables like BMI, WC, HC, weight, height, and WHR at a 95% confidence interval. The ROC analyses were used for reliability of WC, HC, and WHR with high BMI.

Result: Out of 433 participants, correlation coefficients between BMI and WC, BMI and HC, BMI and WHR, and HC and WC were 0.583 ($p<0.001$), 0.518 ($p<0.001$), 0.156 ($p<0.001$), and 0.743 ($p<0.001$). For BMI 25 kg/m^2, the optimal cut-off points for WC, HC, and WHR were 82.55 cm, 95.25 cm, and 84 cm.

Conclusion: There was a positive linear correlation of BMI with WC, HC, and WHR, and also between WC and HC. The optimal cut-off points for WC, HC, and WHR corresponding to a BMI of 25 kg/m2 were less than the WHO standard cut-off point.

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Introduction

Obesity is a risk factor for cardiovascular morbidity and mortality.[1] Body mass index (BMI), waist circumference (WC), and waist-hip ratio (WHR) are commonly used indices to define obesity.[2] A BMI of ≥25 kg/m^2 is considered overweight, and ≥30 kg/m^2 is obese according to the World Health Organization (WHO).[3] However, percentage of body fat is thought to corroborate with relatively lower BMI in the South Asian population, with ≥23 kg/m^2 for overweight and ≥25 kg/m^2 for obese.[4,5] A waist circumference of more than 80 cm (31 inches) and 90 cm (35 inches) is considered abnormal for Asian females and males, respectively.[6] Likewise, a WHR of ≥0.9 in men and ≥0.85 in women is considered to be obese.[7]

The BMI is a commonly used anthropometric parameter for obesity. However, it estimates total body fat and therefore doesn't reflect central obesity. Muscular individuals could be categorized as obese despite having normal fat content.[8]

Studies have reported an independent relation of various anthropometric parameters and obesity, but the relation between anthropometric parameters has not been adequately researched. Simultaneous analyses of all three parameters can help to better estimate the metabolic risk factors associated with obesity.[9-11] This study aims to find out the correlation between different anthropometric measures and to assess the cut-off value for obesity, at a BMI of ≥25 kg/m^2 in the South Asian population.

Method

A descriptive cross-sectional study was conducted among undergraduate pharmacy students, from first to final year, from the University of the Punjab, Lahore, Pakistan, for three months from January to June 2021. The sample size was calculated using Cochran's formula. Assuming a 50% prevalence, a minimum of 385 participants was required. Accounting for a 10% non-response rate, the final target sample size was 422. The study successfully enrolled 433 students. A purposive sampling technique was used.

This research is in line with the guidelines for strengthening the reporting of observational studies in epidemiology (STROBE).[12]

All the measurements were taken without accessories and with minimum clothing. Height was measured using a stadiometer with a precision of 0.1 cm while weight was measured using a digital weighing machine with a precision of 0.1 kg. WC was measured midway between the lowest rib and the iliac crest, and hip circumference (HC) at the widest part of the hip in centimetres using an inelastic measuring tape. The BMI was calculated by using the standard formula, BMI=Weight/Height.[2] The WHR was calculated by dividing WC by HC.

Data were entered into Microsoft Excel 2019, and appropriate commands were used for data cleaning. Entered data were analysed using IBM SPSS (Statistical Product and Service Solutions) v.21. Normality of continuous variables was assessed using the Shapiro–Wilk test. Variables with normal distribution were expressed as mean±SD, while non-normally distributed variables as median (interquartile range).

The BMI was classified according to the classification for the Asia-Pacific population by the Western Pacific Regional Office (WPRO) of the WHO.[13] Normal weight was considered as BMI ranging from 18.50 to 22.99 kg/m^2. The participants with a BMI <18.50 kg/m^2 were considered underweight. The cutoff values for overweight and obesity were >23.00 to 24.99 kg/m^2 and >25.00 kg/m^2, respectively.

Pearson correlation coefficient was applied to test the correlation between the two variables for continuous variables like BMI, WC, HC, weight, height, and WHR at a 95% confidence interval. Receiver operating characteristics (ROC) analyses were used to find out the reliability of WC, HC, and WHR to identify participants with high BMI (≥25 kg/m^2) and to determine the best WC, HC, and WHR cut-off for identifying patients as obese.

Ethics approval was obtained from the Institutional Review Board, University of the Punjab, Lahore, Pakistan (Ref No: 49/DFEMS).

Result

Out of 433 participants, the mean age was 20.59±1.94 years. Majority (61.66 %) were males, the average BMI of male and female participants was 23.33 and 22.59, respectively. The mean of various anthropometric variables is summarized in Table 1.

Around one-fourth (25.09%) males had obesity, less (9.04 %) among females. Overall, both men and women had predominantly (49.06 % and 59.64%) normal BMI followed by overweight (23.22% and 28.92%) and obesity grade I (22.85% and 8.43%), Table 2.

Pearson correlation showed that BMI and WC (r=0.638), BMI and HC (r=0.604), WC and HC (r=0.802), WC and Weight (0.748), and HC and weight (r=0.700) had significant correlation among the male participants. Similarly, the BMI and WC (r=0.567), BMI and HC (r=0.334), WC and HC (r=0.494), WC and Weight (0.642), HC and weight (r=0.375), and BMI and WHR (r=0.429) had significant correlation among the female participants. Overall, the BMI and WC (r=0.583), BMI and HC (r=0.518), WC and HC (r=0.743), WC and Weight (0.798), WC and height (r=0.303), HC and weight (r=0.627), HC and height (0.153), height and weight (0.350), and BMI and WHR (r=0.156) had significant correlation among all the participants, Table 3.

The ROC analysis showed that the area under the curve (AUC) for WC when BMI ≥25 kg/m2 was considered, was 0.862, 0.780, and 0.856 for male, female, and all participants respectively. So, the corresponding cut-off of waist circumference was 87.63, 77.47, and 82.55 cm for male, female, and overall participants respectively. Similarly, the ROC analysis showed that the AUC for HC when BMI ≥25 kg/m^2 was considered, was 0.810, 0.653, and 0.810 for male, female, and all participants respectively. So, the corresponding cut-off of hip circumference was 100.33, 95.25, and 95.25 cm for males, females, and all participants, respectively. Regarding WHR, the ROC analysis showed that the AUC for WHR when BMI ≥25 kg/m^2 was considered, was 0.738 and 0.653 for females and all participants, respectively. So, the corresponding cut-off of WHR was 0.83 and 0.84 for females and all participants, respectively.

The positive LR and negative LR for waist circumference, hip circumference, and WHR were 3.017 and 0.172, 2.514 and 0.271, and 1.313 and 0.313, respectively, for obese participants when the cut-off of WC, HC, and WHR would be 82.55 cm, 92.25 cm, and 0.84, respectively. The AUC for WHR in males was 0.537 (p=0.367), which suggests WHR may not reliably predict obesity in males, Table 4.

Table 1. Background characteristics of university students in a study relationship of waist-hip circumference and waist-hip ratio, n=433

Variables	Male, 267(61.66%) Mean±SD	Female, 166(38.34%) Mean±SD
Weight (Kg)	70.31±7.52)	61.97±4.62
Height (m)	1.74±0.07	1.66±0.04
BMI (Kg/m^2)	23.33±2.86	22.59±1.94
WC (cm)	84.23±5.36	77.13±4.66
HC (cm)	96.66±6.88	92.16±7.64
WHR	0.87±0.03	0.83±0.03

BMI: Body mass index, HC: Hip circumference, WC: Waist circumference, WHR: Waist-hip ratio

Table 2. Categorization of BMI* and obesity status as per BMI, n=433

BMI (Kg/m^2)	Male, 267(61.66%)	Female, 166(38.34%)
Obesity absent	**200(74.91)**	**151(90.96)**
Underweight (<18.5)	7(2.62)	4(2.41)

Normal (18.5-22.9)	131(49.06)	99(59.64)
Overweight (23-24.9)	62(23.22)	48(28.92)
Obesity Present	**67(25.09)**	**15(9.04)**
Obese I (25-29.0)	61(22.85)	14(8.43)
Obese II (>30)	6(2.25)	1(0.60)

BMI: Body mass index, *The BMI classification is done as per the Western Pacific Regional Office (WPRO) for the Asian population

Table 3. Comparison between BMI, WC, HC, weight, height, and WHR in male, female, and overall participants

Parameters	Male (n=267)		Female (n=166)		Overall (n=433)	
	Corr. coeff. (r)	p-value	Corr. coeff. (r)	p-value	Corr. coeff. (r)	p-value
BMI and WC	0.638	<0.001	0.567	<0.001	0.583	<0.001
BMI and HC	0.604	<0.001	0.334	<0.001	0.518	<0.001
WC and HC	0.882	<0.001	0.494	<0.001	0.743	<0.001
WC and Weight	0.748	<0.001	0.642	<0.001	0.798	<0.001
WC and Height	-0.005	0.941	-.005	0.953	0.303	<0.001
HC and Weight	0.700	<0.001	0.375	<0.001	0.627	<0.001
HC and Height	-0.002	0.975	-0.022	0.781	0.153	0.001
Height and weight	0.075	0.221	0.141	0.069	0.350	<0.001
BMI and WHR	-0.064	0.294	0.429	<0.001	0.156	0.001

BMI: Body mass index, Corr. coeff.: Correlation coefficient, HC: Hip circumference, WC: Waist circumference, WHR: Waist-hip ratio

Table 4. ROC curve analysis for waist circumference when BMI ≥ 25 kg/m2: in both males, females, and overall

Gender	AUC	p-value	95% CI	Cut-off	Sensitivity	1-specificity	LR+	LR-	Youden's Index (J)
Waist circumference									
Male	0.862	<0.001	0.815-0.910	87.63	0.672	0.085	7.906	0.358	0.587
Female	0.780	<0.001	0.733-0.344	77.47	0.733	0.344	2.131	0.407	
Overall	0.856	<0.001	0.811-0.901	82.55	0.878	0.291	3.017	0.172	0.587
Hip circumference									
Male	0.810	<0.001	0.755-0.865	100.33	0.672	0.170	3.953	0.395	0.502
Female	0.653	<0.001	0.492-0.814	95.25	0.533	0.192	2.776	0.578	0.341
Overall	0.810	<0.001	0.759-0.862	95.25	0.817	0.325	2.514	0.271	0.492
Waist-hip-ratio									
Male	0.537	0.367	0.456-0.617	0.88	0.507	0.405	1.252	0.829	0.102
Female	0.738	0.002	0.624-0.853	0.83	0.933	0.536	1.741	0.144	0.397
Overall	0.653	<0.001	0.592-0.713	0.84	0.902	0.687	1.313	0.313	0.215

AUC: Area under the curve, BMI: Body mass index, CI: Confidence interval, LR: Likelihood ratio, ROC: Receiver operating characteristic

Discussion

The present study demonstrated a strong positive correlation of WC and HC with BMI (r=0.583–0.638, p<0.001), particularly among males, suggesting that these anthropometric indices are reliable proxies for adiposity. A similar study done among individuals with

metabolic syndrome demonstrated a positive correlation between the two, and the correlation is even stronger (females: r=0.8, males: r=0.78).[14] A systematic review of the correlation of anthropometric parameters showed that the highest concordance rate was between BMI and WC, and they could somehow be used interchangeably.[15]

In contrast, WHR exhibited a weak correlation with BMI overall (r=0.156, *p*=0.001), but a moderate and significant correlation in females (r=0.429, *p*<0.001), aligning with prior studies highlighting sex-based differences in WHR utility.[16] A similar study done among undergraduate students in Pakistan also showed that there was no relation between BMI with waist-hip ratio among overall participants (r=0.124, p>0.05) while there was a positive relation between BMI and waist-hip ratio among females. (r=0.623, p<0.05).[17] The reason for this sex-wise variation is not yet clear.

The strong correlation between WC and HC (r=0.743–0.882, *p*< 0.001) suggests a shared reflection of fat distribution patterns, and further supports their combined use in obesity risk estimation. In ROC analysis, the optimal WC cut-off (82.55cm) for predicting BMI ≥25 kg/m² was lower than the WHO-recommended threshold (90 cm for males, 80 cm for females), indicating that lower thresholds may be appropriate for South Asian populations, who are known to have higher body fat percentage at lower BMI levels.[18]

The derived HC cut-off (95.25cm) is novel, and it showed a better discriminative ability (AUC=0.810) in males than in females (AUC=0.653), suggesting that hip circumference may be a more useful marker in males within this population. Similarly, the WHR cut-off (0.84 overall) was below the WHO standard (0.90 for males, 0.85 for females). However, the low AUC in males (0.738) questions the utility of WHR as a reliable screening tool for obesity in this subgroup, a finding consistent with previous reports highlighting the limited sensitivity of WHR in men.[19]

The mean age of participants in this study is 20.59±1.94 years with a range of 18-25 years. Thus, in contrast to other anthropometric studies that consider a larger range of population, our study population contains mainly younger individuals and is reflective of the metabolic profile of the younger population.[20,21] The mean BMI among Pakistani students in our study was slightly higher in both gender groups as compared to a similar study done among Nepalese medical students.[22] The prevalence of obesity was found to be greater in males as compared to females. The sex predominance in obesity is controversial, with regional differences. Data from the WHO global health observatory 2016 showed that the percentage of overweight and obese individuals was greater among males in Europe, America, and the Western Pacific region, while it was greater among females in Africa, South East Asia, and the Western Mediterranean region.[23]

With reference to a BMI of 25kg/m^2, the optimal cut-off points for waist circumference for males and females in our study are 87.63 and 77.47, respectively. These values are slightly lower than the cut-off points for waist circumference of 90 cm and 80 cm for the South Asian population set by WHO.[24] In a study, the ROC curve derived optimal cut-off points in diabetes for BMI is 25.51 (25.59 in males and 25.49 in females), and that of waist circumference is 86 cm (87 cm in males and 84 cm in females).[25] The sensitivity and specificity of the waist circumference cut-off point are comparable for both sexes in that study. However, in our study, the sensitivity is comparable, while the specificity is high for males but low for females. The optimal cut-off point of WHR in our study is slightly lower for both sexes in comparison to the corresponding WHO cut-off point. The cut-off points were the same (0.89) for both males and females in the study by Zhang et.al. However, our study showed that the cut-off point was higher in males than in females. A large-scale study was done in China to define the optimal cut-off point

for BMI and WC in a population with diabetes, hypertension, dyslipidemia, and metabolic syndromes, which showed that the cut-off values were almost similar, with a slightly higher cut-off point of BMI for hypertension and a higher cut-off point of WC, and among diabetics as compared to other cohorts [26]

This study found that among young South Asian individuals, there is a significant relationship between BMI and anthropometric parameters such as WC, HC, and WHR, with WC and HC showing the strongest correlations. The derived cut-off values (WC: 82.55 cm, HC: 95.25 cm, WHR: 0.84) were lower than WHO-defined standards, indicating that population-specific thresholds may be more suitable for early obesity screening. These findings highlight the need for localized obesity screening criteria and suggest further research in broader age ranges and clinical populations.

There was a positive and significant correlation between all the anthropometric parameters in our study among overall participants. This implies that even if the parameters are not exact equivalents of each other, the rise in one can be interpreted as the rise in the other too, and hence any of them can be used depending on the convenience and feasibility.

This study found that among young South Asian individuals, there is a significant relationship between BMI and anthropometric parameters such as waist circumference (WC), hip circumference (HC), and waist-hip ratio (WHR), with WC and HC showing the strongest correlations. The derived cut-off values (WC: 82.55 cm, HC: 95.25 cm, WHR: 0.84) were lower than WHO-defined standards, indicating that population-specific thresholds may be more suitable for early obesity screening. These findings highlight the need for localized obesity screening criteria and suggest further research in broader age ranges and clinical populations.

Our results also showed that WHR was less effective in males but performed relatively well in females, indicating a potential sex-dependent variation in its diagnostic utility.

The BMI showed a strong positive correlation with both waist and hip circumferences. Additionally, waist and hip circumferences were positively correlated among both male and female participants. WHR also correlated with BMI, especially in females, indicating sex-specific differences in its predictive value.

Conclusion

This study identified significant correlations between body mass index and anthropometric measures, including waist and hip circumference and waist-hip ratio, in young South Asian university students. Waist circumference showed the strongest association with BMI. The derived cut-off values (waist: 82.55 cm, hip: 95.25 cm, WHR: 0.84) were lower than WHO standards, emphasizing the need for population-specific thresholds. Waist-hip ratio performed better in females than in males, reflecting sex-based differences. These findings suggest that relying solely on BMI may be insufficient for obesity screening, and ethnicity- and sex-specific measures should be considered.

Author contribution

Conception, design: SK; Data acquisition: RPG and MAJA; Literature review: KA, PS, and SL; Data analysis, interpretation: KA, PS, GKY, and SL; Drafting: ALL; Revision, final approval of the version to be published and accountability: All

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Conflict of interest

None

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Supplementary material

Data and supplementary material that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Sharma S, Aggarwal N, Joshi B, Suri V, Badada S. Prevalence of metabolic syndrome in pre- and post-menopausal women: A prospective study from apex institute of North India. J Midlife Health. 2016 Oct-Dec;7(4):169-74. DOI PubMed Google Scholar Full Text
2. Muka T, Oliver-Williams C, Kunutsor S, Laven JS, Fauser BC, Chowdhury R, et al. Association of age at onset of menopause and time since onset of menopause with cardiovascular outcomes, intermediate vascular traits, and all-cause mortality: a systematic review and meta-analysis. JAMA Cardiol. 2016;1(7):767-76. DOI PubMed Google Scholar Full Text
3. Hokanson JE. Hypertriglyceridemia as a cardiovascular risk factor. The American journal of cardiology. 1998 Feb 26;81(4):7B-12B.DOI PubMed Google Scholar Full Text
4. Grundy SM, Stone NJ, Bailey AL, Beam C, Birtcher KK, Blumenthal RS, et al. 2018 AHA/ACC/AACVPR/AAPA/ABC/ACPM/ADA/AGS/APhA/ASPC/NLA/PCNA guideline on the management of blood cholesterol: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Journal of the American College of Cardiology. 2019 Jun 25;73(24):e285-350. Google Scholar Full Text
5. Zhang Y, Yamamoto T, Hisatome I, Li Y, Cheng W, Sun N, et al. Uric acid induces oxidative stress and growth inhibition by activating adenosine monophosphate-activated protein kinase and phosphatase in pancreatic β cells. Mol Cell Endocrinol. 2013;375(1-2):89-96. DOI PubMed Google Scholar Full Text
6. Fang J, Alderman MH. Serum uric acid and cardiovascular mortality: the NHANES I epidemiologic follow-up study, 1971-1992. National Health and Nutrition Examination Survey. JAMA. 2000;283(18):2404-10. DOI PubMed Google Scholar Full Text
7. Mandal F, Rijal R, Kafle D, Adhikari K. SERUM LIPID PROFILE AMONG POST-MENOPAUSAL WOMEN ATTENDING TERTIARY HOSPITAL AT CHITWAN, NEPAL. Journal of Chitwan Medical College.2022 12(2), 118–21. DOI Google Scholar Ful Text
8. Mouridsen MR, Bendsen NT, Astrup A, Haugaard SB, Binici Z, Sajadieh A. Modest weight loss in moderately overweight postmenopausal women improves heart rate variability. European journal of preventive cardiology. 2013 Aug 1;20(4):671-7. DOI PubMed Google Scholar Full Text
9. Muka T, Oliver-Williams C, Kunutsor S, Laven JS, Fauser BC, Chowdhury R, et al. Association of Age at Onset of Menopause and Time Since Onset of Menopause With Cardiovascular Outcomes, Intermediate Vascular Traits, and All-Cause Mortality: A Systematic Review and Meta-analysis. JAMA Cardiology. 2016 Oct 1;1(7):767-76. DOI PubMed Google Scholar Full Text
10. Nature Scientific Reports. Hyperuricemia and aging 2020. DOI PubMed Google Scholar Full Text
11. Norms Diagnostics. Hyperuricemia in older age. DOI PubMed Google Scholar Full Text
12. BMC Cardiovascular Disorders. Association between serum uric acid and lipid profiles. DOI PubMed Google Scholar Full Text
13. Qin L, Yang Z, Gu H, Lu S, Shi Q, Xing Y, Li X, Li R, Ning G, Su Q. Association between serum uric acid levels and cardiovascular disease in middle-aged and elderly Chinese individuals. BMC cardiovascular disorders. 2014 Feb 25;14(1):26. DOI PubMed Google Scholar Full Text
14. Lippi G, Montagnana M, Luca Salvagno G, Targher G, Cesare Guidi G. Epidemiological association between uric acid concentration in plasma, lipoprotein (a), and the traditional lipid profile. Clinical cardiology. 2010 Feb;33(2):E76-80. DOI PubMed Google Scholar Full Text
15. Kumar S, Singh AR, Takhelmayum R, Shrestha P, Sinha JN. Prevalence of hyperuricemia in Chitwan District of Nepal. Journal of college of Medical Sciences-Nepal. 2010;6(2):18-23.. DOI Google Scholar Full Text
16. Tao M, Pi X, Ma X, Shi Y, Zhang Y, Gu H, Chi Y, Zhuang S, Liu N. Relationship between serum uric acid and clustering of cardiovascular disease risk factors and renal disorders among Shanghai population: a multicentre and cross-sectional study. BMJ open. 2019 Mar 1;9(3):e025453.. DOI PubMed Google Scholar Full Text
17. Joo JK, Hong GP, Han SE, Lee YJ, Kim SC, Kim CW, Lee KS. The association between serum uric acid level and incidence of metabolic syndrome according to menopausal status in Korean women. Journal of Menopausal Medicine. 2014 Dec 24;20(3):126. DOI PubMed Google Scholar Full Text
18. Poudel B, Yadav BK, Kumar A, Jha B, Raut KB. Serum uric acid level in newly diagnosed essential hypertension in a Nepalese population: a hospital based cross sectional study. Asian Pacific journal of tropical biomedicine. 2014 Jan 1;4(1):59-64. DOI PubMed Google Scholar Full Text
19. Khanal S, Veerman L, Nissen L, Hollingworth S.

Use of healthcare services by patients with non-communicable diseases in Nepal: A qualitative study with healthcare providers. Journal of clinical and diagnostic research: JCDR. 2017 Jun 1;11(6):LC01. DOI PubMed Google Scholar Full Text

20. Aryal KK, Neupane S, Mehata S, Vaidya A, Singh S, Paulin F, Madanlal RG, Riley LM, Cowan M, Guthold R, Singh SP. Non communicable diseases risk factors: STEPS Survey Nepal 2013. Google Scholar Full Text