# Body Mass Index Correlates with Body Fat Percentage in Children and Adolescents in the Democratic Republic of the Congo: A cross sectional study

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## Summary

**INTRODUCTION**

**Paediatric obesity is a worldwide health challenge and parameters to evaluate population obesity risk are needed. The purpose of this study is to report on anthropometric measures for assessing obesity risk for children in sub-Saharan Africa and to confirm that measuring height and weight to calculate BMI can be used as a good indicator of obesity risk.**

**MATERIALS AND METHODS**

**This was a cross-sectional study of a sample of 1,442 students aged 6 to 18 years enrolled in schools in the city of Kinshasa, the capital of the Democratic Republic of Congo. These school children were selected using a multistage sampling method. BMI for-age-sex was calculated using WHO AnthroPlus and expressed in *Z*-scores. Skinfolds were used to calculate percent body fat (%BF). Data were analyzed using SPSS version 21.**

**RESULTS**

**This study showed that the percentage body fat (BF) was higher in girls than in boys (20.5 ± 9.6 vs 12.4 ± 6.3 p< 0.001). The BMI for girls was higher compared to boys (18.5 ± 3.7 vs 17.3 ± 3.0 p<0.001). The positive relationships were observed between percentage BF and BMI by sex. In addition, this relationship appears to be linear in nature. This relationship between BMI and percentage BF was independent at age and increased with BMI. In this sample of youth from DRC, BMI appears to be a good proxy for adiposity. Across the total sample, more boys fall into the very low and low body fat category as compared to girls while proportionately more girls have body fat in the optimal range.**

**CONCLUSION**

**This study showed the positive relationships between BMI and percentage BF in children and adolescents in Sub-Saharan Africa, particularly in DRC but given the difficulties of measuring skin folds, BMI appears to be a simple and easy measure.**

***Keywords:*** *Body Composition, percentage of body fat, Overweight, Obesity, Adolescents, Children*

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# Introduction

Childhood and adolescent overweight and obesity is a major public health problem in the developed world [1]. Those conditions have also significantly increased in low and middle income countries (LMIc) in the past decades. Overweight and obesity in children and adolescents in LMIc now co-exist with underweight, as a result of nutrition transition [2-5].

In sub-Saharan Africa, the prevalence of overweight and obese children and adolescents varies from 5 to 17 % and 1 to 5%, respectively [6-7]. Several reports have shown that overweight and obesity are now increasing in low and middle-income populations (including in Africa), especially in urban areas. From 1990 to 2010, the growth rate of overweight and obesity doubled, indicating that Africa has the fastest growth rates of overweight and obesity [8-9] and is expected to reach 11% in 2025 [8].

Childhood and adolescence are important periods of life, as many physiological and psychological transformations take place at these ages. Moreover, healthy and unhealthy lifestyles and behaviors are established during these years, which can influence the behavior and health status of adults [10-11]. Therefore, it is vitally important to understand the trends in the development of body weight disorders in young people and their negative effects on overall health [5].

To evaluate population trends, tools to assess weight-related risk need to be simple, cost effective and feasible to use across a wide variety of settings.

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health [5]. Chronic disease risk is associated with level of adiposity but getting an accurate measure of fat is very challenging [12]. Direct and highly accurate measurement of body fat or adiposity requires sophisticated equipment such as a Dexa scan using dual-energy X-ray absorptiometry. Other tools such as bio-electrical impedance, the use of skin calipers, and body circumference measures are also used to assess adiposity. But these tools are difficult to use in epidemiological surveys due to the cost of equipment, the time required, or the challenging measurement protocols [5, 13]. To fill this gap, WHO recommends Body Mass Index (BMI) as the most useful population level measure of underweight, overweight and obesity. BMI is also the surrogate measure for prediction of percentage of body fat (% BF) [14].

Several studies have shown a relationship between BMI and percentage body fat (BF) [15-17] but such studies have rarely been performed in sub-Saharan Africa.

The objective of our study was to report on assessment of body fat and height and weight for children in the Democratic Republic of the Congo (DRC) and to confirm that measuring height and weight to calculate BMI can serve as a good indicator of risk for obesity. Comparisons were made between BMI and skinfold thickness, a criterion measure of adiposity. In addition, percentage body fat was compared among boys and girls and by age groups. The results of this present work can provide a baseline for adiposity in youth in Sub-Saharan Africa. In addition, it can help encourage health practitioners in clinics to use the simple measure of BMI to assess the risk of obesity in their patients and to provide public health officials with a good surveillance tool for obesity risk in youth.

# Materials and Methods

## *Study Sample and Design*

This was a cross-sectional study enrolling 6–18-year-old students living in Kinshasa, the capital of DRC. The sample was selected using multistage sampling method from November 15th, 2018 to June 20th, 2019. A total of 568 eligible primary and secondary schools were grouped according to their location into three strata which correspond to the existing three educational provinces in Kinshasa. The schools in each stratum were further stratified into primary and secondary.

The name of each school was written on a piece of paper, wrapped, and put into the corresponding ballot bags representing its stratum. A total of 18 schools, one school from each of the 3 strata, were selected by a simple random method. Within each selected school, classrooms were selected to participate and all students in selected classes were offered the opportunity to participate.

To be eligible, participant were to meet the following selection criteria: Congolese citizen, consent of parents or tutors and age between 6 and 18 years old. School record of birth certificate of each enrolled child was used to establish age. Students with disabilities and pregnant girls were excluded.

## *Ethical Consideration*

To conduct this study, ethical approval was obtained from the Ethical Review Committee of the Ministry of Health (Ref N°.143/CNES/BN/PMMF/2018). Written Permission was obtained from Minister of Education (the Ministry of primary and secondary schools), as well from each participating school and from all classroom teachers. Parents or tutors were informed of the study prior to the survey date. The parents were consented for this intervention and the youth gave their assent.

## *Anthropometric Measurement*

To measure height, weight and percentage BF, we used the World Health Organization and the International Society for the Advancement of Kinanthropometry guidelines [18]. Height was measured in the sagittal plane with a portable SECA 214 anthropometer (Seca®, Hamburg, Germany) to the nearest 0.1 cm. The subjects' height was measured with each subject standing upright, the head in Frankfort plane, without shoes, with both feet flat on the platform and apposed at the medial malleoli; the heels, buttocks, and occiput placed against the scale with arms hanging freely by the sides. The instrument was checked before each measurement ensuring that both headboard and footboard were at 90° to the vertical rule.

Weight was measured in kilograms (kg) with an OMRON body composition BF 511 balance (OMRON Healthcare Europe BV, Hoofddord, the Netherlands) to the nearest 0.1 kg. The students stood on the scale without shoes wearing light cotton material. The scale automatically adjusted to zero before each measurement. It was also checked daily using an object of known weight as a quality control measure to ensure validity and reliability.

Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared ($kg/m^2$) [19].BMI‑for‑age indices were calculated with WHO AnthroPlus® (v1.0.4, World Health Organization, Geneva 2009) [20] and expressed in *Z*‑scores.

Skinfolds in the biceps, triceps, suprailiac, subscapularis and abdominal regions were taken on the right side of the body with Harpenden skinfold caliper (Holtain Limoted, U.K) with a constant pressure of $10g/mm^2$ to the nearest 0.2 mm [21].

## *Operational Definitions*

Using BMI, the children were classified into the following categories: underweight: thin: <-2 SD; severely thin: <-3 SD "overweight" (BMI‑for‑age *Z*‑score >+1 and ≤ +2), "obese" (BMI‑for‑age *Z*‑score >+2), and "normal weight" (BMI‑for‑age *Z*‑score − 2 to + 1). The values were set from the median values of the WHO international growth reference 2007 for 5–19‑year‑old children [19-20].

Percentage body fat (% BF) was based on the sum of triceps and calf skinfolds derived from skinfolds using the equation developed by Slaughter *et al.* (1988) [5] which is internationally accepted for use in children and adolescents from different ethnic groups. All anthropometric measurements were taken twice by Level 2 ISAK-certified anthropometrics' and the average scores of the two measurements. The values were set from the median values of the WHO international growth reference 2007 for 5–19‑year‑old children [19-20].

Percentage body fat was compared with BMI according to Lohman *et al.* (2000) [5] across six categories, as the following: very low 7 - 11, low 12 - 14, optimal range 15 - 18, moderate high 19 - 25, high 26 - 32, and very high 32 and above.

## *Statistical Analysis*

Underweight, overweight and obesity were defined based on the Body Mass Index (BMI) for age-sex of the children. Body Mass Index-for-age-sex was calculated using WHO Anthro plus software V.1.0.4. All data analyses were performed with Statistical Package for the Social Sciences (SPSS), Version 21.0 program (SPSS Inc., 2012). Descriptive statistics of means, minimum, maximum, standard deviations, frequencies for body composition variables were computed. After the computation of the descriptive analyses, independent *t*-test was calculated to test differences of means with respect to statistical significance. The statistical level was set at p-value ≤ 0.05.

# Results

A total of 1,442 pupils (668 females and 774 males) participated in the study. Table 1 shows the descriptive statistics of the sample. There were slightly more boys represented in the total sample than girls and the sample of boys was significantly older than the sample of girls. Girls were shorter than boys and girls were significantly heavier, had significantly higher mean BMI and had higher body fat as measured by skinfold thickness as compared to boys. In the group of younger children, the differences between girls and boys were only statistically significant for the percentage of body fat and skin folds with girls having significantly higher values than boys ($p < 0.001$).

When comparing older children by gender, weight, BMI, percentage of body fat and skin folds were higher in girls than in boys ($p < 0.001$). Boys were, on average, taller than girls ($p < 0.05$).

*Table 1: Characteristics of Study Population by Age Groups*

| Variables | All | | | Age 6-9 years | | | Age 10-18 years | | |
|---|---|---|---|---|---|---|---|---|---|
| | Girl (n=668) | Boy (n=774) | P-value | Girl (n=217) | Boy (n=196) | P-value | Girl (n=451) | Boy (n=578) | p-Value |
| Age (years) | 11.8±3.5 | 12.2±3.4 | 0.012 | 7.6 ±1.1 | 7.7 ±1.0 | 0.481 | 13.7 ±2.5 | 13.7 ±2.4 | 0.978 |
| Height | 1.47±0.17 | 1.51±0.19 | <0.001 | 1.26 ±0.08 | 1.27 ±0.09 | 0.296 | 1.57 ±0.10 | 1.59 ±0.14 | 0.019 |
| Weight | 42.5±15.1 | 41.9±15.4 | 0.022 | 25.7 ±6.1 | 25.6 ±6.0 | 0.895 | 49.2 ±11.9 | 47.5 ±13.6 | 0.037 |
| BMI | 18.5±3.7 | 17.7±3.0 | <0.001 | 15.9 ±2.4 | 15.6 ±2.0 | 0.196 | 19.7 ±3.6 | 18.4 ±3.0 | <0.001 |
| Subsc_tric | 21.8±9.9 | 14.8±7.4 | <0.001 | 16.5 ±7.5 | 12.0 ±4.5 | < 0.001 | 24.4 ±9.9 | 15.7 ±7.9 | <0.001 |
| %BF | 20.5±9.6 | 12.4±6.3 | <0.001 | 15.7 ±7.2 | 11.5 ±4.0 | < 0.001 | 22.8 ±9.8 | 12.7 ±6.9 | <0.001 |
| TSF | 11.7±5.3 | 7.5±3.9 | <0.001 | 9.2 ±4.2 | 6.6 ±2.9 | < 0.001 | 12.8 ±5.4 | 7.8 ±4.2 | <0.001 |
| SSSF | 9.0±4.8 | 6.2±3.9 | <0.001 | 6.2 ±3.4 | 4.4 ±1.9 | < 0.001 | 10.4 ±4.8 | 6.8 ±4.2 | <0.001 |

BMI:body mass index %BF: percentage of body fat using the equation developed by Slaughter et al SSK: sum of skinfolds TSF: triceps skinfolds SSSF:subscapular skinfolds Subsc + tric: subscapular+ triceps skinfolds

Table 2 shows the gender differences by body fat category for the total sample and also by younger and older age groups. Across the total sample, more boys fall into the very low and low body fat category as compared with girls (58.8% and 23.0% vs 12.4 % and 16.9 % p<0.001 and 0.05) while proportionately more girls have body fat in the optimal range as well as in all categories of high body fat (21.6% vs 8.7 % p<0.001 for optimal range body fat and 10.6 % vs 2.5 % p<0.001 for very high body fat).

Nearly 8 times as many girls are in the moderate high body fat category as compared to boys and four times as many girls are in the very high body fat category as compared with boys. At the same time, there are almost five times as many boys in the very low body fat category as compared to girls. For the younger sample, more boys are in the very low body fat category as compared with girls but for the optimal range and the moderately high and high body fat categories, more girls are represented than boys. For the older youth, boys continue to be significantly over-represented in the very low and low body fat categories while girls are significantly over-represented in the optimal range and all high body fat categories.

*Table 2: Categories of Percentage BF by Sex and Age Group*

| | All | | | Age 6-9 years | | | Age 10-18 years | | |
|---|---|---|---|---|---|---|---|---|---|
| **Category of body fat** | **Girl (n=668)** | **Boy (n=774)** | **P** | **Girl (n=217)** | **Boy (n=196)** | **P** | **Girl (n=451)** | **Boy (n=578)** | **p-Value** |
| Very low | 83 (12.4) | 455 (58.8) | <0.001 | 56 (25.8) | 120 (61.2) | < 0.001 | 27 (6.0) | 335 (58.0) | <0.001 |
| Low | 113 (16.9) | 178 (23.0) | 0.002 | 72 (33.2) | 55 (28.1) | 0.154 | 41 (9.1) | 123 (21.3) | <0.001 |
| Optimal range | 144 (21.6) | 67 (8.7) | <0.001 | 45 (20.7) | 12 (6.1) | < 0.001 | 99 (22.0) | 55 (9.5) | <0.001 |
| Moderate high | 208 (31.1) | 35 (4.5) | <0.001 | 29 (13.4) | 4 (2.0) | < 0.001 | 179 (39.7) | 31 (5.4) | <0.001 |
| High | 49 (7.3) | 20 (2.6) | <0.001 | 6 (2.8) | 5 (2.6) | 0.569 | 43 (9.5) | 15 (2.6) | <0.001 |
| Very high | 71 (10.6) | 19 (2.5) | <0.001 | 9 (4.1) | 0 | - | 62 (13.7) | 19 (3.3) | <0.001 |

Percentage body fat classified according to Lohman et al (2000); %BF: percentage of body fat using the equation developed by Slaughter et *al.*

Table 3 shows how the sample falls into four weight status categories (normal, overweight, obese and underweight) as determined by BMI by age and gender. For the total sample slightly more boys are in the normal weight category as compared with girls while girls are more likely to be categorized as overweight, obese and underweight as compared with boys. The differences in weight status by age group are dramatic. While there are no statistically significant differences in the proportion of girls and boys in any weight status category for the younger children, for those children over the age of 10, boys are significantly more likely to be classified as having a normal weight status while girls are more likely to be classified as overweight or obese. No gender differences at either age group are seen in those youth classified as underweight.

*Table 3: Categories BMI by Sex and Age Group*

| | All | | | Age 6-9 years | | | Age 10-18 years | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Girl (n=668)** | **Boy (n=774)** | **P-value** | **Girl (n=217)** | **Boy (n=196)** | **P-value** | **Girl (n=451)** | **Boy (n=578)** | **p-Value** |
| Normal | 436 (65.3) | 602 (77.8) | < **0.001** | 127 (58.5) | 125 (63.8) | 0.161 | 309 (68.5) | 477 (82.5) | **<0.001** |
| Overweight | 85 (12.7) | 46 (5.9) | **<0.001** | 5 (2.3) | 2 (1.0) | 0.268 | 80 (17.7) | 44 (7.6) | **<0.001** |
| Obese | 33 (4.9) | 21 (2.7) | **0.019** | 0 | 2 (1.0) | - | 33 (7.3) | 19 (3.3) | **0.003** |
| Underweight | 114 (17.1) | 105 (13.6) | **0.038** | 85 (39.2) | 67 (34.2) | 0.172 | 29 (6.4) | 38 (6.6) | 0.515 |

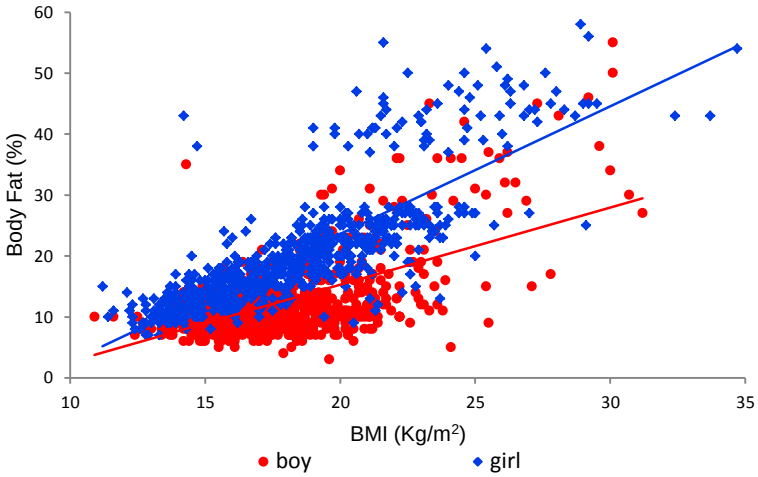


***Figure 1: Scatter Plot of the Relationship between Body Mass Index (BMI) and Percentage of Body Fat (%BF) of School-Aged Girls and Boys in Kinshasa.***

Figure 1 shows the positive relationships between percentage BF and BMI by sex. In addition, this relationship appears to be linear in nature. This relationship between BMI and percentage BF was independent at age and increased with BMI. In this sample of youth from DRC, BMI appears to be a good proxy for adiposity.

# Discussion

Our study sample composed of school-aged children and adolescents (6-18 years) in the city province of Kinshasa tested the hypothesis that body mass index correlates with body fat percentage in children and adolescents in Sub-Saharan Africa. The results of this work, shown in figure 1 proved this hypothesis. Indeed, in the figure 1, BMI places youth in the same category of being at risk for fatness as does the data that more directly measure fatness.

The age and sex risk models for obesity-related diseases are similar when we use a body fat assessment which is a more difficult assessment task and requires large screening and intervention efforts compared to a BMI assessment which is much easier to measure height and weight in large screening and intervention efforts. It is clear that these results have shown that measuring BMI to change obesity and the risk of chronic non-communicable diseases is roughly equivalent to measuring percentage body fat through skin folds. These results are consistent with those reported in other studies outside of Africa [15-17]. However, while the technique for measuring skin folds is inexpensive, easy, and reproducible for an experienced technician, it is not very accurate and is subject to inter observer error [13].

The results of this study also showed that in the younger age group (6 - 9 years), BMI was non-significantly different between the two sexes, while percentage BF was significantly different between girls and boys. However, for the oldest age group (10-18 years), the differences between BMI and the percentage BF were statistically significant between the two sexes.

These large differences in body fat were also observed in table 2 specifically in the younger and older age groups where optimal and moderately high body fat was higher in girls than in boys. Some authors explain that for the same body mass index (BMI), women have ~10% more body fat than men [21, 23]. Striking gender differences appear during puberty: the increase in body weight in boys is mainly due to increases in lean body mass while in girls due to increased fat mass; typical android and gynoid fat distributions also

appear for the first time during this period [23 – 26]. Two studies in black Africa, mainly in Zimbabwe and Kenya, have shown that girls have high percentage BF values compared to boys. Michelin *et al* in their study found that there are typical gender differences in body fat composition for both younger and older adolescents [27-28].

We also found large differences in very low body fat in boys, especially in the older age group (58 % boys vs. 6 % girls). This could be due to a combination of adverse environmental constraints to good growth amplified in boys such as under-nutrition, high burden of infectious or parasitic diseases, poor living conditions including housing, economic insecurity, food crisis and lack of sanitary or educational facilities [29]. However, the difference between girls and boys in the very low-fat category for the total sample (12.4 % of girls versus 58.8 % of boys) is more explained by differences observed in the older age group (6.0 % of girls versus 58.0 % of boys). The gender difference is slightly smaller in the younger age group (25.8 % versus 61.2 %).

## Strength and Limitations of Study

The strengths of our study are the relatively large sample size, the quality of the anthropometric measurements, and the fact that all social categories were present in the sample. The cross-sectional nature of the study could be seen as a limitation and skinfold measures used as the criterion measure of adiposity while DEXA or bioelectrical impedance may be the more rigorous measures of adiposity.

## Conclusion

Our study showed a correlation between BMI and percentage BF in children and adolescents in sub-Saharan Africa. Given the difficulties of measuring skin folds and training experienced technicians, BMI appears to be a simple and easy measure that clinicians can use to analyze the risk of obesity and chronic non-communicable diseases in children and adolescents in sub-Saharan Africa and particularly in DR Congo.

## Conflict of Interest

All authors declared no competing interests.

## Author Contributions

GIW and ESK were involved in the conception, design, data analysis and interpretation of the study. GIW collected in addition data. LL contributed to interpretation. ESK and ARB contributed to data analysis and interpretation. All authors were involved in the writing of the manuscript and provided final approval.

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