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Original Article

The Association between Paediatric Obesity, Anthropometric Parameters and Physiological Traits among Rural Schoolchildren in Alice Location, Eastern Cape, South Africa

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Abstract

Background: Obesity is an epidemic non-communicable disease in South Africa (SA). Few data exist on rural schoolchildren. This study presented the association between paediatric obesity, anthropometric parameters and physiological traits in schoolchildren in the Alice Location of Raymond Mhlaba Municipality, South Africa.

Methods: The sum of 305 schoolchildren including girls 146; boys 159 between 5 – 7 years old were enrolled. Body mass index (BMI) specific for gender and age was used to describe overweight and obesity. Systolic/Diastolic blood pressure (SBP and DBP) was ≥ 90^{th} percentile for gender and age. An aneroid sphygmomanometer was used to measure blood pressure (BP).

Results: 15.75% of girls were overweight compared to 10.69% of boys while 16.35% of boys were obese compared to 10.27% of girls. Pre-hypertension was detected in both girls (2.0%) and boys (0.3%). SBP and DBP were significantly (P<0.05) associated with body mass, stature, BMI, hip and waist circumference (HC & WC), the sum of skinfolds, fat-mass (FM), fat-free mass (FFM), and fat-free mass index (FFMI).

Conclusion: Overweight, obesity and pre-hypertension are predominant amongst rural SA schoolchildren living in Alice location. Routine check-up and control of excessive weight gain in schoolchildren is crucial for early prevention of potential cardiovascular diseases in the future.

Keywords: Anthropometrics; Obesity; Overweight; Physiological traits; Rural-children

Introduction

The term overweight/obesity can be an unnecessary amassing of fat that can have negative impact on a person's health and welfare of a person (1). Various anthropometry measures have been used as an indicator of weight status that includes skinfold measurements, weight-for-age, Body mass index (BMI) (kg/m^2), and waist-to-hip ratio to mention a few (2). While, BMI is not a flawless anthropometric pointer, however, it is the commonly used pointer for weight status. The condition of overweight and obesity in people is now ranked as the number five high-risk source of death globally (3). The health consequences of paediatric obesity are mostly shown during adulthood, as the underlying factors of this disease conditions are commonly initiated during childhood (4). Thus, overweight/obese children are prone to become overweight/obese adults with a greater chance of having high systolic blood pressure (SBP) and diastolic blood pressure (DBP), diabetes, cardiovascular diseases and cancers (4).

Non-Communicable Disease Risk Factor Collaboration (NCD-RisC) pooled 31.5 million of children and adolescents between the ages of 5 – 19 years from 1975 to 2016 in 200 countries to estimate the average body mass index of children as well as adolescents (5). Global age-standardized incidences of obesity rose from 0.7% to 5.6% in girls, and from 0.9% to 7.8% in boys from 1975 to 2016 (5). However, the global estimates of children ages 5 – 19 years that are affected by obesity in 2010 was 4.9%, in 2016 it was 6.8% and 10.5% in 2025 with estimated 205.5 million in 2025 (6). The major reason for overweight/obesity may be attributed to the dietary intake and movement activities (physical activity (PA) and sedentary lifestyles) among others (6).

Overweight/obesity is in the increase among South Africa (SA) children and youths, as this epidemic has become a main public health distress that needs to be urgently addressed (7). The prevalence of overweight/obesity among SA children and adolescents stands equivalent to some advanced countries and is amongst the top in Africa (2). In other words, this explains the fact in the rise of overweight/obesity among SA children and youths. According to Armstrong et al (8), the incidence of obesity in a sample of SA children between the ages of 6 – 13 years was 3.2 % for boys and 4.9 % for girls, while the incidence of overweight was 14.0 % for boys and 17.9 % for girls. The SA Primary Schools' Anthropometric Survey and The Health of the Nation Study (2) also revealed an estimated rise in overweight in SA children and adolescents from 1.2% to 13% and in obesity from 0.2% to 3.3% from 1994 to 2004. Data obtained from the National Income Dynamics Study (NIDS) (9) revealed 16% of children between the ages 5 – 9, 22% of children aged 10 – 14 and 18 % of children between the ages 15 - 17 were seen to be overweight/obese. In 2017, overweight and obesity in children under five years of age in SA rose to 13.7% (10). Obesity/overweight were greater problems in boys than in girls and urban than rural areas (11). In addition, results from Healthy Active Kids South Africa (HAKSA) Report Card grades on overweight/obesity reported a D grade, which means there is a persistence on the increase of overweight/obesity (12).

Hypertension in children and adolescents has been defined according to the normative distribution of blood pressure (BP) in healthy children. Evidences are seen on the associations between physiological characteristics and paediatric obesity. Overweight/obese children had statistically significant greater values for body fat, SBP, and DBP (13). Timnea et al (14) also reported the relationship between physiological traits and obesity. Furthermore, Goon and associates (15) reported the positive correlation between physiological traits (SBP and DBP) with body mass and BMI of 7 – 13 years old schoolchildren.

As far as we know, there is however, a paucity of studies that reveals the relationship between physiological traits and obesity among rural schoolchildren in Alice location in the Raymond Mhlaba Municipality, where there are limited resources, lack of facilities and equipment in schools to promote physical activity (PA), and physical education (PE). Hence, we evaluated the association between physiological traits, paediatric obesity and anthropometrics parameters among rural schoolchildren in Alice location. Findings in this study will inform parents, guardians, caregivers, teachers and public policy makers on implementing appropriate intervention measures.

Methods

Research design

This was a cross-sectional descriptive study. A convenient selection of four primary schools in Alice sub-district were selected. A purposive selection of grade levels one and two in each of the selected schools were done. These grade levels were selected because the targeted ages were 5-7 years.

A simple random balloting was used to select the participants. This gave all learners in each of the selected classes the eligibility to participate in the study. Children were asked to pick a blinded “Yes” and “No” paper. The “Yes” papers were selected to participate in the study.

A sum of 305 schoolchildren, boys 159 and girls 146 between 5-7 years old participated in the study. A child was included in this study if the parent signed the informed consent and had no ailment that could mar anthropometric measurements. Five trained research aides, and postgraduate students from the department of Human Movement Science, University of Fort Hare, participated in the data collection. Research assistants who were kinanthropometrist with level 2 accreditation did the anthropometrics measurements. All measurements were taken in a private room. A specialist did BP measurements.

Ethical considerations

The aim of the study was explained to the children, their parents and legal guardians, who gave their consent. University of Fort Hare ethical committee gave an approval to conduct the study (REC – 270710 – 028 – RA Level 01).

Measurements

BP of the children was taken when they were calm without indulging in any strenuous activities prior to the time of measurement. An aneroid sphygmomanometer was used for BP measurements according to standardized guidelines. Hypertension was considered if SBP and DBP measures were in the $\geq 90^{th}$ percentile for age and gender (16).

The weight, height, triceps and subscapular skinfolds, HC and WC were assessed. All measurements were done based on the International Standards for the Anthropometric Assessment (ISAK) (17). BMI was calculated from weight kilogram (kg) and height centimeters (cm) using the equation (kg/m^2). The summation of 2 skinfolds (triceps and subscapular) was used to calculate body fat percentage (18). Weight was measured in kg to the nearest 0.1kg with an Omron (BF 511) electronic scale, and height was measured to the nearest cm with a Harpenden stadiometer. Skinfolds were evaluated in millimeters (mm) using a Harpenden skinfold calliper while girth measurements were measured with a Girths Lufkin nonextensible flexible steel anthropometric tape to the nearest cm (17).

Anthropometry derived variables

Body fat percentage (%BF)

The skinfold equation (18) was used to predict BF. Different equations using the sum of triceps and subscapular skinfold thickness were used for both boys and girls to calculate the %BF.

Fat Mass = Body weight (kg) x %Fat/100

Fat-Free Mass = Body weight (kg) – fat mass (kg)

Fat Mass Index = $FM/Stature^2$

Fat-Free Mass Index = $FFM/Stature^2$

Waist-to-hip ratio (WHR) = Waist circumference/Hip circumference

Waist-to-height ratio (WHtR) =Waist circumference/Height circumference

Blood pressure derived variables

Mean arterial pressure (MAP)

$$\frac{2\,(DBP) \times SBP}{3}$$

Statistical analyses

Variables used in this study are presented as mean and standard deviation. The Pearson correlation coefficient was applied in order to determine the association between BP and anthropometric variables. The t-test was used for comparisons of these variables, which was according to gender. The level of statistical significance was set at $P<0.05$. Data were analysed using statistical package for the social sciences (SPSS) version 17.0 (Chicago, IL, USA).

Results

The sum of 305 schoolchildren participated in the study. One hundred and fifty nine (52.1%) were boys and 146 (47.9%) were girls. The mean age of the participants was 5.91±0.83 years. The age and gender distributions of the participants are displayed in Table 1.

Table 1: Distribution of the participants according to age and gender

Age (yr)	*Boys n(%)*	*Girls n(%)*	*Combined n(%)*
5	59 (49.2)	61 (50.8)	120 (39.3)
6	55 (59.1)	38 (40.9)	93 (30.5)
7	45 (48.9)	47 (51.1)	92 (30.2)
Total	159 (52.1)	146 (47.9)	305 (100)

n=Number, %=Percentage

Gender based descriptive report of the anthropometric and physiological traits (SBP & DBP) measurements of the samples are represented in Table 2. There was no significant (p>0.05) gender differences in age, stature, weight, BMI, %BF, triceps, WHR, WHtR, HC, FM, FFM, FMI, FFMI, SBP, DBP and MAP. Significant (P<0.05) gender differences were seen in subscapular, and WC. Both SBP and DBP seem to increase with age in 5-6 years and a little decrease in age 7 (Table 3).

Table 2: Anthropometric and physiological measurements of the participants according to gender

Variables	*Boys (n=159) Mean±SD*	*Girls (n=146) Mean±SD*	*Total (n=305) Mean±SD*	*P-value*
Age (years)	5.91 ± 0.81	5.90 ± 0.86	5.91 ± 0.83	0.10
Height (cm)	115.53 ± 6.64	114.77 ± 7.30	115.17 ± 6.97	0.20
Weight (kg)	22.01 ± 4.39	21.27 ± 4.08	21.66 ± 4.26	0.69
BMI (kg/m^2)	16.30 ± 2.13	16.19 ± 2.23	16.25 ± 2.17	0.94
Triceps (mm)	8.72 ± 3.14	9.62 ± 2.95	9.15 ± 3.07	0.44
Subscapular (mm)	5.76 ± 2.48	6.51 ± 2.55	6.12 ± 2.54	0.05
Σ2SKF (mm)	14.30 ± 5.50	16.02 ± 5.37	15.12 ± 5.50	0.73
WHR	0.88 ± 0.08	0.85 ± 0.05	0.87 ± 0.07	0.44
WHtR	0.46 ± 0.03	0.46 ± 0.04	0.46 ± 0.03	0.38
WC (cm)	53.38 ± 4.05	52.27 ± 4.81	52.84 ± 4.46	0.07
HC (cm)	61.04 ± 6.59	61.37 ± 5.60	61.20 ± 6.12	0.99
%BF	12.09 ± 4.60	14.71 ± 4.26	13.34 ± 4.78	0.38
FM (kg)	2.78 ± 1.78	3.21 ± 1.43	2.99 ± 1.60	0.60
FFM (kg)	19.24 ± 3.17	18.07 ± 3.09	18.65 ± 3.13	0.12
FMI (kg/m^2)	2.06 ± 1.16	2.41 ± 0.94	2.23 ± 1.05	0.51
FFMI (kg/m^2)	14.33 ± 1.34	13.64 ± 1.43	13.99 ± 1.38	0.13
SBP (mmHg)	69.19 ± 7.30	68.39 ± 7.97	68.81 ± 7.63	0.37
DBP (mmHg)	38.15 ± 5.91	37.11 ± 7.53	37.65 ± 6.74	0.19
MAP	53.67 ± 5.68	52.75 ± 6.99	53.23 ± 6.35	0.22

SD = standard deviation; BMI = body mass index; Σ2SKF = Sum of two skinfolds (triceps and subscapular); WHR = waist-to-hip ratio; WHtR = waist-to-height ratio; WC = waist circumference; HC = hip circumference; Body fat (%) = body fat percentage; FM = fat mass; FMI = fat mass index; FFM = fat free mass; FFMI = fat free mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure

The SBP and DBP show a significant (P<0.05) correlation with age, weight, stature, BMI, WC, HC, FM, FFM, FFMI and WHtR. There was no significant correlation with triceps, subscapular, sum of skinfolds, %BF, FMI, and WHR (Table 4). The relative frequency and percentage of overweight and obesity in the rural schoolchildren is shown in Table 5. The overall percentage of overweight was higher in girls (15.75%) than in boys (10.69%) while the percentage of obesity was higher in boys (16.35%) than in girls (10.27%). The total incidence of overweight and obesity in the schoolchildren population was 13.12% and 12.46%. Table 6 displays the descriptive status of BP among the study population. The percentage of normal BP was higher in boys (51.8%) compared to girls (45.9%) while pre-hypertension was higher in girls (2.0%) compared to boys (0.3%).

Table 3: Systolic and diastolic blood pressure of the samples according to age groups

		SBP (mmHg)		***DBP (mm Hg)***	
Age (yr)	N	Mean±SD	95% CI	Mean±SD	95% CI
5	114	64.57±7.77	63.13−66.01	35.93±5.87	34.84−37.02
6	90	71.91±5.93	70.67−73.15	39.14±6.92	37.70−40.59
7	90	70.93±6.59	69.55−72.31	38.38±7.23	36.86−39.89

Table 4: Association of systolic and diastolic blood pressure with anthropometric parameters

	SBP (mm Hg)		***DBP (mm Hg)***	
Variables	r value	p-value	r value	p-value
Weight	0.3637	<.0001	0.2265	<.0001
Height	0.3978	<.0001	0.2381	<.0001
BMI	0.1852	0.0015	0.1311	0.0256
TSKF	-0.0122	0.8365	0.068	0.2481
SSKF	0.0645	0.2737	-0.0266	0.6523
HIP	0.2599	<.0001	0.1744	0.0029
WC	0.3343	<.0001	0.1769	0.0025
Σ2SKF	-0.2345	<.0001	-0.1961	0.0008
BF%	-0.0303	0.6078	-0.0177	0.7641
FM	0.1761	0.0026	0.1027	0.0808
FFM	0.3956	<.0001	0.2504	<.0001
FMI	0.0668	0.2567	0.0415	0.4817
FFMI	0.2222	0.0001	0.1626	0.0055
WHR	0.0117	0.8423	-0.0406	0.4912
WHtR	0.0506	0.3906	0.0057	0.923

r: pearson correlation

Table 5: Incidence of overweight and obesity according to gender and age

	Gender (n)		***Overweight***		***Obese***	
Age (yr)	Boys	Girls	Boys (%)	Girls (%)	Boys (%)	Girls (%)
5	59	61	6(10.17)	10(16.39)	9(15.25)	7(11.48)
6	55	38	8(14.55)	6(15.79)	7(12.73)	4(10.53)
7	45	47	3(6.67)	7(14.89)	7(15.56)	4(8.51)
Subtotal	159	146	17(10.69)	23(15.75)	26(16.35)	15(10.27)
Grand total	305		40(13.12)		38(12.46)	

Based on the CDC's BMI age and sex-specific Cole et al (19)

Table 6: Descriptive statistics of blood pressure with gender

Gender (n)	*Boys (%)*	*Girls (%)*	*Total (%)*
Normal	158 (51.8)	140 (45.9)	298 (97.7)
P/HYP	1 (0.3)	6 (2.0)	7 (2.3)
HYP	-	-	-
Grand total	159 (52.1)	146 (47.9)	305 (100)

P/HYP, pre-hypertension; HYP, hypertension

Discussion

The association between anthropometric indicators and BP is important in evaluating the health of children and adolescents, since cardiovascular aberrations are becoming prevalence these days. In this study, the incidence of overweight was high in girls while obesity was high in boys. SBP and DBP appear to rise with age (5-6 years) but a decrease was seen in age 7. The study also presented some anthropometric variables that were significantly, positively and negatively associated with SBP and DBP in the children, which includes height, weight, BMI, HC, WC, sum of skinfolds, FM, FFM and FFMI except %BF, triceps, subscapular, WHR, WHtR and FMI.

The present study indicated that SBP and DBP had a significant correlation among some anthropometric variables which has been previously reported by several studies (15, 20), regardless of age and gender. The significant relationship between SBP and DBP with weight, stature and BMI amongst the children in this study is consistent with the findings reported by several studies (15,21-23). BMI is an essential factor and independent of the adipose tissue beneath the skin. A strong association between elevated BP in the early years of life and consequent advancement of the metabolic condition in later life has been recorded (24). However, this portrays the urgency of the necessity to observe the weight and BMI status of children in order to secure their future well-being. Furthermore, the association between BMI and raised BP may reflect the superiority of BMI in envisaging raised BP of schoolchildren in contrast to other indicators analysed in this study.

WC and HC showed a positive correlation between SBP and DBP in the current study, which is consistent with Dewi et al (25). Their findings revealed that SBP and DBP showed a significant positive correlation with WC and BMI. It was concluded that WC serves as the strongest, significant, predictive factor for elevated SBP while BMI may be a predictive factor for elevated DBP. There is a very low frequency in the practice of BP screening, which is not a routine practice in evaluating children (26). High BMI and WC may indicate children with a higher chance of elevated BP (27).

Also, the result from this present study revealed that SBP and DBP showed no association with skinfolds and %BF. It is possible that %BF may be the best measure to assess the subcutaneous fat in children and adolescents. Nonetheless, BP differences depend on the changes in physique and growth patterns (28). In other words, the imprecise skinfold measurements could have resulted to the lack of relationship between %BF, SBP and DBP in the current study. The same person did all measurements in pre-specified anatomical sites and hence, this factor may be negligible. This can be said, based on our findings, BMI seems to be superior to %BF in relation with BP. According to Ribeiro et al (29, 30) BMI was identified as the top cause of high BP in children, as its predictive ability was higher than that of skinfolds. Contrarily to our findings, Gomwe et al (23) found out that SBP and DBP displayed positive significant correlations with triceps and subscapular skinfolds and %BF. Moser et al (20) also found triceps skinfold to be correlated with SBP and DBP. Thus, triceps skinfold was found to be one of the anthropometric parameters that predict high BP among their populations.

Consistent with the study of Moselakgomo and colleagues (21), the current result demonstrated a

significant negative association between SBP and DBP with sums of skinfolds (Σ2SKF).
Likewise, SBP and DBP showed no correlation with WHR, WHtR and FMI in the current study. In contrast, Amamilo et al (31), found that WHR had a negative correlation with SBP and DBP. WC and WHR serves as predictors of hypertension in children. The study of Moser et al (20) also found WHR to be correlated with SBP and DBP. While study of Gomwe et al (23), found WHR to be correlated with SBP and not DBP.
According to our findings, FM, FFM and FFMI was positively correlated with SBP and DBP. This finding is consistent with the 2 studies (32, 33). Hence, in different age groups and cultural cohorts. However, in alignment with our findings, and also other findings from other studies (32, 33) aside from BMI been a predictor of cardiovascular risk, FM, FFM and FFMI can be considered as substitutes of cardiovascular status and predictors of hypertension.
The percentages of overweight and obesity among the participants in the current study were 13.12% and 12.46% respectively. The incidence of overweight and obesity among schoolchildren and youths in SA is alarming and is on the increase (2, 34). Increase body fatness was reported to be significantly associated with a series of cardiovascular and metabolic irregularities that cluster with obesity, including BP (35). Meanwhile, various studies have found higher levels of raised BP among overweight and obese children (15, 36) nevertheless, the physiological trait of the majority population (97.7%) was normal in the present study with (2.3%) of the population having BP readings slightly above normal (pre-hypertension).

Study Limitations

The schoolchildren used in the current study does not represent the children in the Raymond Mhlaba Municipality, nor does it reflect the Eastern Cape Province. Hence, the generalization of these study findings should be regarded with carefulness. Also, BP was measured once, which is different from the National High Blood Pressure Education Program (NHBPEP) principles that suggests that BP should be measured at least on three occasions, this was due to financial and practical reasons.

Strength

The use of a standardized anthropometric and BP measurement procedures in an understudied rural area.

Suggestions

The fact that high BP and paediatric obesity often starts from childhood to adulthood makes childhood an essential age to investigate paediatric obesity and its association with hypertension. More so, larger sample size involving older age groups may be required.

Conclusion

The result of this study reveals the superiority of BMI and WC over %BF in relation to BP in the current study sample. Routine check-up and control of excessive weight gain in schoolchildren is crucial for early prevention of potential cardiovascular diseases in the future. Data from this study can offer significant perceptions to improve suitable approaches and policies to curtail related risk factors and improve healthy lifestyle.

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Conflict of Interest

No conflict of interest for any of the authors.

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