Prevalence of overweight and obesity among selected schoolchildren and adolescents in Cofimvaba, South Africa

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Background: Childhood obesity has become a growing global epidemic. In South Africa, overweight and obesity during childhood and adolescence are rising. The objectives of this study were (i) to estimate the prevalence of overweight and obesity among selected students in Cofimvaba, a rural settlement in Eastern Cape province, South Africa, and (ii) to assess the accuracy of the mid-upper arm circumference (MUAC) and ultrasound triceps skin-fold thickness (TSF) methods of predicting these health parameters.

Methods: A cross-sectional study was conducted on 211 students (109 girls and 102 boys) selected randomly from five public schools in Cofimvaba and aged 6–19 years. The weight, height, MUAC and TSF were determined by standard techniques. Data obtained were subjected to descriptive statistics, Pearson correlations and receiver operating characteristic (ROC) curve analysis.

Result: Overall 1.9% (1.8% girls and 2.0% boys) of the respondents were underweight, 14.8% (21.1% and 7.8% boys) were overweight and 2.8% (4.6% girls and 1.0% boys) were obese. The prevalence of overweight and obesity was significantly higher (p < 0.05) in girls than boys during adolescence but there was no gender difference in children (6–9 years). Most of the students (80.6%) had a healthy weight, with boys being significantly (p < 0.05) healthier than girls. The BMI showed significant strong correlations with MUAC (r = 0.926; p < 0.001) and TSF (r = 0.843; p < 0.001). ROC curve analysis gave an area under the curve (AUC) of 0.795 (95% CI, 0.761–0.835) and 0.835 (95% CI, 0.771–0.889) for MUAC and TSF respectively.

Conclusion: The study found a high prevalence of overweight children in the sample and a low prevalence of stunting and underweight. The adolescent girls are at a higher risk of being overweight and obese than the boys. MUAC and TSF can adequately predict overweight and obesity among the selected students.

Keywords: children and adolescents, Cofimvaba, MUAC, obesity, overweight, TSF
of Technology (20130520-3) and the Council of Scientific and Industrial Research (CSIR) (75/2013). Written permission was obtained from the School Management Board in Eastern Cape. The research was conducted according to the Medical Research Council’s guidelines for research on human beings as well as the Helsinki Declaration agreement guidelines. Prior to the study a meeting was held with the parents of the children and they were informed about the purpose of the study and the assessment to be conducted on their wards. Those that agreed signed written informed consent (parents and adolescents) and assent (children) forms, respectively.

**Study settings**
The study was conducted in Cofimvaba, a rural community in the Chris Hani District Municipality in the Eastern Cape province of South Africa. It is situated 79 km east of Queenstown and has a land area of 21.19 km² and a predominant black population of over 9 000. Cofimvaba is characterised by high levels of poverty and unemployment with critical skill shortages, subsistence farming, food insecurity and HIV/AIDS. A low level of education among the adult population was observed with less than a third having some form of secondary education and only 4% postsecondary education.

**Study design and population**
The sample size was calculated using the formula

\[
\text{Sample size} = \frac{Z^2 \cdot p \cdot (1-p)}{c^2}
\]

where \(Z\) is the value of 1.96 for 95% confidence level, \(p = 80\%\) expressed as a decimal (0.8 used for sample size needed) and \(c = \text{confidence interval of 6.5, expressed as 0.065.}\)

\[
\text{Sample size} = 1.96^2 \cdot 0.8(1-0.8)/0.065^2 = 146
\]

Of the 21 schools (\(n = 5\) 250 learners) in Cofimvaba, five schools with a population of 1 250 learners aged 6–19 years old were purposively selected by the Department of Basic Education for inclusion in the study, representing 24% of the school-age children in that area. The inclusion criteria were boys and girls in the selected schools between the ages of 6 and 19 years. Students outside that age bracket who reported ill-health or did not present signed informed consent and assent were excluded from the survey. After screening for the inclusion and exclusion criteria, 523 learners were eligible for inclusion in the study from the 556 informed consent and assent forms signed. The sample was then stratified for gender and age and 240 learners were selected from those with informed consent and assent. Data collection was conducted in August 2013 for five days (Monday to Friday).

A total of 211 students aged 6–19 years, randomly selected from five schools using probability according to sample size, completed the survey. A validated well-structured pre-coded socio-demographic questionnaire was used to elicit information on the family characteristics including family size, parental marital status, accommodation type and permanent residency.

**Anthropometric measures**
The field workers for this study were recruited from the Department of Food and Consumer Sciences at the Walter Sisulu University and trained during two eight-hour sessions by a registered dietitian and a public health nutritionist. The four field workers were trained on the ethical and general research philosophies applicable to research on human beings, the importance of accurate measurement and how to complete the socio-demographic questionnaire and 24-hour diet recall without interviewer bias (not reported in this study).

The children’s ages obtained from school records were confirmed by the field workers. The bodyweight and height were measured by a registered dietitian and public health nutritionist according to standard procedures with a calibrated Philips electronic scale, model HF350 (135 kg/100 g) (Philips, Amsterdam, The Netherlands) with a two-point decimal precision and a Seca stadiometer, respectively. All measurements, which were not to vary by more than 0.1 kg for weight and 0.1 cm for height, respectively, were taken twice and the average of the two measurements recorded. The height was measured to the nearest 0.1 cm using the stadiometer as each child stood erect and barefoot with heels touching the wall of the stadiometer. Weight was measured to the nearest 0.1 kg as the child stood still on the weighing scale barefoot with light clothes on having emptied his/her pockets. Body mass index was computed using the standard formula BMI (kg/m²) = weight/height²

The MUAC and TSF were measured by a public health nutritionist. The MUAC was measured on the upper left arm at the midway between olecranon and acromion process using a flexible plastic Seca tape (Seca, Hamburg, Germany). During these measurements, the flexible tape was wrapped round at the midpoint of the upper arm as each child stood in a comfortable position and looking straight ahead with shoulders in normal position and the arm hanging loosely by the side. The tape was examined to ensure it was not too tight or loose and measurement was done to the nearest 1 mm.

The triceps skinfold thickness, which provides a measure of subcutaneous fat, was measured with the aid of a BodyMetrix (BX2000) according to the manufacturer’s user guide (BodyMetrix/Intelametrix, Brentwood, USA). The child stayed in an upright position with the arm hanging loosely by the side, and the ultrasound gel was applied to the posterior surface of the left arm, midway between the olecranon and the acromion process. The tip of the BodyMetrix was used to massage the ultrasound gel on the posterior surface for 1 minute and then pressed firmly for another 30 seconds to measure. The body fat was calculated in percentage from mid-upper arm circumference and triceps fold thickness.

**Data analysis**
Anthropometric data for the students were analysed using the World Health Organization’s (WHO, 2010) Anthroplus version 1.0.2 statistical software. Overweight and obesity were defined using age- and gender-specific international cut-off points for BMI. Data obtained were subjected to descriptive analysis, t-tests to detect difference between means, Pearson’s correlations to evaluate relationships between anthropometric indices and ROC curves were generated and area under the curve (AUC) calculated to determine the global accuracy measure for MUAC and TSF in predicting overweight and obesity. All analyses were done using SPSS version 20 (IBM Corp, Armonk, NY, USA) and a p value < 0.05 was considered as statistically significant.

**Results**

**Socio-demographic and anthropometric characteristics of the respondents**
In total, 211 learners aged 6–19 years completed the study. As shown in Table 1, most of the respondents (74.4%) were...
adolescents (aged 10–19 years old) and the gender was spread 51.7% female versus 48.3% male. Also, 74.9% lived in shared accommodation, 89.6% were permanent residents and 83.3% lived in houses with five or fewer persons.

As indicated in Table 2, there was no significant gender difference in the means of age, weight and MUAC. Although the boys were significantly taller \((p < 0.05)\) than the girls \((144.49 \pm 16.62 \text{ versus } 150.34 \pm 19.19)\), the girls had significantly higher BMI \((19.47 \pm 4.00 \text{ versus } 17.88 \pm 2.67^*)\) and percentage body fat \((22.10 \pm 5.56 \text{ versus } 4.94 \pm 1.28^*)\) than boys. Of all socio-demographic characteristics studied, only gender had significant effect on the weight status of the respondents. The girls had a higher prevalence of being overweight both by BMI and MUAC. Other socio-demographic profiles had no significant effect on the weight status of the learners.

The prevalence of overweight and obesity among the respondents is shown in Figure 1. Using the age and gender specific international cut-off points, 1.8% (3.1% girls and 0% boys) of those aged 6–9 years were overweight. Among the adolescents, 1.9% (2.6% girls and 1.3% boys) were underweight. Overall, 1.9% (1.8% girls and 2.0% boys) of the respondents were overweight, 14.8% (21.1% girls and 7.8% boys) were overweight and 2.8% (3.1% girls and 1.0% boys) were obese. The prevalence of overweight and obesity was significantly higher \((p < 0.05)\) in girls than boys during adolescence but no gender difference \((p > 0.05)\) was observed in children aged 6–9 years. Most of the respondents (80.6%) had healthy weights and boys were significantly healthier than girls (89.2% versus 72.5%; \(p = 0.014\)). As shown in Figure 1, while the trend of overweight increased in girls it reduced in boys from childhood to late adolescence.

### Table 1: Socio-demographic characteristics of the respondents

| Factor                | n (%) | Overweight by BMI for age (%) | Overweight by MUAC for age (%) |
|-----------------------|-------|-------------------------------|-------------------------------|
| Gender                |       |                               |                               |
| Female                | 109 (51.9) | 25.7*                        | 12.8*                         |
| Male                  | 102 (48.3) | 8.8                           | 2.0                           |
| Age:                  |       |                               |                               |
| 6–9 years             | 54 (25.6)  | 20.4                          | 9.3                           |
| 10–19 years           | 157 (74.4) | 16.6                          | 7.0                           |
| Family size:          |       |                               |                               |
| < 6 persons           | 176 (83.3) | 17.0*                        | 3.5                           |
| ≥ 6 persons           | 35 (16.7)  | 36.3                          | 11.1                          |
| Accommodation:        |       |                               |                               |
| Shared                | 158 (74.9) | 20.9                          | 8.5                           |
| Not shared            | 53 (25.1)  | 8.5                           | 2.0                           |
| Permanent residence:  |       |                               |                               |
| Yes                   | 189 (89.6) | 18.1                          | 6.4                           |
| No                    | 22 (10.4)   | 15.0                          | 10.0                          |

### Table 2: Means of anthropometric profiles of the respondents

| Factor                | Girls (n = 109) | Boys (n = 102) |
|-----------------------|----------------|----------------|
| Age (years)           | 12.17 ± 3.79   | 12.80 ± 3.37   |
| Height (m)            | 144.49 ± 16.62 | 150.34 ± 19.19*|
| Weight (kg)           | 42.52 ± 16.72  | 41.91 ± 14.90  |
| BMI (kg/m²)           | 19.47 ± 4.00   | 17.88 ± 2.67*  |
| MUAC (cm)             | 22.21 ± 4.20   | 21.00 ± 3.36   |
| TSF (mm)              | 8.86 ± 5.56    | 4.94 ± 1.28*   |
| Percentage body fat (%) | 22.10 ± 10.2  | 14.3 ± 3.7*    |

Difference in TSF and anthropometry according to weight status

Overweight/obese girls had significantly higher values for BMI \((18.0 \pm 2.7 \text{ versus } 23.7 \pm 4.1)\), MUAC \((20.9 \pm 3.3 \text{ versus } 26.0 \pm 4.5)\), ultrasound TSF \((7.7 \pm 4.8 \text{ versus } 12.3 \pm 6.2)\) and % body fat \((20.5 \pm 9.7 \text{ versus } 26.7 \pm 10.5)\) than their non-overweight counterparts (Table 3). The same trend was observed for overweight/obese boys.

Correlation between MUAC/TSF and other anthropometric characteristics

Table 4 shows the correlation coefficients of MUAC/TSF with other anthropometric characteristics by gender and age groups. MUAC had strong positive correlations with age \((r = 0.789 \text{ versus } r = 0.736; p < 0.001)\) and height \((r = 0.819 \text{ versus } r = 0.781; p < 0.001)\) and very strong positive correlations with weight \((r = 0.951 \text{ versus } r = 0.919; p < 0.001)\) and BMI \((r = 0.951 \text{ versus } r = 0.888; p < 0.001)\). Ultrasound TSF had positive correlations with age, height, weight, BMI and MUAC but when stratified into gender there was no significant correlation with age, height and weight in boys. Also, when stratified into age groups, no significant correlation was observed for TSF and height in either children (6–9 years) or adolescents (10–19 years).

Association of MUAC and ultrasound triceps with obesity

Table 5 indicates the accuracy of MUAC and ultrasound triceps skinfold thickness (TST) to predict overweight and obesity in both girls and boys. Across age groups an AUC of 0.763–0.94 (\(p < 0.05\)) and 0.728–0.924 (\(p < 0.05\)) was obtained for MUAC and TSF respectively. The overall AUC of 0.795 (95% CI 0.761–0.889) for MUAC and 0.835 (95% CI 0.771–0.899) for TSF showed that both
Table 3: Difference in TSFT and anthropometry according to weight status

| Weight status     | n   | BMI (kg/m²) | MUAC (mm) | Ultrasound TSFT (mm) | Body fat (%) |
|-------------------|-----|-------------|-----------|----------------------|--------------|
| **Female**        |     |             |           |                      |              |
| Non-overweight    | 81  | 18.0 ± 2.7  | 20.9 ± 3.3| 7.7 ± 4.8            | 20.5 ± 9.7   |
| Overweight/obese  | 28  | 23.7 ± 4.1  | 26.0 ± 4.5| 12.3 ± 6.2           | 26.7 ± 10.5  |
| Total             | 109 | 19.5 ± 4.0  | 22.2 ± 4.2| 8.8 ± 5.6            | 22.1 ± 10.2  |
| p-value           | 0.000| 0.000       | 0.000     | 0.000                | 0.005        |
| **Male**          |     |             |           |                      |              |
| Non-overweight    | 93  | 17.5 ± 2.2  | 20.7 ± 3.1| 4.7 ± 1.1            | 14.1 ± 3.4   |
| Overweight/obese  | 9   | 21.8 ± 3.9  | 24.1 ± 4.6| 7.1 ± 1.4            | 18.0 ± 4.4   |
| Total             | 102 | 17.7 ± 2.7  | 21.0 ± 3.4| 4.9 ± 1.3            | 14.4 ± 3.7   |
| p-value           | 0.000| 0.003       | 0.000     | 0.002                |              |

Table 4: Correlation coefficients of MUAC/TSF with other anthropometric indicators

| Factor                      | Girls (n = 109) | Boys (n = 102) | 6–9 years (n = 54) | 10–19 years (n = 157) | Total (n = 211) |
|-----------------------------|-----------------|----------------|-------------------|-----------------------|-----------------|
| Mid-upper arm circumference |                 |                |                   |                       |                 |
| Age                         | 0.789**         | 0.736**        |                   |                       | 0.771**         |
| Height                      | 0.819**         | 0.781**        | 0.363**           | 0.602**               | 0.789**         |
| Weight                      | 0.959**         | 0.919**        | 0.828**           | 0.912**               | 0.931**         |
| BMI                         | 0.951**         | 0.888**        | 0.870**           | 0.923**               | 0.921**         |
| Triceps                     | 0.694**         | 0.236**        | 0.503**           | 0.564**               | 0.508**         |
| Triceps skinfold thickness  |                 |                |                   |                       |                 |
| Age                         | 0.607**         | NS             |                   |                       | 0.339**         |
| Height                      | 0.555**         | NS             | NS                | NS                    | 0.240**         |
| Weight                      | 0.682**         | NS             | 0.452**           | 0.453**               | 0.478**         |
| BMI                         | 0.695**         | 0.416**        | 0.854**           | 0.621**               | 0.643**         |
| MUAC                        | 0.694**         | 0.236**        | 0.503**           | 0.564**               | 0.508**         |

** p < 0.001; NS = not significant, p > 0.05.

Table 5: Accuracy of MUAC and ultrasound triceps to predict overweight and obesity

| Age group      | Mid-upper arm circumference | Ultrasound triceps skinfold thickness |
|----------------|-----------------------------|--------------------------------------|
|                | Area SE p-value 95% CI      | Area SE p-value 95% CI               |
| 6–9 years, girls | 0.763 0.119 0.036 0.529–0.997 | 0.860 0.089 0.004 0.686–1.000 |
| 6–9 years, boys | 0.944 0.058 0.006 0.631–1.000 | 0.924 0.075 0.009 0.776–1.000 |
| 10–19 years, girls | 0.934 0.029 0.000 0.877–0.982 | 0.728 0.060 0.002 0.611–0.845 |
| 10–19 years, boys | 0.899 0.081 0.003 0.740–1.100 | 0.903 0.064 0.003 0.777–1.100 |
| Total           | 0.795 0.048 0.000 0.761–0.889 | 0.835 0.033 0.000 0.771–0.899 |

MUAC and TSF had excellent accuracy to predict overweight and obesity in the respondents.

Discussion

The results from this study showed that 1.9% of the learners aged 6–19 years were underweight. The prevalence of underweight was lower than the 10% underweight prevalence reported among South African children aged 1–9 years in the NFCS 2005. The 4.2% prevalence of underweight observed in girls aged 10–12 years was similar to the 4% reported among female primary students aged 10–12 years in rural KwaZulu-Natal. Also, the underweight prevalence was similar to the underweight prevalence of 4.6% girls and 5.2% boys reported among students aged 10–16 years in rural Limpopo using the US Centre of Disease Control and Prevention (CDC) cut-off points but contrary to the 66% prevalence of underweight reported among school children in eThekwini district in KwaZulu-Natal using the WHO guidelines for adults, where BMI < 18.5 kg/m² was regarded as underweight. This explains why adult guidelines are not an appropriate reference for children and adolescents as levels of underweight in the KwaZulu-Natal study may have been overestimated.

This study shows a high prevalence of overweight and obesity (16.9%) among the adolescents, which is consistent with previous findings in South Africa. The report of the 2008 national surveys showed the prevalence overweight/obesity to be 25% in adolescents aged 14–19 years. In a study conducted among children aged 9–13 years in the Northwest province, 22% of the participants were either overweight or obese. A systematic review of overweight and obesity among South African children reported trends of high prevalence across races, provinces, urban and rural settlements. Studies have attributed high prevalence of overweight in rural areas to the consumption of diets rich in starch and fats, sedentary lifestyle and reduced physical activities.
In this study, overweight and obesity consistently increased in girls and decreased in boys with age. A similar trend was observed by Grobbelaar et al.26 who found that while overweight/obesity increased in girls from 0% in 4–8-year-olds to 26.7% in 14–18-year-olds, it reduced in boys from 16.7% to 0% of the same age range.26 Previous studies have found significant age differences in the prevalence of overweight and obesity.1,2,22 The proportion of those who were overweight and obese was higher in girls than in boys. This is consistent with the earlier studies.24,26–30 Studies have linked the development of obesity in girls to the onset of menarche.24,31,32 and lower prevalence of overweight and obesity in boys to higher levels of physical activity.31,32 Other factors suggested to be responsible for the gender disparity in overweight prevalence included differences in energy needs, behavioural and cultural beliefs.24

This study finds a very strong relationship between MUAC and BMI, thus confirming previous studies that MUAC correlated very well with BMI.3,33,34 and could be used to identify not only underweight but also overweight and obesity. Similarly, an association was observed between ultrasound TSF and BMI, which also confirmed previous findings.8 The AUC obtained for both MUAC and TSF shows an excellent accuracy level to predict high BMI or overweight and obesity.

**Study limitation**

The study considered only children attending schools in Cofimvaba, and care must be taken when generalising results from the study.

**Conclusion**

This study reported low prevalence of underweight and higher prevalence of overweight and further confirmed that MUAC as well as ultrasound TSF can be an alternative tool to BMI for determining overweight and obesity in children and adolescents. A tilt towards overweight is apparent among the girls in this rural community. Considering the consequences of overweight and obesity, nutrition intervention and physical activities aimed at promoting healthy lifestyles are recommended for lifelong benefits.

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