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The Relationship Between Obesity Indices and Blood Pressure Among the Population of Derna, Libya

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Abstract: Numerous epidemiological studies on obese adults have found significant correlations between various anthropometric indicators and hypertension; however, there is limited information on non-obese adults. This study investigated the relationship between several anthropometric indices, including body mass index (BMI), waist-height ratio (WHtR), waist-hip ratio (WHpR), waist circumference (WC), and hip circumference (HC), and the risk of hypertension. A cross-sectional survey was conducted on 140 non-obese adults (75 male and 65 female) over 25 years of age. Data was collected from five areas (Sahal al Sharqi, Bab Tobruk, Saiha, Sahal Al-Garbi, and Al-Blad) in Derna City. All participants were non-obese, normotensive, and not using any medications that affect energy regulation. The study employed multiple regression analysis, partial correlation, and descriptive statistics to compare anthropometric measures and blood pressure parameters. The findings indicated correlations between systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MABP) in relation to anthropometric indices. Certain measures demonstrated significant correlations with all blood pressure parameters, whereas others exhibited weaker associations. The study found that waist-to-height ratio (WHtR) was consistently correlated with SBP, DBP, and MABP in males. In females, waist circumference (WC) showed a consistent correlation with systolic blood pressure (SBP). These findings suggest that WHtR and WC could be valuable indicators for the potential development of high blood pressure.

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العلاقة بين مؤشرات السمنة وضغط الدم لدى سكان درنة، ليبيا

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الكلمات المفتاحية

المتغيرات الأنثروبومترية

مؤشرات السمنة

المحددات

غير المصابين بالسمنة

درنة

خلصت العديد من الدراسات الوبائية التي أجريت على البالغين المصابين بالسمنة إلى وجود ارتباطات معنوية بين مختلف المؤشرات القياسات البشرية (الأنثروبومترية) وارتفاع ضغط الدم؛ ومع ذلك، فإن المعلومات المتعلقة بالبالغين غير المصابين بالسمنة لا تزال محدودة. هدفت هذه الدراسة إلى استقصاء العلاقة بين عدة مؤشرات قياسات بشرية، منها مؤشر كتلة الجسم(BMI) ، ونسبة الخصر إلى الطول(WHtR) ، ونسبة

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الخصر إلى الورك(WHpR) ، ومحيط الخصر(WC) ، ومحيط الورك(HC) ، وخطر الإصابة بارتفاع ضغط الدم. أُجريت دراسة مقطعية شملت 140 بالغًا غير مصاب بالسمنة (75 ذكرًا و65 أنثى) ممن تزيد أعمارهم عن 25 عامًا. تم جمع البيانات من خمس مناطق (سحال الشرقي، وباب طبرق، وسيحا، وسحال الغربي، والبلاد) في مدينة درنة. كان جميع المشاركين غير مصابين بالسمنة، وذوي ضغط دم طبيعي، ولم يتناولوا أي أدوية تؤثر على تنظيم الطاقة. استخدمت الدراسة تحليل الانحدار المتعدد، والارتباط الجزئي، والإحصاء الوصفي لمقارنة القياسات البشرية ومتغيرات ضغط الدم. أشارت النتائج إلى وجود ارتباطات بين ضغط الدم الانقباضي(SBP) ، وضغط الدم الانبساطي(DBP) ، ومتوسط ضغط الدم الشرياني (MABP) فيما يتعلق بالمؤشرات القياسات البشرية. أظهرت بعض المقاييس ارتباطات معنوية مع جميع متغيرات ضغط الدم، في حين أظهرت مقاييس أخرى ارتباطات أضعف. وجدت الدراسة أن نسبة الخصر إلى الطول (WHtR) كانت مرتبطة بشكل ثابت بضغط الدم الانقباضي والانبساطي والمتوسط الشرياني لدى الذكور. أما لدى الإناث، فقد أظهر محيط الخصر (WC) ارتباطًا ثابتًا بضغط الدم الانقباضي .(SBP) تشير هذه النتائج إلى أن نسبة الخصر إلى الطول (WHtR) ومحيط الخصر (WC) يمكن أن يكونا مؤشرين قيمين لاحتمالية تطور ارتفاع ضغط الدم.

1. Introduction

Metabolic syndrome (MetS) refers to a cluster of interrelated risk factors, including obesity, dyslipidemia, hypertension, and elevated blood sugar [1]. Central abdominal fat and insulin resistance have been identified as key contributors to the development of MetS [2]. Growing evidence suggests that the distribution and location of body fat can serve as reliable markers for MetS and its associated risk factors [3]. Therefore, identifying a valid anthropometric index to assess both visceral and general obesity is critical [4,5].

In clinical and epidemiological research, obesity measures such as BMI, WC, and WHtR are commonly used. These indices have been found to be reliable indicators of metabolic health issues, including MetS, insulin resistance, hypertension, dyslipidemia, and cardiovascular diseases (CVDs) [6,7]. Studies have shown that BMI correlates positively with blood pressure, body lipid levels, and both random and fasting glucose levels [8].

body mass index is used worldwide to identify and categorize individuals who are overweight and obese. It serves as a preliminary screening tool for identifying individuals who may face issues related to being underweight or overweight [9]. Body fat-based anthropometric measures are essential for predicting higher risks of chronic diseases at both the individual and population levels [10].

The World Health Organization (WHO) uses BMI to assess the risk of metabolic syndrome, focusing on the extent of overweight and obesity. In addition to BMI, central adiposity indicators like waist-to-hip ratio (WHpR) and WC are considered reliable markers for these disorders [11]. The incorporation of WHtR as an additional measure is recommended to evaluate syndromes associated with obesity and overweight, such as hypertension [12].

Although body mass index, waist circumference, and weight-height ratio have been shown to be associated with hypertension in some age groups [13], to the best of our knowledge, no data is available regarding non-obese adults in Derna. The present study examined the relationship between obesity indices and the risk of hypertension. It also analyzed various anthropometric indices as predictors of hypertension in non-obese adults residing in Derna City, located in Northeastern Libya

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2. Materials And Methods

This study was conducted on non-obese adults aged over 25 (37.60 ± 10.65 years, both male and female) from February to April 2023. A total of 381 participants were randomly selected from five different areas—Sahal Al-Sharqi, Bab Tobruk, Saiha, Sahal Al-Garbi, and Al-Blad—in Derna city. The city is located in northeastern Libya on the Mediterranean Sea coast. The study included individuals who were permanent residents of Derna City. Participants were selected randomly. The study excluded individuals under the age of 25, those with known cases of hypertension or diabetes, athletes with significant muscle mass and obesity, pregnant women during the intervention period, individuals taking weight-gain supplements, and those diagnosed with cancer who had undergone chemotherapy.

Data was collected from approximately 381 non-obese adults. All participants underwent a physical examination to obtain anthropometric measurements. After applying the inclusion and exclusion criteria, 140 participants (male, 75; female, 65) remained for data collection. Individuals enrolled in this study underwent a physical examination to obtain anthropometric measurements. Body weight and height were recorded and rounded to the nearest 0.1 kg and 0.1 cm, respectively.

In the standing position, WC was measured by using tape applied horizontally midway between the lowest rib margin and the iliac crest, while HC was measured at maximal protrusion of the buttocks. The mean of two measurements was documented to the nearest 0.1 cm. The purpose of the study is initially explained to all participants before their written consent is obtained.

Body mass index is defined as the weight in kilograms divided by the square of the height in meters (kg/m^2). A BMI of less than 18.5 kg/m^2 will be classified as underweight, a BMI range of 18.5 to 24.9 kg/m^2 as normal weight, a BMI of 25.0 kg/m^2 up to 29.9 kg/m^2 as overweight, and a BMI of more than 29.9 kg/m^2 as obese. Weight-height ratio (WHtR) is calculated as waist circumference divided by height. Waist-hip ratio (WHpR) is calculated as waist circumference divided by hip circumference.

Blood pressure (BP) was measured concurrently with the anthropometric measurements while participants sat for at least 5 minutes of rest. A mercury sphygmomanometer was used for the BP measurements. Systolic BP was recorded as the first Korotkoff sound, and diastolic BP was recorded when the Korotkoff sound disappeared. The mean arterial blood pressure (MABP) is calculated as follows:

MABP = DBP + 1/3 Pulse Pressure (mm/Hg)

Pulse Pressure = Difference between systolic and diastolic blood pressure

Descriptive and inferential statistics were used to analyze data, including mean, standard deviation, polynomial logistic regression, and odds ratio. Correlations were deemed significant at $P \leq 0.05$, with 95% confidence intervals. The analyses of the data were conducted using the Statistical Package for the Social Sciences (SPSS Inc., version 26)

3. Results

The study sample consists of 75 males and 65 females with a mean BMI of 24.88 kg/m^2 ± 3.31 (male) and 24.66 kg/m^2 ± 3.25 (female), which is classified as normal weight, as presented in Table (1) Male participants were significantly taller and heavier than the female, while female participants had significantly smaller WC than male. The mean values of WHpR were 0.88 ± 0.05 for males and 0.81 ± 0.06 for females, both of which were slightly above the classified risk values. Additionally, the means of systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial blood pressure (MABP) were significantly higher in male participants compared to females, with a significance level of $P \leq 0.05$. No significant differences existed in age, BMI, HC, and WHtR between male and female participants ($P \leq 0.05$).

waist-to-height ratio significantly correlated with SBP (male: 0.019*), DBP (male: 0.025*), and MABP (male: 0.013*), while in females only, WC significantly correlated with SBP (0.035*). For the other indicators, no significant differences were observed.

Table (2) shows significant positive relationships between the obesity indices and blood pressure in both sexes.

Table (1). Descriptive characteristics of the study sample

Measurements	Mean ± SD		P < 0.05
	Male (n=75)	Female (n=65)	
Age (years)	38.05 ± 11.60	37.15 ± 9.50	0.615
Weight (Kg)*	76.39 ± 12.29	62.83 ± 8.66	0.000
Height (cm)*	175 ± 0.07	159 ± 0.05	0.000
Body mass index (kg/m^2)	24.88 ± 3.31	24.66 ± 3.25	0.698
Waist circumference (cm)*	89.93 ± 8.81	82.08 ± 8.57	0.000
Hip circumference (cm)	101.08 ± 7.26	100.72 ± 7.35	0.774
Weight-height ratio (WHtR)	0.51 ± 0.05	0.51 ± 0.05	0.986
Waist-hip ratio (WHpR)*	0.88 ± 0.05	0.81 ± 0.06	0.000
Systolic blood pressure (mmhg)*	121.47 ± 12.07	114.22 ± 12.84	0.001
Diastolic blood pressure (mmhg)*	77.27 ± 8.78	73.11 ± 8.78	0.006
Mean arterial blood pressure (mmhg)*	92.00 ± 9.09	86.81 ± 9.47	0.001

*Statistically significant difference of means at (CI 95%, P ≤ .05)

Table (2). Correlation between obesity indices and blood pressure.

Inde x	Male			Female		
	SBP	DBP	MABP	SBP	DBP	MABP
BMI	0.129 (0.269)	0.213 (0.066)	0.195 (0.094)	0.183 (0.144)	0.141 (0.263)	0.170 (0.176)
WC	0.144 (0.219)	0.211 (0.069)	0.200 (0.086)	0.263 (0.035)*	0.124 (0.323)	0.196 (0.118)
HC	0.025 (0.832)	0.196 (0.092)	0.137 (0.240)	0.166 (0.185)	0.068 (0.589)	0.117 (0.352)
WHtR	0.217 (0.019)*	0.259 (0.025)*	0.287 (0.013)*	0.224 (0.073)	0.166 (0.187)	0.204 (0.104)
WHpR	0.204 (0.079)	0.108 (0.358)	0.160 (0.171)	0.194 (0.121)	0.106 (0.400)	0.153 (0.222)

*Correlation is significant at the 0.05 level (P: ≤ 0.05)

The correlation between the dependent variables (SBP, DBP, and MABP) and the independent variables (BMI, WC, HC, WHtR, and WHpR) yielded different results. Some measures were significantly correlated with all blood pressure parameters, while others showed weaker correlations. Systolic blood pressure and the independent variables WC, WHtR, and WHpR were significantly correlated (p-values of 0.000, 0.005, and 0.000, respectively). However, BMI and HC did not have a significant effect on SBP at a 95% confidence level (p-values of 0.603 and 0.997, respectively). Diastolic blood pressure was significantly correlated with BMI (p = 0.031), WC (p = 0.000), WHtR (p = 0.005), and WHpR (p = 0.000), but HC (p = 0.103) was not significantly correlated. Mean arterial blood pressure (MABP) showed significant correlations with BMI (p = 0.029), WC (p = 0.001), WHtR (p = 0.005), and WHpR (p = 0.001), while HC (p = 0.127) was not significantly correlated with MABP Table (3).

Among the independent variables, BMI, WC, WHtR, and WHpR were associated with the blood pressure measures, with varying impacts. The correlation between WC and WHpR was consistent across all blood pressure measures. However, BMI was only significantly correlated with DBP and MABP, not with SBP. WHtR had a significant impact on SBP, DBP, and MABP. Out of all the measures, HC was the least significant and did not affect any of the dependent variables. To determine the value of WHpR, it is necessary to measure it accurately.

4. Discussion

Body mass index is the most widely used indicator for assessing obesity [14]. It has limitations, as it cannot differentiate between fat mass and lean mass. Additionally, its utility in distinguishing between body adiposity across different age groups, genders, and ethnic groups for a given BMI is restricted. Consequently, more specific anthropometric measures, such as WHtR, WHpR, and WC, have been developed and studied to improve the assessment of obesity-related health risks.

Table (3). Regression analysis examining the independent contribution of obesity indices to blood pressure.

Indices	SBP		DBP		MABP	
	R	p-value	R	p-value	R	p-value
BMI	0.158	0.063	0.183	0.031*	0.185	0.029*
WC	0.291	0.000*	0.248	0.003*	0.285	0.001*
HC	0.096	0.258	0.138	0.103	0.130	0.127
WHtR	0.237	0.005*	0.207	0.014*	0.235	0.005*
WHpR	0.312	0.000*	0.212	0.012*	0.272	0.001*

*Correlation is significant at the 0.05 level (P: ≤ 0.05)

In this study, most obesity indices (BMI, WC, WHtR, and WHpR) showed significant correlations with some blood pressure parameters. However, after accounting for gender differences, only two indicators remained significant: WHtR and WC. This suggests that the impact of these indicators may vary by gender, with WHtR having a stronger effect on males and WC more strongly influencing females. These variations could be attributed to the physiological differences between men and women.

Research has increasingly recommended using more relevant body fat distribution indices, such as WHtR and WC, for assessing hypertension and cardiovascular risks. Studies have found that WHtR and WC are significant risk factors for hypertension and cardiovascular events, particularly among elderly females in Egypt [15]. For males, WHtR has been identified as the most accurate anthropometric predictor of cardiovascular events and hypertension. This study further supports these findings by demonstrating that WHtR and WC were statistically better at identifying hypertension in non-obese adults compared to BMI and WHpR.

Significant correlations ($p \leq 0.05$) were found between male WC, BMI, WHtR, and the blood pressure parameters (SBP, DBP, and MABP). For females, WC also showed significant correlations with SBP. These results align with those from [16], which found a strong correlation between WC, WHtR, and blood pressure. Despite these findings, regression analysis did not reveal a significant influence of WHtR or WHpR on blood pressure, especially in females.

A study conducted in Saudi Arabia [17] found that certain anthropometric measures, such as WC and WHtR, were strong predictors of both DBP and SBP, with the exception of hip measurements. Specifically, WHtR was a significant predictor of isolated diastolic hypertension and combined systolic and diastolic hypertension, while WC was the best indicator of isolated systolic hypertension. The waist-to-hip ratio did not predict any hypertension subtypes.

These findings are consistent with an Italian study [18, 19], which found that WC and WHtR were useful in identifying overweight children who are at risk of developing metabolic and CVDs. The result of the study is also in agreement with the findings of many studies [20, 21], who showed WHtR to be a better predictor of CVDs than other anthropometric measurements, including BMI and WHpR. Overall, this study suggests that WHtR and WC are more reliable than BMI and WHpR for predicting hypertension risk in non-obese adults, particularly in different gender groups.

5. Conclusions

The study found that the WHtR was consistently correlated with SBP, DBP, and MABP in the male group. In females, WC was consistently correlated with SBP. This finding indicates that both the WHtR and the WC are the most effective predictors of visceral adiposity. It also implies that reducing intra-abdominal fat may contribute to lower blood pressure.

6. Abbreviations

WHtR, Waist-height ratio; WHpR, waist-hip ratio; WC, waist circumference; HC, hip circumference; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; BP, blood pressure; MABP, mean arterial blood pressure.

Conflict of interest: The authors declare no conflict of interest.

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