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Research Article

# Comparison of the Prevalence of Overweight and Obesity in 9-13 Year-old Children from Two Countries Using CDC and IOTF Reference Charts

[1]Abel Toriola, [2]Olusesi Ajayi-Vincent, [2]Patrick Oyeniyi, [2]Isaac Akindutire, [2]David Adeagbo, [2]Patience Konwea, [2]Olukemi Awosusi, [2]Seyi Ogunsile, [3]Violet Kankane Moselakgomo, [4]Sunday Onagbiye and [5]Makama Monyeki

[1]Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology, Pretoria, South Africa
[2]Department of Human Kinetics and Health Education, Ekiti State University, Ado-Ekiti, Nigeria
[3]Centre for Biokinetics, Recreation and Sports Science, University of Venda, Thohoyandou, South Africa
[4]Department of Sport, Recreation and Exercise Science, University of the Western Cape, Cape Town, South Africa
[5]Physical Activity, Sport and Recreation (PhASRec), Faculty of Health Sciences, North-West University, Potchefstroom, South Africa

## Abstract

**Background and Objectives:** The epidemic of obesity is frequently prevailing, certainly among pediatric inhabitants and could be influenced by environmental and heritable factors. So, the aim of this study was to compare the prevalence of overweight and obesity in 9-13 year old children from Nigeria and South Africa using the criteria of the Centres for Disease Control and Prevention (CDC) and International Obesity Task Force (IOTF) for obesity classification chart based on age and gender-specific BMI cut-off points. **Materials and Methods:** Anthropometric measurements were taken using standardised protocol and used to estimate body mass index (BMI) and waist-to-height ratio (WHtR) in 1361 South African and 1229 Nigeria school children aged 9-13 year old. Height, body weight, BMI and WHtR were examined for Nigerian and South African school children according to sample size and age category. The BMI for age was used to classify the children according to weight categories and by gender, after which the obesity prevalence using the BMI Category for cut-off points chart was performed by age and countries. **Results:** The results showed that 1.1% (IOTF) and 9.9% (CDC) of Nigerian children were overweight. Corresponding data for South African children were 1.8% (IOTF) and 10.0% (CDC). Obesity estimates for Nigerian and South African children slightly varied for IOTF classification (1.1, 0.7%), but were similar when CDC classification was used (5.1%). In contrast, the CDC standard indicated strikingly lower incidence of underweight among the South African (4.9%) and Nigerian (4.8%) children. **Conclusion:** The lack of consistency in body weight classification using CDC and IOTF chart raises the question as to the right classification to use to evaluate weight abnormalities in children and adolescents. The choice of cut-off point in assessing overweight and obesity in childhood and adolescence should be based on reliable judgment as this could undermine the integrity of epidemiological research data.

Key words: CDC, IOTF, children health, obesity, South Africa

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Corresponding Author: A.L. Toriola, Department of Sport, Rehabilitation and Dental Sciences, Faculty of Science, Tshwane University of Technology, 0001 Pretoria, South Africa Tel: +27 (0) 788763471



Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Obesity is a fast growing public health issue among pediatric populations, which does not only persist in high income countries, but also affects middle to lower income nations[1]. Consideration given to overweight and obesity continues to rise due to its increasing prevalence, most especially in children and youth[2]. Overweight is multi-factorial phenomenon, which could be influenced by hereditary and environmental[3]. Furthermore, poor eating habits in terms of fast food rich in a high caloric content have also been widely attributed as a risk factor for cardiovascular diseases. Pediatric overweight and obesity is a public health issue since it persists into adulthood. Early identification of precursors of obesity in children could strengthen preventative intervention strategies[4].

Body mass index (BMI) has often been used to assess obesity and several studies have established significant relationships between BMI and body fat percentage (%BF)[5-7]. Therefore, BMI has become the most commonly used protocol for assessing body fatness[1], probably because it is an easy, economical and non-invasive means of measuring adiposity[1]. Furthermore, the use of BMI technique to measure body fat in childhood and adolescence is globally accepted[8] both in clinical and research settings.

Gender and age are also important considerations in assessing body composition among children and adolescents. In this regard, clarity on which BMI classification to use in screening overweight and obesity among children and adolescents contentious[8]. There are three established BMI cut-off points developed and consistently used worldwide. These are the World Health Organisation's (WHO) classifications, as well as those of the Centres for Disease Control and Prevention (CDC) and the International Obesity Task Force (IOTF). Gonzalez-Casanova *et al.*[8] stated that the IOTF reference, mostly commonly utilized in other countries apart from the United States, possess a lessened receptiveness compared to other cut-off points in screening children for overweight and obesity; thus suggesting that the three classifications could produce different outcomes in assessing obesity prevalence among children. Therefore, the primary objective of this study was to compare the prevalence of overweight and obesity using CDC and IOTF classifications in Nigerian and South African children.

## MATERIALS AND METHODS

**Research design and sample:** A cross-sectional research design was used. A total of 1361 South African (boys = 678, girls = 683) and 1229 Nigeria (boys = 483, girls = 746) school children aged 9-13 years, who were randomly selected from eight and five public schools in Limpopo and Mpumalanga provinces of South Africa, as well as Ado-Ekiti, Ekiti State in South West Nigeria, respectively. Class registers at the schools in each country were used to verify the children's ages. This study was conducted between March, 2015 and October, 2015.

**Ethical considerations:** Before data collection, the Ethics Sub-Committee of the Faculty of Health Sciences, North-West University, South Africa (Ethics No: NWU-00088-12-S1) and school authorities in Ado-Ekiti, Nigeria as well as other relevant provincial/state regulatory organizations granted approval for the study to be conducted. An information leaflet about the study was first distributed and explained to the children and their parents followed by the distribution and completion of written informed consent forms by head teachers and the children's parents/guardians. The children also gave verbal accent.

### Measurement

**Anthropometric:** The anthropometric measures included height, body weight, skin folds (triceps and subscapular), body circumferences (waist and hip), which were assessed using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK)[9]. Height was measured to the nearest 0.1 cm in bare feet with participants standing upright against a stadiometer. A digital weighing scale (Tanita HD 309, Creative Products, MI, USA) calibrated regularly to the nearest 0.1 kg (after every 10 measurements) was used to measure body mass with participants lightly dressed (underwear and T-shirt). Based on the height and body weight measurements, body mass index (BMI) was derived as follows:

$$\text{BMI} = \frac{\text{Body weight (kg)}}{\left[\text{Height (m)}\right]^2} \quad (1)$$

Children were categorised as underweight, normal weight, overweight and or obese for age and gender based on BMI norms[10].

**Body circumferences:** Waist girth was assessed proximal to the thinnest point located between the boundary of the 10th rib and iliac crest. When no clear thinness was evident, measurement was taken at the central point of the anatomical landmarks. Furthermore, readings were taken at the end of normal expiration with the arms naturally placed by the side[1]. Hip (maximal girth of the buttocks) circumference was

measured thrice to the nearest 0.1 cm using the Gullick anthropometric tape while the participant assumed a standing position. The subject was asked to stand erect with feet together and weight evenly distributed. The widest part of the hip was located and marked, i.e., at the level of greater trochanters. Based on the data obtained, the Waist-to-height ratio (WHtR) was calculated as the ratio of the children's waist circumference to their height(calculated by dividing the waist circumference by height). This anthropometric index also assesses the pattern of fat distribution among children.

**Pilot test:** Not part of the main study, 20 children of similar age groups participated in a pilot study to validate the instrument and measurement procedures, from which intra-observer reliability of anthropometric measurements, technical error of measurement (TEM) as well as intra-class correlation coefficient (r) (Pearson's method) were determined[11]. Furthermore, the TEM was within acceptable limits and agreed with the recommendations of Lohman *et al.*[12].

**Statistical analysis:** Differences in the anthropometric variables (height, weight, BMI, WHR) were examined using independent samples t-test based on age categories and nationality. Percentages were calculated for overweight and obesity prevalence based on BMI classifications by gender and also by countries and age categories in order to evaluate CDC and IOTF classification in the cohorts of Nigerian and South African school children. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), version 24. For data analyses, a probability level of $\leq$0.05 was taken to indicate significance.

## RESULTS

The anthropometric features of the Nigerian and South African children by sample size and age are provided in Table 1. In general, the total mean values at age 9 years for body weight (32.9±8.75 kg), height (135.8±8.44 cm), BMI (17.6±2.98 kg $m^{-2}$) and WHtR (0.87±0.05) were significantly higher in Nigerian school-going children, compared to their South African counterpart ($p<0.05$). No significant differences were found in body weight and BMI of the children in both countries. Except for BMI (17.7±3.15 kg $m^{-2}$), which was not significant, there were substantial differences in height (142.3±8.84 cm), body weight (36.0±7.45 kg) and WHtR (0.87±0.06) among 11 years old Nigerian children compared to their South African counterparts. In contrast, no significant differences were found for height, body weight and BMI of the children from both countries at age 12 years. At age 13 years, South African children were significantly taller (150.2±8.49 cm), heavier (42.7±8.84 kg) and fatter (BMI: 18.8±3.15 kg $m^{-2}$), but had significantly lower WHtR (0.80±0.06) compared to their Nigerian peers ($p<0.05$). Overall, the children's height ranged from 135.8±8.44 to 147.9±8.32 cm (Nigerians) and 130.6±6.90 to 150.2 ±8.49 cm (South Africans) ($p<0.05$). The Nigerian children were consistently taller than the South African children at ages 9-12 years, although not significant at age 12 years. But, at age 13 years, the South African children were taller. Height was also found to increase with age irrespective of nationality (Table 1).

When the children from the two countries were compared based on IOTF BMI classifications by gender categories, the results showed that the South African boys (2.6%) were more overweight (BMI$\geq$25) than Nigerian boys (1.2%). Furthermore, Nigerian girls (1.1%) exhibited an increased level of overweight compared to South Africa girls. There was a higher prevalence of obesity among Nigerian boys (1.7%) and girls (0.8%) than South African children: Boys (0.7%) and girls (0.6%) (Table 2). There was a significant difference in the prevalence of overweight between Nigerian and South African children using the IOTF and CDC classifications.

Table 1: Anthropometric characteristics for school children from Nigeria and South Africa by sample size and age

| | Nigeria | | | | | South Africa | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Age (years) | Sample size | Height (cm) M (SD) | Weight (kg) M (SD) | BMI (kg $m^{-2}$) M (SD) | WHtR M (SD) | Sample size | Height (cm) M (SD) | Weight (kg) M (SD) | BMI (kg $m^{-2}$) M (SD) | WHtR M (SD) |
| 9 | 28 | 135.8 (8.44)* | 32.9 (8.75)* | 17.6 (2.98)* | 0.87 (0.05)* | 208 | 130.6 (6.90)* | 27.4 (5.13)* | 15.9 (1.86)* | 0.82 (0.05)* |
| 10 | 133 | 137.3 (7.43)* | 31.9 (5.80) | 16.9 (2.67) | 0.87 (0.04)* | 315 | 134.9 (6.59)* | 31.3 (6.38) | 17.1 (2.66) | 0.81 (0.05)* |
| 11 | 291 | 142.3 (8.84)* | 36.0 (7.45)* | 17.7 (3.15) | 0.87 (0.06)* | 343 | 139.3 (6.67)* | 34.0 (9.32)* | 17.4 (3.99) | 0.80 (0.05)* |
| 12 | 412 | 144.8 (9.74) | 37.6 (7.51) | 18.0 (3.85) | 0.86 (0.12)* | 297 | 143.9 (8.29) | 37.3 (8.82) | 17.9 (3.64) | 0.80 (0.05)* |
| 13 | 365 | 147.9 (8.32)* | 39.5 (7.12)* | 18.0 (2.49)* | 0.86 (0.05)* | 198 | 150.2 (8.49)* | 42.7 (8.84)* | 18.8 (3.15)* | 0.80 (0.06) * |

*Statistically significant ($p\leq0.05$). BMI: Body mass index, WhtR: Waist-to-height ratio, M: Mean, SD: Standard deviation

Table 2: Percentage of BMI classification of Nigerian and South African school children by gender categories

| | Nigeria | | | | South Africa | | | |
|---|---|---|---|---|---|---|---|---|
| | Boys | | Girls | | Boys | | Girls | |
| BMI category | No. | Percentage | No. | Percentage | No. | Percentage | No. | Percentage |
| Underweight | 321 | 66.5 | 547 | 73.3 | 471 | 69.0 | 544 | 80.2 |
| Normal weight | 148 | 30.6 | 185 | 24.8 | 189 | 27.7 | 123 | 18.1 |
| Overweight | 6 | 1.2 | 8 | 1.1 | 18 | 2.6 | 7 | 1.0 |
| Obese | 8 | 1.7 | 6 | 0.8 | 5 | 0.7 | 4 | 0.6 |
| Total | 483 | 100.0 | 746 | 100.0 | 683 | 100.0 | 678 | 100.0 |

$p<0.05$

Table 3: Prevalence of BMI category for cut-off points criteria, by countries and age

| BMI categories | 9 years | 10 years | 11 years | 12 years | 13 years | Total |
|---|---|---|---|---|---|---|
| **Nigeria** | | | | | | |
| **IOTF** | | | | | | |
| Underweight | 21 (75.0%) | 114 (85.7%) | 208 (71.5%) | 286 (69.4%) | 239 (65.5%) | 868 (70.6%) |
| Normal weight | 6 (21.4%) | 17 (12.8%) | 74 (25.4%) | 114 (27.7%) | 122 (33.4%) | 333 (27.1%) |
| Overweight | 1 (3.6%) | 1 (0.8%) | 5 (1.7%) | 5 (1.2%) | 2 (0.5%) | 14 (1.1%) |
| Obese | 0 (0.0%) | 1 (0.8%) | 4 (1.4%) | 7 (1.7%) | 2 (0.5%) | 14 (1.1%) |
| **CDC** | | | | | | |
| Underweight | 1 (3.6%) | 6 (4.5%) | 14 (4.8%) | 19 (4.6%) | 18 (4.9%) | 59 (4.8%) |
| Normal weight | 22 (78.6%) | 106 (79.7%) | 233 (80.1%) | 330 (80.1%) | 291 (79.7%) | 985 (80.1%) |
| Overweight | 3 (10.7%) | 14 (10.5%) | 29 (10.0%) | 42 (10.2%) | 37 (10.1%) | 122 (9.9%) |
| Obese | 2 (7.1%) | 7 (5.3%) | 15 (5.2%) | 21 (5.1%) | 19 (5.2%) | 63 (5.1%) |
| South Africa | | | | | | |
| **IOTF** | | | | | | |
| Underweight | 186 (89.4%) | 249 (79.0%) | 268 (78.1%) | 205 (69.0%) | 107 (54.0%) | 1015 (74.6%) |
| Normal weight | 22 (10.6%) | 62 (19.7%) | 67 (19.5%) | 79 (26.6%) | 82 (41.4%) | 312 (22.9%) |
| Overweight | 0 (0.0%) | 3 (1.0%) | 5 (1.5%) | 9 (3.0%) | 8 (4.0%) | 25 (1.8%) |
| Obese | 0 (0.0%) | 1 (0.3%) | 3 (0.9%) | 4 (1.3%) | 1 (0.5%) | 9 (0.7%) |
| **CDC** | | | | | | |
| Underweight | 10 (4.8%) | 15 (4.8%) | 16 (4.7%) | 14 (4.7%) | 9 (4.5%) | 67 (4.9%) |
| Normal weight | 166 (79.8%) | 252 (80.0%) | 275 (80.2%) | 238 (80.1%) | 159 (80.3%) | 1089 (80.0%) |
| Overweight | 21 (10.1%) | 32 (10.2%) | 34 (9.9%) | 30 (10.1%) | 20 (10.1%) | 136 (10.0%) |
| Obese | 11 (5.3%) | 16 (5.1%) | 18 (5.2%) | 15 (5.1%) | 10 (5.1%) | 69 (5.1%) |

BMI: Body mass index, CDC: Centres of disease control and prevention, IOTF: International obesity task force, n: Number

Using the IOTF and CDC classifications there was a significant difference in the prevalence of overweight between Nigerian and South African children. While 1.1% (IOTF) and 9.9% (CDC)of Nigerian children were found to be overweight, corresponding data for overweight South African children were 1.8 and 10.0% (Table 3).

Among Nigerian children, the IOTF assessments revealed that 1.1% of them were obese, while the CDC criteria estimated obesity among this cohort to be 5.1%. For the South African children, 0.7% was obese according to the IOTF reference, while 5.1% of the children were also classified as obese based on the CDC criterion. When the IOTF cut-off point was used to define underweight, results showed that South African children (74.6%) were more underweight compared to Nigerian children (70.6%). In contrast, a strikingly low percentage of Nigerian (4.8%) and South African (4.9%) children were classified as underweight based on the CDC cut-off point.

## DISCUSSION

This study compares the prevalence of overweight and obesity in Nigerian and South African children using CDC and IOTF classifications. The IOTF and the CDC reference produced dissimilar outcomes in terms of overweight and obesity prevalence in children aged 9-13 years in the two countries. This could be understandable in view of differences in the methodologies utilised in both approaches and the diverse principles used in participant recruitment[2]. The IOTF and CDC's BMI classification has become a potential area of interest from theoretical view point[1] to clinicians and researchers. Excessive body fat in children has been known to be related to health risks such as high blood pressure, hyperinsulinemia, glucose intolerance, type II diabetes, dyslipidaemia, cardiovascular disease and psychosocial hardships[4]. This public health issue has also been understood to progress into adulthood.

This study compares distinct BMI reference to screen youngsters for diseases[13] based on nationality. Although, the IOTF reference seems to have been more satisfactory in defining excessive fatness and overweight among people[13], the BMI is globally accepted as a measure of body fatness but lacks an ability to disconnect body fat from fat-free parts of the body mass and at the end the two are merged together[1,13]. As stated by Lopes[13], the three cut-off points, i.e., those of CDC, IOTF and WHO were understood to be established for different reasons. For example, the CDC reference point was established basically for US citizens on the national nutrition and health examination survey piloted between 1963 and 1994. The WHO reference focused on healthy people although not part of the main focus of this study, while the IOTF was based on attaining a universal cut-off point[4]. Therefore, the inability to decide on global usage of one reference, has made it difficult to determine which reference to use in order to reliably estimate overweight and obesity in children.

In the current study, findings revealed higher prevalence of overweight and obesity using the CDC cut-off point compared to IOTF reference among Nigerian school children. The CDC cut-off point seems to have overestimated prevalence proportions in both overweight and obesity in previous studies[1]. Furthermore, in the Nigerian children, underweight was more prevalent using the IOTF reference compared to CDC criteria. Similarly, for the South African children, IOTF cut-off point showed lower level of overweight and obesity prevalence (gave more room for children to be underweight) compared with the CDC reference. Therefore, the IOTF criteria could yield lower estimates of obesity[14] than the CDC classification because, the IOTF seems to be a more stringent reference compared with the CDC's cut-off point[1].

Overall, the findings about overweight prevalence, based on the IOTF recommendation by country showed that South African children were more overweight than their Nigerian counterparts were. However, it has been established that prevalence of overweight and obesity among South African children could vary based on the age, gender and population group involved[15]. Overweight and obesity among South Africa children have been recorded to be the highest in sub-Sahara Africa[16,17] and can be compared with similar estimates in developed nations[18], the girl child being more affected. Some of the major causes seem to be due to unhealthy diets.

It has been reported that the obesity epidemic has risen in Nigeria to approximately 20% in 2010[16]. Recently, a "2016 Nigerian Report Card on Physical Activity for Children and Youth" focusing on physical activity as the major risk factors for non-communicable diseases (NCDs), showed an increase in the prevalence of overweight and obesity. This was attributed partly to the decline in children's physical activity levels[18] and nutritional disorder which co-existed with both under nutrition and increased diet[19]. Although, the present findings which compared the children's BMI classification based on gender revealed that overweight levels ($\geq$25) in South African boys were higher than those of Nigerian boys, Nigerian girls were found to be more overweight compared to South African girls. These findings are surprising considering the prevalence of overweight and obesity among South African children reported in the literature[15]. Also surprising was the higher incidence of obese boys and girls among Nigerian children compared to those from South Africa; although as stated by Rossouw *et al.*[15], this prevalence might not produce a factual image of heaviness and obesity when age group, ethnicity and geographical locations are taken into consideration.

Apart from overweight and obesity status, which could be based on the age, gender and group of people involved, using the IOTF cut-off point, the low levels of overweight and obesity found in this study could underestimate the findings[1]. This could possibly affect the timely identification and prevention of such unhealthy weight status. Consistent with the objectives of our study, previous research has suggested the need to focus obesity-related research on the following cardinal directions: to [1] Evaluate children's overweight and obesity status, [2] Ascertain the occurrences, swings and contributing factors, [3] Propose the right communal medical disorder improvement and [4] Classify the people at risk[8]. The achievements of these objectives may be farfetched without a consensus among researchers regarding the appropriate reference to use.

**Limitations of the study:** A major limitation of this study is that, firstly BMI-for-age values might not denote the real body proportions since it combines the body fat and fat free mass[1]. Secondly, many of the children were from low socio-economic backgrounds where food availability is scarce. Thirdly, the findings of this study cannot be generalized and should be interpreted in the light of these constraints. These limitations should be considered in interpreting the results of the study.

## CONCLUSION

The CDC reference conveyed a much higher prevalence of overweight and obesity as compared to that of the IOTF. The results indicate a considerably higher level of underweight in South African school children compared to Nigerian children using the IOTF benchmark. Future studies are needed to clarify the suitability of reference chart for the determination of overweight and obesity prevalence as this could undermine the health policy decisions taken in various countries.

## SIGNIFICANCE STATEMENT

The study evaluated obesity in two populations of children in Nigeria and South Africa with CDC and IOTF charts and discovered that there is inconsistency within analyzed weight data based on the two reference standards. The findings of the study suggest that researchers or clinicians should determine the appropriateness of international reference charts for assessing obesity before they are applied in data analysis. Otherwise, research data will be unreliable and health policy decisions could be made on erroneous conclusions.

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