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Full Length Research Paper

Estimating waist circumference from BMI in South African children

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Waist circumference (WC) is proposed as a better marker in the diagnosis of metabolic syndrome in children than body mass index (BMI). As important as this anthropometric index may appear, it is not as commonly measured in schools as BMI. Thus unlike BMI, data on WC are scarce. Therefore, we investigated whether there is an alternative way to estimate WC even in those children whose WC measurement has not been taken. We evaluated the relationship between BMI and the WC of 1136 schoolchildren (548 boys; 588 girls) aged 9 to 13 years, attending public primary schools in Pretoria Municipality, South Africa. The measurements were taken using the protocol of International Society for the Advancement of Kinanthropometry (ISAK). Significant linear relationship between BMI and WC were observed in each age-and sex-stratified groups [(9-year-old boys: waist = 0.17 + 3.03 BMI (r = 0.65, p < 0.001); 9-year-old girls: waist = 26.24 + 1.73 BMI (r = 0.95, p < 0.001); 10-year-old boys: waist = 19.64 + 2.21 BMI (r = 0.90, p < 0.001); 10-year-old girls: waist = 18.36 + 2.13 BMI (r = 0.81, p < 0.001); 11-year-old boys: waist = 25.88 + 1.89 BMI (r = 0.78, p < 0.001); 11-year-old girls: waist = 23.08 + 1.97 BMI (r = 0.94, p < 0.001); 12-year-old boys: waist = 27.50 + 1.80 BMI (r = 0.72, p < 0.001); 12-year-old girls: waist = 26.26 + 1.92 BMI (r = 0.91, p < 0.001); 13-year-old boys: waist = 25.46 + 2.05 BMI (r = 0.91, p < 0.001); 13-year-old girls: waist = 24.59 + 1.96 BMI (r = 0.84, p < 0.001)]. The result indicates the possibility of estimating WC from stature and body mass, at least among South Africa children. WC could be used as an alternative way of screening childhood metabolic syndrome or obesity in which waist circumference is essential.

Key words: Waist circumference, BMI, South African children.

INTRODUCTION

The most recent international preventive guidelines for the identification and treatment of childhood obesity recognize the importance of including anthropometry measures of both overall adiposity and abdominal obesity when screening obesity-related health risks (Freedman et al., 2007). Body mass index (BMI) is used as an indicator of overall adiposity, whereas the waist circumference (WC) is advocated as an indicator for central obesity because it is a good predictor of abdominal fat and is more closely related to the development of cardio-vascular disease and type 2 diabetes mellitus (Watts et al., 2008) in both children and adults (Burke et al., 2005; Falkner et al., 2006). Compared to BMI, several studies (Savva et al., 2000; Garnett et al., 2007; Flores-Huerta et al., 2009) have proposed WC as a better predictor of cardiovascular disease risk factors than BMI. Cross-validation against magnetic resonance imaging confirmed that among children, WC can be considered as a good predictor of visceral adipose tissue (Brambilla et al., 2006). Therefore, measurement of WC has practical significance in clinical and health screenings, especially children.

Whilst there seem to be available data on BMI, WC measurement is seldom taken in most South African schools. Given the increasing importance of WC for clinical and diagnostics practice, and findings reported by Morinoto et al. (2007) that it is possible to estimate WC from stature and body mass, we sought to investigate whether there is an alternative way to estimate WC even in those children whose WC measurement had not been

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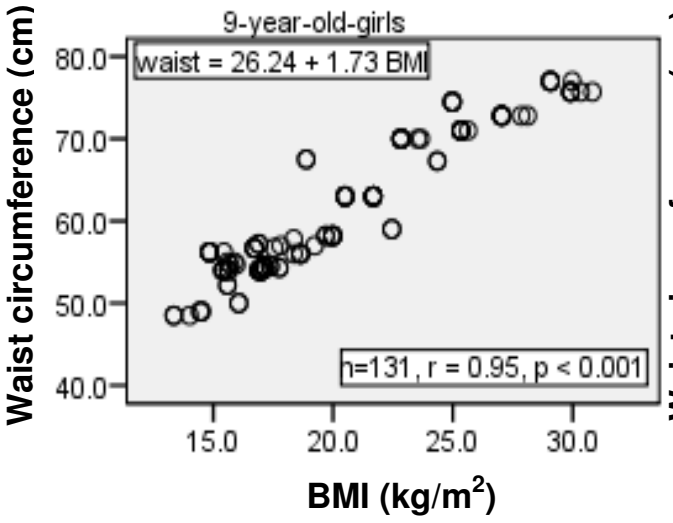
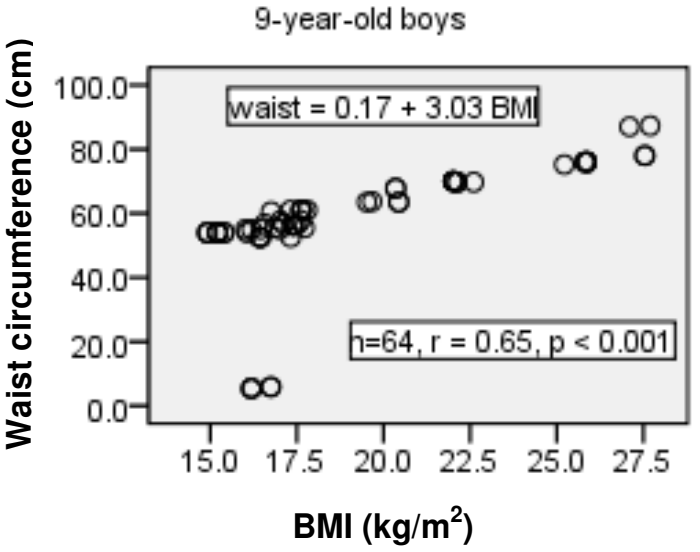
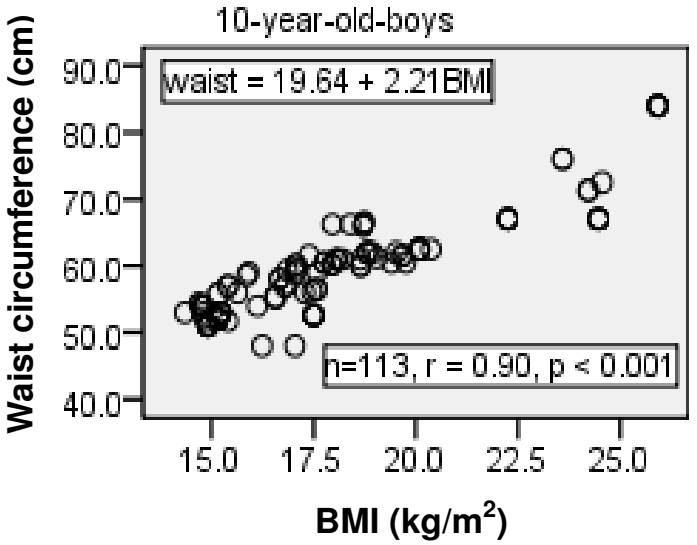
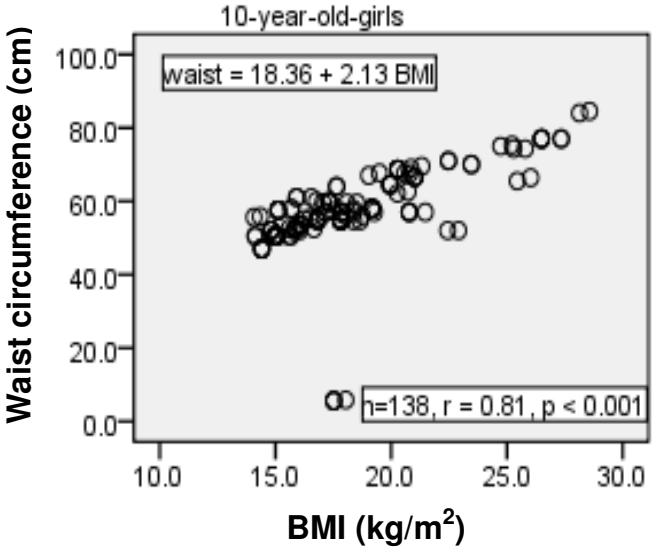
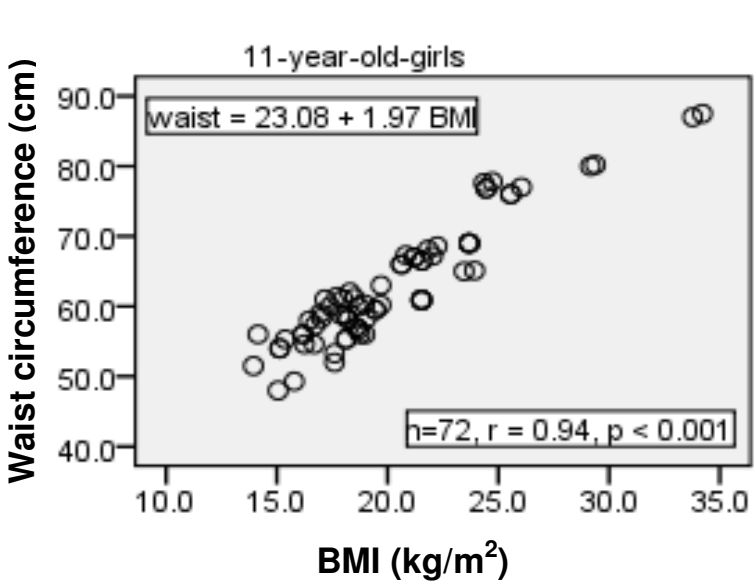
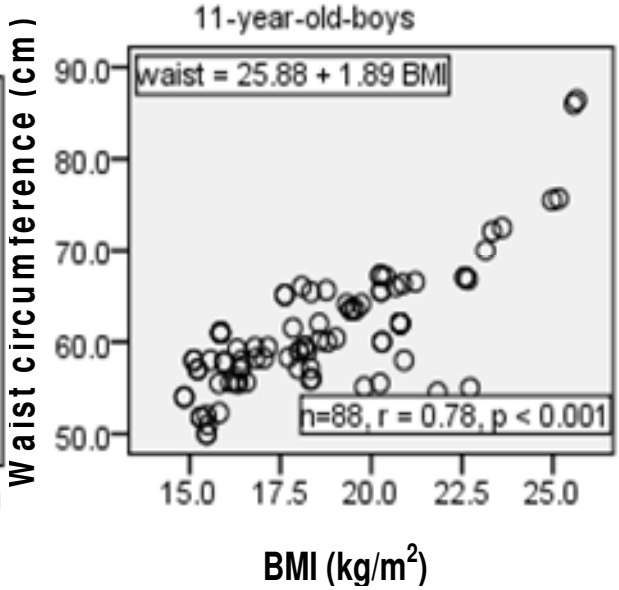

9-year-old-girls
waist = 26.24 + 1.73 BMI
n=131, r = 0.95, p < 0.001
Waist circumference (cm)
BMI (kg/m2)


9-year-old boys
waist = 0.17 + 3.03 BMI
n=64, r = 0.65, p < 0.001
Waist circumference (cm)
BMI (kg/m2)


10-year-old-boys
waist = 19.64 + 2.21BMI
n=113, r = 0.90, p < 0.001
Waist circumference (cm)
BMI (kg/m2)


10-year-old-girls
waist = 18.36 + 2.13 BMI
n=138, r = 0.81, p < 0.001
Waist circumference (cm)
BMI (kg/m2)


11-year-old-girls
waist = 23.08 + 1.97 BMI
n=72, r = 0.94, p < 0.001
Waist circumference (cm)
BMI (kg/m2)


11-year-old-boys
waist = 25.88 + 1.89 BMI
n=88, r = 0.78, p < 0.001
Waist circumference (cm)
BMI (kg/m2)

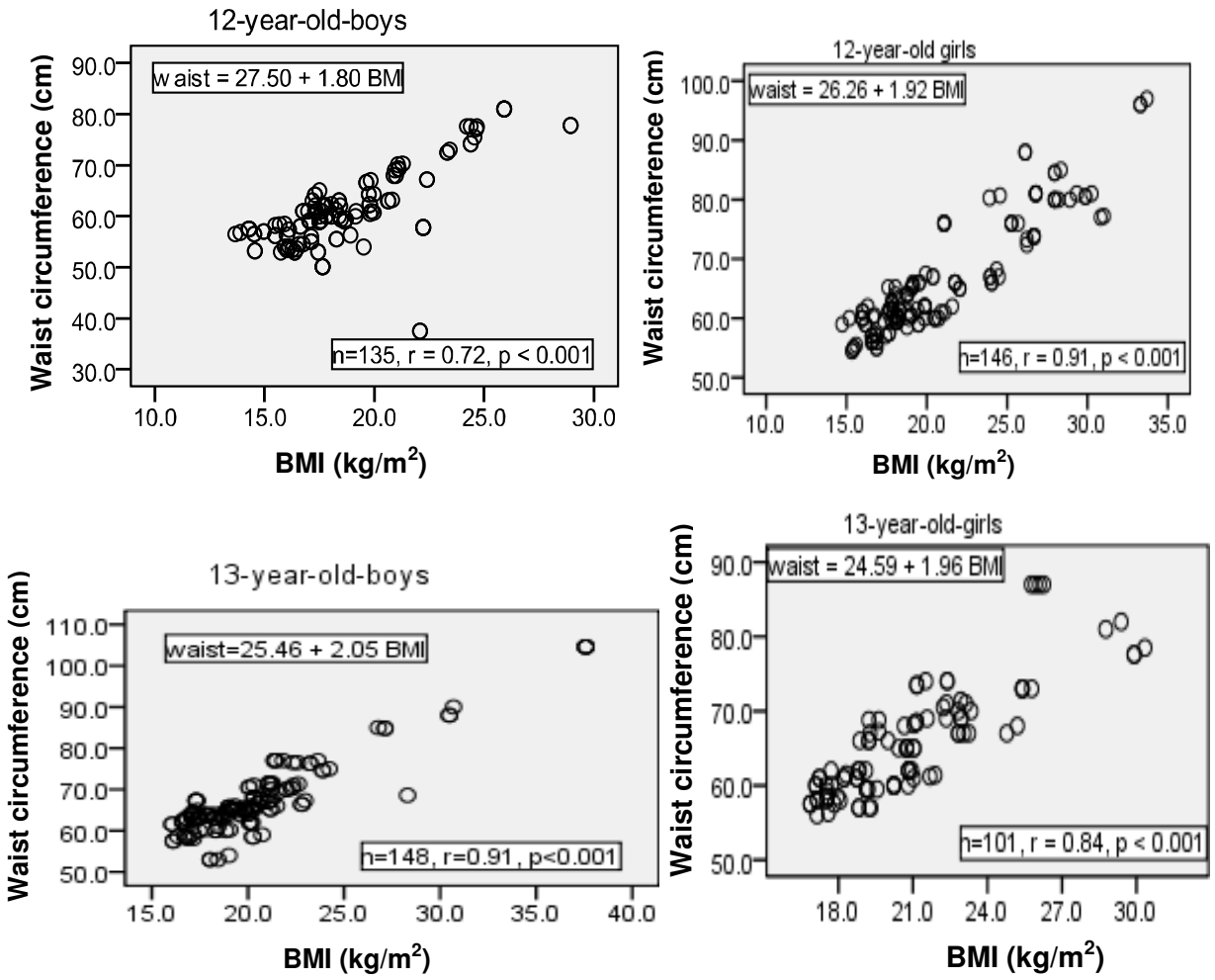


Figure 1. The linear relationship between BMI and waist circumference in each age-and sex-divided group. *r*: Pearson's correlation coefficients.

previously taken and further its utility as a diagnostic tool in screening for risk factors of metabolic syndrome in pediatric South African population.

MATERIALS AND METHODS

The study sample consisted of 1136 (548 boys and 588 girls) South African children, aged 9 to 13 years, living in Pretoria Municipality, South Africa. They were randomly selected from 15 public primary schools in the region. The sampling frame was defined using the enrolment number for each school. This study employed a stratified, two stage cluster sampling strategy. This procedure ensures adequate representativeness of the study population in the sample. The procedure involved arrangement of study population into schools and class-level clusters.

The first stage involved selecting randomly, schools with a probability proportional to the size and enrolment of each school. The second stage involved selecting classes within the participating schools systematically and with equal probability of participation. All learners in the selected classes were thus eligible to participate in the study. However, due to absenteeism and incomplete data of 374 participants, 1136 participants (548 boys and 588 girls) eventually completed the tests and their data were used in the final statistical analysis.

Ethical considerations

Prior to the study, the children's parents and guardians were briefed regarding the purpose and procedures of the study. Written informed consent was obtained from the children's parents or guardians and individual head teachers using prescribed guidelines (Thomas et al., 2005). Permission to carry out the study was granted by the Department of Education, Gauteng Regional Office. Ethical approval was obtained from the Research and Innovation Committee of Tshwane University of Technology, Pretoria, South Africa.

Anthropometric measurements

Anthropometric measurements, including stature, body mass and

WC, were taken according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2006). These measurements were performed by the same trained tester (one for each sex) whose quality of performance was evaluated against prescribed ISAK guidelines prior to the study.

WC was measured in the standing position at the level of the narrowest point between the lower costal (10^{th} rib) border and the iliac crest to the nearest 0.1 cm, using a flexible tape (Lufkin W606 PM, Creative Health Products, MI, USA). Pearson's correlation coefficient was applied to examine the relationship between BMI and WC using SPSS version 17.0. The level of significance was set at 0.05.

RESULTS

As indicated in Figure 1, there is a significant linear relationship between BMI and WC observed in each of the age-and sex-stratified groups [(9-year-old boys: waist = 0.17 + 3.03 BMI ($r = 0.65$, $p < 0.001$); 9-year-old girls: waist = 26.24 + 1.73 BMI ($r = 0.95$, $p < 0.001$); 10-year-old boys: waist = 19.64 + 2.21 BMI ($r = 0.90$, $p < 0.001$); 10-year-old girls: waist = 18.36 + 2.13 BMI ($r = 0.81$, $p < 0.001$); 11-year-old boys: waist = 25.88 + 1.89 BMI ($r = 0.78$, $p < 0.001$); 11-year-old girls: waist = 23.08 + 1.97 BMI ($r = 0.94$, $p < 0.001$); 12-year-old boys: waist = 27.50 + 1.80 BMI ($r = 0.72$, $p < 0.001$); 12-year-old girls: waist = 26.26 + 1.92 BMI ($r = 0.91$, $p < 0.001$); 13-year-old boys: waist = 25.46 + 2.05 BMI ($r = 0.91$, $p < 0.001$); 13-year-old girls: waist = 24.59 + 1.96 BMI ($r = 0.84$, $p < 0.001$)].

DISCUSSION

Evidence suggests that central adiposity in children is more closely linked with metabolic disease risk than BMI (Lee et al., 2006; Lurbe et al., 2001) however, WC is not recommended for universal screening programmes (Barlow and Expert Committee, s2007) and has rarely been investigated in screening studies. This study investigates whether there is an alternative method to estimate WC even in those children whose WC measurement has not been taken. Information from this study supports the data published by Morimoto et al. (2007), who presented results from a project involving a relatively large-scale population-based cohort in Japan. Morimoto et al. (2007) study found a significant linear relationship between BMI and WC in each-and sex-divided group. In the present study, a significant linear relationship was observed between WC and BMI stratified by each-and sex-divided group. The result of this study proves that it is possible to estimate WC from stature and body mass, at least among South Africa children.

Measuring WC requires inexpensive simple equipment and the recording of a single value (or a mean of two or three measurements), in contrast to BMI which requires more complex equipment and mathematical calculations. However, while there seem to be plenty of data on BMI among South African children, there is paucity of data on WC. This situation pertains so especially in schools where the culture and religion of the people forbids the raising of clothes particularly among the girls, and even in both genders, where it is considered a shameful act. Thus, in such circumstances, using stature and body mass to estimate WC for those who do not have WC data could be an alternative method, and this can be useful in detecting childhood metabolic syndrome or obesity disease in which a waist circumference figure is necessary (Morimoto et al., 2007). Similar studies examining this BMI-WC linearity relationship in other age groups of children and adolescents are warranted.

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