Anthropometric measures of adiposity as correlates of atherogenic index of plasma in non-obese sedentary Nigerian males

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Background: The increase in cardiovascular events has necessitated the identification of possible predictors that can help in predicting atherogenicity.

Objective: The study sought to identify the anthropometric measures of adiposity that are associated with atherogenic risk in sedentary, non-obese, young male adults.

Methods: A cross-sectional design was used to recruit a purposive sample of 414 sedentary males in a university campus. Anthropometric measures of adiposity, lipid parameters, and atherogenic index of plasma (AIP) were assessed. Pearson correlation and stepwise multiple regression were used to analyze the data collected. Alpha level was set at \( p < 0.05 \).

Results: There was a high risk of cardiovascular events (AIP = 0.36 ± 0.04 SD) among the participants. A significant correlation \( (p = 0.000) \) was obtained between each of the anthropometric measures (except conicity index) and AIP. Body mass index, body adiposity index, and percent body fat were significant predictors accounting for 38.9, 3.1, and 2.2% of the variance due to AIP.

Conclusions: Sedentary status among young males is associated with high atherogenic risk in the presence of normal lipid and anthropometric parameters. Both central and general measures of adiposity predict less than half of the atherogenic risk in sedentary young males.

Keywords: atherogenicity; sedentary; predictors; anthropometric; adiposity; males

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non-obese sedentary males is unknown. Hence, the aim of the present study was to assess the anthropometric indices that predict atherogenic risk in sedentary, non-obese, young university males.

Methods

Participants
A cross-sectional design was used to recruit a purposive sample of 414 sedentary non-obese males from the University of Nigeria, Enugu Campus (UNEC). To meet with the requirements of the study, participants had to be apparently healthy with no active participation in sports or any known structured regular exercise. Only male students aged between 18 and 35 years were involved in the study. Sedentary status was characterized by a level of physical activity of ≤ 7 as evaluated by Baeeke’s questionnaire (15) and as recommended by Daussin et al. (16).

Instruments
Anthropometric measures
All anthropometric measurements were obtained with the participant standing upright. Height was measured with a stadiometer, with the shoulders in a relaxed position and the arms hanging freely. Weight was measured using a weighing scale, with the participant in light clothing without shoes. Waist and hip circumferences were taken as close to the skin as possible using an inelastic tape measure. Waist circumference was measured at the narrowest part of the trunk between the last rib and the anterior superior iliac spine, and hip circumference was measured at the widest part between the anterior superior iliac spine and the greater trochanter. Both measurements were taken to the nearest 0.5 cm. Measurements were taken in duplicate, with a preselected maximum acceptable variation of 0.5 kg for weight and 0.5 cm for height and circumference. A third measurement was taken if the difference of the first two measures was greater than the preselected limit. An average of the two closest measurements was used in the analysis. Waist-to-hip ratio was calculated for each participant by dividing the waist circumference (in cm) by the hip circumference (in cm). Body mass index (BMI) was calculated as weight (in kg)/height squared (in m²).

Fat mass was obtained by multiplying the percent fat by body weight (in kg). Fat mass index was obtained by dividing the fat mass (in kg) by the height squared (in m²). Fat-free mass index was obtained by dividing the fat-free mass (in kg) by the height squared (in m²). The conicity index (C index) was determined from the measurements of weight, height, and waist circumference by using the following mathematical equation (19):

\[
\frac{\text{waist circumference (in meters)}}{0.109} \times \frac{1}{\sqrt{\frac{\text{weight (in kilogram)}}{\text{height (in meters)}}}}
\]

Abdominal volume index was obtained from the formula (20):

\[
2 \text{ cm (waist)}^2 + 0.7 \text{ cm (waist circumference – hip circumference)}^2 \times \frac{1000}{9}
\]

Biochemical profile
Blood samples were obtained in the morning after 12 h of fasting. The blood was allowed to clot and was then centrifuged to separate the serum for lipid analysis. The values used for the present study were baseline values of participants recruited for the purpose of participating in an experimental study. Lipid analysis was done using spectrophotometer SM23A (Microfield Listmal, UK) and the reagents manufactured by Randox Laboratories Limited (Crumlin, UK). The analysis was done by an enzymatic photometric test known as ‘CHOD PAP’ using a wavelength of 520 nm and an optical path of 1 cm. Serum cholesterol was estimated by mixing 0.01 ml serum with 1 ml of working reagent. The mixture was incubated at 37 °C for 5 min and absorbance was measured after 60 min against distilled water as a blank. Other lipids were measured similarly using the relevant working reagents.

Administration of the instruments
Ethical approval was obtained from the institutional ethical committee before commencement of the study. The procedure was described to the prospective participants.
Adiposity measures as predictors of atherogenic marker

Methods of data analysis
Kolmogorov–Smirnov test was used to assess if the data were distributed normally. Descriptive statistics was used to summarize measurements as means and standard deviations. Pearson correlation coefficient was used to determine the anthropometric correlates of AIP. Stepwise multiple regression was used to determine the most significant predictor of AIP. Alpha level was set at $p < 0.05$.

Results
A total of 445 volunteers consented to participate in the study. Thirty-one individuals were excluded because they did not meet the requirements for participating in the study. Kolmogorov–Smirnov test of the variables obtained were normally distributed ($p$-values ranged from 0.431 to 0.742).

Table 1 shows the characteristics of the participants. The results indicate that, except for AIP, all parameters were within the normal range.

Table 2 shows that, except for conicity index, all anthropometric indices had significant positive correlations with AIP. The relationship was strongest between AIP and BMI ($r = 0.625; p = 0.000$) and the least was between AIP and waist-to-hip ratio ($r = 0.214; p = 0.000$).

Table 3 shows the coefficients of linear multiple regression on AIP using the stepwise method. BMI ($\beta = 0.327, p = 0.000$), body adiposity index (BAI) ($\beta = 0.252, p = 0.000$), and percent body fat ($\beta = 0.204, p = 0.000$) were the significant anthropometric predictors of AIP. BMI accounted for 38.9% of variance in AIP. When BAI was added to the model, this increased to 42%, while percent body fat further increased it to 44.2%.

Discussion
AIP, a new marker of atherogenicity, is directly related to the risk of atherosclerosis (21). People with high AIP have a higher risk of coronary heart disease than those with low AIP (22), and vice versa. Identifying individuals at the highest risk of comorbidities of obesity is essential in order to identify those who might benefit most from management programs (23). Our findings show that the participants were at high risk of future cardiovascular events, despite the seemingly normal lipid measurements (possibly except triglyceride, which may be borderline high) and anthropometric parameters. This is not in agreement with Pap et al. (24), who reported that students of the University of Novi Sad with high risk of cardiovascular disease have increased anthropometric and lipoprotein status. However, they did not determine the sedentary status of the students in their study. Recently, it was claimed that inactivity could be the primary criterion for early identification of those at risk of cardiovascular disease (25). The present finding suggests a tendency toward atherogenic lipoproteins over

| Variables | Mean (SD) | Range |
|-----------|-----------|-------|
| Age (years) | 22.87 (1.57) | 21–26 |
| Height (m) | 1.82 (0.04) | 1.76–1.93 |
| Weight (kg) | 71.04 (5.37) | 62.4–84.0 |
| Body mass index (kg/m²) | 21.36 (1.46) | 19.29–24.25 |
| Conicity index | 1.15 (0.04) | 1.05–1.31 |
| Abdominal volume index | 12.40 (0.95) | 10.63–15.52 |
| Waist circumference (cm) | 78.18 (3.17) | 71.80–88.00 |
| Waist-to-hip ratio | 0.84 (0.03) | 0.77–0.93 |
| Waist-to-height ratio | 0.43 (0.02) | 0.39–0.49 |
| Body adiposity index | 19.65 (1.05) | 17.40–22.00 |
| Percent body fat (%) | 11.04 (0.99) | 9.20–12.60 |
| Triglycerides (mmol/L) | 2.25 (0.30) | 1.80–2.70 |
| High density lipoprotein (mmol/L) | 0.98 (0.14) | 0.80–1.20 |
| Low density lipoprotein (mmol/L) | 1.65 (0.70) | 0.60–2.75 |
| Total cholesterol (mmol/L) | 3.75 (0.88) | 2.65–5.13 |
| Atherogenic index of plasma | 0.36 (0.04) | 0.28–0.41 |

Table 2. Correlation between anthropometric indices and atherogenic index of plasma

| Variables | $r$ | $p$ |
|-----------|-----|-----|
| Body mass index | 0.625 | 0.0000* |
| Conicity index | $-$0.086 | 0.0820 |
| Abdominal volume index | 0.389 | 0.0000* |
| Waist circumference | 0.366 | 0.0000* |
| Waist-to-hip ratio | 0.214 | 0.0000* |
| Waist-to-height ratio | 0.476 | 0.0000* |
| Body adiposity index | 0.544 | 0.0000* |
| Percent body fat | 0.515 | 0.0000* |

*Significant at $p < 0.05$; $r$ = Pearson correlation coefficient.
protective lipoproteins in sedentary males who have normal anthropometric and lipid parameters. This risk can be decreased by physical activity and balanced nutrition, which cannot be replaced by medication (24). As part of physical activity aimed to prevent or reduce atherogenic risk, it is recommended that individuals engage in at least 30 min of regular physical activity daily (18, 26).

A significant positive correlation was obtained between the respective anthropometric measures of BMI, AI, WC, W–H, W–Ht, BAI, %BF, and AIP. The relationship between CI and AIP was negative but not significant. Previous studies have not been consistent in their findings on relationships between anthropometric measures of adiposity and atherogenic risk indices. Lack of association was reported between central adiposity and cardiovascular risk in a sample of 55 men with an atherogenic lipoprotein phenotype, aged 34 – 69 years (27). In contrast, one study reported a significant association of indices of adiposity with atherogenic lipoprotein subfractions among a sample of 93 men aged between 18 and 69 years. There is a dearth of studies on the use of AIP as an index of atherogenic risk in determining anthropometric predictors. Also, there is dearth of visible literature on studies evaluating these associations among young sedentary males. It is possible that the age range and physical activity status may have influenced the pattern of relationships in previous findings.

The findings of this study imply that BMI, BAI, and percent body fat together accounted for 44.2% of the variance due to AIP. This disagrees with Alboqai et al. (28), who reported that central adiposity rather than general obesity measures contributed to cardio-metabolic risk among adult males in Northern Jordan. Our findings suggest that general (BMI and %BF) and central measures of adiposity (BAI) contribute to atherogenic risk. However, general measures contributed more than central measures of adiposity in predicting AIP. The results also imply that 55.8% of variance in AIP was not accounted for by BMI, BAI, and percent body fat. It is possible that other lifestyle, environmental, or hemato-biochemical factors that were not taken into consideration in the present study may account for the unexplained variance in AIP. This indicates the need for further studies to identify other possible factors and the extent of their contributions to predicting AIP.

A major limitation of the present study was the use of a cross-sectional design, which cannot be used to make causal inferences. Another limitation is the use of non-probability sampling to recruit participants, as this could influence the external validity of the findings.

Conclusions
Sedentary status among young males is associated with high atherogenic risk in the presence of seemingly normal lipid and anthropometric parameters. Except for the conicity index, all anthropometric measures of adiposity had significant positive associations with AIP in sedentary non-obese young males. BMI, BAI, and percent body fat are significant predictors of AIP in sedentary non-obese males. Both central and general measures of adiposity predict less than half of the atherogenic risk in sedentary young males.

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References
1. Freedman D, Serdula M, Srinivasan S, Berensen G. Relation of circumferences and skinfold thickness to lipid and insulin concentrations in children and adolescents: the Bogalusa Heart study. Am J Clin Nutr. 1999; 69: 308–17.
2. Kissebah A. Intra-abdominal fat: is it a major factor in developing diabetes and coronary artery disease? Diabetes Res Clin Pract. 1996; 30: 25–30.
3. Jee SH, Sull JW, Park J, Lee S-Y, Ohrr H, Guallar E, et al. Body-mass index and mortality in Korean men and women. N Engl J Med. 2006; 355: 779–87.
4. Rexrode KM, Buring JE, Manson JE. Abdominal and total adiposity and risk of coronary heart disease in men. Int J Obes. 2001; 25: 1047–56.
5. Canoy D, Boekholdt SM, Wareham N, Luben R, Welch A, Bingham S, et al. Body fat distribution and risk of coronary heart disease in men and women in the European prospective investigation into cancer and nutrition in Norfolk cohort: a population-based prospective study. Circulation. 2007; 116: 2933–43.
6. Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Commerford P, et al. Obesity and the risk of myocardial infarction in 27000 participants from 52 countries: a case-control study. Lancet. 2005; 366: 1640–9.
7. Dobiasova M, Frohlich J, Sedova M, Chenng MC, Brown BG. Cholesterol esterification and atherogenic index of plasma correlate with lipoprotein size and findings on coronary angiography. J Lipid Res. 2011; 52: 566–71.
8. Litwin SE. Which measures of obesity best predict cardiovascular risk? J Am Coll Cardiol. 2008; 52: 8.
9. Tariq M, Rajab A. Comparative study for atherogenic index of plasma (AIP) in patients with type 1 diabetes mellitus, type 2 diabetes mellitus, beta thalassemia and hypothyroidism. Int J Chem Res. 2012; 2: 1–9.
10. Nwagha UI, Ikepazu EJ, Ejiezie FE, Neboh EE, Maduka IC. Atherogenic index of plasma as useful predictor of cardiovascular risk among postmenopausal women in Enugu, Nigeria. Afr Health Sci. 2010; 10: 248–52.
11. Dobiasova M. Atherogenic index of plasma as a significant predictor of cardiovascular risk: from research to practice. Vnitr Lek. 2006; 52: 64–71.
12. Merrill GF, Friedrichs GS. Plasma lipid concentrations in college students performing self-selected exercise. J Am Coll Nutr. 1990; 9: 226–30.

13. Nemetz PN, Roger VL, Ransom JE, Bailey KR, Edwards WD, Leibson CL. Recent trends in the prevalence of coronary disease: a population-based autopsy study of non-natural deaths. Arch Intern Med. 2008; 68: 264–70.

14. Bowden RG, Lanning BA, Doyle EI, Johnston HM, Slonaker GS. Lipid levels in a cohort of sedentary university students. Internet J Cardiovasc Res. 2005;2. DOI: 10.5580/281d.

15. Baecke JAH, Burema J, Frijters JER. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr. 1982; 36: 936–42.

16. Daussin FN, Zoll J, Dufour SP, Ponsot E, Lonsdorfer-Wolf E, Doutreleau BM, et al. Effects of interval versus continuous training on cardio respiratory and mitochondrial functions relationship to aerobic performance improvements in sedentary subjects. Am J Physiol Regul Integr Comp Physiol. 2008; 295: R264–72.

17. Jackson AS, Pollock ML. Practical assessment of body composition. Phys Sports Med. 1985; 13: 76–90.

18. American College of Sports Medicine. ACSM’s guidelines for exercise testing and prescription. 8th ed. Philadelphia, PA: Lippincott, Williams and Wilkins; 2009.

19. Valdez R. A simple model-based index of abdominal adiposity. J Clin Epidemiol. 1991; 44: 955–6.

20. Guerrero-Romero F, Rodriguez-Morán M. Abdominal volume index: an anthropometry-based index for estimation of obesity is strongly related to impaired glucose tolerance and type 2 diabetes mellitus. Arch Med Res. 2003; 34: 428–32.

21. Rajab TMA. Comparative study for atherogenic index of plasma (AIP) in patients with type I diabetes mellitus, Type 2 diabetes mellitus beta thalassemia and hypothyroidism. Int J Chem Res. 2012; 2: 1–9.

22. Tan MH, Johns D, Glazer NB. Pioglitazone reduces atherogenic index of plasma in patients with type 2 diabetes. Clin Chem. 2004; 50: 1184–8.

23. Cornier M, Despres JP, Davis N, Grossniklaus DA, Klein S, Lamarche B, et al. Assessing adiposity: a scientific statement from the American Heart Association. Circulation. 2011; 124: 1996–2019.

24. Pap D, Colak E, Singh NM, Grubor-Lajsic G, Vickovic S. Lipoproteins and other risk factors for cardiovascular disease in a student population. J Med Biochem. 2013; 32: 140–5.

25. Abraham PA, Kazman JB, Zeno SA, Deuster PA. Obesity and African Americans: physiologic and behavioural pathways. ISRN Obes. 2013; ID314295.

26. Fourth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice. European guidelines in cardiovascular disease prevention in clinical practice. Eur J Cardiovasc Prev Rehabil. 2007; 14: S1–S113.

27. Minihane AM, Khan S, Talmud PJ, Williams DL, Wright JW, Murphy MC, et al. Lack of association between lipaemia and central adiposity in subjects with an atherogenic lipoprotein phenotype (ALP). Int J Obes. 2000; 24: 1097–106.

28. Alboqai O, Suleiman A, Hourani HA, Obeidat B, Abuirmeileh N, El-Qudah JM, et al. Central adiposity rather than overall obesity influences cardio-metabolic risk factors among adult males in Northern Jordan. Diabetol Croat. 2009; 38: 73–82.