Reference Value for Waist Circumference and Waist to Height Ratio Among Young Adults Aged 18 To 60 Years

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Abstract

There is currently no established reference value for WHtR and WC as an indicator of metabolic and cardiovascular risk for the Nigerian young adult population despite their sensitivity. The study provided reference values for WC and WHtR among apparently healthy Nigerian adults aged 18 to 60 years.

A sample size of 1201 participated in this study. Waist circumference was measured with a non-stretchable plastic tape, placed at the thinnest portion of the abdomen, midpoint between the lower margin of the last palpable rib and the top of the iliac crest. Weight and height were measured as well following standard protocol. Data was summarized using descriptive and inferential statistics with Alpha level set at 0.05.

Results showed that the mean and 95th percentile values of waist to height ratio for male of ages 18 to 60 years of age were 0.48± 0.02 and 0.60 respectively while that of female were 0.47+ 0.04 and 0.63 respectively. The mean and 95th percentile of waist circumference for male were 82.77 cm and 100.21 cm respectively while that of female were 83.00 cm and 96.07 cm respectively. There was a significant relationship between WHtR and each of age (r = 0.188, p<0.01), waist circumference, (r = 0.203, p<0.01), and BMI (r = 0.227, p<0.01).

Conclusion: *It can be concluded that the cut off value of waist circumference for the population of the study was 100.2cm for male and 97.1cm for female while waist to height ratio for male was 0.60 while that of female was 0.63.*

Key words: *waist- circumference, waist to height ratio, workers, male, adult*

Introduction

Globally, cardiovascular diseases (CVDs), which include coronary heart disease (CHD), strokes, rheumatic heart disease (RHD), cardiomyopathy, and other heart diseases, represent the leading cause of death (Mathers *et al* 2006) being is a major cause of mortality and morbidity. Ischaemic heart disease has topped the list of causes of years of life lost for more than a decade (GBD *et al* 2015), highlighting the shift in the global burden of disease from communicable to chronic disease (Lozano *et al* 2012). Risk factors for CVD, including raised blood pressure, hypercholesterolemia, and high body mass index (BMI), are among the most important contributors to disability-adjusted life years. (GBD *et al* 2015).

Primary prevention of CVD is achievable through early identification and modification of 'lifestyle risk factors and secondary prevention, through appropriate risk reduction, which slows disease progression. Effective prevention and treatment are reliant on the identification of people at risk of or with current CVD, and systems that facilitate monitoring of management.

Traditional risk factors of CVDs include hypertension, diabetes mellitus, dyslipidemia, obesity, smoking, and so on. Newer risk factors include ethnic origin, socioeconomic status, increased Serum levels of homocysteine, C-Reactive protein (Nkpozi *et al* 2020). For this study, we will be focusing on obesity.

In adults, there is abundant evidence that a predominantly central fat distribution is associated with an increased risk of cardiovascular and metabolic diseases (Piché et al, 2016, Sahakyan et al 2015). Early identification of young adults at risk may help in preventing these complications. Body Mass Index has been proven to have as is strongly relationship with percent body fat in different population, but there are limitation in its predictability of body fat estimation for a given individual when age of the person sex the race or ethinicity are considered. (Pack et al, 2013, Okorodudu et al., 2010, Heymsfied et al., 2016 and Rao et al., 2015) Screening with BMI is arduous especially in busy outpatient clinics, as it requires calculation and reference charts to interpret. A simple screening tool like waist circumference and waist-hip/height ratio is a good alternative to BMI, which has the added advantage of detecting central obesity also. These ratios with a single cut-off value can be used by non-professionals like health workers/teachers and thereby detect many undiagnosed obese children. (Krishnan *et al* 2021). In epidemiological studies and clinical practice, anthropometric measures such as waist circumference (WC) and Waist-to-Height Ratio (WHtR) are used to assess abdominal obesity, and these measures are associated with increased risk of all-cause mortality and to make better cardiometabolic disease risk prediction than BMI in both adults (Louie and Abraham, 2023)

Waist to Height Ratio (WHtR), commonly referred to as waist to stature ratio, is the measurement of waist circumference divided by height, both measured in the same units. WHtR measures relative overall body fat distribution and is widely used by adults. Studies have shown that higher values of WHtR indicate obesity-related cardiovascular disease (Kwon *et al*... 2017). Furthermore, WHtR is positively associated with traditional anthropometric measures of body circumferences and indices such as the body mass index (BMI, kg/m) and neck circumference and other physiological and biochemical measures of cardiovascular risk. Research has shown that ratios like WHR, WHtR are better predictors of obesity (Krishnan, *et al* 2021).

The advantage of WHtR is that a single cutoff can be used, which means that tables for age-dependent cutoffs are not required. Among the inexpensive and non-invasive variables to predict central obesity are circumference around the waist and waist to height ratio; they were not costly and need no technicality for the usage. Researches have established that waist circumference was very sensitive and very specific when it comes to the detection of abdominal fat in comparison with dual- energy X-ray absorptiometry (Taylor et al 2000). Prospective studies and meta-analyses of adults have revealed that the WHtR is equivalent to or slightly better than WC and superior to BMI in predicting higher cardiometabolic risk (Yoo *et al*, 2016).

Although there were studies on the reference value of several anthropometric measures, there was a reference value ages 3-18 among Nigerian population (Anumah et al 2019). There's little or no baseline data for waist circumference and waist to height ratio among the working class/active population of Nigeria. The reference value we refer to in Nigeria regarding these population is that of the European nation and to a greater extent can't suit the populace of Nigeria. Owning to the fact that the physical build or stature of a Nigerian is quite different from that of a European, and of course due to these disparities, the values can't be appropriate or be adapted as a baseline data for WC and WHtR in relation to obesity in Nigeria. Therefore it is of high importance to develop a reference value for the Nigerian population.

Methods

Participants

The participants of this study were apparently healthy male and female adults.

Inclusion Criteria

Apparently healthy adults between 18 to 60 years of age shall be eligible for this study.

Exclusion Criteria

To be included were sports men and woman and Pregnant woman

Study Design

This was a cross-sectional research design.

Sampling and Sampling Techniques

Sample of convenience will be used to recruit apparently healthy adults in Obafemi Awolowo University environment in Ile-Ife.

Sample size determination

The sample size was calculated using the formula by Cochran (1977)

n= [Z^2Ppq]/ e^2

Z is the degree of confidence i.e 95% confidence interval which is equal to 1.96

P is the estimated proportion of the target population that has the attribute and is equal to 0.5

Q is 1.0-p

e is the desired level of precision put at 0.022

n=[(1.96)^2 X (0.50] /(0.029)

Inserting the variable in the formula n is equal to 1141.

So, a sample size of 1200 individuals shall be recruited for the study.

Site of the study

The site of this study was the Department of Medical Rehabilitation, Obafemi Awolowo University, Ile-Ife.

Instrument

The instruments used for this study were;

i. Measuring tape: was used to measure the waist circumference of participants. An inelastic tape rule known as the tailor's tape rule was used. It was manufactured in China by Goldfish company graded in cm and inches.

ii. Stadiometer: Was used to measure the heights of participants. It was a metallic and consists of a vertical graduated ruler with a movable horizontal rod which is adjusted to rest on the vertex of the head. It measures from 4.5 inches to 81 inches 11.5cm. It was invented by Maa international industries in India. The model number is M120.

iii. Weighing scale: it was used to measure the weight of participants. A bathroom weighing scale which is calibrated in Kg was used.

Procedure

Ethical approval was obtained from the Health Research and Ethical Committee of the Institute of Public Health (HREC) of the College of Health Sciences of Obafemi Awolowo University, Ile-Ife.

The aims and objectives was explained to the participants and their cooperation shall be solicited. Participants verbal informed consent shall be obtained before the commencement of this study.

Waist measurement; The WHO Steps protocol for measuring waist circumference instructs that the measurement be made at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest (WHO, 2008b). Then tape was placed gently on their skin. The waist circumference was measured in centimeters.

Height: The height was measured by instructing the subject to stand barefoot before the vertical meter rule of the stadiometer. The head were positioned in the Frankfort horizontal plane, the arms hanging freely by the sides of the trunk with the palms facing the thigh and the heels together. The movable horizontal rod were then placed on the vertex of the head (Lohman, et al 1988). The height was measured in centimeter

After the measurement of both Waist circumference and height, then the waist measurement was divided by the height measurement.

Data Analysis

Data was analysed using descriptive analysis (mean, standard deviation, percentages) and Percentile method were used for the age group, the 25 percentile, 50 percentile, and 95 percentile was calculated. Pearson Moment correlation was used to examine the relationship among the waist circumference, waist to height ratio and other anthropometric variables. Alpha level was set at p=0.05

Results

Physical Characteristics of Participant

Shown in table 1 are the physical characteristics of participants. The mean age, weight, height and waist to height ratio were 35.67±13.29years, 64.78±13.60kg, 1.67±0.10m, 0.43±0.12cm respectively. The minimum waist circumference was 58.40cm while the maximum was 116.60cm.

Comparison Between Male and Female Physical Characteristics

Table 2 shows the comparison between male and female anthropometric variables. There was a significant difference (t= 3.253, p=0.001) between WHtR of female and male participants. There was significant difference (t=-4.097, p=0.000) between BMI of female and male

Waist to Height Ratio Percentile with Sex and Age

Presented in table 3 is the 25,50,75 and 95 percentiles of the WHtR by sex and age group. The 95 percentiles of male participants of ages 18 to 20 years was 0.57, 21 to 30 years was 0.53, 31 to 40 years was 0.60, 41 to 50 years was 0.56, 51 to 60 was 0.61. The 95 Percentile of total WHtR is 0.60.

Waist circumference Percentile with Sex and Age

Presented in table 4 is the 25,50,75 and 95 percentiles of the waist circumference by sex and age group. The 95 percentiles of male participants between 18 to 20 years were 98.50 cm, 21 to 30

years was 93.1 cm, 31 to 40 years was105.46 cm , 41 to 50 years was 94.50 cm, 51 to 60 was 100.42. The 95 Percentile of total Waist circumference was 100.21 cm.
The 95 percentiles of female participants between 18 to 20 years was 93.00 cm, 21 to 30 years was 92.92 cm, 31 to 40 years was101.60 cm , 41 to 50 years was 95.50 cm, 51 to 60 was 96.80. The 95 Percentile of total Waist circumference was 96.07 cm.

Relationship Between Waist to Height Ratio and Each of Age, Weight, Height and BMI
As seen in table 5, it outlines the relationship between WHtR and each of age, weight, height, and BMI. There was a significant relationship between WHtR and each of age ($r = 0.188$, $p<0.01$), waist ($r = 0.203$, $p<0.01$), and BMI ($r = 0.227$, $p<0.01$).

Table 1: physical characteristics of participant (N =1201)

Variables	Minimum	Maximum	Mean±SD
Age (years)	18.00	60.00	35.67±13.29
Height (m)	1.30	2.00	1.67±0.10
Weight (kg)	35.00	120.70	64.78±13.60
Waist (cm)	58.40	116.60	79.42±10.28
BMI (Kg/m^2)	14.70	43.50	23.77±4.17
WHtR (cm)	0.35	0.74	0.43±0.12

Key: SD= standard deviation, BMI= Body mass index, WHtR= weight to height ratio, m= meters, kg= kilogram, cm= centimeter, n= number of participants

Table 2: Independent –t-test Comparing between male and female physical Characteristics (N=1201)

Variables	Male Mean± SD	Female Mean± SD	t	p
Age (years)	34.01±12.21	37.05±13.99	3.976	0.000
Height (m)	1.73±0.07	1.61±0.07	8.322	0.000
Weight (kg)	71.90±12.36	58.86±11.60	-18.816	0.000
Waist (cm)	82.78±9.25	76.63±10.27	-10.800	0.000
BMI (Kg/m^2)	24.30±3.75	23.32±4.44	-4.097	0.000
WHtR (cm)	0.41±0.13	0.44±0.12	3.253	0.001

Key: SD= standard deviation, BMI= body mass index, WHtR=weight to height ratio, m= meters, kg= kilogram, cm= centimeter, n= number of participants

Table 3: WHtR percentile with sex and age group(N=1201)

Variables (years)	Min	25th percentile	50th percentile	Median	Mean±SD	75TH Percentile	95th Percentile	Max
Male								
18-20	0.35	0.43	0.46	0.46	0.47±0.05	0.49	0.57	0.61
21-30	0.36	0.42	0.45	0.45	0.45±0.05	0.49	0.53	0.64
31-40	0.35	0.46	0.49	0.49	0.50±0.06	0.52	0.60	0.64
41-50	0.41	0.47	0.50	0.50	0.49±0.04	0.52	0.56	0.56
51-60	0.38	0.47	0.50	0.50	0.51±0.06	0.54	0.61	0.67
Total	0.35	0.43	0.49	0.49	0.48±0.02	0.52	0.60	0.67
Female								
18-20	0.35	0.40	0.42	0.42	0.42±0.07	0.49	0.60	0.63
21-30	0.36	0.41	0.44	0.44	0.45±0.06	0.49	0.57	0.74
31-40	0.38	0.46	0.50	0.50	0.51±0.07	0.55	0.62	0.75
41-50	0.38	0.45	0.51	0.49	0.49±0.06	0.54	0.59	0.68
51-60	0.40	0.48	0.49	0.51	0.52±0.58	0.56	0.63	0.67
Total	0.35	0.41	0.49	0.49	0.47±0.04	0.55	0.63	0.75

Key: Min= minimum, max= maximum, SD = standard deviation

Table 4: Waist Circumference percentile with sex and age group(N=1201)

Variable (years)	Min	25th perc	50th perc	Median	Mean±SD	75TH Percentile	95th Percentile	Max
Male								
18-20	62.50	73.45	78.70	78.70	79.57+9.05	84.65	98.50	107.00
21-30	61.00	72.45	78.55	78.55	79.03±8.18	84.00	93.15	108.80
31-40	61.50	78.85	85.00	85.00	86.11±10.27	90.70	105.46	113.10
41-50	70.10	81.40	85.00	85.00	85.13±5.76	89.00	94.50	104.00
51-60	66.00	79.75	84.50	84.50	84.95±9.25	90.00	100.42	109.30
Total	61.00	76.25	82.00	82.00	82.77±9.73	88.30	100.21	113.10
Female								
18-20	58.40	64.90	70.00	70.00	72.54±9.73	78.70	93.00	102.00
21-30	58.50	66.00	71.10	71.10	73.53±9.54	78.70	92.92	116.60
31-40	59.00	72.00	81.00	81.00	80.57±11.17	87.00	101.60	109.20
41-50	59.00	70.45	76.40	76.40	77.37±9.89	82.80	95.50	108.70
51-60	61.00	74.00	78.00	78.00	79.49±9.04	85.25	98.80	104.10
Total	58.40	68.50	75.50	75.50	76.63±10.26	83.00	96.07	116.60

Key: Min= minimum, max= maximum, SD = standard deviation

Table 5: Relationship between Waist to height ratio and each of age, weight, height and BMI (N=1201)

	WHtR	Waist	BMI	Heights	Weight	Age
WHtR (cm)	1					
Waist (cm)	.203**	1				
BMI (Kg/m^2)	.227**	.787**	1			
Height (m)	-.206**	.261**	-0.12	1		
Weight (kg)	.061	.801**	.811**	.544**	1	
Age (yrs)	.188**	.201**	.080**	-.249**	-.102**	1

Key: WHtR= Waist to height ratio, ** = correlation is significant at the 0.001 level (2- tailed), * = correlation is significant at the 0.05 level (2-tailed)

DISCUSSIONS

Provided in this study is the reference value for waist circumference and waist to height ratio of apparently healthy adults from the age of 18- 60 years. From the result the cut off values of waist to height ratio of the total female population was ≥ 0.63cm while the cut off values for the entire male population was ≥ 0.60cm. The cut off value of waist circumference for male and female were 100.2 cm and 96.1 cm respectively. The WHO recommendation for different countries of the world regarding waist circumference showed that for Europid, men > 94 cm, meanwhile for the South Asians, Chinese, and Japan the cut off for men was > 90 cm while all the countries mentioned had reported >80 cm for women (WHO, 2008). It will be observed that the cut off values regarding the waist circumference of Nigerians were found to me relatively more than that of the other countries mentioned. Sun et al., (2021) reported that the regulation of distribution of fat in the body is determined by the genetic factors of an individual. Across different ethnic group, there are variation of fat distribution. A less adiposity was reported among African compared to the Europeans and Asian, therefore Asian with lower BMI is likely to be at risk of type 2 diabetes compare to the African.

It will not be a far fetch fact if the waist circumference and waist to height ratio values are in alignment with that of BMI comparing Africans and Europeans. An indication that Asian and Europeans may be susceptible to chronic disease with less value of waist circumference compared with Africans population. This is in line with the findings of our study

The mean value of waist to height ratio in this study for male and female varies within the range mark of 0.48 and 0.47 respectively. This is a bit less than the standard value of Waist to height ratio of ≤0.5 by WHO, (2008). A study among South Asian adults by Jayawardana et al (2013) found out that the mean value for WHtR to be 0.48 for male and 0.51 for female. Peng et al (2013) in their study in Chinese population found out the cut-off value of WHtR for detecting central obesity to be 0.54 and 0.57 for male and female respectively. This study revealed a potential difference in the distribution of body fat among individuals in Nigeria and South Africa, particularly among the population of Nigeria where the study was carried out. A study among Kurdish adults by Pasdal et al (2020) shows that the value for WHtR is 0.56 for men and 0.65 for women. Another study by Signa et al (2018) among Ethiopian adults reveals that the cut off value for WHtR. Is 0.49 and 0.50 for male and female respectively, also a study in Benin and Haiti by El Mabchour et al (2015) showed that the cut off value of WHtR is 0.51 in men and 0.59 in women. Variation of the cut off values among different populations showed that the fat distribution

are difference when comparing these populations, hence there are different values regarding the waist circumference and waist to height ratio.

The cut off values for female in this study within the age groups 18 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years were found to be 0.60cm, 0.57cm, 0.62cm, 0.59cm, and 0.63cm respectively. The cut off values for males in this study in the age of 18 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years was found to be 0.57cm, 0.53cm, 0.60cm, 0.56cm, and 0.61cm respectively. These implies that values that are greater than this cut off values can predispose individuals to chronic non-communicable disease such as obstructive sleep apnea, obesity, diabetes, metabolic conditions, some hormonal diseases, hypertension, and other cardiovascular conditions.

A study carried out by Corrêa et al (2019) reveal that WHtR has a strong correlation with identifying health risk than the combination matrix between the body mass index and the waist circumference. WHtR could have the best clinical utility in identifying patients with CVD risk factor in adults, as stated in a study by Lam et al (2015). A study by Cai et al (2021) identifies WHtR as the strongest predictor of metabolic dysfunction associated fatty liver disease (MAFLD).

Regarding waist circumference, the cut off values for male ages 18-20, 41-50 and 51-60 years old are 98.6 cm, 94.5cm, and 100.42cm respectively. The general cut off values was 102.21cm for male and for female of 18-20, 41-50 and 51-60 years, the cut off point were 93.00cm, 101.60 and 98.60 cm and the total female was 100.21 cm . One of the risk factors for cardiovascular disease is obesity which alse increase the blood pressure and level of triglyceride. Van-Gaal, (2006). Abdominal subcutaneous, and intra-abdominal adiposity have been circumference estimated using abdominal or waist circumference. Certain proteins and hormones such adipokine, inflammation, angiotensinogen, and cortisol, have been reported to be produced by intra abdominal adiposity. These proteins have been document to have association with with the production cardiometabolic diseases such as dyslipidemia, coronary heart diseases, and hypertension in the body (Xiao et al, 2016, Dong et al, 2018, Manios et al., 2018).

A strong association between WHtR as a measure of adiposity and cardiometabolic risk factors was reported by Jayawardana et al (2013). Unal et al (2019) reported that a high value of WHtR is associated with the presence of severity of obstructive sleep apnea syndrome, which shows high correlation between WHtR and sleep apnea. A study by Zhang et al (2021) reveals that WHtR is closely related to diabetes than BMI. Jablonowska et al (2017) reveal that WHtR can be useful in the assessment of increased Visceral adiposity accumulation associated with disturbances in glucose and lipid metabolism.

This study shows significant correlation between waist to height ratio and age, weight, height, and BMI. This further explains that as a person grows older the waist to height ratio increases.

The waist to height ratio of female was found to be slightly higher than that of male, as it follows same trend with several studies stated earlier such as the studies carried out by Unal et al (2019), Jayawardana et al (2013) and Cai et al (2021). This is because on the average, men are taller than women and have larger waist circumference which then results in lesser WHtR in men than women. A study carried out among south Asian population revealed that male had significant lower WHtR than female.

Conclusion

From the study the cut off values of female and male WHtR of 41 to 50 years was 0.59cm and 0.56cm respectively, while the age group of 51-60 has a value of 0.63cm and 0.61cm for female and male respectively. There was also a significant correlation between the waist to height ratio and each of age, weight, height, and BMI.

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