Relationships between overweight, obesity and physical fitness of nine- to twelve-year-old South African children

[a] **Truter L,** MSc [a] **Pienaar AE**, PhD [b] **Du Toit D,** PhD
[a] School of Biokinetics, Recreation and Sport Science, North West University, Potchefstroom Campus, South Africa
[b] School of Education, North West University, Potchefstroom Campus, South Africa
Correspondence to: Prof AE Pienaar, e-mail: Anita.pienaar@nwu.ac.za
Keywords: overweight; obesity; children; gender; physical fitness

Abstract

SA Fam Pract 2010;52(3): 227-233

Background: South African children show the same tendencies in overweight and obesity as children in developed countries a decade ago. Childhood overweight is associated with chronic diseases, early mortality in adulthood and psycho-social effects with lifelong consequences. This study aimed to determine relationships between overweight, obesity and physical fitness of nine- to twelve-year-old South African children.

Methods: Anthropometric (body-mass index [BMI], fat percentage) and physical fitness (cardiovascular endurance, body composition, muscle strength, muscle endurance, flexibility) measurements were obtained from 280 children aged nine to twelve years (128 boys, 152 girls) using the Fitnessgram and Bruininks-Oseretsky Test of Motor Proficiency II. International cut-off points were used to categorise children into normal-weight, overweight or obese categories. Data were analysed using descriptive statistics, Spearman rank order correlation and variance of analysis.

Results: One in five children was overweight or obese, while girls were twice as likely as boys to be obese. Aerobic capacity and muscle strength, especially leg strength, decreased progressively with an increase in BMI. A progressive but non-significant decline was found in muscle endurance with increasing BMI, while flexibility showed the poorest relationships with various degrees of weight. Variance of analysis indicated significant relationships between BMI, cardiovascular endurance and strength ($p < 0.05$), while different relationships were found when gender was taken into consideration.

Conclusions: Health-enhancing physical fitness of young children is negatively affected by overweight and obesity, and intervention strategies are recommended to improve the quality of life of such childre,n but also to prevent early mortality during adulthood.

Ⓟ **Peer reviewed. (Submitted:2009-10-08, Accepted:2009-12-21).**

Introduction

Recent research shows that the worldwide occurrence of obesity in children (an increase in body weight above that of skeletal and physical standards as a result of over-accumulation of body fat)[1] is worryingly high. On the basis of a comparison of statistics obtained from the National Health and Nutrition Examination Survey (NHANES) III (1988–1994) and the NHANES (1999–2000), it is clear that there is an increase in overweight among American children from 7.2 to 10.4% in two to five-year olds, from 11.3 to 15.3% in six to eleven-year olds and from 10.5 to 15.5% in twelve to nineteen-year-olds.[2] Research conducted in South Africa exhibits similar tendencies in children. The National Food Health Consumption Survey, performed in 1999, shows that 6% of one to nine-year-old South African children are overweight.[3] Somers et al[4] found that 10 to 16-year-old South African girls (21.1%) were significantly more overweight than boys (6.4%), but found no significant differences with regard to obesity. Armstrong and co-workers[3] reported the prevalence of obesity and overweight in six- to thirteen-year-old South African children to be 14.0 and 3.2% in boys and 17.9 and 4.9% in girls respectively. They concluded that South African children exhibit the same tendencies with regard to overweight and obesity as children from developed countries a decade ago.

It seems that the physical development of children can be negatively impacted by overweight and obesity. Health promotion based on physical activity includes improvement in cardiovascular function, body composition, muscle strength, muscle endurance and flexibility.[5] In this regard, researchers show that there is a negative correlation between the body mass index (BMI) and the cardiovascular

function of overweight and obese children, and that children of normal weight scored better in tests that determined cardiovascular function than did overweight and obese children.[6-8] Furthermore, Nassis et al[9] showed that the BMI as well as the body fat percentage of overweight and obese children with a higher cardiovascular endurance is lower in relation to children in the same BMI category with a lower cardiovascular endurance. According to various researchers, the body composition of overweight and obese children in all age groups, as well as both genders, consists of a high percentage of fat mass together with a low percentage of fat-free mass.[7,10-12] The size of the skinfold measurements in overweight and obese children is also significantly larger than those of normal-weight children.[13] According to researchers, overweight and obese children fare significantly weaker in standing long-jump as well as in vertical jump activities as measurements of muscle strength.[8,14] Researchers further indicate that overweight and obese boys, as well as girls in the six to eighteen-year-old age group, perform significantly weaker in abdominal muscle endurance tests.[7,8] It would, however, appear from existing studies that the lower back and hip flexibility of overweight and obese children do not differ significantly from that of children of normal weight.[7,8]

Apart from these relationships between health-promotional physical fitness, overweight and obesity in children are also associated with various other illnesses. These include pulmonary (asthma), orthopaedic (increased linear growth, flat feet, sprained ankles), neurological (idiopathic intracranial hypertension), gastro-intestinal (liver steatosis, gastro-oesophageal reflux), endocrine (glucose intolerance/insulin intolerance, type II diabetes, menstrual irregularities/early puberty, polysystic ovarian syndrome, hypercorticism) and cardiovascular (hypertension, dyslipidaemia) diseases.[1,15-18] Many of these conditions are possibly related to the physical fitness profile of overweight and obese children.

These health risks associated with overweight and obesity in children demand action. South African statistics also show that a large number of children are affected by this problem.[3,19,20] In order to plan an effective intervention programme, it is important to determine the nature of the relationships between physical parameters and overweight and obesity in South African children, as little literature is available in this regard on children between the ages of nine to twelve years within the diverse population of South Africa. Therefore, the aim of this study was to determine to what extent overweight and obesity affect the health-promotional physical abilities of nine to twelve-year-old South African children and whether gender plays a role in possible associations that were found.

Method

Research design

The study was a one-way design based on baseline measurements.

Research group

The research group consisted of 280 Grade 4, 5 and 6 learners (128 boys and 152 girls) from two primary schools in Potchefstroom that represented a good distribution of socio-economic status, race and gender. The ages included in the group varied between nine and thirteen years [9 years (n = 53); 10 years (n = 77); 11 years (n = 92); 12 years (n = 51); 13 years (n = 5)]. The five 13-year-old children were not excluded from the group as they turned 13 shortly before the assessments and the researchers wanted to include as far as possible all the children in grades 4 to 6.

Measuring instruments

Anthropometrical measurements

Body mass (kg), stature (m) and the triceps, sub-scapular and medial calf skinfolds (mm) were measured by a trained researcher as prescribed by the International Society for the Advancement of Kinanthropometry.[21] Each skinfold was measured twice and the mean of the two measurements was obtained. The percentage of body fat of the subjects was gender-specifically calculated based on the triceps and the calf skinfolds.[22] The BMI of each subject was calculated using the formula for BMI. A BMI of more than 25 kg/m^2 and 30 kg/m^2 indicates overweight and obesity in adults respectively.[1] We adopted Cole and colleagues'[23] table with set cut-off points to calculate BMI in overweight and obese children in our study population.

Physical measurements

The physical abilities of the subjects (cardiovascular endurance, muscle strength, muscle endurance and flexibility) were determined using the Fitnessgram[24] and the Bruininks-Oseretsky Test of Motor Proficiency II.[5] The Fitnessgram[24] is a health-related test battery consisting of five components, of which two, namely cardiovascular endurance and flexibility, were used in this study. Cardiovascular endurance was determined by using the PACER subtest, where the child was required to run back and forth over a distance of 20 m at a predetermined pace that progressively increased in speed. Flexibility was determined by means of the sit-and-reach tests to the right and left. The Bruininks-Oseretsky test of Motor Proficiency II[5] consists of eight subcomponents, of which one, namely strength, was used for this study. The strength subcomponent consisted of five test items, namely standing long-jump, knee push-ups, bent leg sit-ups, wall-sitting and aeroplane lying. During

the standing long-jump test, the subjects had to jump as far as possible from a standing position and the distance between the starting point and the nearest part of their feet during the landing was measured and scored. The knee push-ups required the subjects to stand on their hands and knees with their knees, hips and shoulders in line with one another. Their upper body then had to be lowered and lifted, while this shape had to be maintained, and the number of correct attempts was scored. With the bent leg sit-ups, the subjects had to lie on their back with their legs bent at a 45° angle and then had to repeatedly lift their chest toward their knees and then lower it again. During the wall-sitting test, the subjects had to stand with their back against a wall and move their body downward until their legs were bent to 90° at their hips and then had to attempt to maintain this position for 60 seconds. During the lying aeroplane, the subjects had to lie on their stomach and had to simultaneously lift both their arms and legs at their hips and shoulder joints off the ground. The time holding this position was scored. The total of the various sub-items was then calculated, after which it was converted to a scale, a standard score and a percentile. Age equivalents and descriptive categories for the various subtests were calculated from this information.

Procedure

Approval to conduct this study was granted by North West University's Ethics Committee (No. 07M07). Permission was granted by the school principal and consent was given by parents. The response rate was 99.64%. One child did not participate due to a sports injury.

Statistical analysis

The data were analysed using the Statistica software package[25] by making use of descriptive statistics (M, SD, maximum and minimum values), while relationships between the variables were determined by Spearman correlation matrices. One-way variance of analysis (ANOVA) was used to determine the significance of differences between the groups.

Results

The demographic information of the subjects is displayed in Table I. From this it would appear that 78.2% (n = 219) of the learners were classified as being of normal weight, 5.5% (n = 43) as overweight and 6.5% (n = 18) as obese. The girls showed a higher prevalence of overweight (8.3% vs 7.2%) and obesity (4% vs 2.5%) than the boys, although the gender differences were not very large.

The anthropometrical composition of the subjects in the various BMI categories (normal weight, overweight and obese) is shown in Table II. It shows a mean body mass

Table I: Demographic information of the subjects

	T (n)	T (%)	N (n)	N (%)	O (n)	O (%)	OB (n)	OB (%)
Boys	128	45.7	101	36.1	20	7.2	7	2.5
Girls	152	54.3	118	42.1	23	8.3	11	4
Total	**280**	**100**	**219**	**78.2**	**43**	**15.5**	**18**	**6.5**

T = Total; N = Normal weight; O = Overweight; OB = Obese; n = number of subjects; % = percentage of subjects

difference of approximately 15 kg between the normal-weight, overweight and obese groups, where the obese group weighed approximately 30 kg heavier than the normal-weight group. The mean BMI of the normal-weight subjects was 17.12 (± 1.7), compared to that of the overweight (22.30 ± 1.5) and obese groups (29.5 ± 3.7). The mean BMI of the obese group is equal to the BMI of an obese adult. The mean sub-scapular, triceps and calf skinfold measurements of the overweight groups were respectively 6 mm (± 3.5), 8 mm (± 4.1) and 7.5 mm (± 5.3) larger than that of the normal-weight group, while that of the obese group was 16.1 mm (± 6.4), 14.6 mm (± 5.9) and 16 mm (5.4) larger than that of the normal-weight group.

Table III displays the correlation quotients that were used to analyse the relationship between BMI and body fat percentage and physical abilities. This analysis shows that all the anthropometrical variables (except the upper arm circumference) exhibit a significantly positive correlation with BMI and body fat percentage. Negative correlations with a medium practical significance were found between cardiovascular endurance, explosive leg strength and arm endurance. Flexibility and muscle endurance also exhibited negative correlations, but with a small practical effect. Abdominal muscle strength exhibited no correlation with BMI. Body fat percentage correlated slightly higher than BMI with the different parameters. A further analysis of the possible correlations between gender and all the variables that were analysed was also performed. Except for flexibility and muscle endurance, gender exhibited a moderate to large significant correlation with all the variables (varies between r = 0.20 and r = 0.93). Further analysis of gender differences was therefore done in the various categories of BMI.

Table IV, which represents the mean values of each of the physical fitness testing components of the subjects in the various BMI groups, confirmed a decrease in the mean values of all the variables as the BMI of the subjects increases and, although correlations in the abdominal, arm and back muscle endurance and flexibility were smaller, the mean values of these variables also decreased with an increase in BMI. These differences between the normal-weight, overweight and obese groups were significant in

Table II: Anthropometrical information of the subjects in the various BMI categories

Variables	Normal weight				Overweight				Obese			
	N = 219				N = 43				N = 18			
	M	SD	Min	Max	*M*	SD	Min	Max	*M*	SD	Min	Max
Stature (m)	1.4	0.1	1.2	1.7	1.5	0.1	1.3	1.6	1.5	0.1	1.3	1.6
Body mass (kg)	35.2	6.5	19.5	54.0	49.4	8.4	33.0	65.0	64.9	12.3	49.1	96.0
BMI (kg/m²)	17.2	1.7	12.8	21.2	22.3	1.5	19.7	25.2	29.5	3.7	24.5	40.0
Waist circumference (cm)	41.5	19.2	15.4	70.7	50.8	23.3	23.3	81.5	63.6	27.1	27.0	96.3
Upper arm circumference												
(relaxed) (cm)	20.4	2.1	15.1	26.1	25.6	2.5	21.0	35.4	29.9	2.8	24.2	34.3
Sub-scapular SF (mm)	6.5	2.7	2.0	21.0	12.5	3.5	7.0	21.9	22.6	6.4	13.0	36.0
Triceps SF (mm)	10.3	3.5	3.0	20.5	18.3	4.1	11.0	33.0	24.9	5.9	15.9	37.0
Calf SF (mm)	11.6	4.4	3.0	25.8	19.1	5.3	8.0	34.7	27.6	5.4	19.3	42.0
Body fat %	17.7	5.2	6.1	32.7	28.2	6.0	15.7	48.0	38.2	7.7	27.1	59.1

Body fat % = Body fat percentage; BMI = Body Mass Index

Table III: Correlation quotients of BMI and body fat percentage with demographic, anthropometrical and physical parameters

Variable	BMI				Body fat percentage			
	T	N	O	OB	T	N	O	OB
Demographic parameters								
Age	*0.17	*0.23	*0.61	0.21	*0.15	*0.14	0.12	0.40
Gender	0.02	0.05	0.07	-0.39	*0.20	*0.42	-0.07	-0.38
Anthropometrical parameters								
Stature	0.16	*0.31	*0.52	0.15	0.07	*0.25	0.05	0.19
Body mass	*0.84	*0.75	*0.79	*0.77	*0.61	*0.54	0.20	*0.66
Waist circumference	0.16	*0.20	0.18	-0.29	0.03	*0.48	-0.03	-0.31
Upper arm circumference	*0.71	*0.82	*0.32	*0.63	*0.54	*0.72	0.20	0.42
Sub-scapular skinfold	*0.83	*0.54	*0.42	*0.70	*0.74	*0.70	*0.43	*0.75
Triceps skinfold	*0.68	*0.71	0.27	*0.68	*0.94	*0.91	*0.90	*0.94
Calf skinfold	*0.75	*0.63	*0.48	*0.75	*0.94	*0.94	*0.91	*0.93
Physical parameters								
PACER	*-0.39	*-0.29	-0.12	*-0.50	*-0.48	*-0.43	*-0.39	-0.20
Sit-and-reach R	*-0.19	*-0.16	-0.14	-0.29	*-0.21	*-0.18	-0.10	-0.24
Sit-and-reach L	*-0.20	-0.13	-0.14	-0.27	*-0.20	*-0.13	-0.02	-0.24
Standing long-jump	*-0.35	-0.13	0.00	*-0.50	*-0.42	*-0.32	-0.15	-0.23
Knee push-ups	*-0.28	*-0.16	0.01	-0.22	*-0.37	*-0.33	-0.16	-0.22
Sit-ups	-0.06	-0.05	0.13	0.21	*-0.17	*-0.25	-0.05	0.26
Wall-sitting	*-0.22	-0.08	0.10	-0.31	*-0.25	*-0.14	-0.17	-0.18
Aeroplane lying	-0.10	*-0.14	0.16	-0.40	*-0.12	*-0.17	0.08	-0.22

T = Total; N = Normal weight; O = Overweight; OB = Obese; * = $p < 0.05$

the PACER subtest, where the cardiovascular endurance of the subjects was determined, while the differences in the standing long-jump and the knee push-ups subtests were significant between the normal-weight and obese groups. The body composition of the overweight and obese subjects consisted of a higher fat percentage (31.1%) than that of the subjects of normal weight (17.7%), and the differences were significant between all three groups.

When comparing the gender differences of the three groups, it appeared that different gender type tendencies occurred in the different variables. The boys and girls of normal weight possessed significantly higher muscle strength than did the obese boys and girls, while muscle endurance abilities with regard to the knee sit-ups and wall-sitting test items differed significantly only between the boys of normal weight and the obese boys. No significant differences in muscle

Table IV: Significance of differences in physical fitness components in the various BMI categories in the group and for gender alone

Variable	Normal weight				Overweight				Obese				Significance
	M	SD	Min	Max	M	SD	Min	Max	M	SD	Min	Max	of group differences
Muscle strength													
Standing long-jump (cm)	120.1	22.9	8.1	173.8	110.4	17.7	70.2	149.3	94.6	14.7	70.8	136.1	1 & 3
Boys	127.1	21.4	13.2	173.8	115.9	16.3	92.3	149.3	94.3	20.9	70.8	136.1	1 & 3
Girls	114.1	22.5	8.1	157.2	105.7	17.9	70.2	140.9	94.7	10.3	75.7	110.2	1 & 3
Muscle endurance													
Knee push-ups	14.7	6.4	3.0	70.0	12.8	4.7	1.0	22.0	8.9	5.2	1.0	21.0	1 & 3
Boys	16.7	4.5	4.0	28.0	15.2	3.7	10.0	22.0	10.4	4.7	3.0	17.0	1 & 3
Girls	13.0	7.2	3.0	70.0	10.8	4.6	1.0	19.0	8.0	5.4	1.0	21.0	
Sit-ups	20.8	5.6	5.0	34.0	20.4	7.2	0.0	36.0	19.1	4.3	14.0	26.0	
Boys	22.2	5.9	5.0	34.0	23.8	6.7	12.0	36.0	21.7	3.8	18.0	26.0	
Girls	19.6	5.0	6.0	32.0	17.4	6.4	0.0	30.0	17.5	3.9	14.0	25.0	
Wall-sitting (sec)	43.7	16.5	5.0	60.0	37.9	18.7	5.0	60.0	31.8	17.6	12.0	60.0	
Boys	42.4	16.3	10.0	60.0	40.4	17.9	5.0	60.0	22.1	13.2	12.0	50.0	1 & 3
Girls	44.8	16.6	5.0	60.0	35.8	19.5	7.0	60.0	37.9	17.7	14.0	60.0	
Aeroplane lying (sec)	48.8	17.0	5.8	60.0	47.0	19.4	2.0	60.0	46.4	17.0	12.0	60.0	
Boys	50.0	17.0	5.9	60.0	51.6	16.5	6.0	60.0	47.6	15.5	29.0	60.0	
Girls	60.0	16.9	5.8	60.0	43.0	21.2	2.0	60.0	45.6	18.6	12.0	60.0	
Cardiorespiratory endurance													
PACER (laps)	26.8	15.2	5.0	69.0	18.3	9.3	6.0	38.0	12.1	6.8	5.0	29.0	1 & 2; 1 & 3
Boys	32.9	17.0	5.0	69.0	18.7	10.4	7.0	38.0	11.7	7.7	5.0	28.0	1 & 2; 1 & 3
Girls	21.7	11.3	5.0	58.0	18.0	8.3	6.0	35.0	12.3	6.5	5.0	29.0	
Flexibility													
Sit-and-reach R (cm)	24.6	6.7	0.0	39.0	23.6	7.6	4.0	41.0	21.4	8.3	2.0	32.0	
Boys	24.3	6.4	6.0	39.0	24.9	6.8	8.0	40.5	17.0	10.3	2.0	26.0	
Girls	24.8	6.9	0.0	37.0	22.4	8.3	4.0	41.0	24.3	5.5	14.0	32.0	
Sit-and-reach L (cm)	24.2	7.0	0.0	40.0	22.5	7.2	1.0	41.0	20.4	7.5	2.0	29.0	
Boys	23.5	6.6	4.0	37.0	22.5	6.4	11.0	41.0	16.1	9.7	2.0	27.0	
Girls	24.7	7.3	0.0	40.0	22.4	8.1	1.0	37.0	23.1	4.3	17.0	29.0	
Body composition													
Body fat percentage	17.7	5.2	6.1	32.7	28.2	6.0	15.7	48.0	38.2	7.7	27.1	59.1	1 & 2; 1 & 3; 2 & 3
Boys	15.3	5.3	6.1	31.9	28.6	7.7	15.7	48.0	41.7	9.2	33.3	59.1	1 & 2; 1 & 3; 2 & 3
Girls	19.7	4.3	11.7	32.7	27.8	4.1	21.9	39.0	35.9	5.9	27.1	42.2	1 & 2; 1 & 3; 2 & 3

1 = Normal weight; 2 = Overweight; 3 = Obese

endurance were present in the various weight categories for girls. The cardiovascular endurance abilities of the boys of normal weight differed further from that of the overweight as well as the obese boys, while there were no differences between the girls. The body fat percentage of the boys and girls became significantly larger with an increase in BMI.

Discussion of results

The results showed that the occurrence of overweight (18.55%) and obesity (6.5%) in the research this group correlates with those of findings by researchers in other developing countries eight years ago.[2] It also confirmed the findings of Armstrong et al[3] that South African children are as obese and overweight as children from developed countries a decade ago. The results in our study showed that one in five children can be classified as overweight or obese, although these findings are slightly lower than the findings of other researchers in South Africa. Girls possess a higher prevalence of overweight as well as obesity than boys. The occurrence of obesity in this study was almost

double in the girls (4%) as in the boys (2.5%). This could be due to a decrease in physical activity levels in girls in the adolescent phase[26] and fat accumulation associated with puberty.[27]

The results showed that the cardiovascular endurance of the subjects differed significantly from one another in the various BMI categories, with the subjects of normal weight possessing a higher cardiovascular fitness than the overweight or obese subjects. Aerobic capacity therefore decreased progressively as the BMI increased. These results correlate with other studies that researched the same variables.[6-8] Gender also exhibited a relationship with cardiovascular endurance abilities, which indicates that boys possess a higher cardiovascular fitness than girls. It is also clear that aerobic capacity among obese boys and girls is significantly weaker than that of normal-weight children.

The body composition of the subjects as measured in fat percentage in the various BMI categories further differed significantly from each other, and this result was also found separately in the genders. These results were confirmed in previous similar studies.[10–12] The results show further that overweight and obesity are associated with lowered muscle strength, especially in the legs, as seen in the results of the standing long-jump test. It compares well with findings by Wearing et al[14] and Tokmakidis et al,[8] which showed that children of normal weight fare statistically better in the standing long-jump than obese children, while overweight children fare better than obese children, although not significantly. Correlation coefficients that were calculated to analyse the possible relationship between gender and the physical parameters indicated a relationship with muscle strength, where boys fared better in the standing long-jump activities. In both genders significant differences between the children in the various BMI categories with regard to leg strength were also indicated, where the obese children continuously fared the weakest.

The muscle endurance of the subjects progressively declined with an increase in BMI, although these decreases were not significant. The results differ from that of Chen et al,[7] who indicated that the abdominal muscle endurance of overweight and obese boys and girls was significantly weaker than that of children of normal weight. In this study, the boys of normal weight did however fare significantly weaker in two muscle endurance tests, namely knee push-ups and wall-sitting, than the boys in the obese category, while there were no similar results with the girls in any of the muscle endurance tests. The analysis of the gender correlations showed that the girls fared significantly weaker in the abdominal muscle endurance abilities than the boys. This could possibly be due to the fact that the girls had a significantly larger waist circumference than the boys (62.41 cm vs 22.81 cm; Table IV).

With regard to flexibility, literature[7,8] indicates no significant differences between children in different BMI categories, and these findings are confirmed by the results of this study, although there is a decreasing tendency present with an increase of BMI.

It is clear from the results of the study that overweight and obesity do have a negative effect on the health-promotional physical fitness parameters of school children in grades 4 to 6 who are between the ages of approximately nine and twelve years. The detrimental effect is the greatest in cardiovascular endurance and muscle strength, and similar gender tendencies were also present in the variables. Muscle endurance ability is influenced negatively to a lesser degree by obesity, although it would appear that the effect is slightly larger in boys than in girls. Flexibility appears not to be affected by the various degrees of weight. Gender also played a role in the extent of the correlations that were found.

Conclusion

Health-promotional physical fitness is negatively affected to a great degree in children between the ages of nine and twelve years who are overweight and obese. Although the negative health effects of poor health-related physical fitness are not necessarily present at this age as a sickness or a disease, it is apparent that child obesity is the precursor of various chronic diseases in adulthood, which includes hypertension, type II diabetes mellitus, coronary heart disease and hyperlipidaemia. Statistics worldwide also indicate that the obesity rates seen among these young children will most probably not improve in the future. The information obtained from this study can therefore be used in the compilation of intervention programmes for school children in grades 4 to 6 who are between the ages of nine and twelve years. The study, however, had a shortcoming that must be taken into account when interpreting the results. The subject size was relatively small, which made generalisation of the results difficult. Notwithstanding this, the study offered important information that can be used by health workers in a strategy to address overweight and obesity among young children by means of intervention.

Acknowledgements

We wish to acknowledge grants that were received from the National Research Foundation and the LOTTO, **which** made this study possible. The authors have no conflicts of interest to declare.

References

1. World Health Organization (WHO). Obesity and overweight. Available from: http://www.who.int/mediacentre/factsheets/fs311/en/index.html (Accessed 01/02/08).
2. Boon CS, Clydesdale FM. A review of childhood and adolescent obesity interventions. Crit Rev Food Sci 2005;45:511–25.
3. Armstrong MEG, Lambert MI, Sharwood KA, Lambert EV. Obesity and overweight in South African primary school children – the Health of the Nation Study. JEMDSA 2006;11(2):52–63.
4. Somers A, Hassan MS, Rusford E, Erasmus RT. Overweight and obesity in learners residing in the Belhar, Delft and Mfuleni communities of Cape Town, Western Cape, South Africa. Medical Technology SA 2006;20(1):11–20.
5. Bruininks RH, Bruininks BD. Bruininks-Oseretsky test of motor proficiency. 2nd edition. Los Angeles: American Guidance Service; 2005.
6. Graf C, Koch B, Kretshmann-Kandel E, et al. Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-Project). Int J Obesity 2004;28:22–6.
7. Chen LJ, Fox KR, Haase A, Wang JM. Obesity, fitness and health in Taiwanese children and adolescents. Eur J Clin Nutr 2006;60:1367–75.
8. Tokmakidis SP, Kasambalis A, Christodoulos AD. Fitness levels of Greek primary schoolchildren in relationship to overweight and obesity. Eur J Pediatr 2006;165:867–74.
9. Nassis GP, Psarra G, Sidossis LS. Central and total adiposity are lower in overweight and obese children with high cardiorespiratory fitness. Eur J Clin Nutr 2005;59:137–41.
10. Tyrell VJ, Richards GE, Hofman P, Gillies GF, Robinson E, Cutfield WS. Obesity in Auckland school children: A comparison of the body mass index and percentage body fat as the diagnostic criterion. Int J Obesity 2001;25:164–9.
11. Angelopoulos PD, Milionis HJ, Moschonis G, Manios Y. Relations between obesity and hypertension: Preliminary data from a cross-sectional study in primary schoolchildren: The children study. Eur J Clin Nutr 2006;60:1226–34.
12. Hamidi A, Fakhrzadeh H, Moayyeri A, et al. Obesity and associated cardiovascular risk factors in Iranian children: A cross-sectional study. Pediatr Int 2006;48:566–71.
13. Mamalakis G, Kafatos A, Manios Y, Anagnostopoulou T, Apostolaki I. Obesity indices in a cohort of primary school children in Crete: A six year prospective study. Int J Obesity 2000;24(6):765–71.
14. Wearing SC, Hennig EM, Byrne NM, Steele JR, Hills AP. The impact of childhood obesity on musculoskeletal form. Obes Rev 2006;7:209–18.
15. Van der Merwe MT. 2004. Childhood obesity. SA Fam Pract 2004;46(6):16–9.
16. Kruger HS, Puoane T, Senekal M, Van der Merwe MT. Obesity in South Africa: Challenges for government and health professionals. Public Health Nutr 2005;008(005):491–500.
17. Labadarios D, Steyn NP, Mgijima C, Daldla N. 2005. Review of the South African nutrition policy 1994–2002 and targets for 2007: Achievements and challenges. Nutrition 2005;21(1):100–8.
18. Nemet D, Barkan S, Epstein Y, Friedland O, Kowen G, Eliakim A. Short- and long-term beneficial effects of a combined dietary-behavioural-physical activity intervention for the treatment of childhood obesity. Pediatrics 2005;115(4):443–9.
19. Labadarios D, Steyn NP, Maunder E, et al. The National Food Consumption Survey (NFCS): South Africa, 1999. Public Health Nutr 2005;008(005):533–43.
20. Pienaar AE, Bell GJ, Dreyer LI. The incidence of obesity and Developmental Coordination Disorder (DCD) among 10-12-year-old girls of different race groups in the North West province: THUSA BANA study. AJPHERD 2007;13(1):221–37. September, Special edition.
21. International Society for the Advancement of Kinanthropometry (ISAK). International standards for anthropometric assessment. Adelaide; 2001.
22. Slaughter MH, Lohman TG, Boileau RA, et al. Skinfold equations for estimation of body fatness in children and youth. Hum Biol 1988;60 (5):709-23.
23. Cole TJ, Belizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. Brit Med J 2000;320(7244):1240–3.
24. Meredith MD, Welk GJ. Fitnessgram: Test administration manual. 2nd edition. Dallas, Texas: The Cooper Institute for Aerobics Research; 1999.
25. Statsoft. Statistica for Windows. 8th edition. Tulsa, Oklahoma; 2008.
26. Engelbrecht C, Pienaar AE, Coetzee B. Racial background and possible relationships between physical activity and physical fitness of girls: The THUSA BANA study. SAJR SPER 2004;26(1):41–53.
27. Parizkova J, Hills AP. Childhood obesity: Prevention and treatment. 2nd edition. Boca Raton, FL: CRC Press; 2005.