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Comparative Assessment of Obesity Using Body Mass Index and Waist-To-Height Ratio among Freshmen Undergraduates Who Secured Admissions into a Private Tertiary Institution

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Abstract

Background : Obesity is the accumulation of adipose tissue beyond the normal limit to the extent of affecting both physical and psychosocial health. It is now considered a pandemic with an increasing rate in adults, adolescents and children worldwide. ***Objective :*** This study aimed to determine the prevalence of obesity using various anthropometric indices among fresh-men university students in a private university. ***Methods :*** A cross-sectional pre-admission school-based questionnaire was administered to collect socio-demographic data followed by physical assessment to collect data on the weight, height, and waist circumference of the students. ***Results :*** There were 1329 male and 1428 females, giving a ratio of 0.93:1. Most of study participants were 18 years and above (n=2554, 92.6%), with the mean age of 18.9±1.503. Majority of study subjects (n=2267, 82.2%) were in the 51-100 kg weight categories with mean weight is 69.38±17.90 kg. Also, most study participants were above 1.5m in height, with a mean height of 1.69±11.9 m. The BMI showed that among the study participants, 137 (5.0%) were underweight, 1852 (67.2%) had healthy weight, and 373 (13.5%) were overweight, while 395 (14.3%) were obese. The measured WHtR showed that 267 (9.7%) were underweight, 1984 (72.0%) had normal weights, 114 (4.1%) were overweight, while 392 (14.2) were obese. The Mean waist to height ratio was 0.45±0.07. Age and gender varied significantly with BMI (P<0.001 and p= 0.04 respectively), WC (P<0.001 and p=0.02 respectively), while age and ethnicity varied significantly with WHtR (p<0.001 and p=0.033 respectively). BMI and WHtR performed better than WC in identifying freshmen with obesity. When compared with BMI, WHtR had a sensitivity of 56.8% and a specificity of 96.2% with a positive predictive value of 93.7.% and a negative predictive value of 6.9%. ***Conclusion :*** This study shows that a significant number of fresh-men university students, especially females above the age of 18 years are obese. This underlines the fact that obesity is fast becoming a public health issue among adolescents and young adults in developing countries. The need for the utility of BMI, WC and WHtR in identifying individuals with obesity cannot be over emphasized. ***Keywords:***body mass index, obesity, overweight, underweight, waist circumference, waist-to-height ratio

Introduction

There is an exponential increase in the population of obese people globally, with an estimated 30% of the world's population being either overweight or obese resulting in increased morbidity and mortality from its sequelae in both developed and developing world. [1, 2] Obesity is defined as the accumulation of adipose tissue beyond the normal limit to the extent of affecting both physical and psychosocial health. [2, 3]It is now considered a pandemic [4] withan increasing rate in adults, adolescents and children in about 144 countries. [2]The International Obesity Task Force (IOTF) reported that about 1 out of 10 children globallyare overweight, the number of children and adolescents classified as overweight and obese are 155 million and 30 – 45 million respectively. [5]

Childhood and adolescent obesity is the end result of a complex interaction of psychosocial, biological, environmental and behavioral factors(sleep duration, computer usage time, television viewing time, physical activity, and food consumption), it is a key early predictor of adult obesity[6, 7] Obesity results when energy intake exceeds energy expenditure (a positive energy balance)[7, 8, 9].Parental obesity, higher parental education, family size and family patterns of inactivity, the obvious transition from the traditional diet with a high intake of cereals and vegetables and low intake of animal food, to the Western pattern of high intake of animal foods and other high-energy-dense foods, reduced physical activities to a more sedentary lifestyle, more screen time. [8, 10, 11]

Overweight and obesity can be assessed by various methods, although hydrostatic weighing and dual-energy X-ray absorptiometry (DEXA) stand out among the indirect methods, their usage on a large scale is hampered by the high cost and need for a qualified technical team for assessing the measurements thus limiting their use to only clinical research settings, Magnetic resonance imaging (MRI) can also be used.[2, 12] Among double the indirect methods, anthropometry is considered a simple, rapid, inexpensive method that can be used on for a large population.[13]

Due to the lack of simple, accurate methods for assessing body fat directly, anthropometric measures such as skin fold, circumferences and weight and height indices are often used as an alternative for assessing body composition, [14] the most widely used is the Body mass index (BMI).BMI was developed by AdolpheQuetelet in 1832,[15]and has been extensively used as a traditional proxy measure of adiposity. [16]It is a weight-for-height measure and thus can't differentiate between fat and muscle mass and also unable to establish regional fat distribution,[17]because of these important limitations, the discriminatory power of BMI is being questioned in practice as, there is a possibility of overestimation of fat accumulation in tall people, and underestimation in short people.[16]More importantly, the limitation in estimating central obesity matters, as

abdominal fat, is a more specific Cardiometabolic (CM)risk predictor compared with overall body fat. [17, 18]

Waist circumference (WC) has the advantage of being able to assess central adiposity; [19] however, it has different cutoff points for men and women anda variation in diagnostic thresholds between ethnic groups.[17] Similarly, the waist to hip ratio (WHR) as a measure of relative fat distribution requires specific gender and ethnic group cutoff points. Furthermore, during weight loss, there is a reduction of both waist and hip circumferences, with minimal change in the ratio of waist to hip circumference and therefore limits the practical utility. [18, 20] To eliminate the confounding impact of height on the association between anthropometry and CM risk, waist-to-height ratio (WHtR) was proposed as a simple, noninvasive, and effective screening tool[20] benefiting from the extensive literature to support its use in relation with CM risk,[18, 21] and cross validation with a widely used universal cutoff point measure for identification of the abdominal obesity in different ethnic groups. [18, 22, 23]

Bergman et al. proposed another measure, Body Adiposity Index (BAI), calculated from hip circumference and height as a predictor of percentage body fat, which was validated against dual-energy X-ray absorptiometry (DXA) measurements in a large sample of Mexican adults. [24]Several studies confirmed validity and practical use of BAI. The Clinica Universidad de Navarra-Body Adiposity Estimator (CUN-BAE) has been proposed to estimate percentage body fat from BMI, gender, and age. [25] A Body Shape Index (ABSI) was developed taking into consideration WC as a proxy measure of abdominal obesity but adjusting for weight and height.[18, 26]

World health organization (WHO) classify obesity using BMI: BMI < 18.5 is underweight, BMI 18.5-24.9 is within normal range, BMI 25-29.9 is pre-obese, BMI >30 depicts obesity. The pre-obese category is often referred to as overweight, despite the fact that, the term technically refers to individuals having a BMI of 25 or above, which includes the obese. Obesity is further subdivided into three categories: BMI 30-34.9 - Class I, BMI 35-39.9 - Class II, BMI>40 - Class III.[5, 27] Otherclassifications include: Overweight = age and gender-specific BMI at ≥85th to 94th percentile, Obesity = age and gender-specific BMI at ≥95th percentile.[28]Obesity: BMI-for-age more than 2 SD above the WHO growth reference median, Overweight: BMI-for-age more than 1 SD above WHO growth reference median. [29]

The physical and psychological health consequences of obesity extend from childhood and adolescents to adult life. Obesity is a direct cause ofgastrointestinal, musculoskeletal and orthopedic complications, sleep apnea, and the accelerated onset of cardiovascular disease and type-2 diabetes in childhood.[12] Obesity in childhood can cause difficulties

with behavior and emotion leading to depression, stigmatization, low self-esteem and poor socialization and academic performance.[28, 30]Obese children are more likely to become obese adult with the effect on the economy and health of the individual, family and the society.[15, 16]Childhood obesity has a permanent effect on the health in adulthood, though controlling BMI in adulthood will reduce morbidity and mortality.[31]

Major health threats associated with overweight and obesity include dyslipidaemia, metabolic syndrome.[5]Evidence suggests that childhood and adolescent obesity can have a sizeable health impact. Obese children and adolescents have an increased risk of asthma, and nonalcoholic fatty liver disease; are more likely to have cardiovascular risk factors; and have greater anesthesia risk.[5] They may also experience more mental health and psychological issues such as depression8 and low self-esteem.[28, 32]Promoting intake of healthy foods and physical activities leads to effective weight management.[29]The United States Preventive Services Task Force(USPSTF) found that effective comprehensive weight-management programs incorporated counseling and other interventions that targeted diet and physical activity. Interventions also included behavioral management techniques to assist in behavior change.[28]

Other forms of management include medications (Orlistat, Sibutramine), [28] and surgery (Bariatric surgery) for severe cases. The most performed procedures are Roux-en-Y gastric bypass (RYGB) (Jejunojejunal anastomosis and Gastrojejunal anastomosis) and sleeve gastrectomy.[1]All children and adolescents from 6 years upward should be screened for overweight and obesity and managed appropriately following the (USPSTF recommendation.[28]The message to be preached is “keep your waist less than half your height”.[1, 20] This study was designed to evaluate the prevalence of obesity and pre-obesity and associated factors among fresh undergraduate students at Babcock University, Ilishan Remo, Ogun sate, Nigeria.

Methodology

Study Population/Setting

The study was conducted at the health post of a private tertiary institution in Ilishan-Remo, Ogun State, Nigeria. The health post is located within the university campus in Ikenne Local Government, Ogun state, Nigeria. The university is privately owned by the Seventh Day Adventist Church, Nigeria. All students age 15 years and above who attended the health post of the university, and gave both written and verbal informed consent were included in the study. Students who were acutely ill or undergoing treatment for any chronic illness were excluded from the study.

Study design and duration

This was a cross-sectional study of fresh undergraduates seeking admission to study various courses in a tertiary educational institution in Nigeria. The study subjects were recruited at the health post of the university during pre- admission medical screening.

Study population and duration

The study population consisted of adolescent male and female undergraduate students who were newly enrolled into various undergraduate programs in a tertiary institution. We included students who had no acute illness nor were being treated for any chronic medical illness. We employed consecutive sampling method in this study. The study questionnaire was administered after obtaining oral and written informed consent between August and September, 2022.

Sample size estimation/Sampling technique

We employed a consecutive sampling method in a sample population of two thousand, nine hundred and seventy three (2,973) students, excluding those with acute and chronic medical conditions. Two hundred and sixteen (216) subjects were excluded from the study as they did not fulfill the inclusion criteria. However, two thousand, seven hundred and fifty-seven (2,757) participants took were enrolled for this study.

Data collection

Student who presented to the health post, fulfilled the inclusion criteria and gave oral and written informed consent were recruited for the study. Data for this study was collected with the aid of a self-administered questionnaire. The data collected included the socio-demographic characteristics such as gender, age, ethnicity, and religion after which the height, weight, and waist circumference were measured.

Body weight was measured with a weighing scale after checking for zero error at each measurement and the reading was taken to the nearest 0.1 kg. Subjects were weighed barefooted, stood still, without support. Belts and other accessories were removed and pockets emptied.[7, 16] Height was measured with a stadiometer to the nearest 0.5 cm. Subjects were barefooted, stood erect, with heels together and looked straight ahead. The lower edge of the socket was in the same horizontal plane as the external auditory meatus, and heels and back were pressed against the height rule, while the headpiece was gently brought down until it touched the hair without exerting any pressure on the head.[16, 17, 19]

The waist circumference was measured using a tape measure wrapped around the belly half-way in-between the hip and the bottom of the ribs, just above the belly button. The measurement was taken while the subjects were expirating. For men, a waist circumference below 94cm (37in) is 'low risk' for obesity, 94–102cm (37-40in) is 'high risk' for obesity and more than 102cm (40in) is 'very high' for obesity. For women, below 80cm (31.5in) is low risk, 80–88cm (31.5-34.6in) is high risk and more than 88cm (34.6in) is very high.[19]

This is a measure of healthy adiposity; waist to height ratio 0.4-0.49, indicates no or low risk for obesity, value of 0.5-0.59 indicative of high risk for obesity, and waist to height ratio 0.6 or more, indicating very high risk for obesity.[4]BMI was calculated as body weight divided by squared height (kg/m2) and classified Underweight = < 5th percentile, Healthy Weight = 5th percentile to < 85th percentile, Overweight = 85th percentile to < 95th percentile, Obesity = ≥ 95th percentile or greater, Severe Obesity = 120% of the 95th percentile or greater OR 35 or greater.[9]

Data analysis

Data collected was edited for accuracy, readability, consistency and completeness and analyzed using the IBM Statistical Package for Social Sciences (SPSS) statistics for windows, version 20 (IBM Corp, Armonk, N.Y. USA). Continuous and categorical variables were presented as frequency, mean and standard deviation. Significant statistical differences were assessed with chi-squared (X^2) test for categorical variables and Student's *t*-test or *F*-test for continuous variables. Associations between variables were analyzed with Poisson regression analysis. Level of statistical was set at p-value of 0.05.

Ethical approval

Ethical clearance was sought and obtained from the ethical committee of Babcock University Health Research and Ethics Committee (BUHREC/553/18). Confidentiality and privacy of respondents was duly respected during and after the period of collecting and collating data. The study was performed following the ethical standards of the 2008 Declaration of Helsinki. All participants gave informed consent before they participated in the study.

Results

The study group had a total population of 2757 apparently healthy freshmen undergraduate students (1329 males and 1428 females) with male: female ratio of 0.93:1. Table 1 reveals the socio-demographic characteristics of respondents who participated in the survey. From the data gathered, majority of study participants were 18 years and above (n=2554, 92.6%), with the mean age of 18.9±1.503. Gender distribution reveals that 48.2% of respondents are Males while 51.8% are Females, it can therefore be concluded that most respondents were females. Marital status distribution shows that 99.9% of respondents are Single and 0.1% was married. Religion distribution shows that 98.6% of respondents are Christians, while 1.4% was Muslims. Ethnicity distribution reveals that 50.1% of respondents are Yoruba, 40.4% are Igbo, 0.6% are Hausa and 8.9% belong to other ethnic groups in Nigeria like; Edo, Fulani, Etsako, Gbagyi, Ibani, Ibibio, Igala, Igbira, Ijaw, Igede, Ika, Ikewerre, Ikom, Efik, Jaba, Kwale, Kadara, Kwale, Obudu, Tapa, Tiv, Tarok, Urhobo, and Uwano.
Table 2 shows the shows the anthropometric parameters of study subjects. From the table, majority of study subjects (n=2267, 82.2%) were in the 51-100 kg weight categories with mean weight is 69.38±17.90 kg. Also, majority of subjects were above 1.5m in height, with a mean height of 1.69±11.9 m.

However, 1871 (67.9) subjects were in the low risk group of obesity using the waist circumference.The mean waist circumference was 77.22±10.89cm.The BMI calculated using Adolescent BMI calculator with height, weight, age and gender. Showed that 137 (5.0%) respondents were underweight, 1852 (67.2%) respondents had healthy weight, and 373 (13.5%) respondents are overweight while 395 (14.3%) were obese. According to WHO, waist to height ratio defines obesity as any value greater than or equal to 0.5. therefore, ratio of equal and less than 0.39 means underweight, 0.4 - 0.49 is normal weight, equal to 0.5 is overweight, 0.51 – 0.59 is type 1 obesity, 0.6 – 0.69 is type 2 obesity and 0.7 and above means type 3 obesity. Table 2 showed that 267 (9.7%) subjects were underweight, 1984 (72.0%) had normal weights, 114 (4.1%) were overweight, while 185(6.7%) subjects had type 1 obesity, 141(5.1%) had type 2 obesity, and 66 (2.4%) subjects had type 3 obesity. The Mean waist to height ratio was 0.45±0.07.

Table 3 shows the associations between socio-demographic characteristics and anthropometric parameters. The study shows significant relationships between the BMI categories and the age ($p<0.001$), and gender ($p=0.04$)) of respondents. There were also statistically significant relationships between the measured waist circumferences of the respondents and age ($p<0.001$) and gender ($p=0.02$). The study also revealed statistically

strong relationships between the waist height ratio of the respondents and their gender (p=0.001) and ethnicity (p=0.033).

Table 4 revealed the relationship between BMI and Waist circumference to height ratio. From the Chi-square test conducted, it can be concluded that there is a significant relationship between BMI and Waist circumference to height ratio of respondents as the chi-square calculated value (899.194) is greater than the tabulated value (31.410) at 5% error margin and degree of freedom of 20. Therefore, Null hypothesis (H_0) was rejected and Alternative hypothesis (H_1) was accepted.

Table 5 shows the cross tabulation between Body Mass Index and waist to height ratio. We can deduce the values needed for specificity, sensitivity, predictive value and diagnostic accuracy tests. The True positive in this table is when waist to height ratio records obese and BMI also records obese. Therefore, the true positive is 56.8%. The True negative is when waist to height ratio records not obese and BMI records not obese. The value is therefore, 96.2%. The False positive is when waist to height ratio records not obese and BMI records obese. The value is therefore, 3.8%. The False negative is when waist to height ratio records obese and BMI records not obese, with value; 43.2%

$$\textbf{Sensitivity} = \frac{TRUE\ POSITIVE}{TRUE\ POSITIVE+FALSE\ NEGATIVE}$$

$$= \frac{56.8}{56.8+43.2}$$

$$= 0.568$$

$$= 0.57$$

$$\textbf{Specificity} = \frac{TRUE\ NEGATIVE}{TRUE\ NEGATIVE+FALSE\ POSITIVE}$$

$$= \frac{96.2}{96.2+3.8}$$

$$= 0.962$$

$$= 0.96$$

$$\textbf{Positive predictive} = \frac{TRUE\ POSITIVE}{TRUE\ POSITIVE+FALSE\ POSITIVE}$$

$$= \frac{56.8}{56.8+3.8}$$

$$= 0.937$$

$$= 0.94$$

$$\textbf{Negative predictive} = \frac{TRUE\ NEGATIVE}{TRUE\ NEGATIVE + FALSE\ NEGATIVE}$$

$$= \frac{96.2}{96.2+43.2}$$

$$= 0.690$$

$$= 0.7$$

Diagnostic accuracy: The diagnostic accuracy is 76.5%, which is 0.765 with the values above used to calculate.[33]

Discussion

Several studies among African children and adolescents have shown gradual change in trends of body weight with a significant proportion tending towards obesity and overweight. Some efforts have been made to curb this trend and reduce risk of cardiometabolic disorders in the future. Our study was designed to determine the prevalence of obesity and pre-obesity and associated factors among freshmen undergraduates in a tertiary educational institution in Nigeria. The prevalence of obesity using the BMI of 14.3% and 14.2%, using the waist circumference to height ratio is at variance with other studies done in Oshogbo,[8]and in Lagos.[10]The reason for this can be attributed to the fact that majority of the students who participated in this study come from urban centers whose parents are of high socio-economy class and from diverse ethnic groups. However, the prevalence of obesity and pre-obesity in this study is similar to findings in other studies from China, [34] and India.[35] The reason for this may be due to the fact that these studies cut across schools public and private schools as well as segregated and non-segregated schools. Our study also revealed that more boys were overweight while more girls were obese. This may be explained by the fact that in Africa, more girls are involved in culinary chores, consume more calories as many take more high calorie beverages and are less physically active than their male counterparts. The study also shows that those above the age of 18 years are more overweight and obese. This is converse to findings in South America, in which obesity and overweight was more prevalent in younger children.[36]

Comparing the different indices of measuring obesity, this study shows similar performances between BMI and Waist circumference to height ratio in identifying freshmen students who were obese, despite the fact that BMI is believed to poorly predict fat adiposity compared to waist circumference height ratio as fat adiposity is a better

representation of cardio-metabolic risk.[6]This study showed significant statistical differences between BMI and the gender (p=0.04) and age (p<0.001) of study participants; between waist circumference and the age (p=0.02) and gender (p<0.001), as well as between the waist circumference to height ratio and gender (p=0.001) of study subjects. The study also shows a statistically significant association between BMI and Waist to height ratio of study subjects. In comparing BMI, WC and WHtR, the BMI and WHtR performed better in identifying the students who had obesity compared to the WC. When compared with BMI,WHtR had a high specificity (96.2%) but low sensitivity (56.9%) with a positive predictive value of 93.7.% and a negative predictive value of 6.9%. Although BMI is commonly used in research to evaluate obesity, it can't differentiate between fat and muscle mass and also unable to establish regional fat distribution.[17]The high level of obesity using the BMI may be from high levels of adiposity.[32, 34]WHtR have therefore, been advocated for screening for body fat, as a result of the established relationship between waist measurement and body fat distribution which has been validated as a better reflection of cardiometabolic risk factors.[36]

The obvious limitations of this study are its cross-sectional design, which precludes statements of cause-and effect and its lack of exploitation of possible risk factors of overweight and obesity in the study population, concentrating mainly on the prevalence of obesity. This becomes particularly important in interpreting associations that could have multiple pathways, which could explain associations, negative or positive between possible risk factors and obesity.

Conclusion

Our findings from this study show that a significant number of fresh-men university students, especially females above the age of 18 years, in a private tertiary institution in Ogun State, Nigeria are obese. This underlines the fact that obesity is fast becoming a public health issue among adolescents and young adults in developing countries. In addition, the utility of BMI, WC and WHtR in identifying individuals with obesity should be emphasized at all times. Despite the fact that they are easier to use, they tend to miss many individuals with obesity when compared to BMI. Therefore, a combination of BMI, WC and WHtR are recommended for screening for obesity in individuals.

Conflict of interest : The authors have no conflict of interest to declare

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Authors' declarations

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Table 1 showing the socio-demographic data of study participants

Variable	**Response**	**Frequency (N= 2757)**	**Percentage (%)**
Age	< 18 years	203	7.4
	≥ 18 years	2554	92.6
Mean Age		18.9±1.503	
Sex	Male	1329	48.2

	Female	1428	51.8
Marital status	Single	2754	99.9
	Married	3	0.1
Religion	Christian	2718	98.6
	Islam	39	1.4
Ethnicity	Yoruba	1381	50.1
	Igbo	1114	40.4
	Hausa	17	0.6
	Others	245	8.9

Source: Field Survey (2022)

Table 2 shows the anthropometric parameters of study subjects

Parameters	**Class**	**Frequency (N=2757)**	**Percentage (%)**
Weight (kg)	0-50	292	10.6
	51-100	2267	82.2
	>100	198	7.2
Height (m)	< 1.5	101	3.7
	≥1.5	2656	96.3
Waist circumference (cm) **WC**	Low risk	1871	67.9
	High risk	559	20.3
	Very high risk	327	11.8
BMI (Kg/m²)			
	Underweight	137	5.0
	Healthy weight	1852	67.2
	Overweight	373	13.5

	Obese	395	14.3
Waist (circumference) to height ratio (WtHR)	Underweight	267	9.7
	Normal weight	1984	72.0
	Overweight	114	4.1
	Type 1 obesity	185	6.7
	Type 2 obesity	141	5.1
	Type 3 obesity	66	2.4

Mean weight= 69.38±17.90, mean height= 1.69±0.19m, mean waist circumference= 77.22±10.89,* and *waist to height ratio=0.45±0.07

Table 3 shows the associations between socio-demographic characteristics and anthropometric parameters

Variables	**Gender (%)**		**Age in years (%)**		**Ethnicity (%)**			
	Male	**Female**	**< 18**	**≥ 18**	**Yoruba**	**Igbo**	**Hausa**	**Others**
Body mass index (BMI)								
Underweight	42(1.5)	95(3.4)	16(0.6)	121(4.4)	23(0.8)	55(2.0)	3(0.1)	57(2.1)
Normal	837(30.4	1015(36.8)	64(2.3)	1788(64.9	997(36.2	813(29.4)	8(0.3)	34(1.2)
Overweight	)	101(3.7)	93(3.4)	)	)	142(5.2)	6(0.2)	68(2.5)
Obese	272(9.9)	217(7.8)	30(1.0)	280(10.2)	157(5.7)	104(3.8)	0(0.0)	86(3.1)
	178(6.5)			365(13.2)	204(7.4)			
P-value	0.04*		<0.001*		0.089			
Waist Circumference (WC)								
Low obesity risk	842(30.5	1029(37.3)	101(3.7)	1770(64.2)	974(35.3	702((25.5)	9(0.4)	186(6.7)
High obesity risk	)	217(7.9)	69(2.5)	490(17.8)	)	123(4.5)	5(0.2)	39(1.4)
Very high obesity risk	342(12.4)	182(6.6)	33(1.1)	294(10.7)	216(7.8)	289(10.5)	3(0.1)	20(0.7)
	145(5.3)				191(6.9)			
P-value	0.02*		<0.001*		0.069			

Waist to Height ratio (WtHR)								
Underweight	119(4.3)	148(5.4)	37(1.3)	230(8.3)	229(8.3)	211(7.9)	11(0.4)	68(2.5)
Normal weight	959(34.8	1025(37.2)	103(3.7	1881(68.2)	896(32.5	659(23.9)	5(0.2)	99(3.4)
Overweight	)	35(1.3)	)	91(3.3)	)	210(7.6)	1(0.0)	52(1.9)
Type 1obesity	79(2.9)	112(4.1)	23(0.8)	172(6.2)	203(7.4)	17(0.6)	0(0.0)	17(0.6)
Type 2 obesity	73(2.6)	67(2.4)	13(0.5)	126(4.6)	26(0.9)	11(0.4)	0(0.0)	7(0.3)
Type 3 obesity	74(2.7)	41(1.4)	15(0.5)	54(2.0)	15(0.5)	7(0.3)	1(0.0)	2(0.1)
	25(0.9)		12(0.4)		12(0.4)			
P-value	0.001*		0.433		0.033*			

Statistically significant*

Table 4 shows the associations between BMI and Waist to height ratio

Variable	**WtHR (f), n=2757**						**Total**	**X^2**	**P-value**
BMI	**Under-weight**	**Normal weight**	**Over weight**	**Type 1 obesity**	**Type 2 obesity**	**Type 3 obesity**			
Underweight	67	54	0	9	6	1	137		
Normal	173	1606	29	27	10	7	1852		
Overweight	17	158	21	104	37	36	373	899.19	<0.001
Obese	10	166	64	45	88	22	395		
Total	267	1984	114	185	141	66	**2757**		

Table 5 shows the comparison of diagnostic characteristics between BMI and Waist to height ratio

waist to height ratio * body mass index Cross tabulation					
			body mass index		
			Not obese	Obese	Total
waist to height ratio(WtHR)	Not obese	Count	1019	164	1183
		% within body mass index	96.2%	43.2%	82.2%
	Obese	Count	40	216	256

		% within body mass index	3.8%	56.8%	17.8%
Total		Count	1059	380	1439
		% within body mass index	100.0%	100.0%	100.0%