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The Novelty of using Obesity Indices as Blood Pressure Predictors

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Abstract: ***Aims***: To study the association between selected obesity indices, systolic blood pressure (SBP), and diastolic blood pressure (DBP).

Methods: A cross-sectional study on 491 Jordanian adults (19-65 years old). The sociodemographic data, anthropometrics, and blood pressure were measured and recorded. Obesity indices (Conicity Index (CI), Abdominal volume index (AVI), Body Roundness Index (BRI), and Weight-adjusted-waist index (WWI)) were calculated using standard validated formulas.

Results: Based on age, the SBP had a significant moderate correlation with BRI and AVI in all age groups. In the age group 20 to 34 years, SBP had a significantly moderate correlation with CI, and DBP had a significantly moderate correlation with BRI and AVI. In the age group 35 to 44 years, DBP had a significantly moderate correlation with CI, BRI, WWI, and AVI. For the age group 45 to 65 years, the SBP had a significantly moderate correlation with all the obesity indexes, opposite to DBP. Obesity indices explain 23.6% to 24.1% of the changeability in SBP, and one unit increase in them resulted in an increase in SBP range from 0.61 ± 0.14 to 19.88 ± 4.45. For DBP, obesity indices explained 15.9% to 16.3% of the variability in DBP, and raising them by one unit led to an increase in the DBP range from 0.27 ± 0.11 to 10.08 ± 4.83.

Conclusion: All the studied obesity indices impacted SBP and DBP with the highest reported effect for AVI and BRI and a lower impact for WWI. The impact of obesity indices on DBP was affected by age group.

Keywords: Systolic blood pressure, diastolic blood pressure, conicity index, obesity indices, hypertension, cardiovascular disease.

1. INTRODUCTION

Hypertension is one of the significant risk factors for cardiovascular disease [1]. It can cause chronic kidney disease, heart failure, and type 2 diabetes [2]. Furthermore, hypertension complications are associated with high disability and fatality rates [3]. The estimated annual mortality rate from high blood pressure is 9.4 million worldwide [4]. Due to these trends, low- and middle-income countries today have higher rates of hypertension than high-income nations. Systolic blood pressure (SBP) of more than 115 mmHg was projected to cause 8.5 million fatalities in 2015, 88% of which occurred in low- and middle-income nations [5]. Reducing the prevalence of high blood pressure by 25% by 2025 compared to its level in 2010 is one of the global noncommunicable disease (NCD) targets set by the World Health Assembly in 2013 [6]. Unfortunately, hypertension remains a hidden condition for many affected people and is poorly managed among known patients [7]. In this situation, identifying high blood pressure has elevated to the top of the public health priority list [8].

Recently, with the improvement in living standards, the prevalence of overweight and obesity has increased worldwide and has become a worldwide public health problem affecting nearly one billion people [9]. Obesity is a significant independent and modifiable risk factor for raised blood pressure, and many epidemiological studies have suggested a progressive increase in the prevalence of elevated blood pressure and hypertension [10-12]. Moreover, obesity-related indices could be essential in screening hypertension and determining high-risk individuals and deserve attention for their applicability in population studies [3, 8]. Recent research has shown that body mass index (BMI) and the anthropometric indices of central adiposity are important risk factors for the development of hypertension. Because these anthropometric indices may be more accurate predictors of

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hypertension than BMI alone, researchers recommend routinely incorporating them into clinical practice as simple and low-cost techniques [13, 14]. The abovementioned indices include body roundness index (BRI), abdominal volume index (AVI), conicity index (CI), and weight-adjusted waist index (WWI) [15-18]. These indices were associated with the risk of premature death resulting from the accumulation of adipose tissue around the abdominal region and appear to be a significant risk factor for health complications [7, 19]. To date, the results of relevant studies have been controversial. Based on this, studying and exploring suitable indices for the population is necessary. Thus, the study investigated the Jordan community to explore the best way to predict the risk of obesity indices, which had the strongest association with blood pressure.

2. METHODS

2.1. Study Design and Participants

A population-based cross-sectional survey was conducted in outpatient clinics located in two public hospitals in the central areas of the Hashemite Kingdom of Jordan. Adults over 18 who appeared to be in good health were included to determine the association between obesity indices and blood pressure as predictors. Females who were pregnant or nursing and patients who had recent abdominal surgery that would have altered anthropometric or intra-abdominal measurements were also excluded. Only 491 Jordanian adults met the inclusion criteria, free of diabetes mellitus, dyslipidemia, hypertension, and heart disease, and agreed to participate in this study.

2.2. Ethical Approval of the Study Protocol

The study protocol was reviewed and approved by the institutional review board of Hashemite University (No.7/13/2020/2021) and following the Helsinki Declaration. Before enrolment in the study, informed written consent was obtained from each willing and eligible subject. A face-to-face interview was done using a standardized questionnaire to gather sociodemographic information. Data on general health, including questions on chronic diseases or any other health issues, were collected. During these interviews, anthropometrics and blood pressure were measured and recorded.

2.3. Anthropometric Measurements

To measure the height, the participants' feet were positioned next to one another, their heels, buttocks, and shoulder blades pressed against a portable stadiometer, and their heads were placed in the Frankfurt horizontal plane. Height was measured to the closest 0.5 cm. Weight was determined using a portable electronic scale calibrated in the manual. Before taking each measurement, the scale was positioned on a solid, flat surface, and its zero balance was confirmed. The subjects were weighed while standing upright, in light clothing, and without shoes. Their weights were recorded to the nearest 0.1 kg. A non-elastic measuring tape (Seca) measured waist circumferences at the narrowest point between the lowest rib and the iliac crest after a typical expiration. The buttocks' largest circumference was where the hip circumference (HC) was measured while wearing light clothes. The measurements of both circumferences were adjusted to the nearest 0.1 cm. Body mass index (BMI) was calculated (kg/m^2); it was calculated according to Quetelet's formula [20]. Then, the BMI values were categorized into groups based on 2.3. World Health Organization categories (25-29.9 is considered overweight, while ≥30 is considered obese) [21].

2.4. Blood Pressure Measurement

A standard oscillometric sphygmomanometer (type USM- 700GSi, Elquest Corporation, Chiba, Japan) was used to measure each subject's blood pressure in the sitting position after a 5-minute rest period by a trained, qualified nurse. The blood pressure was measured in the right arm two times, and the average of two measurements was used for data analysis. Blood pressure is recorded as two numbers: systolic blood pressure (SBP: the first number) and diastolic blood pressure (DBP: the second number), which indicates how much pressure the participant's blood is exerting against their artery walls when the heart beats and when the heart is resting between beats, respectively.

2.5. Anthropometric Indices Calculations

Traditional abdominal obesity was evaluated through the measured waist circumferences (WC). Six anthropometric indices- CI, AVI, BRI, and WWI- were calculated. The calculation formulas used in this study are listed below:

$$\text{CI} = \text{Waist circumference (m)}/(0.1093 * \sqrt{\left(\frac{\text{Weight(kg)}}{\text{height(m)}}\right)}) \quad \text{...... [22]}$$

$$\text{AVI}=2(\text{WC (cm)})^2 + 0.7(\text{waist-hip})^2/1000 \quad \text{.......... [23]}$$

$$\text{BRI}=364.2 - 365.5\sqrt{1-\left(\frac{(Waist\ circumference(cm)/2\pi)^2}{(0.5*Height\ (cm))^2}\right)} \quad \text{........[24]}$$

$$\text{WWI}= (\text{Waist circumference (cm)})/((Weight\ (kg))^{0.5} \quad \text{........[24]}$$

2.6. Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 25 (IBM, Chicago, IL, USA) was used to perform all the statistical data analyses. Means and standard deviations were used for continuous variables, and frequencies and percentages were used for categorical variables calculated using frequency descriptive statistical tests to describe the sample. Pearson correlation was performed to determine the correlation between obesity indices and blood pressure. Multiple linear regression analysis was performed using blood pressure as a dependent factor and obesity indexes, age, gender, BMI, and smoking history as independent factors to calculate beta and r-square change. The statistical significance was set at $p< 0.05$.

3. RESULTS

Four hundred and ninety-one adults participated in this study. As shown in Table **1**, the mean for height was 1.69±0.09 m, mean weight was 78.53±16.04 kg, for WC 96.18 ±14.94 cm, for HC 105.44±10.66 cm, for BMI

27.62±5.40 kg/m^2, for SBP 122.32±10.56 mmHg, and DBP 80.76±8.22 mmHg. Further, 70.1% were male and 29.9% were female. Most participants were between 20 and 34 years old (40.3%), 34.4% were aged between 35 and 44, and 25.3% were aged from 45 to 65. Around half of the participants had a university education (52.1%) and were physically active (57.2%). More than seventy percent (71.9%) were married, and 40.7% were smokers.

Table 1. General characteristics (n=491).

Variables	Mean ± SD
Height (m)	1.69 ± 0.09
Weight (kg)	78.53 ± 16.04
Waist circumference (cm)	96.18 ± 14.94
Hip circumference (cm)	105.44 ± 10.66
Body Mass Index (kg/m^2)	27.62 ± 5.40
Systolic blood pressure (mmHg)	122.32 ± 10.56
Diastolic blood pressure (mmHg)	80.76 ± 8.22
Variables	n (%)
Gender	
Male	344 (70.1)
Female	147 (29.9)
Age	
20-34	198 (40.3)
35-44	169 (34.4)
45-65	124 (25.3)
Education level	
School education level	235 (47.9)
University education level	256 (52.1)
Marital status	
Married	353 (71.9)
Single	132 (26.9)
Divorced	4 (0.8)
Widow	2 (0.4)
Total physical activity classification	
Physically active	281 (57.2)
Physically inactive	210 (42.8)
Smoking	
Yes	200 (40.7)
No	162 (33.0)
Ex-smoker	43 (8.8)
Passive smoking	86 (17.5)

Table **2** presents the Pearson correlations between blood pressure and obesity indices for the total study population. There was a significant positive moderate correlation between SBP, DBP, and CI (r=0.384 and 0.304, p <0.001; respectively), BRI (r=0.437 and 0.343, p <0.001; respectively), and AVI (r=0.452 and 0.396, p <0.001; respectively). While SBP had a positive moderate correlation with WWI (r=0.376, p <0.001), the DBP had a weak positive correlation with WWI (r=0.290, p <0.001).

In Table **3**, the Pearson correlation between blood pressure and obesity indices stratified by age sub-groups is illustrated. For the age group from 20 to 34 years, the SBP had a significant moderate correlation with CI (r=0.318; p<0.001), BRI (r=0.365; p<0.001), and AVI (r=0.397; p<0.001), while had a significant weak correlation with WWI (r=0.286; p<0.001). On the other hand, DBP had a significantly moderate correlation with BRI (r=0.320; p<0.001) and AVI (r=0.344; p<0.001) and a significantly weak correlation with CI (r=0.296; p<0.001), and WWI (r=0.273; p<0.001). For the age group from 35 to 44 years, the SBP had a significantly moderate correlation with BRI (r=0.433; p<0.001) and AVI (r=0.431; p<0.001) and a significantly weak correlation with CI (r=0.278; p<0.001), and WWI (r=0.271; p<0.001). In the same group, DBP had a significantly moderate correlation with CI (r=0.321; p<0.001), BRI (r=0.421; p<0.001), WWI (r=0.302; p<0.001), and AVI (r=0.436; p<0.001. For the age group from 45 to 65 years, the SBP had a significantly moderate correlation with all the obesity indexes (CI: r=0.387, p<0.001; p<0.001; BRI: r=0.365, p<0.001; WWI: r=0.379, p<0.001; and AVI: r=0.402, p<0.001). At the same time, the DBP had only a significant weak correlation with BRI (r=0.178; p=0.048) and AVI (r=0.195; p=0.030).

Multiple regression analysis between obesity indices and blood pressure adjusted for age, gender, BMI, and smoking history is shown in Table **4**; 23.6% of the changeability in SBP was explained by the regression model of AVI, 23.6% by CI, 24.1% by BRI, and 23.8% by WWI. Whereas one unit increase in AVI resulted in a 0.61 ± 0.14 rise in SBP, BRI resulted in a 4.05±0.84 increase in SBP, CI resulted in a 19.88±4.45 rise in SBP, and WWI resulted in a 2.40±0.52 increase in SBP (p <0.001). Regarding DBP, AVI was reported to explain 15.9% of the variability in DBP, and its raising by one unit led to a 0.27±0.11 increase in DBP (p <0.001). While BRI explains 16.2% of the variability in DBP and results in a 1.89±0.68 DBP increase by one unit, CI explains 16.2% and results in a 10.08±4.83 addition in DBP, and WWI presents 16.3% of the variability and a 1.23±0.43 increase in DBP due to one unit increase in its level.

4. DISCUSSION

Obesity and overweight correlate to elevated blood pressure and hypertension [25]. Notably, in the present study, about two-thirds of the population was classified as excess weight (overweight or obese). This aligns with Ajlouni and colleagues' findings, who estimated that about 75% of Jordanian adults from both genders were overweight or obese [26]. Recently, many obesity indices have been proposed and used for blood pressure and hypertension prediction and assessment. Thus, this study aimed to investigate the association between four selected obesity indices (CI, AVI, BRI, and WWI) and SBP and DBP.

Table 2. The Pearson correlation between blood pressure and obesity indices (n=491).

Variables		CI	BRI	WWI	AVI
SBP	Pearson r	0.384**	0.437**	0.376**	0.452**
	p-value	<0.001	<0.001	<0.001	<0.001
DBP	Pearson r	0.304**	0.343**	0.290**	0.369**
	p-value	<0.001	<0.001	<0.001	<0.001

Abbreviation: CI: Conicity Index; BRI: Body Roundness Index; WWI: Weight-adjusted-waist index; AVI: Abdominal volume index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 3. The pearson correlation between blood pressure and obesity indices stratified by age sub-groups.

Variables		CI	BRI	WWI	AVI
Age group = 20-34 years (n=198)					
SBP	Pearson r	0.318**	0.365**	0.286**	0.397**
	p-value	<0.001	<0.001	<0.001	<0.001
DBP	Pearson r	0.296**	0.320**	0.273**	0.344**
	p-value	<0.001	<0.001	<0.001	<0.001
Age group = 35-44 years (n=169)					
SBP	Pearson r	0.278**	0.433**	0.271**	0.431**
	p-value	<0.001	<0.001	<0.001	<0.001
DBP	Pearson r	0.321**	0.421**	0.302**	0.436**
	p-value	<0.001	<0.001	<0.001	<0.001
Age group = 45-65 years (n=124)					
SBP	Pearson r	0.387**	0.365**	0.379**	0.402**
	p-value	<0.001	<0.001	<0.001	<0.001
DBP	Pearson r	0.155	0.178*	0.149	0.195*
	p-value	0.086	0.048	0.098	0.03

Abbreviation: CI: Conicity Index; BRI: Body Roundness Index; WWI: Weight-adjusted-waist index; AVI: Abdominal volume index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure. **Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Table 4. Multiple linear regression association between blood pressure and obesity indices adjusted for age, gender, body mass index, and smoking history.

Indices	β	Std. Error	t	*p*-value*	Change Statistics		
					R Square Change	% of Change	*p*-value*
Systolic blood pressure (SBP)							
Conicity Index (CI)	19.88	4.45	4.47	<0.001	0.236	23.6	<0.001
Abdominal volume index (AVI)	0.61	0.14	4.47	<0.001	0.236	23.6	<0.001
Body Roundness Index (BRI)	4.05	0.84	4.85	<0.001	0.241	24.1	<0.001
Weight-adjusted-waist index (WWI)	2.40	0.52	4.58	<0.001	0.238	23.8	<0.001
Diastolic blood pressure (DBP)							
Conicity Index (CI)	10.08	4.83	12.80	<0.001	0.162	16.2	<0.001
Abdominal volume index (AVI)	0.271	0.11	2.45	0.015	0.159	15.9	<0.001

(Table 4) Contd….

Indices	β	Std. Error	t	*p*-value*	Change Statistics		
					R Square Change	% of Change	*p*-value*
Body Roundness Index (BRI)	1.89	0.68	2.77	0.006	0.162	16.2	<0.001
Weight-adjusted-waist index (WWI)	1.23	0.43	2.88	0.004	0.163	16.3	<0.001

Note: *The $p < 0.05$ level (2-tailed) is considered statistically significant.

The present findings indicated a significant positive correlation between SBP, DBP, and CI. The strength of this relationship varied according to different age sub-groups. While CI described 23.6% of the SBP changeability, it described 16.2% of the DBP changeability. The current results were supported by Donkor *et al*., who found that CI was positively and significantly associated with SBP, DBP, and fasting blood glucose [27]. CI had a significantly weak association with DBP and moderate correlation with SBP in the participants aged between 20 and 34 years, contrary to the findings in young adults aged 21−30 years in South Africa rural; CI had the strongest association with CVD risk factors (hypertension and dyslipidemia) [18]. Remarkably, according to Adegoke *et al*., CI was an independent predictor of hypertension, with an OR (95% CI) of 0.704 (0.555-0.894) [13]. On the other hand, in a sample of Albanians aged 15 to 59 years, Islam and colleagues evaluated the association between several indices, including the CI and hypertension, and they concluded that BMI performed better than the CI in both sexes [28].

The present findings indicated that SBP, DBP, and BRI had significant positive moderate correlations. Except for the age group from 45 to 65 years, where the association with DBP was weak, the moderate connections between the other age sub-groups and BRI continued. The regression model of BRI explained 24.1% of the variance in SBP and 16.2% of the variability in DBP. In line with the present findings, several observational studies have shown that the BRI can be used as an adipose indicator to determine high blood pressure or hypertension [2, 17, 29]. Both the SBP and DBP showed strong correlates with the BRI (r values of 0.42 and 0.46, respectively; p<0.001), supporting Jeppu and Kumar's notion that the BRI and WHtR are helpful tools for determining an individual's blood pressure [30]. Calderón-García and colleagues revealed that increased BRI was correlated to increased hypertension risk. Thus, BRI was a significantly better predictor of hypertension. Additionally, they confirmed that BRI has the ability to discriminate toward hypertension in adult men and women from different populations [1]. Furthermore, Tian *et al*. approved that the innovative index BRI, as opposed to BMI and WHtR, could be utilized as a single useful anthropometric measure in a cluster of cardiometabolic disorders (including diabetes, hypertension, metabolic syndrome, dyslipidemia, and hyperuricemia) in Chinese individuals [22]. Along the same lines, Liu and colleagues found that BRI had the greatest correlation with prehypertension and hypertension among nonobese Chinese respondents. In addition, BRI outscored CI in persons with normal BMI and WC for detecting prehypertension and hypertension. Therefore, BRI could be a valuable indicator for those with prehypertension and hypertension to manage their weight [31]. Moreover, BRI was significantly linked with high cardio-metabolic risk (OR 3.27, 95% CI 3.01–3.55). The optimal cut-off values of BRI for high cardio-metabolic risk were (< 60 y: 3.49 vs. ≥60 y: 3.46) in males and (< 60 y: 3.47 vs. ≥60 y: 3.60) in females [32]. Besides, BRI had the highest sensitivity for systolic and diastolic hypertension (70.1% and 65.9%, respectively) among male participants, according to Adegoke *et al*. [13]. Moreover, BRI could identify hypertension (AUC: 0.602 for males, 0.688 for females) as documented by Wu *et al*. [33]; however, we did not examine the gender differences in the present investigation's sample.

Additionally, the current findings indicated a significant positive moderate correlation between SBP, DBP, and AVI. The modest relationships between other age sub-groups and BRI persisted, except in the age range of 45 to 65 when the correlation with DBP weakened. The regression model of AVI explained 23.6% and 15.9% of the changeability detected on SBP and DBP, respectively. Among apparently healthy Ghanaian adults, Quaye and colleagues' results showed better performance by AVI and CI in the prediction of metabolic syndrome and its components in females [25] being aware that elevated blood pressure is a part of the metabolic syndrome and that it raises the risk of chronic diseases, such as CVD. An earlier study discovered that AVI had superior prediction power for metabolic syndrome compared to other novel anthropometric measures and conventional indicators [34].

In line with this study's findings, Adegoke *et al*. found that indices of central adiposity (AVI, WC, waist-to-height-ratio (WHtR), BRI) had a moderate predictive significance for hypertension. BRI, AVI, and CI cut-off values for predicting systolic and diastolic hypertension were generally higher in females than in males in Nigeria [13]. In addition, they discovered that BRI, CI, AVI, WC, and WHtR provided the highest and most similar AUCs with overlapping 95% confidence intervals in both genders and for both systolic and diastolic hypertension. AVI also displayed the largest AUCs, with systolic AUCs of 0.638 and diastolic AUCs of 0.658[13]. On the other hand, Wu *et al*. examined the anthropometric indices' propensity to predict metabolic syndrome in obese individuals. They discovered that AVI had the best ability to detect metabolic syndrome (AUC: 0.743 for males, 0.819 for females), whereas WHtR or BRI could also see hypertension and dysglycemia with reasonable accuracy [33].

Gowda and Philip discovered that AVI and CI might be used for the early management of metabolic diseases, including diabetes and hypertension [23]. Lee and colleagues looked at obesity-related indices to determine their capabilities in hypertension prediction. The optimal cut-off points for identifying hypertension in men and women were for

BRI (4.05, 4.32), AVI (16.31 cm^2, 13.83 cm^2), and CI (1.23 $m^{2/3}/kg^{1/2}$, 1.27 $m^{2/3}/kg^{1/2}$), according to their findings, which also revealed that the AUC of BRI, AVI, and CI among men were between 0.71 and 0.72 and for women were between 0.77 and 0.78. They concluded that while predicting the risk of hypertension, the central obesity-associated indices of waist-to-hip ratio (WHR), waist circumference (WC), and AVI performed better than the general indices of percentage body fat (PBF) and BMI, which are also connected to obesity [35].

While SBP had a moderate correlation with WWI in the present data, the DBP had a weak positive correlation. SBP and DBP correlations with WWI typically varied among age sub-groups, with minor differences in their strengths. The regression model of WWI explained a 23.8% changeability detected on SBP and 16.3% of the DBP variability. Consistently, to investigate the association between WWI and the incidence of hypertension in Rural Chinese, Li *et al*. examined data from 10,338 non-hypertensive participants. The highest WWI category (>10.91 cm/√kg) was 1.50-fold associated with hypertension as compared with the lowest WWI category (<9.94 cm/√kg); they found a non-linear association between WWI and hypertension [36]. Ding *et al*. found that higher WWI levels were also associated with increased levels of age, SBP, DBP, and higher prevalence of stroke and hypertension [3]. Although WWI was recognized by Park *et al*. and claimed to have strong predictive value for cardiometabolic illnesses, CVD, and all-cause mortality risk [24], Wu *et al*. classified it as a weak discriminator for metabolic syndrome [33]. Contrary to the present findings, Fang and colleagues found that each unit of higher WWI was linked to a 48% increase in CVD risk after controlling for all variables (OR: 1.48, 95% CI: 1.25-1.74). Additionally, the multivariable-adjusted OR in the highest quintile (≥11.8 cm/√kg) was 3.18 (95% CI: 1.80-5.59) compared to the lowest quintile (<10.3 cm/√kg). Likewise, more significant correlations between WWI and CVD were found in people under 50, according to subgroup analyses (p<0.001). Furthermore, high WWI levels were strongly related to an elevated risk of CVD in US individuals, especially in those under 50 [37]. Xiong and colleagues found that WWI might be an intervening factor in preventing and treating arterial stiffness and blood pressure management [38].

The current results highlight the significance of the present research in alerting medical and public health practitioners about the value of anthropometry in identifying the elevation of blood pressure and the link between central obesity-related indices and cardiometabolic risk and promoting the creation of novel solutions while firmly addressing this public health problem's necessity of reducing its growth and preventing the building up of its adverse consequences.

5. STRENGTHS AND LIMITATIONS

Regarding the research methods, some limitations need to be acknowledged. First, the findings of this cross-sectional study do not expressly establish a causal relationship between blood pressure and the CI, BRI, and other indices. As a result, we must be cautious when interpreting the current results, and additional cohort studies are required to shed more light on them. Second, we needed to explore the underlying mechanisms. Finally, participants of this study were from a central area, which may limit the generalizability of our findings to rural populations.

Notwithstanding these limitations, the study has many strengths, such as the use of multiple obesity indices enabled us to explore and determine the most usability measures for blood pressure and the potential clinical utility of these measures.

CONCLUSION

In conclusion, the obesity indices CI, AVI, BRI, and WWI may significantly impact blood pressure. BRI and AVI indices may have the highest impact and better indicators for blood pressure among obesity induces. The impact of obesity indices on DBP and SBP was affected by age group. Despite the age group, there was a moderate correlation between SBP and DBP with AVI and BRI. Given that these indices are non-invasive quick tools, studies to explore their potential as indicators of high blood pressure and some heart disease and defining the cut-off point for these conditions are advised and necessary. The innovative anthropometric markers are currently beneficial in several areas of health. They deserve clinical and public health promotion for their capacity to anticipate obesity-related problems like elevated blood pressure, dyslipidemia, diabetes, and hypertension, as well as deaths at an earlier stage. However, longitudinal studies in a larger population must explore their predictive power further.

AUTHORS' CONTRIBUTIONS

Conceptualization, I.A and L.A.; methodology, I.A., A.A., and B.A.; investigation, B.A., L.A., I.A., and A.A.; data curation, B.A., L.A., and I.A., ; writing—original draft preparation, B.A., A.A., and I.A.; writing—review and editing, B.A., L.A., I.A., and A.A.;; visualization, B.A., L.A., I.A., and A.A.; supervision, L.A. All authors have read and agreed to the published version of the manuscript.

LIST OF ABBREVIATIONS

AVI	=	Abdominal Volume Index
BMI	=	Body Mass Index
BRI	=	Body Roundness
CI	=	Conicity Index
CVD	=	Cardiovascular Diseases
DBP	=	Diastolic Blood Pressure
HC	=	Hip Circumference
NCD	=	Non-Communicable Diseases
SBP	=	Systolic Blood Pressure
WC	=	Waist Circumference
WWI	=	Weight-Adjusted-Waist Index

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was reviewed and approved by the institutional review board of Hashemite University, Jordan (No. 7/13/2020/2021).

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committees and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all participants of this study.

STANDARDS OF REPORTING

Strobe guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data supporting this study's findings are available from the corresponding author upon reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest financial or otherwise.

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