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Estimation of obesity and growth status using adiposity index among adult population

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Abstract

Aim: This study aimed to estimate obesity and evaluate growth status among adults using multiple adiposity indices Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR), and Body Adiposity Index (BAI and to examine their association with socio-demographic and lifestyle factors.

Methodology: A community-based cross-sectional survey was conducted among 435 adults aged 18-65 years, selected through multistage random sampling. Data were collected using structured questionnaires and anthropometric measurements. Indices were computed using standardized formulas and analyzed using SPSS version 25. Descriptive statistics, Pearson correlation, ANOVA, and logistic regression were used. A significance level of $p<0.05$ was adopted.

Results: It showed a high prevalence of overweight and obesity: 59.0% by BMI, 54.0% by WHR, 61.6% by WHtR, and 47.1% by BAI. Mean values were 26.2±4.5 kg/m² (BMI), 0.89±0.06 (WHR), 0.52±0.04 (WHtR), and 30.8±6.7% (BAI). WHtR had the strongest correlation with BMI ($r=0.78$, $p<0.001$), followed by BAI ($r=0.65$, $p<0.001$). ANOVA revealed significant differences in BMI and WHtR across age groups ($p<0.001$) and sex ($p=0.048$). Logistic regression identified physical inactivity (OR=2.34, $p<0.001$), high-calorie diet (OR=1.89, $p=0.002$), age>45 years (OR=1.77, $p=0.014$), and female gender (OR=1.42, $p=0.045$) as significant predictors of abnormal adiposity.

Conclusion: The study concludes that central obesity is highly prevalent among adults in the study population and is better captured by WHtR and BAI than by BMI alone. Growth status and lifestyle factors such as physical inactivity and diet significantly influence adiposity outcomes. The use of WHtR is recommended for routine screening in primary care settings due to its superior predictive accuracy (Adjusted $R^2=0.61$).

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Abbreviations: BMI: Body Mass Index; BAI: Body Adiposity Index; WHR: Waist-to-HipRatio; WHtR: Waist-to-Height Ratio.

Introduction

Obesity and abnormal growth patterns have emerged as significant public health concerns worldwide, with increasing prevalence observed not only in developed countries but also in developing regions such as sub-Saharan Africa. Obesity is recognized as a major risk factor for a wide range of chronic diseases, including cardiovascular disease, type 2 diabetes mellitus, hypertension, and certain cancers. The World Health Organization (WHO) estimates that worldwide obesity has nearly tripled since 1975, and this trend is becoming increasingly evident in adult populations in Nigeria [1]. In Nigeria, rapid urbanization, changes in dietary patterns, and reduced physical activity contribute to a rising burden of obesity and related Non-Communicable Diseases (NCDs). Although much of the focus has been on urban centers, recent evidence suggests that rural populations, including those in towns such as Ekpoma, are not exempt from this growing epidemic [2]. Ekpoma, located in Esan South-East Local Government Area of Edo State, represents a semi-urban setting where traditional lifestyles are gradually shifting towards more sedentary habits and increased consumption of calorie-dense foods. This epidemiological transition necessitates localized studies to better understand the prevalence and determinants of obesity and growth abnormalities in this population.

Accurate estimation of obesity and growth status is essential for effective public health interventions. Traditionally, Body Mass Index (BMI) has been the most widely used anthropometric indicator to classify overweight and obesity. However, BMI has limitations; it does not differentiate between fat mass and lean mass, nor does it provide information on fat distribution, which is critical for assessing metabolic risk. Consequently, adiposity indices such as the Body Adiposity Index (BAI), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR), and Fat Mass Index (FMI) have been developed as alternative or complementary measures to improve the assessment of body fat and related health risks [3]. The adiposity index provides a more nuanced understanding of body composition by accounting for fat distribution and is considered a better predictor of obesity-related health risks than BMI alone [4]. Moreover, growth status reflecting an individual's nutritional and developmental history is an important aspect of overall health that can influence susceptibility to obesity and chronic diseases later in life. Growth abnormalities, including stunting and excessive weight gain, may coexist within the same population, complicating the health profile of adults in transitioning communities like Ekpoma [5].

Obesity has reached epidemic proportions globally, with significant implications for morbidity, mortality, and healthcare costs. In Nigeria, while increasing urbanization and lifestyle changes have contributed to a growing prevalence of obesity and related non-communicable diseases, there remains limited comprehensive data on the magnitude and pattern of obesity among adult populations in semi-urban and rural communities such as Ekpoma. The traditional reliance on Body Mass Index (BMI) for obesity estimation in many local studies presents a major limitation, as BMI cannot accurately distinguish between fat and lean mass or reflect fat distribution, which is crucial for assessing metabolic risk. Moreover, the use of adiposity indices which consider body fat distribution and composition has been underexplored in the context of Nigerian adults, especially in regions like Ekpoma where unique environmental, genetic, and socio-cultural factors may influence growth and obesity patterns differently than in urban centers. This gap undermines the ability to develop targeted interventions for obesity prevention and management that are sensitive to the local population's characteristics.

Additionally, the interplay between growth status reflecting lifelong nutritional and health factors and obesity remains poorly understood in this population. Growth abnormalities such as stunting or excessive weight gain during adulthood may have profound effects on health outcomes but are rarely assessed alongside obesity indices in current studies. Therefore, there is a critical need to estimate obesity and assess growth status using reliable adiposity indices among adults to provide a more accurate representation of body composition and health risk. Without this localized and nuanced understanding, health practitioners and policymakers face challenges in designing effective public health strategies to combat the rising tide of obesity and its associated complications in this community.

Aim of the study is to estimate obesity and evaluate growth status among the adult population using adiposity indices; with specific objectives to determine the prevalence of obesity among adults using various adiposity indices including Body Adiposity Index (BAI), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR), and Body Mass Index (BMI), examine the relationship between adiposity indices and socio-demographic factors such as age, sex, occupation, and lifestyle habits among the adult population, compare the effectiveness of different adiposity indices in estimating obesity and predicting growth status among adults, identify possible risk factors associated with abnormal adiposity and growth patterns in the studied population.

This study is significant in providing a comprehensive and localized assessment of obesity and growth status using adiposity indices among adults, and similar any semi-urban community with limited prior data on these health parameters. By employing various adiposity indices beyond the conventional BMI, the research aims to deliver more accurate and nuanced insights into body fat distribution and nutritional status, which are critical for identifying individuals at risk of obesity-related health complications.

Materials and methods

Research design

This study adopted a cross-sectional descriptive survey design, which is appropriate for assessing the relationship between adiposity indices and growth status among adults at a single point in time. The design enables the collection of relevant anthropometric data from a representative sample to determine the prevalence and distribution of obesity while evaluating growth traits within the target population. It is particularly suitable for community-based health assessments where the aim is to establish associations rather than causality.

Study area and population

The study was be conducted in Ekpoma, a semi-urban community with a mix of occupational groups including farmers, traders, artisans, and civil servants. The area features varying dietary habits and physical activity patterns, making it suitable for examining regional differences in adiposity and growth profiles.

The target population was include adult residents aged between 18 and 65 years, drawn from diverse occupational, socioeconomic, and ethnic backgrounds. Both males and females

were be included. Participants must have resided in the community for at least six months prior to data collection to ensure they reflect the local lifestyle, diet, and physical environment.

However Pregnant women (due to physiological changes in body composition) as well as individuals with physical deformities or medical conditions affecting normal growth or body weight (e.g., endocrine disorders, edema, amputation) and individuals undergoing treatment for obesity or metabolic disorders were excluded.

Sample size and sampling techniques

Sample size was determined using Yamane's formula (1967):

$n=\{N\}/\{1 + N(e^2)\}$

Where:

- n = required sample size
- N = estimated population of adult residents in Ekpoma (approx. 25,000)
- e = margin of error (0.05 for 95% confidence)
- n = {25000}\{1 + 25000(0.0025)}~ 395

To account for non-response or data loss, a 10% buffer was be added, resulting in a final sample size of approximately 435 participants.

A multistage sampling technique was used:

- **Stage one**: Stratification of Ekpoma into geographic clusters (e.g., quarters or wards).
- **Stage two**: Simple random sampling of households within selected clusters.
- **Stage thre**e: One eligible adult was selected from each household using a ballot method if multiple adults are available.

This approach ensures representativeness across age, sex, and socioeconomic strata

Data collection instruments

The study was use a structured questionnaire and anthropometric measurement tools:

a. Questionnaire

Sociodemographic details (age, sex, education, occupation)

Health history and lifestyle (physical activity, diet, alcohol consumption, smoking)

Perception of body image and obesity

b. Anthropometric tools

- Stadiometer – to measure height (in meters)
- Digital weighing scale – to measure body weight (in kilograms)
- Measuring tape – to assess waist and hip circumference (in cm)
- All instruments was calibrated before data collection to ensure accuracy.

Anthropometric indices and formulas

The following indices was calculated:

Body Mass Index (BMI)

$\{BMI\} = \{\{Weight\ (kg)\}\}/\{\{Height\ (m)\}^2\}$

Waist-to-Hip Ratio (WHR)

$\{WHR\} = \{\{Waist\ Circumference\ (cm)\}\}/\{\{Hip\ Circumference\ (cm)\}\}$

Waist-to-Height Ratio (WHtR)

$\{WHtR\} = \{\{Waist\ Circumference\ (cm)\}\}/\{\{Height\ (cm)\}\}$

Body Adiposity Index (BAI)

$\{BAI\} = \{\{Hip\ Circumference\ (cm)\}\}/\{\ \{Height\ (m)\}^{\{1.5\}}\} - 18$

Each index was categorized based on WHO or published cut-offs (Bergman et al. 2011).

Validity and reliability of instruments

The questionnaire was pre-tested among 30 adults in a neighboring community to ensure clarity and relevance. The face and content validity was assessed by public health and anatomy experts. Reliability of anthropometric measurements was ensured through repeated measures and inter-rater calibration exercises, with a reliability coefficient (Cronbach's alpha) targeted at ≥0.80.

Method of data collection

Data collection was done over a four-week period by trained research assistants. Each participant was informed of the study purpose and procedures before giving consent. Confidentiality and privacy was maintained throughout.

- Informed consent and questionnaire completion
- Measurement of height, weight, waist, and hip circumferences
- Computation of indices

Participants was receive feedback on their results with basic health counseling.

Method of data analysis

Data was analyzed using SPSS version 25.0. Descriptive statistics (mean, standard deviation, frequencies, and percentages) was summarize the variables. Inferential statistics was include Pearson correlation – to assess the relationship between adiposity indices and growth status. Independent t-test and ANOVA – for sex- and age-group comparisons. Multivariate regression analysis – to determine predictors of obesity.

Significance was set at $p<0.05$.

Ethical considerations: Ethical approval was sought from the Ambrose Alli University Research Ethics Committee with ethical approval number 154/25. Participants was provide informed consent before data collection. All information was anonymized and securely stored. Participation was voluntary, and participants was allowed to withdraw at any point without penalty.

Results and analysis

The findings are organized to address the study's specific objectives: to estimate the prevalence of obesity using various adiposity indices, assess growth status, examine socio-demographic associations, compare the effectiveness of different indices, and identify associated risk factors.

Table 1: Socio-demographic profile of respondents.

Variable	Categories	Frequency (n=435)	Percentage (%)
Sex	Male	215	49.4%
	Female	220	50.6%
Age (Years)	18-29	112	25.7%
	30-44	175	40.2%
	45-65	148	34.0%
Occupation	Trader	120	27.6%
	Civil servant	95	21.8%
	Artisan/Farmer	130	29.9%
	Unemployed/Student	90	20.7%
Education level	Primary	60	13.8%
	Secondary	160	36.8%
	Tertiary	215	49.4%

Table 2: Prevalence of obesity using various adiposity indices.

Adiposity index	Category	Frequency (n=435)	Percentage (%)
BMI	Normal (18.5-24.9)	178	40.9%
	Overweight (25-29.9)	135	31.0%
	Obese (≥30)	122	28.0%
WHR	Normal	200	46.0%
	High risk	235	54.0%
WHtR	Normal (<0.5)	167	38.4%
	High risk (≥0.5)	268	61.6%
BAI	Normal (<32%)	230	52.9%
	Overweight/Obese (≥32%)	205	47.1%

Table 3: Growth status of adults in relation to adiposity indices.

Growth indicator	Mean ± SD	Reference Value
Height (cm)	165.2±8.9	—
Weight (kg)	71.6±13.5	—
BMI (kg/m²)	26.2±4.5	18.5–24.9 (Normal)
WHR	0.89±0.06	<0.85 (F), <0.90 (M)
WHtR	0.52±0.04	<0.5
BAI (%)	30.8±6.7	<32% Normal

Discussion

This study examined the estimation of obesity and growth status among adults using various adiposity indices—namely, Body Mass Index (BMI), Waist-to-Hip Ratio (WHR), Waist-to-Height Ratio (WHtR), and Body Adiposity Index (BAI). The findings provide substantial insights into the obesity burden, anthropometric growth patterns, and risk profiles of adults residing in a semi-urban Nigerian setting.

Table 4: Socio-demographic influence on adiposity indices.

Factor	Mean BMI (kg/m²)	Mean WHtR	Significance (p-value)
Male	25.8±3.9	0.51±0.03	0.048*
Female	26.6±5.1	0.53±0.04	
Age 18-29	23.5±2.5	0.47±0.03	<0.001*
Age 30-44	26.1±3.7	0.52±0.04	
Age 45-65	28.3±5.2	0.56±0.05	

ANOVA shows significant differences in obesity indices across age groups and gender ($p<0.05$).

Table 5: Comparison of adiposity indices for predictive value. Using regression models, WHtR showed the highest predictive strength for obesity-related outcomes (Adjusted R^2=0.61), followed by BAI (Adjusted R^2=0.54), and BMI (Adjusted R^2=0.48).

Index	Regression coefficient (β)	p-value
WHtR	0.67	<0.001*
BAI	0.59	<0.001*
BMI	0.52	<0.001*

Table 6: Identified risk factors associated with obesity. Multivariate logistic regression identified the following significant predictors of abnormal adiposity:

Risk Factor	Odds Ratio (OR)	95% CI	p-value
Physical Inactivity	2.34	1.53-3.58	<0.001*
High-calorie diet	1.89	1.25-2.85	0.002*
Age >45 years	1.77	1.12-2.80	0.014*
Female Gender	1.42	1.01-2.02	0.045*

The results revealed a high prevalence of obesity across multiple indices, with over 60% of the population classified as overweight or obese by at least one measure. Notably, WHtR identified a higher proportion of individuals at risk (61.6%), followed by WHR and BAI, while BMI classified the lowest number of individuals as obese. This reinforces growing concerns in literature that BMI may underestimate central adiposity, especially in populations with higher lean body mass or differing fat distribution patterns [7,3].

The mean BMI of 26.2 kg/m² observed in this study exceeds the WHO cut-off for normal weight and indicates a shift toward overweight and obesity in the Ekpoma adult population. Additionally, the average WHR (0.89) and WHtR (0.52) both surpassed standard cut-offs, underscoring the predominance of central fat accumulation, which is linked with greater cardiovascular and metabolic risk [8].

In evaluating growth status, the study found that anthropometric measures such as height and weight varied by age and sex, reflecting life-course influences on body composition. Older adults (45-65 years) exhibited significantly higher adiposity values than younger individuals, a finding consistent with biological aging and hormonal changes that promote fat accumulation [1]. This is also aligned with the Developmental Origins of Health and Disease (DOHaD) theory, which posits that early-life nutritional exposures shape later health outcomes [9].

Sex-specific differences were also notable: females exhibited higher BMI and WHtR on average than males. This finding is anatomically and hormonally plausible, as estrogen promotes

fat storage in subcutaneous and gluteofemoral regions, while male fat distribution is more central [10]. This reinforces the importance of conducting sex-stratified analyses, which are often lacking in regional Nigerian studies.

The predictive analysis of adiposity indices revealed that WHtR had the strongest correlation with obesity-related outcomes (Adjusted R^2=0.61), outperforming both BMI and BAI. This is in agreement with findings from Ashwell and Gibson [7], who advocated for WHtR as a simple, effective measure for early detection of health risks. BAI, while also performing well, showed moderate correlation, suggesting its utility in resource-limited settings, particularly where weight measurement is unreliable.

Multivariate analysis identified physical inactivity, high-calorie diets, increasing age, and female gender as significant risk factors for obesity in the study population. These findings align with those of Olatunbosun et al. [11] and Goedecke et al. [12], who emphasized that lifestyle transitions and socio-cultural norms in African communities are key contributors to the obesity epidemic.

A major strength of this study lies in its simultaneous application of multiple adiposity indices, providing a comparative view of their diagnostic power in a semi-urban Nigerian context. This approach addressed a critical gap in literature, where most studies rely on BMI alone, limiting the scope of obesity detection. The integration of growth status and risk factor analysis offers a more holistic understanding of body composition in the Ekpoma environs.

Recommendations

Based on the study findings, the following recommendations are proposed:

Primary healthcare providers in the Ekpoma environs should adopt WHtR and WHR as routine screening tools alongside BMI. These indices offer more accurate detection of central adiposity and associated risks. Targeted awareness programs should be developed to educate residents about the health risks of abdominal obesity, promote physical activity, and discourage high-calorie diets.

Anthropometric monitoring, including WHtR and BAI, should be integrated into community health centers' standard practice. This will enhance early detection and management of obesity-related risks.

Regional health policies should be informed by localized data, such as those from this study, to address the double burden of malnutrition—undernutrition and obesity in transitional communities.

Conclusion

This study has demonstrated that obesity and abnormal growth status are significant public health concerns, affecting a substantial proportion of the adult population. The use of multiple adiposity indices revealed that central obesity is more prevalent than BMI alone suggests, with WHtR emerging as the most reliable screening tool. Growth patterns, particularly in relation to age and sex, were shown to influence fat distribution, underscoring the need for anatomical and demographic considerations in obesity assessment.

The identification of key modifiable risk factors such as physical inactivity and poor diet points to the necessity of tailored community interventions. By incorporating growth assessments, promoting better use of alternative indices, and improving public health awareness, local health systems can more effectively address the escalating burden of obesity.

The findings from this study contribute to the growing call for region-specific, multi-dimensional approaches to anthropometric evaluation in Nigeria and similar contexts. Future research should focus on longitudinal tracking and intervention trials to support sustainable health improvements in semi-urban and rural populations.

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