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Body Mass Index and Waist-Hip Ratio as Health Risk Predictors among selected Southern Nigerian University Undergraduates

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Abstract

Objective*: The use of clinical anthropometry in the evaluation of several forms of health risks associated with dietary patterns and lifestyle habits has been encouraged globally. This present study aimed to assess the body mass index (BMI) and waist-hip ratio (WHR) of selected South-Southern Nigerian tertiary students.*

Methods*: The study involved 100 students (50 males: 50 females) of Madonna University, Elele between 18 to 25 years. The health risk classification based on the BMI of both genders was grouped into seven (7) classes; severely underweight, underweight, normal weight, overweight, obese I, II, and III. The WHR health risk classification was grouped into three (3) classes for both genders; low, moderate, and high risks. A stadiometer was calibrated to the nearest 0.01m to obtain body height while body weight was measured to the nearest 0.1kg with a HD358 Tanita digital bathroom weighing scale. Waist (WC) and hip circumferences (HC) were measured to the nearest 0.5cm with a non-stretchable measuring tape.*

Results*: The study showed that the highest proportion of students was either normal (27%) or overweight (24%). Females had a mean BMI and WHR of 26.56kg/m^2 and 0.77, respectively while males had a mean BMI and WHR of 30.99kg/m^2 and 1.04, respectively. Based on WHR health risk classification, a higher percentage of males had a high risk (40%) in comparison to females (18%). There was a significant difference in the distribution of the WHR health risk classification between males and females (p=0.045).*

Conclusion*: The current study concluded that both BMI and WHR could significantly be utilized as health risk predictors of disorders associated with diet and lifestyle habits in the study population.*

Keywords*: Clinical anthropometry, body mass index, waist-hip ratio, South-Southern Nigeria, health risk.*

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Introduction

The assessment of health risks using anthropometric parameters involves using measurements of the human body, such as height, weight, body circumferences, and skinfold thickness, to evaluate an individual's body composition and potentially identify health-related concerns [1-3]. These measurements provide valuable insights into an individual's nutritional status, body fat distribution, and overall health risks. In the pursuit of achieving and maintaining optimal health, understanding and monitoring key indicators of body composition is crucial [4-5]. Two widely recognized metrics in this regard are Body Mass Index (BMI) and Waist-Hip Ratio (WHR). These measurements serve as valuable tools in assessing an individual's risk of various health conditions, ranging from cardiovascular diseases to metabolic disorders [3].

Body mass index (BMI) is a numerical value derived from an individual's weight and height [6]. It provides a standardized assessment of body composition, allowing for categorization into different weight status classifications such as underweight, normal weight, overweight, and obesity [6-8]. Underweight people usually have a BMI of less than 18.5, which is associated with health risks such as malnutrition, weakened immune system, osteoporosis, and reproductive issues [9-10]. Those with normal weight possess a BMI ranging from 18.5 to 24.9 and are generally considered a healthy range for most people. Overweight individuals tend to have a BMI between 25 to 29.9, which is closely linked to health risks including increased risk of heart disease, high blood pressure, type 2 diabetes, and other health issues. The Class I obese individuals do have a BMI ranging from 30 to 34.9 which predisposes them to certain health risks such as elevated risk of cardiovascular disease, type 2 diabetes, sleep apnea, and certain cancers [11-13]. Class II obese individuals have a BMI ranging from 35 to 39.9, accompanied by a significant increase in risk for serious health conditions including heart disease, stroke, and type-2 diabetes. Finally, class III obese individuals do have a BMI of 40 or higher, which together with an extremely high risk of developing serious health conditions like heart disease, stroke, diabetes, and certain cancers [11, 14]. Since its inception, BMI has been extensively utilized by healthcare professionals, researchers, and policymakers as an initial screening tool to evaluate an individual's weight-related health risks [6, 15-17].

In addition to BMI, the Waist-Hip ratio (WHR) offers a deeper insight into the distribution of body fat. The waist-hip ratio (WHR) is then calculated by dividing the waist circumference by the hip circumference. In men, the WHR classifications for health risks are as follows, low risk with a WHR less than 0.90, moderate risk with a WHR between 0.90 and 0.99, while for high risk, the WHR is usually 1.00 or higher. In women, the WHR classifications for health risks are as follows, low risk with a WHR less than 0.80, moderate risk with a WHR between 0.80 and 0.84, while for high risk, the WHR is usually 0.85 or higher [18-20]. A lower WHR tends to suggest a healthier distribution of body fat, which is associated with a lower risk of cardiovascular diseases and other obesity-related health issues [11, 21-22]. Individuals who fall under the moderate WHR indicate an increased risk compared to individuals with a lower WHR. It suggests that there may be a higher proportion of abdominal fat, which is associated with higher health risks. A higher WHR indicates a potentially significant accumulation of abdominal fat. This is associated with a higher risk of conditions like heart disease, type 2 diabetes, and certain cancers [7, 23]. Unlike BMI, WHR specifically focuses on the distribution of fat around the abdomen and hips. This ratio is obtained by dividing the circumference of the waist by that of the hips. A higher WHR signifies an increased accumulation of visceral fat, which is known to be associated with a higher risk of metabolic disorders, cardiovascular diseases, and other health complications [24-26].

The significance of BMI and WHR lies not only in their ability to identify potential health risks but also in their versatility as tools for health interventions [7, 27]. By understanding the implications of these indicators, individuals can make informed decisions regarding lifestyle choices, including diet, exercise, and other preventive measures. Furthermore, healthcare providers can use these metrics to formulate personalized health plans and track the progress of their patients over time. For example, body mass index (BMI) is a commonly used tool for classifying individuals into different health risk categories based on their weight relative to their height. It provides a general assessment of whether a person is underweight, normal weight, overweight, or obese [6, 8]. The waist-hip ratio (WHR) is another useful tool for assessing health risks associated with body fat distribution. It takes into account the distribution of fat around the abdomen and hips as a higher WHR indicates that more fat around the waist is associated with increased health risks [11, 21, 28] . However, it is crucial to acknowledge that while BMI and WHR are valuable screening tools, they do have limitations. They do not provide a comprehensive assessment of an individual's overall health, taking into account factors such as muscle mass, bone density, and specific health conditions [29]. Though, a general approach to health assessment, involving additional measurements and clinical evaluations, is essential for a thorough understanding of an individual's well-being. Therefore, this current study aimed to evaluate the Body Mass Index (BMI) and Waist-Hip Ratio (WHR) of selected South-Southern Nigerian students and explore whether these variables can provide an understanding of possible health risks associated with these student populations.

Materials and Methods

This study employed a cross-sectional, and a descriptive design to assess the BMI and WHR of students of Madonna University, Elele within the ages of 18 to 25 years. Out of 100 students, 50 were males while 50 were females. Before the period of collection of data, ethical approval was obtained and informed consent was obtained from each participant as the purpose of this study was explained to them. The inclusion criteria were that selected participants were devoid of any physical deformities, and had not taken any meal six hours before the point of obtaining measurements. Individuals who met the inclusion criteria were randomly selected using a non-probability, convenience sampling technique. The materials used in carrying out the study include a stadiometer, measuring tape, and weighing scale.

Upon the calibration of the stadiometer to the nearest 0.01m, body height was measured while body weight was measured to the nearest 0.1kg with an HD358 Tanita digital bathroom weighing scale. The body mass index (BMI) was then calculated from the weight and height using the standardized formula ($\mathrm{BMI} = \mathrm{Weight}/\mathrm{Height}^2$). Both waist (WC) and hip circumferences (HC) were measured (in centimeters) to the nearest 0.5cm with a non-stretchable measuring tape. WC was measured at a point midway between the iliac crest and the lower rib margin on both sides while HC was measured at the widest point of the buttocks [30]. Waist-hip ratio (WHR) was calculated by dividing the waist circumference by the hip circumference. All measurements were performed twice and the calculated means were recorded to ensure the precision of data.

Statistical Analysis: Data was analyzed using Statistical Package for the Social Sciences (SPSS IBM version 23.0) and Microsoft Excel 2016 edition. Both descriptive and inferential statistics were employed and the results were presented in the form of tables. Independent sample t-test was used to determine gender differences in measured parameters. Pearson correlation was used to determine correlation statistics between observed variables in the studied population. The chi-square test was used to determine the association between gender and body mass index classification in the studied population. The levels of statistical significance were set at a p-value less than 0.05.

Results

Out of a total of 100 subjects as shown in Table 1, 5% were severely underweight, 3% were underweight, 27% had a normal weight, 24% were overweight, 19% belonged to the obese class I, 13% belonged to the obese class II and 9% belonged to the obese class III. Table 2 shows the descriptive statistics of weight, height, waist circumference (WC), hip circumference (HC), body mass index (BMI), and waist-hip ratio (WHR) in the population. The mean weight was 90.36kg, mean height was 1.78m, mean WC was 77.96cm, mean HC was 89.16cm, mean BMI was 28.78kg/m^2, and mean WHR was 0.91.

Table 3 depicts the descriptive statistics of all variables for the female category. Their mean weight was 80.78kg, mean height was 1.75m, the mean WC was 72.13cm, mean HC was 94.22cm, mean BMI was 26.56kg/m^2, and the mean WHR was 0.77. Table 4 illustrates the descriptive statistics of all variables for the male category. Their mean weight was 99.94kg, mean height was 1.81m, the mean WC was 83.79cm, mean HC was 84.11cm, mean BMI was 30.99kg/m^2, and the mean WHR was 1.04.

Table 4 shows that using an independent t-test, the results showed male subjects had significantly higher mean values in weight, height, waist circumference (WC), body mass index (BMI), and waist-hip ratio (WHR) while females showed significantly higher mean value for hip circumference ($p<0.05$).

Table 5 describes the gender-based chi-square test of association in health risk classification using the BMI between male and female subjects in the studied population. No statistically significant difference was observed in the distribution of the health risk classification between males and females (p=0.052).

In Table 6, significant and strong correlations were observed between weight and waist circumference (r=0.580, p=0.001), and body mass index (r=0.786; p=0.001) while although significant, several weak correlations were observed between weight and height (r=0.263; p=0.008), hip circumference (r=0.207; p=0.039) and waist to hip ratio (r=0.298; p=0.003). A significant but weak correlation was observed between height and body mass index (r=-0.374; p=0.001). While weak and non-significant correlation was observed between height and waist circumference (r=0.102; p=0.314), hip circumference (r=0.001; p=0.998), and waist-to-hip ratio (r=0.089; p=0.376).

A significant but weak correlation was observed between waist circumference and hip circumference (r=0.433; p=0.001), body mass index (r=0.492; p=0.001), and waist-to-hip ratio (r=0.479; p=0.001). A significant but weak correlation was observed between hip circumference and body mass index (r=0.197; p=0.049) and waist-to-hip ratio (r=-0.551; p=0.001). A significant but weak correlation was also observed between body mass index and waist-to-hip ratio (r=0.235; p=0.018).

Table 7 explains the gender-based chi-square test of association in health risk classification using the WHR between male and female subjects in the studied population. Females with a lower health risk were more predominant than males with 70% and males with a higher health risk were more predominant than the females with 40%. A statistically significant difference was observed in the distribution of the health risk classification between males and females (p=0.045).

Table 1. Distribution of Body Mass Index classification of the studied population

Body Mass Index classification	Frequency (%)
Severely underweight	5 (5.0)
Underweight	3 (3.0)
Normal	27 (27.0)
Overweight	24 (24.0)
Obese Class I	19 (19.0)
Obese Class II	13 (13.0)
Obese Class III	9 (9.0)

Table 2. Descriptive statistics of measured variables in the studied population.

Variables	N	Minimum	Maximum	Mean	Standard Deviation
Weight (kg)	100	43.00	140.00	90.36	22.89
Height (m)	100	1.37	2.08	1.78	0.15
WC (cm)	100	23.50	125.00	77.96	18.14
HC (cm)	100	24.50	121.30	89.16	20.84
BMI (kg/m^2)	100	13.99	45.82	28.78	7.72
WHR	100	0.51	2.05	0.91	0.28

N = Number of participants

Table 3. Descriptive statistics of measured variables based on gender in the studied population.

Gender	Variables	N	Minimum	Maximum	Mean	Standard Deviation
Female	Weight (kg)	50	43.00	140.00	80.78	25.02
	Height (m)	50	1.37	2.08	1.75	0.15
	WC (cm)	50	23.50	99.10	72.13	16.82
	HC (cm)	50	24.50	121.30	94.22	20.83
	BMI (kg/m^2)	50	13.99	45.82	26.56	8.23
	WHR	50	0.51	1.41	0.77	0.13
Male	Weight (kg)	50	73.00	140.00	99.94	15.67
	Height (m)	50	1.54	2.03	1.81	0.14
	WC (cm)	50	53.00	125.00	83.79	17.68

HC (cm)	50	50.80	115.70	84.11	19.79
BMI (kg/m^2)	50	20.11	44.65	30.99	6.55
WHR	50	0.59	2.05	1.04	0.32

N = Number of participants

Table 4. T-test inferential statistics of the observed variables based on gender in the studied population.

Variables	Gender	N	Mean	Standard Deviation	t	df	P-value
Weight (Kg)	Female	50	80.78	25.020	-4.589	98	**0.001**
	Male	50	99.94	15.672			
Height (m)	Female	50	1.7464	0.14679	-2.049	98	**0.043**
	Male	50	1.8060	0.14404			
WC (cm)	Female	50	72.1342	16.81653	-3.378	98	**0.001**
	Male	50	83.7886	17.67845			
HC (cm)	Female	50	94.2150	20.82454	2.488	98	**0.015**
	Male	50	84.1068	19.78919			
BMI (kg/m^2)	Female	50	26.5642	8.22490	-2.979	98	**0.004**
	Male	50	30.9920	6.54558			
WHR	Female	50	0.7696	0.13189	-0.562	98	**0.001**
	Male	50	1.0394	0.31661			

N = Number of participants, df = degree of freedom

Table 5. Gender-based Chi-square test of association in the BMI health risk classification in the studied population

Body Mass Index classification	Gender		Chi-square	df	p-value
	Female	Male			
Severely underweight	5 (10.0%)	-	12.475	6	0.052 (NS)
Underweight	3 (6.0%)	-			
Normal	16 (32.0%)	11 (22.0%)			
Overweight	11 (22.0%)	13 (26.0%)			
Obese Class I	6 (12.0%)	13 (26.0%)			
Obese Class II	5 (10.0%)	8 (16.0%)			
Obese Class III	4 (8.0%)	5 (10%.0)			

(NS = Not Significant)

Table 6. Pearson Correlation statistics between observed variables in the studied population.

		Weight (Kg)	Height (m)	WC (cm)	HC (cm)	BMI (kg/m^2)	WHR
Weight (Kg)	Pearson Correlation	1	0.263**	0.580**	0.207*	0.786**	0.298**
	Sig. (2-tailed)		**0.008**	**0.001**	**0.039**	**0.001**	**0.003**
	N	100	100	100	100	100	100
Height (m)	Pearson Correlation	0.263**	1	0.102	0.001	0.374**	0.089
	Sig. (2-tailed)	**0.008**		0.314	0.998	**0.001**	0.376
	N	100	100	100	100	100	100
WC (cm)	Pearson Correlation	0.580**	0.102	1	0.433**	0.492**	0.479**
	Sig. (2-tailed)	**0.001**	0.314		**0.001**	**0.001**	**0.001**
	N	100	100	100	100	100	100
HC (cm)	Pearson Correlation	0.207*	0.001	0.433**	1	0.197*	0.551**
	Sig. (2-tailed)	**0.039**	0.998	**0.001**		**0.049**	**0.001**
	N	100	100	100	100	100	100
BMI (kg/m^2)	Pearson Correlation	0.786**	-0.374**	0.492**	0.197*	1	0.235*
	Sig. (2-tailed)	**0.001**	**0.001**	**0.001**	**0.049**		**0.018**
	N	100	100	100	100	100	100
WHR	Pearson Correlation	0.298**	0.089	0.479**	-0.551**	0.235*	1
	Sig. (2-tailed)	**0.003**	0.376	**0.001**	**0.001**	**0.018**	
	N	100	100	100	100	100	100

**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).

Table 7. Gender-based Chi-square test of association in the WHR health risk classification in the studied population

Health Risk Classification	Gender		Chi-square	df	p-value
	Female	Male			
Low (Female: <0.80; Male <0.90)	35 (70.0%)	27 (54.0%)	6.205	2	**0.045**
Moderate (Female: 0.80 – 0.84; Male: 0.90 – 0.99)	6 (12.0%)	3 (6.0%)			
High (Female: ≥0.85; Male: ≥1.00)	9 (18.0%)	20 (40.0%)			

Discussions

The burden of health risks due to diet and lifestyle habits is a significant global public health concern [31-33]. Poor diet and unhealthy lifestyle choices contribute to a range of chronic diseases and conditions that can lead to reduced quality of life, increased healthcare costs, and even premature death [34-35]. Examples of the major health risks associated with diet and lifestyle habits include obesity, cardiovascular diseases, type 2 diabetes, hypertension, etc. The clinical assessments of health risks using anthropometric approaches involve the systematic measurement of various body parameters to gather information about an individual's physical health, growth, development, and nutritional status. These measurements are used to diagnose, monitor, and manage various health conditions [36-38]. They can provide awareness of an individual's body composition, including measures of body fat percentage, muscle mass, and distribution of fat. Parameters like weight-for-age, height-for-age, weight-for-height, and body mass index (BMI) are used to identify malnutrition, both under-nutrition and over-nutrition [39-40]. For individuals with chronic health conditions, such as obesity, diabetes, or cardiovascular disease, clinical anthropometry can be a valuable tool in assessing disease progression and response to treatment. The current study was done to understand the possible health risks of selected South-Southern Nigerian students upon the application of BMI and WHR.

Based on the assessment of health risks from BMI in the sample population of the present study, those with normal and overweight BMI formed the highest proportions among these undergraduates 27% and 24% respectively while other categories of BMI made up for the lowest proportions among them. The statement is consistent with global trends in BMI distribution, where individuals falling within the normal and overweight categories tend to be the majority in many populations. Research indicates that individuals in these categories generally have a lower risk of various health conditions compared to those classified as underweight or obese [6, 41-42]. However, it's important to note that within the overweight category, there can still be varying levels of health risk depending on factors such as the distribution of fat and overall lifestyle. It is also important to recognize that BMI distributions can vary based on demographic factors such as age, gender, and ethnicity [43-44]. Furthermore, regional or cultural differences may influence the prevalence of different BMI categories [45-46]. While having a normal or overweight BMI might indicate a lower immediate risk of health problems, it does not necessarily guarantee long-term health. Lifestyle choices, such as diet and exercise, play a significant role in overall health and should be considered in conjunction with BMI.

In trying to explain and compare the descriptive statistics of measured variables between gender categories in line with related literature, there were significant differences between females and males in terms of weight, height, waist circumference (WC), hip circumference (HC), BMI, and waist-to-hip ratio (WHR). The mean BMI values for both females (26.56 kg/m^2) and males (30.99 kg/m^2) suggest that, on average, individuals in both categories fall within the overweight range. This is consistent with global trends, where a considerable portion of the population, regardless of gender, is classified as overweight or obese [6, 42, 46]. The mean waist circumference values for females (72.13 cm) and males (83.79 cm) indicate that, on average, the males have a larger waist circumference. Elevated waist circumference is associated with an increased risk of metabolic conditions like diabetes and cardiovascular diseases, as supported by research emphasizing the importance of central obesity as a predictor of health risks [24, 47]. The mean hip circumference values for females (94.22 cm) and males (84.11 cm) suggest that, on average, females have wider hips. The mean WHR for females (0.77) indicates a lower risk for central obesity-related health issues, while the male category's mean WHR (1.04) suggests a higher risk. This aligns with literature highlighting WHR as a valuable indicator of body fat distribution and associated health risks.

In line with the results of the present study, there was a significant and moderately strong positive correlation ($r=0.580$) between weight and waist circumference (WC). This suggests that as weight increases, WC tends to increase as well [6, 48]. Also, there was a significant and strong positive correlation ($r=0.786$) between weight and BMI. This means that as weight increases, BMI also tends to increase [6, 49-50]. However, there was a significant but relatively weak positive correlation ($r=0.263$) between weight and height, signifying that as weight increases, height tends to increase to some extent. Furthermore, there was a significant but weak positive correlation ($r=0.207$) between weight and hip circumference (HC), implying that as weight increases, HC tends to increase, but the relationship is not as strong as with WC [51]. The p-value of 0.039 indicates that this correlation is statistically significant. In addition, there is a significant but weak positive correlation (r=0.298) between weight and waist-to-hip ratio (WHR). This means that as weight increases, the ratio tends to increase, indicating a potentially higher proportion of abdominal fat [6, 52-53]. The p-value of 0.003 indicates that this correlation is statistically significant. There is a significant but weak negative correlation (r=-0.374) between height and BMI. This suggests that as height increases, BMI tends to decrease.

As shown from the study results, there were significant differences in health risk classifications between males and females in the studied population when the WHR was considered. This means that a larger proportion of females (70%) in the study population were classified as having a lower health risk. This could be due to various factors such as differences in body composition, hormonal influences, and potentially healthier lifestyle habits. Conversely, among males, a larger percentage (40%) was classified as having a higher health risk. This could indicate that, on average, males in the study population had a higher proportion of risk factors associated with health conditions like obesity, heart disease, and diabetes [6, 54-55]. This indicates that the observed difference in health risk distribution between males and females is unlikely to have occurred by chance alone at a p-value of 0.045. The study suggests that there are notable gender differences in health risk distribution [56]. This highlights the importance of considering gender-specific health interventions and tailored approaches to address specific risk factors.

The limitations of this study would be that due to ethnic differences in body composition and genetics among racial populations, the health risks that are associated with the limits of BMIs and WHRs in this study might not be universally appropriate across other racial groups. The sample size of the study is only a true representation of the undergraduates of Madonna University, Elele, and not the entire undergraduate population of all Nigerian universities. **Conclusion**

The current study concludes that both BMI and WHR could significantly be utilized as health risk predictors of disorders associated with diet and lifestyle habits in the study population. Understanding the gender differences in the application of these clinical anthropometric variables can be crucial for public health agencies in South-Southern Nigeria towards the promotion of healthy lifestyles and management of health disorders associated with abuse of dietary and lifestyle habits.

These study findings might have implications for public health initiatives on the university campus. For example, there might be a need for targeted interventions to address issues related to nutrition and physical activity. It is also important to consider that while BMI is a useful screening tool, it does not provide a complete picture of an individual's health. Other factors like muscle mass, body composition, and metabolic health should also be taken into account.

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Conflicts of Interest

There is no form of competing interests that exists among the authors.

Author's Contributions

All authors contributed to the various components of the study such as research design, collection of data and its analysis, write-up of the initial and final manuscript, and the submission of the finalized manuscript

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