

# Cardiometabolic risk and its association with dietary diversity, activity patterns and the nutritional status of workers in tertiary educational institutions in Southwestern Nigeria

Adeleye Abiodun Adeomi (✉ [aadeomi@cartafrica.org](mailto:aadeomi@cartafrica.org))

Obafemi Awolowo University <https://orcid.org/0000-0002-6645-7295>

Roseline Oluyemisi Akande

Department of Community Medicine, Bowen University, Iwo

Chukwubueze Obiajunwa

Community Health Department, Obafemi Awolowo University, Ile-Ife

Olajuwon Oduntan

Community Health Department, Obafemi Awolowo University, Ile-Ife

Ebuka Ogbukwo

Obafemi Awolowo University Hezekiah Oluwasanmi Library

---

## Research article

**Keywords:** Cardiometabolic risk, dietary diversity, nutritional status, tertiary workers

**Posted Date:** May 4th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-25987/v1>

**License:**  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Introduction** Waist-to-height ratio (WHtR) is increasingly being reported as a simple, but accurate measure of cardiometabolic risk, even better than BMI, WHR and even waist circumference. Therefore, the objective of this study was to determine the cardiometabolic risk using WHtR, and its association with dietary diversity, activity patterns and the nutritional status of workers in tertiary educational institutions in Southwestern Nigeria.

**Materials and Methods** This was a descriptive cross-sectional study carried out among workers in 3 randomly selected tertiary educational institutions in Osun State, Nigeria who were adults (18 years and above). Only apparently healthy people were recruited for the study. Cardiometabolic risk was assessed using WHtR, and respondents were categorized into low risk (WHtR < 0.5) or high risk (WHtR ≥ 0.5). Bivariate and multivariate (logistic regression model) analyses were used to determine the significant predictors of cardiometabolic risk. Level of significance was set at p-value less than 0.05.

**Results** The mean age of the respondents was 45.8 ± 10.4 years, with a male:female ratio of 1:1.1. The mean WHtR among the respondents was 0.53 ± 0.08, and 36.5% had low cardio-metabolic risk while 63.5% had high cardiometabolic risk. The prevalence of overweight and obesity were 44.0% and 25.8% respectively using the BMI categories. At bivariate level, there were statistically significant associations between WHtR and age (p < 0.001), gender (p = 0.002), educational level (p = 0.046), marital status (p = 0.022), dietary diversity (p = 0.027) and activity patterns (p = 0.030). When these were entered into a binary logistic regression model, age (p = 0.028; CI = 1.003 to 1.060) and gender (p = 0.010; CI = 1.149 to 2.784) remained the only statistically significant explanatory variables for cardiometabolic risk using WHtR.

**Conclusion** The study found a relatively high prevalence of cardiometabolic risk, overweight and obesity among the respondents, with age and gender being the main predictors of cardio-metabolic risk using WHtR. Therefore, there is a need for early screening for cardiometabolic risk using WHtR, especially among the females.

## Background Information

Cardiometabolic risk is a broad term comprising risk factors for cardiovascular diseases which include obesity, hypertension, diabetes or dyslipidemia.[1] Globally, cardiovascular diseases contributed significantly to about 17.6 million deaths in 2016, making it the foremost cause of mortality resulting from non-communicable diseases.[2] Evidence from American National Survey has revealed that approximately 10% of the youth population exhibits clustering of cardiometabolic risks.[3] Reports also showed that approximately 114 million Chinese adults had diabetes mellitus and 265 million had hypertension in 2010. Similarly, in Nigeria, the National non-communicable disease survey, conducted on a cross-sections of Nigerians, found that there is an increase in the burden of cardiovascular diseases across the six geo-political zones of the country.[4, 5]

WHtR is increasingly being reported as a simple, but accurate measure of cardiometabolic risk, even better than BMI, WHR and even waist circumference.[6–9] For several years, BMI has been traditionally used as a predictor for total obesity. Evidences abound that central obesity carries more health risks in comparison with total obesity assessed by BMI. Although BMI is correlated with total body fat tissue, it does not take body fat distribution into account.[8, 9] More recently, waist circumference (WC), waist-to-hip ratio (WHR) and WHtR have been used as proxies for central obesity.[8] Waist-to-height ratio is increasingly being reported as the best measure of central adiposity and of cardiometabolic risk.[6–9]

Understanding the relationship of cardiometabolic risks with modifiable habits and practices like diet and physical activity is important because it holds a great potential for the prevention and control of the cardiometabolic risks and diseases. There is accumulating evidence that physical exercise may help in improving health via different mechanisms including a decrease in the percentage body fat and improvement in many cardio-metabolic risk factor levels obtained during blood assessment.[10] A balanced diet has also been shown to reduce cardiovascular disease (CVD) risk factors.[11] It is important to determine these relationships in different contexts and among different populations.

Cardiometabolic risks might not be the same across different regions and population groups due to differences in socioeconomic characteristics, culture, ethnicity, geographical location and even occupations. Tertiary educational institution workers may differ from the general population in terms of socio-economic status and their activity patterns. In Nigeria, few studies have focused on assessment of cardiometabolic risk among apparently healthy population using WHtR, and fewer still among tertiary educational institution workers. Therefore, the study aimed to assess cardiometabolic risk and its association with dietary diversity, activity plans and nutritional status among tertiary educational institution workers in Nigeria; and this is necessary and critical to design appropriate cardiometabolic and nutritional intervention programmes for this group.

## Materials And Methods

The study was carried out among workers of tertiary educational facilities in Osun State who were adults (18 years and above). Only apparently healthy people were recruited for the study. All those who were acutely ill or had been diagnosed and/or were being managed for chronic illnesses like sickle cell disease anaemia, cancer, hypertension and diabetes mellitus were excluded. Others with disabilities that made them unable to stand were also excluded. The sample size was calculated to get an absolute precision of  $\pm 5\%$  using STATCALC on the Epi-Info software. The proportion of expected outcome was taken as 38.46% which was the proportion of the adults with abdominal obesity in a similar study carried out in Ekiti State, Southwestern Nigeria.[12] With an acceptable margin of error of 5%, the calculated sample size was 344, and after correcting an anticipated non-response of 10%, the sample size came to 400, who were recruited from 3 randomly selected tertiary educational institutions in Osun State using multi-stage sampling technique.

Height was measured to the nearest 0.1 meter using the stadiometer (Leicester® Height Measure, Seca, UK), weight was measured using the Seca® electronic bathroom weighing scale (SECA GmbH & Co, Germany) and waist and hip circumferences using the Goldfish brand non-elastic tape measure. The anthropometric measurements were done according to standard protocols recommended by the International Society for the Advancement of Kinanthropometry.[13]

Cardiometabolic risk was assessed using WHtR, which has been shown to be the best predictor of cardiovascular risk and mortality.[14] WHtR was calculated by dividing waist circumference in cm by height in cm, and those with  $\geq 0.5$  were classified as high. Other measures of nutritional status were BMI, waist circumference, WHR and neck circumference. BMI was calculated by dividing the weight in kilograms by the height in meter<sup>2</sup>. Those with BMI < 18.5, 18.5–24.9, 25.0–29.9 and  $\geq 30$  were classified as underweight, normal, overweight and obese respectively. Waist circumference (in centimeters) was categorized into 3 groups for males and females into low risk, increased risk ( $\geq 80$  cm for females; 94 cm for males) and substantially increased risk ( $\geq 88$  cm for females and 102 cm for males). WHR was calculated as waist circumference in centimeters (cm) divided by hip circumference in cm. WHR was classified such that males with ratio equal to or greater than 0.9 and females with ratio equal to or greater than 0.85 had increased risk for cardiometabolic disease. The neck circumference was also used as a measure of nutritional status and was measured in centimeters.

The dietary diversity were assessed using fourteen (14) food groups,[15] and a 24 hour dietary recall. Respondents were given a score of 1 if they ate any of the food groups giving a maximum possible score of 14. The respondents were then categorized into those with Low ( $\leq 4$ ), medium (5–9) and high (> 10). The physical activity was assessed using the short form of the International Physical Activity Questionnaire (IPAQ-SF), which is arguably the most widely used instrument for assessing activity.[16] This was used to classify the activity patterns of the respondents into low, moderate/medium and high.

Ethical clearance was obtained from the Ethical Review Committee, Institute of Public Health, Obafemi Awolowo University, Ile-Ife. The participants' information sheet and consent were given to them. Important information on the participants' information sheet included that the information volunteered will be kept confidential as all questionnaires were coded without names or addresses of respondents. It also emphasized that participants were free to opt-out if they were not comfortable with the information in the questionnaire. Signed consent forms were then obtained from the respondents before being recruited for the study.

## Results

The mean age of the respondents was  $45.8 \pm 10.4$  years, with a male:female ratio of 1:1.1. Most of the respondents were married (87.7%), and lived in monogamous family settings (92.0%). Expectedly, more than half of them (53.1%) had postgraduate degrees and 53.5% earned 100,000 naira (\$278) dollars or more monthly.

The mean waist-to-height ratio among the respondents was  $0.53 \pm 0.08$ , and 36.5% had values less than 0.5 (low cardio-metabolic risk) while 63.5% had values up to or above 0.5 (high metabolic risk). The mean dietary diversity score was  $6.95 \pm 1.50$ , with 4.8%, 91.2% and 4.0% having low, medium and high dietary diversity respectively. One hundred and forty-four (35.9%) had low activity patterns, while 45.3% and 18.8% had moderate and high activity patterns respectively. The prevalence of overweight and obesity were 44.0% and 25.8% respectively using the BMI categories. Using the waist circumference categories, 54.6% had increased or substantially increased risk for cardio-metabolic disease, while 63.5% had high cardio-metabolic risk using the waist-hip ratio. (Table 1)

Table 1  
Dietary diversity, Activity patterns and the Nutritional status of  
Respondents (N = 400)

<b>Variables</b>	<b>Frequency</b>	<b>Percent (%)</b>
Dietary diversity (DD)		
Low	19	4.8
Medium	365	91.2
High	16	4.0
Activity Patterns		
Low	144	35.9
Medium	181	45.3
High	75	18.8
Body Mass Index (BMI)		
Underweight	9	2.3
Normal	112	28.0
Overweight	176	44.0
Obese	103	25.8
Waist-Hip Ratio (WHR)		
Low risk for *CMD	159	39.8
Increased risk for CMD	241	60.2
Waist Circumference		
Low risk for CMD	182	45.5
Increased risk for CMD	87	21.8
Substantially increased risk for CMD	131	32.8
*CMD – cardiometabolic disease		

At bivariate level, there were statistically significant associations between WHtR and age ( $p < 0.001$ ), gender ( $p = 0.002$ ), educational level ( $p = 0.046$ ), marital status ( $p = 0.022$ ), dietary diversity ( $p = 0.027$ ) and activity patterns ( $p = 0.030$ ). These relationships were such that, older people, females, those with higher educational levels, married/widowed, those with higher dietary diversity and those with low activity patterns were more likely to have high cardiometabolic risk. (Table 2) When these were entered into a binary logistic regression model, age ( $p = 0.028$ ; CI = 1.003 to 1.060) and gender ( $p = 0.010$ ; CI = 1.149 to

2.784) remained the only statistically significant explanatory variables for cardiometabolic risk using WHtR. (Table 4; Fig. 1)

Table 2  
Factors associated with Cardiometabolic risk (using WHtR) among the Respondents (N = 400)

Variable	Cardiometabolic Risk (WHtR)		Statistics
	< Low risk (%) (n = 146)	High risk (%) (n = 254)	
<b>Age groups (in years)</b>	43.0 ± 9.7	47.4 ± 10.4	<sup>a</sup> p < 0.001*
<b>Gender</b>	86 (44.3)	108 (55.7)	$\chi^2 = 9.964$ df = 1 p = 0.002*
Male	60 (29.1)	146 (70.9)	
Female			
<b>Highest level of education</b>	27 (35.1)	50 (64.9)	$\chi^2 = 9.668$ df = 4 p = 0.046*
Secondary	16 (37.2)	27 (62.8)	
Bachelor's	34 (50.0)	34 (50.0)	
Master's	27 (26.7)	74 (73.3)	
Doctorate	42 (37.8)	69 (62.2)	
Others			
<b>Marital status</b>	17 (47.2)	19 (52.8)	LR = 7.593 df = 2 p = 0.022*
Single	128 (36.5)	223 (63.5)	
Married	1 (7.7)	12 (92.3)	
Widowed			
<b>Monthly income</b>	40 (36.4)	70 (63.6)	$\chi^2 = 8.334$ df = 4 p = 0.080
Less than ₦50,000	29 (38.2)	47 (61.8)	
₦50,000 – ₦99,000	52 (42.6)	70 (57.4)	
₦100,000 – ₦249,000	19 (33.9)	37 (66.1)	
₦250,000 – ₦500,000	6 (16.7)	30 (83.3)	
Greater than ₦500,000			
<b>Dietary diversity</b>	6.73 ± 1.48	7.07 ± 1.50	<sup>a</sup> p = 0.027*

LR – Likelihood ratio used \* Statistically significant  $\chi^2 =$  Chi-square test used

<sup>a</sup> = t-test for 2 independent test used

Variable	Cardiometabolic Risk (WHtR)		Statistics
	< Low risk (%) (n = 146)	High risk (%) (n = 254)	
<b>Activity patterns</b>	43 (29.9)	101 (70.1)	$\chi^2 = 7.039$
Low	67 (37.0)	114 (63.0)	df = 2
Medium	36 (48.0)	39 (52.0)	p = 0.030*
High			
LR – Likelihood ratio used * Statistically significant $\chi^2$ = Chi-square test used			
a = t-test for 2 independent test used			

The waist-to-height ratio had a positive statistically significant correlation with all the measures of nutritional status including waist circumference, body mass index and neck circumference. The strongest relationship was with waist circumference (Coefficient = 0.923,  $p < 0.01$ ), followed by BMI (Coefficient = 0.711,  $p < 0.01$ ), neck circumference (Coefficient = 0.434,  $p < 0.01$ ) and waist-hip ratio (Coefficient = 0.417,  $p < 0.01$ ). (Table 3) Multiple regression analysis also showed that all the other measures of nutritional status could predict the waist-to-height ratio except the waist-hip ratio that was not statistically significant. Similarly, the strongest predictor was waist circumference (Beta Coefficient = 0.901), followed by BMI (Beta Coefficient = 0.247) and neck circumference (Beta Coefficient = - 0.188). (Table 3)

Table 3  
 WHtR and its association with other measures of  
 nutritional status using Correlation and Regression  
 Analyses (N = 400)

Variables	<sup>a</sup> Correlation Analysis	
	Coefficient	p-value
Body Mass Index	0.711	< 0.001*
Waist Circumference	0.923	< 0.001*
Waist-Hip Ratio	0.417	< 0.001*
Neck Circumference	0.434	< 0.001*
	Regression Analysis	
	Beta coefficient	p-value
Waist Circumference	0.901	< 0.001*
Body Mass Index	0.247	< 0.001*
Neck Circumference	-0.188	< 0.001*
Waist-Hip Ratio	-0.030	< 0.085
* Statistically significant a = Pearson correlation used		

Table 4  
Predictors of Cardiometabolic Risk (WHtR) using Binary Logistic Regression (N = 400)

Variables	p-value	Odds ratio	Confidence interval	
			Lower	Upper
Age in years	0.028*	1.031	1.003	1.060
Gender Male (Reference Value) Female	0.010*	1.789	1.149	2.784
Marital Status Single (Reference Value) Married Widowed	0.537 0.372	0.773 2.803	0.342 0.291	1.749 26.983
Highest level of education Secondary (Reference value) Bachelor's Master's Doctorate Others	0.774 0.181 0.903 0.886	0.887 0.608 1.047 1.048	0.391 0.293 0.500 0.550	2.013 1.260 2.194 1.996
Dietary diversity	0.074	1.149	0.986	1.338
Activity patterns Low Medium High (Reference Value)	0.136 0.324	1.637 1.337	0.857 0.750	3.128 2.384
* Statistically significant				

## Discussion

Previous studies have found that WHtR and WC were more significant predictors of cardio-metabolic outcomes than BMI,[4, 17] and others have even reported that WHtR is the best predictor.[6, 8, 9] Therefore, use of BMI alone could lead to an underestimation of the at-risk population. Over the last several decades, efforts to prevent or treat cardiovascular diseases have resulted in the identification of certain cardiometabolic risks. By targeting lifestyle behaviours associated with cardiometabolic risk, it may be possible to prevent and manage risk for cardio-metabolic disease and adverse outcomes of these disease processes at the early stages of development.

The prevalence of cardiometabolic risk, using WHtR was high among the respondents, with nearly two-thirds of them having high cardio-metabolic risks. A study among workers in a District Municipality in South Africa similarly reported about two-thirds of the workers having high WHtR.[18] With different studies reporting WHtR as a predictor for cardiometabolic diseases,[6–9] this finding should be a cause

of worry to stakeholders in cardio-vascular health, economics, labour and productivity. This is because workers form the productive group in any society and their health should be of importance, not only to them but the Nation at large.

The other anthropometric measures of the nutritional status of the respondents further underscore the level of cardiometabolic risk among the respondents. Nearly 7 out of 10 of the workers were overweight or obese using the BMI categories and about three-fifths had raised WHR and WC. This prevalence is in tandem with that reported by previous studies among workers in Ireland[19] and South Africa.[18] Thabit et al[19] in Ireland opined that this may be related to long hours of sedentary and highly stressful work related activities, compounded by poor health choices such as excessive alcohol consumption, smoking and lack of healthy dietary options within the work environment.

Results from this present study also provides evidence that waist-to-height ratio had a positive statistically significant correlation with all the measures of nutritional status including waist circumference, body mass index and neck circumference. The relationships between WHtR, BMI, WC and WHR have been previously reported by various studies.[6, 8–11, 20] Neck circumference as an indicator of cardiometabolic risk has also been reported,[21–23] but it is relatively recent and an emerging topic which should be better explored.

Statistically significant associations were observed in the present study between WHtR and gender ( $p = 0.002$ ), educational level ( $p = 0.046$ ), marital status ( $p = 0.022$ ), dietary diversity ( $p = 0.027$ ) and activity patterns ( $p = 0.030$ ). Consistent with this, are findings from previous studies which also reported the relationship of cardiometabolic risk with age, socioeconomic status, body composition and physical activity.[24, 25] After controlling for confounders using logistic regression analysis, age and gender were the only variables that were still significantly associated with cardiometabolic risk using WHtR. This was such that older respondents and the female gender were more likely to have high cardio-metabolic risk compared to others. This is similar to the finding of Raimi et al also in southwestern Nigeria, where older respondents and females were more likely to have raised WHtR than others.[26] Other studies from outside Nigeria have reported similar findings.[18, 27]

## **Conclusion**

There was a high prevalence of overweight/obesity and cardiometabolic risk among the tertiary educational institution workers. The cardiometabolic risk using WHtR was significantly associated with age, gender, educational level, marital status, dietary diversity and activity patterns of the respondents. However, after controlling for confounders, only age and gender were the predictors of cardiometabolic risk that were statistically significant. Therefore, there is a need for early screening for cardiometabolic risk using WHtR, especially among the females.

## **Abbreviations**

BMI Body mass index

CI Confidence interval

CVD Cardiovascular disease

IPAQ-SF International Physical Activity Questionnaire - short form

OR Odds ratio

SPSS Statistical Package and service solutions

UK United Kingdom

WC Waist circumference

WHO World Health Organization

WHR Waist-hip ratio

WHtR Waist to height ratio

## **Declarations**

Ethics approval and consent to participate

Ethical clearance was obtained from the Ethical Review Committee, Institute of Public Health, Obafemi Awolowo University, Ile-Ife. The participants' information sheet and consent were given to them. Important information on the participants' information sheet included that the information volunteered will be kept confidential as all questionnaires were coded without names or addresses of respondents. It also emphasized that participants were free to opt-out if they were not comfortable with the information in the questionnaire. Signed consent forms were then obtained from the respondents before being recruited for the study

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

## Funding

This research was funded by the authors

## Authors' contributions

AAA, CO, OO and EO were involved in the conception of the research idea and topic. AAA and ARO wrote the background of the study, AAA wrote the methodology section. AAA, CO, OO and EO authors were involved in data collection, data entry and initial data analysis. AAA and ARO wrote the results and discussion sessions. All the authors read and approved the final version of the manuscript.

## Acknowledgements

The authors appreciate the workers for their cooperation through the period of the study.

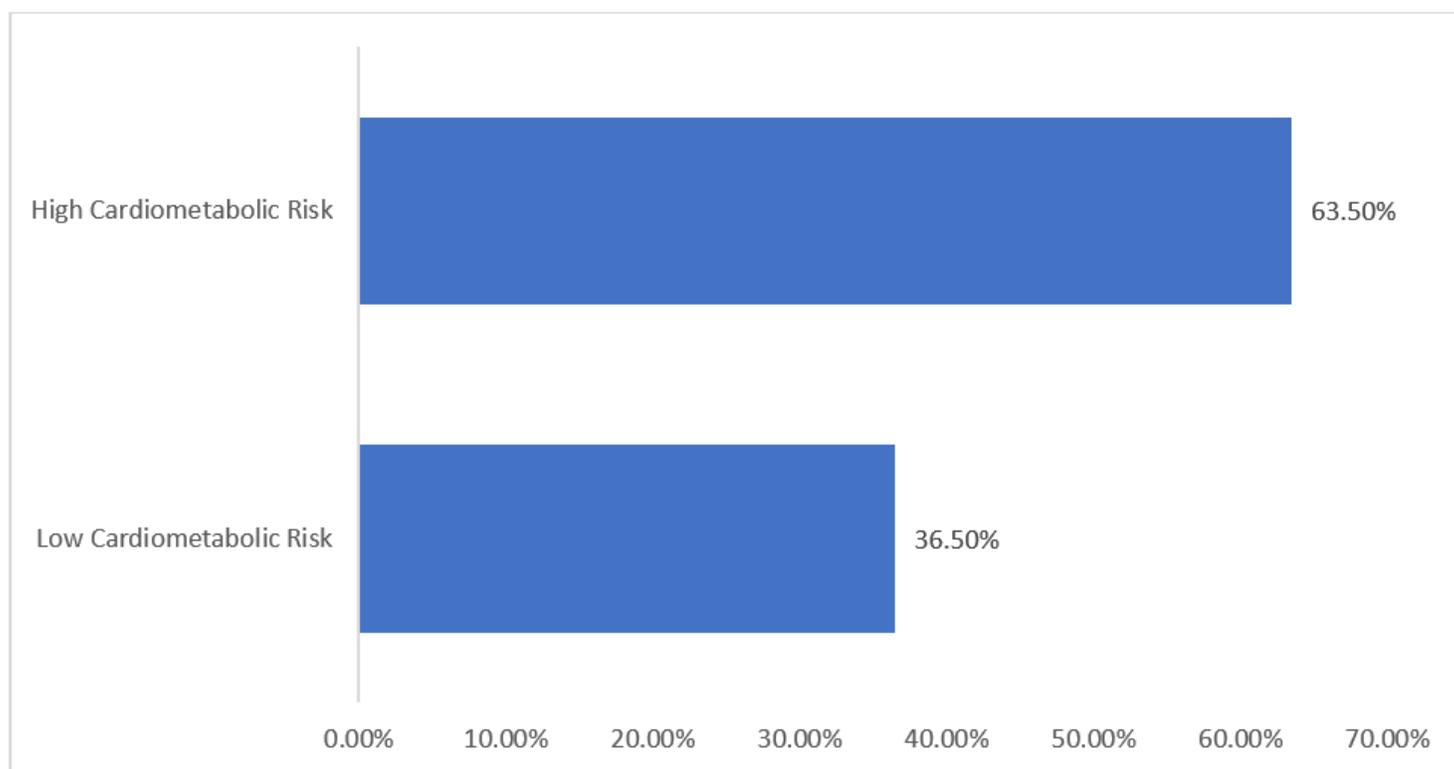
## References

1. Shi L, Morrison JA, Wiecha J, Horton M, Hayman LL. Healthy lifestyle factors associated with reduced cardiometabolic risk. *Br J Nutr*. 2011;105 January 2014:747–54.
2. Tarp J, Child A, White T, Westgate K, Bugge A, Grøntved A, et al. Physical activity intensity, bout-duration, and cardiometabolic risk markers in children and adolescents. *Int J Obes*. 2018;42:1639–50.
3. Burgos MS, Reuter CP, Possuelo LG, Valim ARDM, Renner JDP, Tornquist L, et al. Obesity parameters as predictors of early development of cardiometabolic risk factors. *SciELO Public Heal*. 2015;20:2381–8.
4. Okafor C, Raimi T, Gezawa I, Sabir A, Enang O, Puepet F, et al. Performance of waist circumference and proposed cutoff levels for defining overweight and obesity in Nigerians. *Ann Afr Med*. 2016;15:185–93.
5. Iloh G, Iro O, Collins P. Cardiovascular risk factors among geriatric Nigerians in a primary care clinic of a tertiary hospital in Southeastern Nigeria. *Arch Med Surg*. 2018;3:11–8.
6. Ashwell M, Gibson S. Waist-to-height ratio as an indicator of early health risk: Simpler and more predictive than using a matrix based on BMI and waist circumference. *BMJ Open*. 2016;6.
7. Thomas B, Repas D. Challenges and strategies in managing cardiometabolic risk. *J Am Osteopath Assoc*. 2007;107(4 Suppl 2):4–11.
8. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors - systematic review and meta-analysis.pdf. *Obes Rev*. 2012;13:275–86.
9. Xu Z, Qi X, Dahl AK, Xu W. Waist-to-height ratio is the best indicator for undiagnosed Type 2 diabetes. *Diabet Med*. 2013;30:201–7.

10. Kujala UM, Jokelainen J, Oksa H, Saaristo T, Rautio N, Moilanen L, et al. Increase in physical activity and cardiometabolic risk profile change during lifestyle intervention in primary healthcare: 1-year follow-up study among individuals at high risk for type 2 diabetes. *BMJ Open*. 2011;1.
11. Van Hulst A, Ybarra M, Mathieu ME, Benedetti A, Paradis G, Henderson M. Determinants of new onset cardiometabolic risk among normal weight children. *Int J Obes*. 2019;44:781–9.
12. Ogunmola OJ, Olaifa AO, Oladapo OO, Babatunde OA. Prevalence of cardiovascular risk factors among adults without obvious cardiovascular disease in a rural community in Ekiti State, Southwest Nigeria. *BMC Cardiovasc Disord*. 2013;13:89.
13. International Society for the Advancement of Kinanthropometry. *International Standards for anthropometric Assessment*. 2001;;53–5.
14. Schneider HJ, Friedrich N, Klotsche J, Pieper L, Nauck M, John U, et al. The Predictive Value of Different Measures of Obesity for Incident Cardiovascular Events and Mortality. *J Clin Endocrinol Metab*. 2010;95:1777–85.
15. Food and Agriculture Organization. *Guidelines for measuring household and individual dietary diversity*. Italy: Food and Agriculture Organization of the United Nations; 2010.
16. Bauman AE, Craig CL, Marshall AL, Sjo M, Booth ML, Ainsworth BE, et al. International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Med Sci Sports Exerc*. 2003;35:1381–95.
17. Abeywickrama HM, Wimalasiri KMS, Koyama Y. Assessment of Nutritional Status and Dietary Pattern of a Rural Adult Population in Dry Zone, Sri Lanka. *Int J Environ Res Public Health*. 2019;17:1–14.
18. Muluvhu TC, Monyeki MA, Strydom GL, Toriola AL. Relationship Between Selected Metabolic Risk Factors and Waist-to-Height Ratio among Employees in Vhembe District Municipality of Limpopo Province, South Africa. *Asia J Sci Res*. 2018;11:42–50.
19. Thabit H, Burns N, Shah S, Brema I, Crowley V, Finnegan F, et al. Prevalence and predictors of diabetes and cardiometabolic risk among construction workers in Ireland: The Construction Workers Health Trust screening study. *Diabetes Vasc Dis Res*. 2013;10:337–45.
20. Zhao W, Yu K, Tan S, Zheng Y, Zhao A, Wang P, et al. Dietary diversity scores: an indicator of micronutrient inadequacy instead of obesity for Chinese children. 2017;;1–11.
21. 10.1016/S2359-3482(15)30022-1  
da Silva Magalhães EI, Sant’Ana LF, da R, Priore, Franceschini SE S do CC. Waist circumference, waist/height ratio, and neck circumference as parameters of central obesity assessment in children\*  
\*Study conducted at Departamento de Nutrição e Saúde, Universidade Federal de Viçosa, Viçosa, MG, Brazil. *Rev Paul Pediatr (English Ed)*. 2014;32:273–81. doi:10.1016/S2359-3482(15)30022-1.
22. Ataie-Jafari A, Namazi N, Djalalinia S, Chaghamirzayi P, Abdar ME, Zadehe SS, et al. Neck circumference and its association with cardiometabolic risk factors: a systematic review and meta-analysis. *Diabetology & Metabolic Syndrome*. 2018;10.  
<https://dmsjournal.biomedcentral.com/articles/10.1186/s13098-018-0373-y>. Accessed 20 Apr 2020.

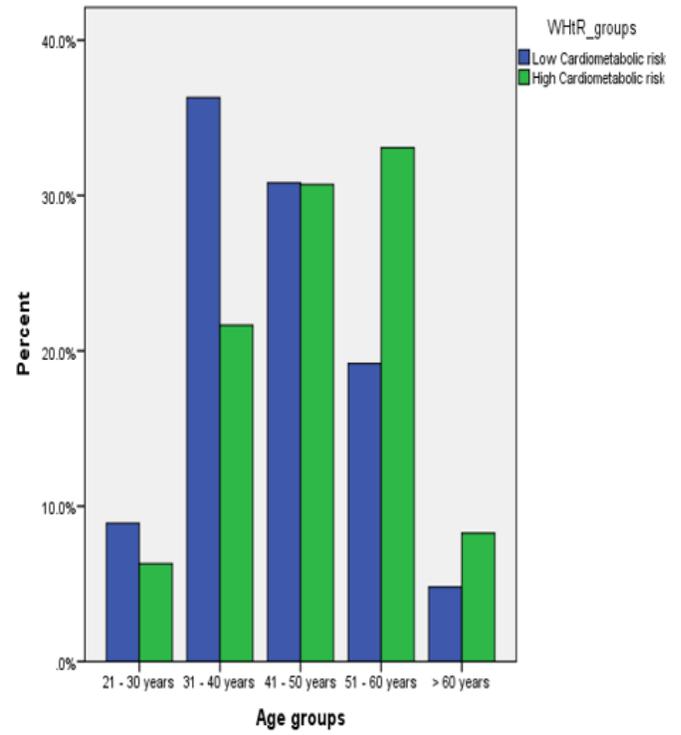
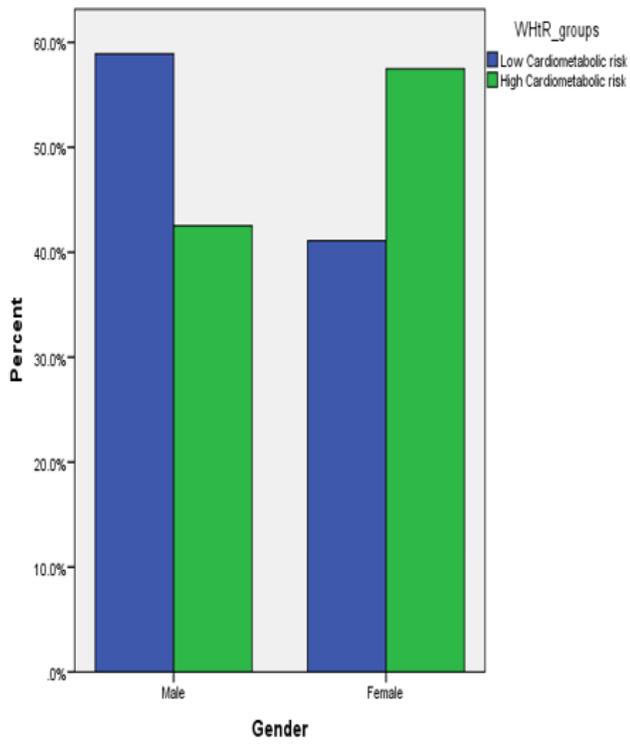
23. Zanutto VV, Pessoa MC, Pereira PF, Longo GZ. Neck circumference, cardiometabolic risk, and Framingham risk score: Population-based study. *Rev Nutr.* 2017;30:771–81.
24. Ondicho MZ, Omondi DO, Onyango AC. Prevalence and Socio-demographic Factors Associated with Overweight and Obesity among Healthcare Workers in Kisumu East Sub-County, Kenya. *Am J Med Med Sci.* 2016;6:66–72.
25. Goedecke JH. Addressing the problem of obesity and associated cardiometabolic risk in black South African women – time for action ! black South African women – time for action ! *Glob Health Action.* 2017;10.
26. Raimi TH, Odunsan O, Fasanmade O. High prevalence of central obesity in rural South-Western Nigeria: Need for targeted prevention. *Journa Diabetes Endocrinol.* 2015;6:12–8.
27. Owolabi EO, Goon D, Ter, Adeniyi OV. Central obesity and normal-weight central obesity among adults attending healthcare facilities in Buffalo City Metropolitan Municipality, South Africa: a cross-sectional study. *Journal of Health, Population and Nutrition.* 2017;36.  
<https://link.springer.com/content/pdf/10.1186/s41043-017-0133-x.pdf>. Accessed 21 Apr 2020.

## Figures



**Figure 1**

Distribution of Respondents according to their Cardiometabolic Risk using WHtR (N = 400)



**Figure 2**

Distribution of Cardiometabolic risk according to gender and age groups