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To cite this article: Antoninus O. Ezeukwu & Elias O. Agwubike (2014) Anthropometric measures of adiposity as correlates of atherogenic index of plasma in non-obese sedentary Nigerian males, Libyan Journal of Medicine, 9:1, 23798, DOI: [10.3402/ljm.v9.23798](https://doi.org/10.3402/ljm.v9.23798)

To link to this article: <https://doi.org/10.3402/ljm.v9.23798>



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Published online: 03 Apr 2014.



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ORIGINAL ARTICLE

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 ($AIP = 0.36 \pm 0.04$ 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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Received: 11 January 2014; Accepted in revised form: 11 March 2014; Published: 3 April 2014

The mechanism responsible for atherogenesis has been explored for ages. The role of anthropometric measures of obesity in contributing to the increased risk for a cascade of atherogenic events has been an enormous controversy. Recent evidence shows that the distribution of fat during early adulthood is associated with increased metabolic disease risk in later adulthood (1, 2). Some authors attribute this to generalized measures of obesity (3, 4), while others have identified central measures of obesity (5, 6). It has also been suggested that the composition and size of lipoprotein sub-populations can be influenced by anthropometric characteristics (7). The robustness of this assertion is influenced by the specific population, gender, age group, and ethnicity (8).

Atherogenic index of plasma (AIP), a new marker of atherogenicity, has been shown to significantly increase

with atherogenic risk (9) and to be significantly valuable for assessing atherogenic risk in the Nigerian population (10). It has been suggested that $AIP < 0.1$ is associated with low risk, 0.1–0.24 with medium risk, and > 0.24 with high cardiovascular risk (11). Young male university students have been shown to be at high risk of cardiac events due to a higher tendency toward dyslipidemia (12). It is also known that the life expectancy of males in Nigeria is decreasing drastically. This is coupled with an increase in metabolic and cardiovascular dysfunction in younger persons (13), which has necessitated lipid research intervention at a much younger age (14).

Sedentary lifestyle and physical inactivity, either individually or in combination, are known precursors of atherogenic risks. However, the extent to which a sedentary lifestyle establishes a relationship between anthropometric fat distribution and atherogenic markers in

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 Baecke'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).

Percent fat was obtained using the three-site skinfold (chest, abdomen, and thigh) caliper formula described by Jackson and Pollock (17) and recommended by American College of Sports Medicine (ACSM) (18). All skinfold measurements were taken on the right side of the body with the participant standing upright. The caliper was placed directly over the skin surface, 1 cm away from the thumb and finger, perpendicular to the skinfold, and halfway between the crest and the base of the fold. The reading of the caliper was obtained after maintaining a pinch on the skin for 1–2 s. Duplicate measures were

taken at each site and another measurement was done if the duplicate measurements were not within a range of 2 mm. The chest skinfold was obtained at the diagonal fold, halfway between the anterior axillary line and the nipple. The abdominal skinfold was taken at the vertical fold, 2 cm to the right side of the umbilicus. The thigh skinfold was taken at the vertical fold on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal crease (hip). The generalized skinfold equation was used to calculate body density (18) as follows: $1.10938 - 0.0008267 (\text{sum of three skinfold}) + 0.0000016 (\text{sum of three skinfolds})^2 - 0.0002574 (\text{age})$.

The population-specific formula for young black males (18) was used to convert the body density to percent fat as follows: $\left(\frac{4.37}{\text{body density}}\right) - 3.93$.

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):

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

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

$$\frac{2 \text{ cm (waist)}^2 + 0.7 \text{ cm (waist circumference - hip circumference)}^2}{1000}$$

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

and informed consent was obtained before participation. Those who consented to participate in the study were screened for eligibility using Baecke's questionnaire before being enrolled in the study. Measurements of anthropometric and lipid parameters were obtained.

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) ($\beta = 0.252$,

Table 1. Descriptive characteristics of the participants ($n = 414$)

| 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/m^2) | 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.

$p = 0.000$), 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

Table 3. Multivariate linear regression analysis of anthropometric parameters with atherogenic index of plasma

| Factors | Regression coefficient (standardized) | Adjusted R^2 | p |
|----------------------|---------------------------------------|----------------|---------|
| Body mass index | 0.327 | 0.389 | 0.0000* |
| Body adiposity index | 0.252 | 0.420 | 0.0000* |
| Percent body fat | 0.204 | 0.442 | 0.0000* |

*Significant at $p < 0.05$.

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.

Acknowledgements

The authors are grateful for the assistance of the staff of the Gymnasium Unit, Department of Medical Rehabilitation, UNEC during the data collection.

Conflicts of interest and funding

The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

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