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Original Research Article

Correlation of Anthropometric Indices and Hypertension: An Observational Study

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ABSTRACT

Background and Objectives: Globally, elevated blood pressure ranks among the most prevalent and consequential non-communicable diseases, and its co-occurrence with excess adiposity is well-recognised in contemporary epidemiological literature. Within the Indian context, hypertension is responsible for more than half of all stroke-related fatalities and nearly a quarter of deaths attributable to coronary artery disease. A variety of body composition surrogates have been proposed to quantify adiposity-associated cardiovascular risk, yet their utility differs considerably across genders owing to the dimorphic nature of human fat distribution. The present study was therefore designed to evaluate the gender-stratified correlation between three anthropometric indices—Body Mass Index (BMI), A Body Shape Index (ABSI), and Waist-to-Hip Ratio (WHR)—and blood pressure in a cohort of adults with confirmed hypertension.

Methods: A cross-sectional observational study was conducted among 141 hypertensive adults (67 males, 74 females; mean age 51.7±6.4 years) recruited from a physiotherapy outpatient department in Ahmedabad via systematic random sampling. Blood pressure was recorded using a calibrated mercury sphygmomanometer following standard auscultatory technique, and anthropometric indices were measured according to established protocols. Spearman's rank correlation coefficient was employed for all association analyses given the non-normal distribution of the data.

Results: WHR demonstrated the strongest positive association with systolic blood pressure (SBP) across the entire cohort ($\rho=0.66$, $p<0.05$), while BMI ($\rho=0.26$, $p<0.05$) and ABSI ($\rho=0.22$, $p<0.05$) showed weaker but statistically significant correlations. No significant relationship was identified between any anthropometric index and diastolic blood pressure (DBP). Gender-stratified analysis revealed that in males, both BMI ($\rho=0.46$, $p<0.05$) and WHR ($\rho=0.40$, $p<0.05$) correlated moderately with SBP, whereas in females, ABSI ($\rho=0.47$, $p<0.05$) and WHR ($\rho=0.92$, $p<0.05$) were the dominant correlates of SBP.

Conclusion: Systolic blood pressure is most robustly associated with WHR across both genders, with BMI being the additional significant correlate in males and ABSI in females. Diastolic blood pressure appears independent of the anthropometric parameters studied. Clinicians are encouraged to integrate WHR and ABSI into hypertension assessment rather than relying exclusively on BMI, particularly when evaluating female patients.

Keywords: *Hypertension; Anthropometric indices; Body Mass Index; Waist-to-Hip Ratio; A Body Shape Index; Systolic Blood Pressure*

INTRODUCTION

Hypertension constitutes one of the foremost preventable contributors to global cardiovascular morbidity and mortality, with the World Health Organization estimating that approximately 1.28 billion adults between 30 and 79 years of age are currently affected worldwide.[1] The epidemiological trajectory of this condition is particularly alarming in South Asia, where rapid urbanization and lifestyle transition have accelerated its prevalence.[2] In India specifically, the condition underlies 57% of all stroke deaths and 24% of all coronary heart disease fatalities, reflecting a disproportionate national burden.[1]

Obesity and excess adiposity are among the most consistently implicated modifiable determinants of elevated blood pressure.[3] The biological mechanisms linking adiposity to hypertension are multifaceted and include heightened sympathoadrenal activity, activation of the renin-angiotensin-aldosterone axis, sodium and fluid retention, and the elaboration of vasoactive substances from adipose tissue.[4] Of particular pathophysiological relevance is visceral adipose tissue, whose proximity to splanchnic vasculature and high lipolytic activity facilitates portal delivery of free fatty acids and adipokines, thereby promoting insulin resistance and endothelial dysfunction.[4,5]

Body Mass Index (BMI), expressed as the quotient of body weight in kilograms and the square of height in meters, has historically served as the primary clinical index of adiposity.[6] Its widespread adoption stems from measurement simplicity, low cost, and strong population-level associations with metabolic disease.[6] Nonetheless, BMI carries well-documented limitations: it conflates fat mass with lean tissue, and—crucially—provides no information regarding the topographical distribution of adipose deposits within the body.[7,8] Since abdominal and visceral fat accumulation rather than global adiposity is thought to drive blood pressure elevation, surrogate measures that capture regional fat distribution may possess superior predictive validity.[7]

The Waist-to-Hip Ratio (WHR) is a widely adopted anthropometric measure of central adiposity, computed as the ratio of circumference at the narrowest abdominal point to the broadest circumference of the gluteal region.[9] Higher WHR values have been associated with visceral fat accumulation, dyslipidemia, insulin resistance, and incident cardiovascular events across diverse ethnic groups.[5,10] More recently, Krakauer and Krakauer proposed A Body Shape Index (ABSI), a dimensionless index that incorporates waist circumference alongside BMI and height, and demonstrated its capacity to predict all-cause mortality independently of BMI.[6] Whether ABSI provides incremental value over BMI and WHR in identifying blood pressure risk, however, remains a subject of ongoing debate in the literature.[11]

An often-overlooked dimension of this research area is the role of biological gender in moderating the adiposity-hypertension relationship.[12] Males typically exhibit android (abdominal) fat distribution, characterized by preferential deposition of adipose tissue around the trunk and viscera, whereas females in the reproductive years tend toward a gynoid pattern involving gluteo-femoral accumulation.[12,13] Post-menopausal redistribution of fat towards the abdomen in females further complicates a uniform interpretation of anthropometric indices across genders.[13] Despite these well-established dimorphisms, the preponderance of existing studies evaluating anthropometric correlates of blood pressure aggregate males and females without stratification, potentially masking clinically meaningful gender-specific differences.[8,11]

Against this background, the present investigation was designed to determine the

gender-stratified correlations between BMI, ABSI, and WHR with systolic and diastolic blood pressure in a cohort of confirmed hypertensive adults attending a physiotherapy outpatient setting in Ahmedabad, India. The findings are intended to inform clinical decision-making regarding which anthropometric index warrants priority assessment depending on the gender of the patient.

Aim And Objectives

Aim: To determine the correlation between anthropometric indices and blood pressure in individuals diagnosed with hypertension.

Specific Objectives:

- Blood pressure will be measured by mercury sphygmomanometer
- Anthropometric indices:

1. Body Mass Index will be calculated by weight (kg)/height^2(m^2)
2. Waist-to-Hip Ratio will be calculated by waist circumference (cm)/hip circumference cm
3. A Body Shape Index (ABSI) will be calculated by Waist circumference/BMI$^{2/3}$*height$^{1/2}$
4. 4. Blood pressure will be correlated with values of BMI, Waist to Hip Ratio and ABSI respectively.

MATERIALS & METHODS

Study Design and Setting

This cross-sectional observational study was conducted at the Physiotherapy Outpatient Department of a hospital in Ahmedabad, India.

Sample Size and Sampling Strategy

A sample of 141 hypertensive adults was recruited using systematic random sampling with a sampling interval of three (every third eligible patient). The required sample size was calculated a priori using G*Power software (version 3.1), with statistical power set at 80% and an alpha level of 0.05.[12]

Inclusion and Exclusion Criteria

Individuals were eligible if they: (i) were aged 25–60 years; (ii) were of either gender; (iii) provided voluntary written consent; and (iv) had a confirmed diagnosis of Stage 1 or Stage 2 Hypertension as defined by the 2017 ACC/AHA guidelines.[1]

Participants were excluded if they had: (i) a recent history of surgery or trauma; (ii) concurrent diagnoses of Diabetes Mellitus, neurological, orthopaedic, or cardiovascular conditions other than hypertension, or active pregnancy; (iii) conditions that could materially distort anthropometric measurements, including gross oedema, ascites, limb amputation, or severe postural malalignment; or (iv) recent steroid use within six months or current hormone replacement therapy.

Outcome Measures

The primary outcome measures were Systolic Blood Pressure (SBP, mmHg) and Diastolic Blood Pressure (DBP, mmHg). The anthropometric exposure measures were Body Mass Index (BMI, kg/m^2), A Body Shape Index (ABSI), and Waist-to-Hip Ratio (WHR).

Blood Pressure Measurement

Blood pressure was recorded using a calibrated mercury sphygmomanometer following standardized auscultatory methodology recommended by Pickering et al.[13] Cuff dimensions were selected according to arm circumference (Table 1), a procedural consideration known to influence measurement accuracy.[13] The participant was seated in a relaxed, back-supported posture with feet flat on the floor, and a minimum five-minute rest period was observed before measurement.[13] Two readings were taken at a one-minute interval, and their mean value was used in all analyses.[13]

Table 1: Cuff Size Selection Based on Arm Circumference (Adapted from Pickering et al., 2005) [14]

Arm Circumference (cm)	Recommended Cuff Size (cm × cm)
22–26	12 × 22
27–34	16 × 30
35–44	16 × 36

Anthropometric Measurements

Body weight was recorded to the nearest 0.1 kg on a calibrated digital scale with the participant in light clothing and without footwear; height was measured to the nearest 0.1 cm using a standard stadiometer with the participant in the Frankfurter horizontal plane.[6] BMI was subsequently derived as weight (kg) divided by height squared (m^2).[6]

Waist circumference was measured at the midpoint between the inferior costal margin and the superior border of the iliac crest during gentle expiration, while hip circumference was recorded at the maximum protrusion of the buttocks; WHR was calculated as their quotient.[9]

ABSI was calculated according to the formula originally described by Krakauer and Krakauer: ABSI = Waist Circumference (m) ÷ [$BMI^{2/3}$ × $Height^{1/2}$ (m)], which was developed to isolate waist shape as a mortality predictor independently of overall body size.[6]

Statistical Analysis

All statistical computations were performed using IBM SPSS Statistics (version 25, IBM Corp., Armonk, NY). Normality of each continuous variable was assessed using the Shapiro-Wilk test, which has demonstrated superior statistical power over alternative normality tests in small-to-moderate samples.[14] Since the distribution of the variables violated assumptions of normality, Spearman's rank correlation coefficient (ρ) was applied to quantify the monotonic association between blood pressure and each anthropometric index.[14] Separate correlation analyses were conducted for the total sample and for male and female subgroups. A two-tailed p-value of <0.05 was considered statistically significant for all tests.

RESULT

Participant Characteristics

A total of 141 hypertensive adults were enrolled, comprising 67 males (47.5%) and 74 females (52.5%), with a mean age of 51.7±6.4 years. The overall mean SBP was 138.5±6.07 mmHg and mean DBP was 85.07±4.65 mmHg, consistent with the Stage 1–2 hypertension profile of the sample.[1] Full descriptive statistics are presented in Table 2.

Table 2: Baseline Demographics and Outcome Measure Characteristics (n=141)

Variable	Total Sample (Mean ± SD)
Sample Size (n)	141
Males / Females (n)	67 / 74
Age (years)	51.7 ± 6.4
Systolic Blood Pressure (mmHg)	138.5 ± 6.07
Diastolic Blood Pressure (mmHg)	85.07 ± 4.65
Body Mass Index (kg/m²)	31.15 ± 4.89
A Body Shape Index (ABSI)	0.073 ± 0.007
Waist-to-Hip Ratio (WHR)	0.889 ± 0.096

Gender-wise distribution of the outcome measures is detailed in Table 3. Male participants exhibited higher mean ABSI (0.076 vs. 0.071) and WHR (0.94 vs. 0.83) compared to females, while female participants had marginally higher mean BMI (31.7 vs. 30.49 kg/m²) and DBP (85.42 vs. 84.7 mmHg).

Table 3: Gender-wise Distribution of Outcome Measures

Outcome Measure	Males (Mean ± SD)	Females (Mean ± SD)
SBP (mmHg)	139.55 ± 6.15	137.6 ± 5.89
DBP (mmHg)	84.7 ± 4.69	85.42 ± 4.6
BMI (kg/m²)	30.49 ± 5.29	31.7 ± 4.44
ABSI	0.076 ± 0.007	0.071 ± 0.006
WHR	0.94 ± 0.04	0.83 ± 0.09

Correlation of Anthropometric Indices with Systolic Blood Pressure – Overall Sample

WHR demonstrated the strongest and most clinically meaningful correlation with SBP in the pooled sample (ρ=0.66, p<0.05), categorised as a strong positive relationship. BMI and ABSI both yielded statistically significant but weaker positive associations with SBP (ρ=0.26 and ρ=0.22, respectively; both p<0.05), as detailed in Table 4.

Table 4: Spearman's Rank Correlation of Anthropometric Indices with Systolic Blood Pressure (Overall Sample, n=141)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
Body Mass Index (BMI)	0.26	< 0.05	Weak positive; significant
A Body Shape Index (ABSI)	0.22	< 0.05	Weak positive; significant
Waist-to-Hip Ratio (WHR)	0.66	< 0.05	Moderate positive; significant

Correlation of Anthropometric Indices with Diastolic Blood Pressure – Overall Sample

None of the three anthropometric indices returned a statistically significant correlation with DBP in the overall sample (Table 5). Spearman's ρ values were negligibly small—0.006 for BMI (p=0.34), −0.009 for ABSI (p=0.87), and 0.01 for WHR (p=0.29)—indicating an absence of any meaningful monotonic relationship between adiposity indices and diastolic blood pressure in this cohort.

Table 5: Spearman's Rank Correlation of Anthropometric Indices with Diastolic Blood Pressure (Overall Sample, n=141)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
Body Mass Index (BMI)	0.006	0.34	Negligible; not significant
A Body Shape Index (ABSI)	-0.009	0.87	Negligible; not significant
Waist-to-Hip Ratio (WHR)	0.01	0.29	Negligible; not significant

Gender-Specific Correlations – Male Participants

In the male subgroup, both BMI (ρ=0.46, p<0.05) and WHR (ρ=0.40, p<0.05) showed moderate positive correlations with SBP (Table 6), while ABSI was not significantly associated with SBP in males (ρ=−0.11, p=0.41). For DBP in males (Table 7), only ABSI returned a statistically significant—albeit weak—positive correlation (ρ=0.23, p<0.05), while BMI and WHR did not.

Table 6: Spearman's Rank Correlation of Anthropometric Indices with Systolic Blood Pressure in Males (n=67)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
BMI	0.46	< 0.05	Moderate positive; significant
ABSI	-0.11	0.41	Weak negative; not significant
WHR	0.40	< 0.05	Moderate positive; significant

Table 7: Spearman's Rank Correlation of Anthropometric Indices with Diastolic Blood Pressure in Males (n=67)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
BMI	0.02	0.25	Negligible; not significant
ABSI	0.23	< 0.05	Weak positive; significant
WHR	0.02	0.64	Negligible; not significant

Gender-Specific Correlations – Female Participants

The female subgroup yielded a markedly different pattern (Tables 8 and 9). WHR demonstrated very strong positive correlation with SBP in females (ρ=0.92, p<0.05), and ABSI also showed a moderate positive association (ρ=0.47, p<0.05), while BMI was not significantly correlated with SBP (ρ=0.10, p=0.47). No anthropometric index was significantly correlated with DBP in the female subgroup.

Table 8: Spearman's Rank Correlation of Anthropometric Indices with Systolic Blood Pressure in Females (n=74)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
BMI	0.10	0.47	Weak positive; not significant
ABSI	0.47	< 0.05	Moderate positive; significant
WHR	0.92	< 0.05	Strong positive; significant

Table 9: Spearman's Rank Correlation of Anthropometric Indices with Diastolic Blood Pressure in Females (n=74)

Anthropometric Index	Spearman's ρ	p-value	Interpretation
BMI	-0.03	0.53	Negligible; not significant
ABSI	0.004	0.86	Negligible; not significant
WHR	-0.01	0.75	Negligible; not significant

DISCUSSION

The present study examined three widely employed anthropometric indices in relation to blood pressure across a hypertensive adult population, with a specific focus on identifying whether the pattern of associations diverges between genders. The principal finding is that WHR is the most robust anthropometric correlate of systolic blood pressure across both genders, while the relevance of BMI appears confined to males and that of ABSI appears more pronounced in females. Diastolic blood pressure was unrelated to any of the indices examined, regardless of gender.

BMI and Systolic Blood Pressure

The modest positive correlation observed between BMI and SBP in the pooled sample (ρ=0.26) aligns with evidence from several large cross-sectional investigations demonstrating that overall adiposity is a statistically, though not clinically, strong predictor of blood pressure.[3] Minh and Vo, in a cross-sectional study of Vietnamese adults, reported that BMI was an imprecise predictor of hypertension risk when compared with abdominal adiposity measures, arguing that the distribution of fat within the body—rather than its aggregate quantity—holds the dominant physiological influence on vascular function.[8] The gender-specific analysis in the present study reinforces this argument: while BMI correlated moderately with SBP in males (ρ=0.46), it failed to reach significance in females (ρ=0.10), a pattern that may reflect the higher proportion of visceral fat per unit BMI typically seen in males compared with females of equivalent BMI.[15] Collectively, these observations caution against the uncritical use of BMI as the solitary anthropometric index in hypertension risk assessment.[7,8]

ABSI and Systolic Blood Pressure

ABSI yielded a weak but statistically significant correlation with SBP across the combined sample (ρ=0.22), a finding that offers only partial support for its proposed

utility as a blood pressure biomarker. Wu and colleagues, in a notably large cross-sectional survey encompassing over 45,000 adults, reported a considerably stronger association between ABSI and hypertension prevalence.[11] The apparent attenuation in the present data relative to that study may be attributable to the substantially smaller sample enrolled here, as effect sizes derived from smaller samples are subject to greater variability and imprecision.[14] Additionally, the combined-gender analysis in the present cohort may have obscured the index's signal, given that males exhibit systematically higher ABSI values than females owing to gender-related differences in the relationship between waist circumference and height.[6] The gender-stratified results reveal that ABSI achieves a moderate and statistically significant correlation with SBP specifically in females ($\rho=0.47$, $p<0.05$), suggesting that ABSI may capture dimensions of central adiposity relevant to blood pressure that are sex-specific and not detectable when the sample is treated as homogeneous.[14] This finding carries meaningful clinical implications, particularly for postmenopausal women in whom fat redistribution toward the abdomen may be inadequately reflected by BMI.[15]

WHR and Systolic Blood Pressure

The strong correlations of WHR with SBP—both overall ($\rho=0.66$) and in females specifically ($\rho=0.92$)—constitute the most noteworthy finding of this investigation. These observations are consistent with the conclusions of Mbae et al., who identified a significant positive relationship between WHR and blood pressure levels in hypertensive patients attending a county referral hospital in Kenya,[10] as well as with findings reported by Bouchi and Ohara linking higher WHR to subclinical end-organ changes in adults with cardiometabolic disease.[5] The mechanistic basis for the WHR-SBP association is multifactorial. Visceral adipose tissue, which is sensitively reflected by a high WHR, is characterised by elevated lipolytic activity, macrophage infiltration, and the release of pro-inflammatory cytokines including tumour necrosis factor-α and interleukin-6.[4,5] These mediators promote endothelial dysfunction, increase arterial stiffness, and augment longitudinal vascular strain, which collectively translate into higher systolic blood pressure.[4] Furthermore, individuals with central adiposity and high WHR frequently exhibit hypoadiponectinemia, wherein reduced circulating adiponectin impairs nitric oxide–mediated vasodilatation and predisposes to vasoconstriction and blood pressure elevation.[5]

The exceptionally high correlation between WHR and SBP in females ($\rho=0.92$) warrants dedicated commentary. The Quebec Family Study, a landmark investigation of over 600 participants, demonstrated that broader hip circumference relative to waist circumference in females was independently associated with lower cardiovascular risk factor burden, including lower blood pressure, a protective relationship mediated by the metabolically favourable properties of gluteo-femoral adipose tissue.[18] Critically, WHR simultaneously encodes both waist and hip dimensions; a high WHR in a female therefore signals not merely increased abdominal fat but also a relative reduction in the protective gynoid depot.[17] This dual signal plausibly explains why WHR emerges as such a powerful predictor of SBP in females within the present cohort, exceeding the correlations seen for either BMI or ABSI in the same group.

Anthropometric Indices and Diastolic Blood Pressure

The complete absence of statistically significant associations between any anthropometric index and DBP across both the total sample and gender-stratified subgroups is a noteworthy and physiologically coherent finding. Diastolic blood pressure primarily reflects total peripheral vascular resistance, which is governed by the contractile tone and structural remodelling of resistance

arterioles rather than by acute adiposity-driven haemodynamic changes.[18] While chronic obesity may eventually contribute to increased peripheral resistance through mechanisms such as vascular smooth muscle hypertrophy and impaired endothelium-dependent relaxation,[4] the cross-sectional nature of the present study and the relatively narrow DBP range observed in the sample (mean 85.07±4.65 mmHg) may have attenuated any detectable signal. The current literature offers limited dedicated examination of the DBP-WHR relationship specifically,[10] and prospective investigations designed to capture longitudinal changes in both variables would be better positioned to elucidate this association.

Gender-Specific Patterns: Mechanistic Perspectives

The gender-divergent patterns of anthropometric correlates identified in the present study align with the broader literature on gender differences in fat distribution and adipokine biology.[15,16] In males, the android fat phenotype means that BMI itself—even without information about fat distribution—carries some predictive value for SBP because a greater share of excess weight is deposited viscerally.[15] In females, however, the gynoid fat deposit at equivalent or even higher BMI values buffers the adiposity-blood pressure relationship, rendering BMI a poor correlate, while indices that specifically encode abdominal shape—WHR and ABSI—become more informative.[16] The pathway through which abdominal adiposity elevates blood pressure across both genders ultimately converges on visceral adipocyte-macrophage crosstalk: macrophage infiltration of hypertrophied adipocytes triggers a cascade of pro-inflammatory cytokine elaboration, endothelial nitric oxide synthase suppression, and increased arterial stiffness, providing the structural and functional basis for sustained systolic pressure elevation.[4,5]

CONCLUSION

This gender-stratified observational study demonstrates that WHR is the pre-eminent anthropometric correlate of systolic blood pressure in hypertensive adults, achieving a strong association in females and a moderate association in males. BMI retains moderate relevance as a correlate of SBP exclusively in males, while ABSI shows moderate significance for SBP in females, reinforcing the notion that the clinical utility of anthropometric indices is gender-dependent.[8,11] Diastolic blood pressure was not significantly associated with any of the three indices across either gender, a finding that is consistent with the distinct haemodynamic determinants of diastolic function.[18] These results advocate for a shift in clinical hypertension assessment from a singular reliance on BMI toward a broader anthropometric profile that includes WHR and ABSI, with particular emphasis on the latter two measures in female patients.

Clinical Implications

- WHR and ABSI should be incorporated routinely into the anthropometric assessment of hypertensive patients, supplementing—rather than replacing—BMI, especially in females.
- Given the exceptionally strong WHR-SBP relationship in females (ρ=0.92), monitoring changes in WHR over time may serve as a practical, low-cost indicator of blood pressure trajectory in women with or at risk of hypertension.
- Physiotherapy-led interventions targeting reduction of central adiposity—including structured aerobic exercise, resistance training, and dietary counselling—are likely to exert meaningful blood pressure benefits, particularly in individuals with elevated WHR.
- Gender-specific anthropometric thresholds and risk stratification tools should be considered in future hypertension management guidelines, informed by the gender-divergent

patterns observed in the present and related studies.

Limitations and Future Directions

- The cross-sectional study design precludes any inference regarding temporal or causal relationships between anthropometric indices and blood pressure; longitudinal designs are warranted to establish directionality.
- The study assessed only three anthropometric indices; future investigations may consider incorporating additional measures such as conicity index, waist-to-height ratio, or body fat percentage estimated by bioelectrical impedance.

Declaration by Authors

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