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The effect of a multidisciplinary physical activity intervention on the body composition and physical fitness of obese children

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Aim. **The aim was to determine the effect of a physical activity, diet, and behaviour modification intervention of 13 weeks, 3x per week for 60 minutes on the body composition and physical fitness of overweight and obese children.**
Methods. **A convenience sample of 37 subjects with a mean age of 11 years (±0.99) was used, where 20 subjects (13 girls; seven boys) took part in the intervention and 17 (11 girls; six boys) formed part of the control group. Body composition (height, body mass, skinfolds, circumferences, body fat percentage, and body mass index) and health-promoting physical fitness (cardiorespiratory endurance, flexibility, muscular strength, and muscular endurance) were analysed using the Fitnessgram and the Bruininks-Oseretsky Test of Motor Proficiency-II during baseline, after the intervention programme, and after a follow-up period of three months.**
Results. **The results showed statistical (P<0.05) and practical significant (d>0.2) improvement in the body composition of the group, after participation in the intervention, with a sustainable effect, three months later on body fat percentage and the subscapular skinfold. Muscular strength and flexibility improved significantly after the intervention, but with no sustainable effect.**
Conclusion. **It is concluded that a multi-disciplinary obesity intervention can improve the body composition profile and the health-related physical fitness of young obese children, although the effect will not be sustainable without ongoing, controlled intervention.**

KEY WORDS: Overweight - Obesity - Child - Body composition - Physical fitness.

The "Healthy Active Kids South Africa" report, an overview of the current well-being of South African children, describes overweight as one of the four primary health risks for children.[1, 2] The report was compiled in 2007 for the first time and states that more than 30% of adolescent girls and nearly 10% of adolescent boys can be classified as overweight or obese, while similar statistics are reported in primary school learners (22% of girls and 17% of boys) and children under the age of nine years (17%). A follow-up report in 2010 showed that the occurrence of overweight and obesity in adolescents had increased between 2002 and 2008 (overweight from 17% to 20% and obesity from 4% to 5%).

Obesity is described as an imbalance between energy intake and expenditure that causes the storage of excessive energy as fatty tissue.[3] It is a complex medical condition that is not limited to a specific race, gender, or socioeconomic status and is influenced by various cultural, environmental, and genetic factors.[4] Obesity in children is associated with a variety of health problems, including hypertension (high blood pressure), sleep apnoea or hypoventilation accompanying asthma, Type II diabetes mellitus or glucose intolerance, and an accumulation of visceral fatty tissue or an increase in waist circumference.[5] Schwimmer *et al.*[6] state that obese children show the same health-related quality of life as that of cancer patients who are undergoing chemotherapy treatment. Apart from physical discomfort and

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physiological states of disease, there is often discrimination against overweight and obese children, which leads to psychosocial problems such as feelings of inferiority, a low self-image, and isolation.[7] Research further shows that a large percentage of overweight and obese children become overweight and obese adults.[8, 9] Researchers also show that overweight and obesity relate to the health-related physical fitness (cardiorespiratory endurance, flexibility, muscular strength, muscular endurance, and body composition) of children. In this regard, Truter *et al.*[10] indicated that aerobic capacity and muscular strength decreased significantly with an increase in Body Mass Index (BMI), while muscular endurance showed similar trends, although not significantly. The findings of Tokmakidis *et al.*[11] show that obese children perform significantly worse in leg muscular strength, abdominal muscular endurance, and cardiorespiratory endurance activities than their normal-weight classmates. In this regard, Sung *et al.*[12] show a significantly lower arm muscular strength and abdominal, leg, and arm muscular endurance in obese children. From the literature, it appears that flexibility is influenced the least by overweight and obesity.[11, 13] The above-mentioned health risks and psychosocial problems are indicative of the necessity of the implementation of intervention programmes to address overweight and obesity in children.

Steyn,[8] indicates that a successful intervention programme should be based on principles that include an increase in physical activity, nutritional guidance and dietary adaptations, behaviour modification, and family support. In this regard, Parizkova and Hills [14] indicate that this combination of intervention principles is necessary to obtain successful and sustainable results. Studies that incorporated these principles to address the body composition and also the health-related physical fitness of overweight and obese children showed that BMI and body fat percentage decreased significantly after a participation period of 12 weeks, while cardiorespiratory endurance increased significantly.[15-17] No studies with the treatment of overweight and obesity as a goal, could be found that studied the intervention effect on flexibility, muscular strength, and muscular endurance on children between the ages of nine and 12 years, as well as the sustainable effect of the intervention, although these parameters constitute an important part of the health-related fitness of children who are overweight and obese. Beckman *et al.*[18] believe that different techniques are required to get children to take responsibility for their health as compared to adults, because they tend to be more extrinsically motivated in general and, it is not clear when they shift to intrinsic motivation with regard to health related goals. It is also shown that long-term weight maintenance can be significantly improved with extended contact to therapeutic resources.[18] In a three-month diet, behaviour, and physical activity intervention carried out on 24 obese children between the ages of six and 16 years, Nemet *et al.*,[15] however, show a significant decrease in BMI and body fat percentage, with an increase in cardiorespiratory endurance, although not significant, after a follow-up period of one year. Dreimane *et al.*[19] also show a decrease in BMI, although not significant, in 129 overweight subjects between the ages of seven and 17 years who took part in an eight-week or a 12-week hospital-based, family-oriented lifestyle programme after a follow-up period of approximately 9.64 months. It would appear as if the few intervention studies published on children show more positive lasting effects particularly on the body composition and, to a lesser extent, on the cardiorespiratory endurance of overweight and obese children. The aim of this study was to determine the immediate, as well as short-term, effect of a physical activity, diet, and behaviour modification intervention programme on the body composition and health-related physical fitness parameters of nine- to 12-year-old overweight and obese children.

Materials and methods

Research design

The study has a two-group, pre-test, post-test, and retest experimental design, based on a convenience sample.

Research group

The research group was recruited after a baseline evaluation of the anthropometric composition of 280 children between the ages of nine and 12 years at primary schools in Potchefstroom, with a good distribution of socio-economic status, race, and gender. Participation in the programme was recommended

for children with a BMI above the cut-off point for normal weight. Notices were further placed in a local newspaper to invite parents to enroll their children in the study. The research group consisted of 37 overweight and obese boys (N.=13) and girls (N.=24), with a mean age of 11 years (±0.99). The group of subjects were divided into an intervention group (N.=20, boys N.=7, girls N.=13) and a control group (N.=17, boys N.=6, girls N.=11), where the intervention group underwent the intervention. After the group was retested, the researchers invited the control group to enrol for three months, free of charge into an ongoing obesity prevention programme at the Kinderkinetics clinic.

Measuring instruments

Anthropometric parameters

Height (m), body mass (kg), waist circumference (cm), relaxed upper arm circumference (cm), and the triceps, subscapular, and medial calf skinfold (mm) were taken by trained researchers, as prescribed by the "International Society for the Advancement of Kinanthropometry (ISAK)".[20] Body mass was taken to the nearest 0.1 kg by an electronic scale, and height was taken to the nearest 0.5 cm by a stadiometer. Waist circumference was taken at the halfway mark between the inferior border of the tenth rib and the superior border of the crista ileum, and relaxed upper arm circumference was taken at the halfway mark between the acromial and radial landmarks. Both circumferences were taken to the nearest 0.5 cm with an anthropometric measuring tape. The body composition of the subjects was analysed by means of skinfolds and through body mass index (BMI). The triceps, subscapular, and medial calf skinfold were taken twice on the right-hand side of the body, after which an average measurement was obtained. The body fat percentage of the subjects was calculated according to the formula of Slaughter *et al.*,[21] and the BMI was calculated through the formula BMI=body mass in kg/(height in m)^2. The age-specific BMI cut-off points of Cole *et al.*[22] were used to classify the subjects as overweight or obese. According to these cut-off points, an 11-year-old boy with a BMI smaller than 20.55, a BMI between 20.55 and 25.10, and a BMI greater than 25.10 was classified as normal, overweight, or obese, respectively and an 11-year-old girl with a BMI smaller than 20.74, a BMI between 20.74 and 25.42, and a BMI greater than 25.42 was respectively classified as normal, overweight, or obese.

Physical fitness parameters

The physical fitness of the subjects was determined by means of the "Fitnessgram" [23] and the strength subtest of the Bruininks-Oseretsky Test of Motor Proficiency II (BOT-2).[24] The Fitnessgram consists of five main components, of which two, namely, cardiorespiratory endurance and flexibility, were used in this study. Cardiorespiratory endurance was determined by means of the "PACER", where the children were expected to run back and forth over a distance of 20 m for as long as possible at a pace that became progressively faster. Flexibility was determined by means of the sit and reach test to the right- and to the left side of the body. The BOT-2 consists of eight subtest components, of which one, namely-, strength, was used for this study. The strength subtest consists of five test items, namely-, standing long jump (leg muscular strength), knee push-ups (arm muscular endurance), bent-leg sit-ups (abdominal muscular endurance), wall-sit (leg muscular endurance), and v-up (back muscular endurance). In the standing long jump test, the subject had to jump as far as possible from a standing position, and the best distance of two trails between the starting line and the heel or body part closest to the starting line was recorded. The knee push-ups test requires that the subject must stand on the hands and knees, with the knees, hips, and shoulders in line with one another. The upper body must then be lowered towards the floor to at least 90-degrees angles, pushing back up again until the arms are straight, while this form is maintained, and the number of correct knee push-ups is then recorded. In the bent-leg sit-ups test, the subject perform sit ups with the legs bent at 90-degrees angle, feet flat on the floor and and then repeatedly raise the head and shoulder blades off the floor and reaching for the knees with the arms. In the the wall-sit test, the subject had to stand with the back against a wall, take 2-3 steps forward and slides the back downwards to a sitting position against the wall until the legs are bent to a 90-degree angle and then tries to maintain the position for up to 60 seconds. The time that the subject was able to hold the position, was recorded. During the execution of the

v-up test item, the subject lied face down on the floor, arms extended forward and legs extended behind and feet touching the floor and then had to simultaneously raise the head, chest, arms and legs off the floor, and hold the form for up to 60 seconds. The total point scores of the different subitems for strength were then calculated, and converted to scale scores, standard scores, percentiles, age-equivalents and descriptive categories for strength.

Research procedure

The Ethics Committee of the North-West University (No. 07M07) provided ethical approval for performing the research study. Each subject had to be declared medically fit by a medical practitioner, and the parents had to provide informed consent for participation before a child were allowed to enrol in the intervention. The body composition of the subjects was determined through anthropometric measurements, and the physical fitness profile was compiled by making use of test items in the the "Fitnessgram" and the "Bruininks-Oseretsky Test of Motor Proficiency-II". Anthropometric and physical fitness parameters were determined before commencement of the intervention, after the intervention, and again after a follow-up period of three months.

Intervention programme

The intervention was offered three times per week for one hour, for a period of 13 weeks, at the Kinderkinetics laboratory of the Potchefstroom Campus of the North-West University. During the intervention, the intervention group was divided into smaller groups (N.=6) to ensure individual attention. The intervention programme consisted of three components, namely-, physical activity, dietary guidance, and behaviour modification. A home programme, holiday programme, and parent meetings also formed part of the intervention.

Physical activity

The physical activity sessions were offered three times per week, and on two of these days, for 60 minutes, while on the third day for 20 minutes. The "Sports, Play, and Active Recreation for Kids (SPARK)" curriculum [25] was used to compile the physical activity component of the intervention programme. The physical activity sessions lasted 60 minutes and were divided into aerobic activities (30 minutes of moderate to high intensity), strength and flexibility activities (15 minutes), and basic sport skills (15 minutes). Actical® monitors were used to monitor the energy expenditure. The target energy expenditure of the exercise session was set at 100 kilocalories.

Dietary guidance and behaviour modification

The dietary guidance and behaviour modification sessions were offered on the third day of the week and were based on the guidelines of "Eat well and keep moving".[26] These sessions lasted 60 minutes and were divided into dietary guidance (20 minutes), behaviour modification (20 minutes), and physical activity in the form of a game (20 minutes). The aim of this part of the intervention was to empower the group with knowledge and skills about lifestyle adaptations, and it consisted of lessons addressing healthy eating habits, knowledge regarding food, self-perception, methods to increase physical activity, and physical activity objectives.

Home programme

Each subject received a home programme that had to be followed at least twice a week in addition to the intervention. The home programme consisted of aerobic, arm, leg, and abdominal exercises and the subjects were expected to choose and perform two exercises from each of the sections according to a specific frequency. The parents of the subjects were requested to monitor that the subjects follow the home programme, and the subjects received a sticker to stick onto a participation poster in the intervention venue if they indicated that they followed the home programme. At the end of the intervention period, the subject with the greatest number of stickers was rewarded with a gift in the form of an exercise ball.

Holiday programme

Since the intervention period included the September school holidays, a week-long holiday programme was offered for the subjects in collaboration with recreation therapists. The holiday programme was offered as an adventure programme and ad-

TABLE I.—*Pre-test differences between the intervention and the control group.*

Variables	Intervention group		Control group		Significance of pre-test differences		
	M	SD	M	SD	t	df	P
Body composition							
Stature (m)	1.50	0.09	1.51	0.09	-0.57	35	0.5740
Body mass(kg)	62.00	13.17	64.48	12.55	-0.58	35	0.5623
Waist circumference (cm)	89.38	11.64	91.49	15.48	-0.47	35	0.6380
Upper arm circumference (cm)	28.87	3.44	27.88	3.37	0.87	35	0.3881
Subscapular skinfold (mm)	28.18	9.23	22.29	5.88	2.23	35	0.0319*
Triceps skinfold (mm)	28.83	7.69	28.59	7.89	0.09	35	0.9270
Calf skinfold (mm)	33.58	7.45	43.00	14.06	-2.60	35	0.0135*
BMI (kg/m^2)	27.52	4.05	28.02	4.55	-0.36	35	0.7230
Body fat percentage (%)	44.16	8.88	50.85	13.83	-1.78	35	0.0844
Physical fitness							
Cardiorespiratory endurance							
PACER (laps)	9.45	5.22	13.35	6.50	-2.03	35	0.0504
Flexibility							
Sit and reach to the right (cm)	24.45	5.07	23.71	6.95	0.38	35	0.7095
Sit and reach to the left (cm)	22.40	5.32	22.00	7.59	0.19	35	0.8521
Muscular strength							
Standing long jump(cm)	110.65	19.06	109.12	20.48	0.24	35	0.8152
Muscular endurance							
Knee push-ups (number)	11.00	5.46	11.82	6.29	-0.43	35	0.6723
Sit-ups(number)	10.45	4.37	13.24	5.56	-1.71	35	0.0970
Wall-sit (sec)	37.01	19.47	39.53	19.57	-0.39	35	0.6980
V-up (sec)	38.66	18.29	47.41	14.56	-1.59	35	0.1210

BMI: Body Mass Index; M: mean; SD: standard deviation; t: *t*-value; :df: degree of freedom; P: p-value; statistical significance – *P-value <0.05

dressed behaviour modification aspects such as problem-solving, self-perception, motivation, and team-building, while adequate opportunity was created to be physically active.

PARENT MEETINGS

Information evenings were offered for the parents of the subjects on three different occasions. Trained professionals in the field of nutrition and physical activity addressed the parents on the incidence, causes, and effects of obesity in children, healthy lunch boxes, and lifestyle changes, after which opportunity was provided for the parents to ask questions.

Statistical analysis

The STATISTICA software program [27] was used to analyse the data. Descriptive information (means, standard deviations, maximum and minimum values) was, firstly, obtained from the data, after which the pre-test differences between the intervention and the control group were analysed by means of independent t-testing. Adjustments were made for pre-test differences, after which the intervention effect was determined by means of an ANCOVA with the pre-test as a covariable. Lastly, a repeated-measures ANOVA over time with a Bonferroni adaptation was performed to determine the time effect of the intervention between and within the groups. Statistical significance was set at $P<0.05$, while practical significance of differences was determined by using the guidelines provided by Cohen for the interpretation of effect sizes (small ES=0.01, medium ES=0.1, and large ES=0.25.[28]

Results

The intervention and the control groups consisted of 20 (13 girls and seven boys) and 17 (11 girls and

TABLE II.—*Djusted post-test means with the pre-test as a covariable (ANCOVA).*

Variables	Group	N	M	SD	-95.00%	95.00%	ES
Body compostion							
Stature (m)	1	20	1.52	0.00	1.52	1.52	0.09
	2	17	1.52	0.00	1.51	1.52	
Body mass (kg)	1	20	60.35	0.28	59.78	60.92	0.82*
	2	17	65.49	0.31	64.87	66.11	
Waist circumference (cm)	1	20	83.14	0.47	82.18	84.10	0.87*
	2	17	93.49	0.51	92.45	94.53	
Upper arm circumference (cm)	1	20	25.18	0.20	24.77	25.59	0.89*
	2	17	30.13	0.22	29.69	30.58	
Subscapular skinfold (mm)	1	20	21.90	0.30	21.30	22.50	0.83*
	2	17	27.72	0.32	27.07	28.37	
Triceps skinfold (mm)	1	20	24.47	0.40	23.66	25.27	0.84*
	2	17	32.17	0.43	31.29	33.04	
Calf skinfold (mm)	1	20	33.91	0.50	32.89	34.94	0.73*
	2	17	41.28	0.54	40.18	42.38	
BMI (kg/m^2)	1	20	25.77	0.13	25.52	26.03	0.85*
	2	17	28.37	0.14	28.09	28.65	
Body fat percentage (%)	1	20	41.82	0.55	40.71	42.93	0.81*
	2	17	51.72	0.59	50.52	52.93	
Physical fitness							
Cardiorespiratory endurance							
PACER (laps)	1	20	15.20	1.76	11.62	18.78	0.06
	2	17	11.36	1.90	7.50	15.23	
Flexibility							
Sit and reach to the right (cm)	1	20	26.99	1.09	24.77	29.20	0.25*
	2	17	21.54	1.18	19.14	23.94	
Sit and reach to the left (cm)	1	20	24.69	1.02	22.63	26.76	0.16*
	2	17	20.89	1.10	18.64	23.13	
Muscular strength							
Standing long jump (cm)	1	20	115.40	2.59	110.14	120.67	0.27*
	2	17	102.00	2.81	96.29	107.71	
Muscular endurance							
Knee push-ups (number)	1	20	14.39	1.24	11.87	16.91	0.10
	2	17	10.82	1.35	8.08	13.55	
Sit-ups (number)	1	20	13.51	0.98	11.52	15.49	0.12*
	2	17	10.29	1.06	8.15	12.44	
Wall-sit (s)	1	20	50.59	2.99	44.52	56.67	0.04
	2	17	55.91	3.24	49.32	62.49	
V-up (s)	1	20	54.02	2.96	48.01	60.03	0.03
	2	17	49.42	3.20	42.92	55.92	

1: intervention group; 2: control group; BMI: Body Mass Index; M: adjusted mean; SD: standard deviation; ES: practical significance (effect size) (small =0.01, medium =0.1, large =0.25)*

six boys) subjects, respectively (N.=37), with a mean group age of 11 years (±0.99). The control group initially consisted of 20 subjects, but incomplete data was obtained from three subjects, since two subjects moved away and one sustained a leg injury. The mean attendance percentage of the intervention programme was 89.2%.

Table I describes the mean values obtained by the

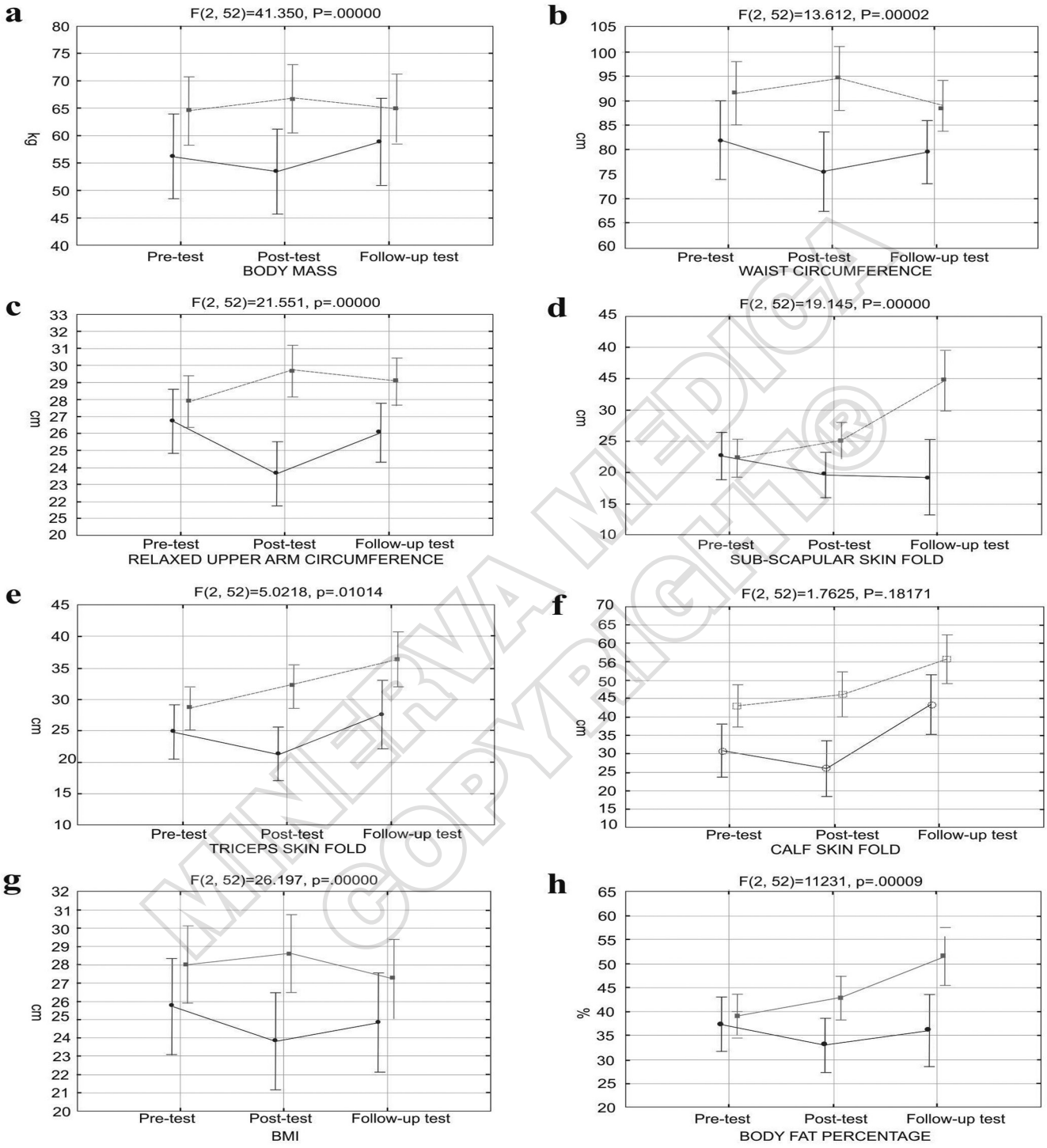

Figure 1.—Time effect on the body composition variables; A) body mass; B) waist circumference; C) relaxed upper arm circumference; D) subscapular skinfold; E) triceps skinfold; F) calf skinfold; G) BMI; and H) body fat percentage; ___ Intervention group; ..... Control group.

TABLE III.—*Significance of within group differences.*

Variables	Intervention group			Control group		
	PrT[a]	PoT[b]	FT[c]	PrT[a]	PoT[b]	RT[c]
Body composition						
Stature	1.48[c]	1.49[c]	1.53[ab]	1.51[b]	1.52[ac]	1.54[ab]
Body mass	56.28[b]	53.46[ac]	58.86[ab]	64.48[b]	66.73[ac]	64.91[b]
Waist circumference	81.96[b]	75.55[ac]	79.50[b]	91.49	94.50[c]	88.94[b]
Upper arm circumference	26.73[b]	23.64[ac]	26.05[b]	27.88[b]	29.67[a]	29.06
Subscapular skinfold	22.64	19.59	19.27	22.29[c]	25.12[c]	34.71[ab]
Triceps skinfold	24.82	21.27[c]	27.55[b]	28.59[bc]	32.06[ac]	36.35[ab]
Calf skinfold	30.86[c]	26.05[c]	43.36[ab]	43.00[c]	46.12[c]	55.71[ab]
BMI	25.73[b]	23.83[ac]	24.83[b]	28.02[bc]	28.62[ac]	27.23[ab]
Body fat percentage	37.31	32.97	36.02	39.06[c]	42.86[c]	51.54[ab]
Physical fitness						
Cardiorespiratory endurance						
PACER	11.18[b]	16.18[a]	14.18	13.35	12.77	15.29
Flexibility						
Sit and reach to the right	24.36[b]	27.82[ac]	21.82[b]	23.71	21.18	21.18
Sit and reach to the left	21.82[b]	24.96[ac]	20.91[b]	22.00	20.71	20.71
Muscular strength						
Standing long jump	114.64	121.27	126.91	108.94	101.47	107.09
Muscular endurance						
Knee push-ups	10.46[b]	16.64[a]	11.91	11.82	11.06	11.88
Sit-ups	11.18	13.55	11.27	13.24	10.65	9.76
Wall-sit	35.55	53.64	46.00	39.53[b]	56.18[a]	47.88
V-up	36.46[b]	57.09[a]	45.82	47.41[c]	50.24	58.82[a]

PrT: pre-test; PoT: post-test; FT: follow-up test; BMI: Body Mass Index; a: pre-test; b: post-test; c: retest; Means with superscript differs significantly (P<0.05) from the indicated group

intervention and the control groups during the pre-test and indicates any possible significant differences that occurred between the two groups before commencement of the intervention. The two groups compared well with regard to the body composition variables. Only the subscapular (P=0.03) and the calf skinfold measurements (P=0.01) differed significantly between the groups (the intervention group had a greater subscapular skinfold measurement and the control group a greater calf skinfold measurement), while body fat percentage yielded a borderline significant difference (P=0.08). No significant differences occurred between the groups in the physical parameters, although cardiorespiratory endurance (PACER) and sit-ups showed borderline differences in the means between the groups.

Since slight differences were indicated between the intervention and the control group, adjustments were made for pre-test differences by means of a co-variance of analysis. Table II displays the adjusted mean values of the intervention group and the control group on completion of the intervention, which indicates the immediate intervention effect.

The intervention programme brought about a significant change in all the body composition parameters, except for height. Body mass F(1.34)=152.83 (P=0.000), waist circumference F(1.34)=219.87 (P=0.000), relaxed upper arm circumference F(1.34)=277.00 (P=0.000), subscapular skinfold F(1.34)=167.08 (P=0.000), triceps skinfold F(1.34)=172.88 (P=0.000), calf skinfold F(1.34)=91.46 (P=0.000), BMI F(1.34)=194.11 (P=0.000), and body fat percentage F(1.34)=144.89 (P=0.000) all reflect statistically as well as large practically significant differences (ES>0.25) between the groups (Table II). Decreasing mean values, which indicated improvement, occurred in all the variables of the intervention group, while an increasing tendency,

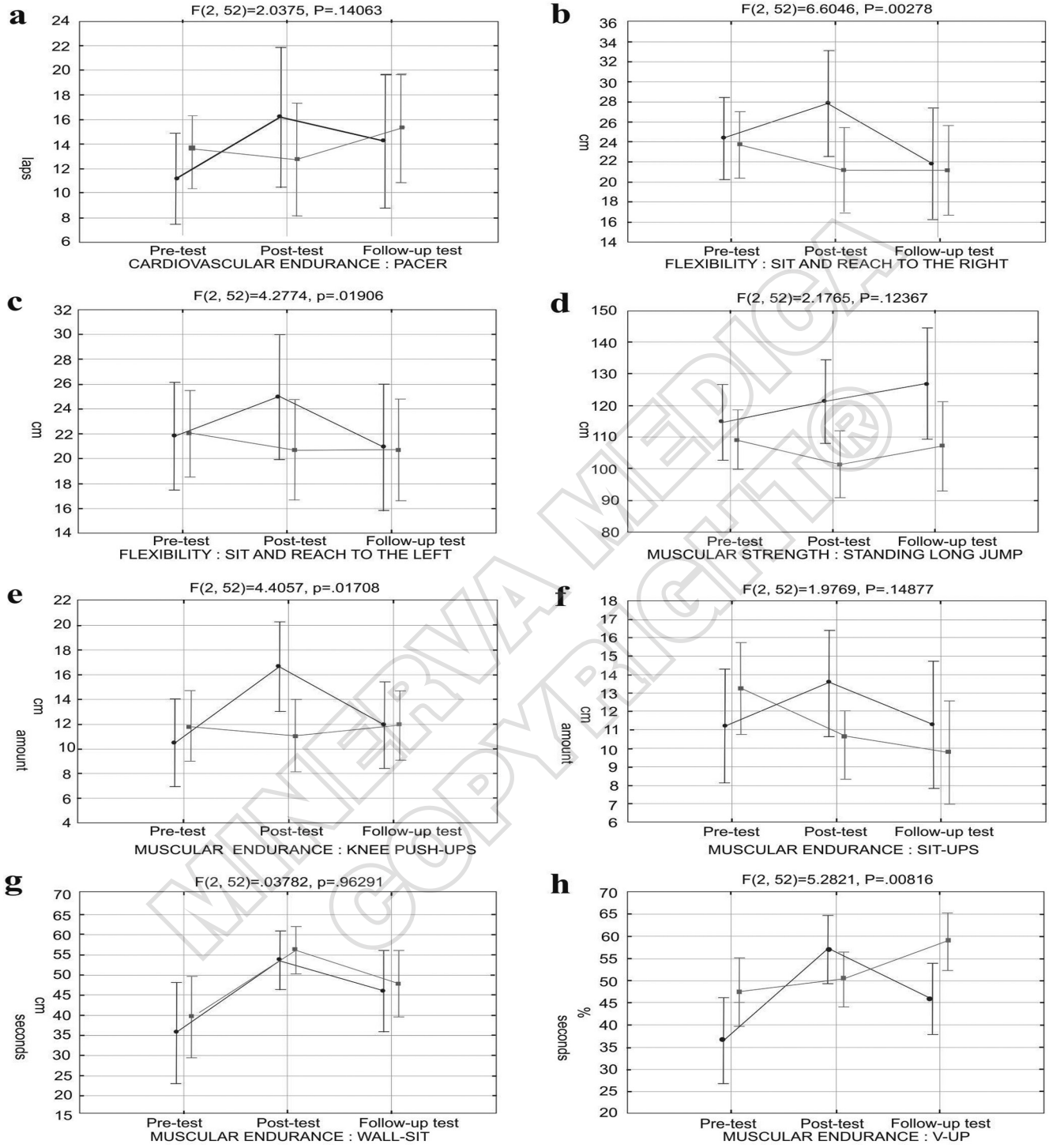

Figure 2.—Time effect on the physical fitness parameters; A) cardiorespiratory endurance: PACER; B) flexibility: sit and reach to the right; C) flexibility: sit and reach to the left; D) muscular strength: standing long jump; E) muscular endurance: knee push-ups; F) sit-ups; G) wall-sit; and H) v-up; ____ Intervention group; ..... Control group.

indicative of a worsening effect, was found in the control group.

The intervention also contributed to an improved cardiorespiratory endurance F(1.34)=2.0772 (P=0.1586), while the cardiorespiratory endurance of the control group deteriorated, although these changes did not contribute to significant differences between the groups. The flexibility of the intervention group, as determined by the sit and reach test item to the right side F(1.34)=11.47 (P=0.0018) and to the left side F(1.34)=6.44 (P=0.0159), however, improved statistically significantly in the intervention group, and these improvements contributed to significant differences between the groups with a small practical significance (ES>0.01).

The standing long jump test item which assess muscular strength, showed an increase in the intervention group and a decrease in the control group F(1.34)=12.29 (P=0.0130), and this difference between the groups was statistically (P<0.05) and practically significant (ES=0.27). Of the four test items that were used to determine muscular endurance, only the sit-ups test item showed improvement in the intervention group F(1.34)=4.80 (P=0.0354), which also indicates a group difference with a small practical significance (ES=0.01). Although higher mean values are reported for the the knee push-ups, wall-sit, and v-up test items, the differences were not significant between the groups.

Although it was an important goal of the study to determine the effect of the intervention immediately after completing the programme, the short-term intervention effect after a lapse of a three-month period was also studied. Since not all the subjects could be measured during this retesting, the results of the analysis are only applicable to 28 subjects (intervention grouP=11, control group=17). These follow-up results are particularly important for analysing the effect of the intervention on health related physical fitness parameters such as cardiorespiratory endurance in order to determine whether the subjects will be able to maintain a physical activity level of a moderate intensity that will enable them to control their body mass effectively.

Figure 1A-H graphically represents the results of the body composition variables over the period of the intervention and the follow-up evaluation. From this, changes are seen in the intervention group that were significantly different from the control group over time in seven of the eight body composition parameters, and this effect is especially visible after completion of the intervention. Only the calf skinfold measurement showed no significant difference between the groups over time. These differences were further analysed with a repeated-measures over time analysis of variance with a Bonferroni post hoc test, which showed that, as far as the follow-up test was concerned, the intervention group differed significantly from the control group in the subscapular skinfold (P=0.0000) and in body fat percentage (P=0.005). The mean values achieved during the follow-up test for the subscapular skinfold (19.27 and 34.70) and for body fat percentage (36.02 and 51.54 in the intervention and the control group, respectively) are indicative of a decrease in the intervention group and an increase in the control group compared to what was observed from the pre-test values (Table I) (although the values cannot be compared directly because the follow-up testing consisted of fewer subjects). Within group differences were also computed to further analyse the effect within each group separately. From these results (Table III), it can be seen that the body fat of the intervention group did not increases significantly while the subscapular skinfold showed increasingly lowering values over time. The group's body mass did however increase significantly, from which it can be deduced that the intervention possibly contributed to a higher muscle mass in the group. The BMI of the intervention group also did not change significantly from the pre-testing to the follow-up testing, which indicates a stabilising effect in this aspect of their body composition.

Figure 2A-H provides a graphic representation of the physical parameters of the intervention group who underwent all three measurements. Within group differences were further analysed to determine the effect within each group separately, and the results showed no differences in the intervention group and the control group respectively (Table III).

From this, it appears that the physical fitness of the intervention group underwent changes that were significantly different over time compared to the control group in four of the eight physical fitness parameters, namely, sit and reach to the right and to the left side of the body (flexibility), knee push-ups (arm muscular endurance), and v-up (back muscular endurance). Cardiorespiratory endurance, muscular strength, and abdominal and leg muscular endurance showed no

significant group differences over time. A further analysis of the differences between the groups during the follow-up measurements showed that the intervention group did not differ significantly from the control group in any of the components.

Discussion

The aim of this study was, firstly, to determine the immediate effect of this physical activity, diet, and behaviour modification intervention on the body composition and the health-related physical fitness parameters of nine- to 12-year-old overweight and obese children. The results showed that body mass, waist circumference, relaxed upper arm circumference, subscapular skinfold, triceps skinfold, calf skinfold, BMI, and body fat percentage of the subjects who followed the intervention decreased significantly after participation in the intervention, which did not yield similar results in the control group. These findings agree with the results of researchers [15, 16, 17, 19] who also found significant decreases in BMI, body mass, body fat percentage, and waist circumference after participation in a multi-disciplinary intervention programme for a period of 12 weeks. This decrease in body composition variables further showed large practical significant effects, which indicates that the intervention programme can be offered successfully to improve the body composition profile of overweight and obese children in this age group.

The intervention further contributed to a statistically and practically significant improvement in flexibility, muscular strength, and abdominal muscular endurance, while cardiorespiratory endurance, and back, arm and leg muscular endurance showed improved mean values after participation in the intervention, although the increases were not significant.

With regard to cardiorespiratory endurance, these findings are in agreement with the results of researchers such as Nemet *et al.*,[15] Sacher *et al.*,[16] and Eliakim *et al.*[17] No studies could be found on children of the same age with which to compare the improvement in muscular strength and flexibility.

The greatest challenge of obesity interventions is, however, to maintain the body composition changes brought about by an intervention after completion of the intervention. Physical fitness changes brought about by such interventions are also important to maintain due to the health-enhancing value of these variables in the total well-being of children. The study consequently also analysed the effect of the intervention on the body composition and physical fitness of the subjects after a lapse of three months after completion of the intervention. The results of 28 (11 intervention and 17 control) were used in this analysis.

The results showed that the intervention group underwent changes that were significantly different from the control group during the course of the research period with regard to certain body composition variables. An analysis of the intergroup differences indicates that the subscapular skinfold and the body fat percentage of the intervention and the control group differed significantly during the follow-up test, where the intervention group showed a smaller subscapular skinfold and a lower body fat percentage than the control group. In order to better explain this difference, the within group differences of the intervention and the control group were determined separately. It appears that the intervention group's body fat percentage did show an increase during the follow-up test, but that the subscapular skinfold decreased over time, although the group's body mass showed significant increases. The conclusion can be drawn that the intervention possibly led to a greater muscle mass in the intervention group who took part in it. As far as the physical fitness parameters of the intervention group are concerned, it appears that the group did not significantly differ from the control group, although the intervention group showed better mean values than the control group during the follow-up test in flexibility, muscular strength, arm muscular endurance, and abdominal muscular endurance. Consequently, it could be that the intervention group did made dietary adjustments that could have contributed to these effects. It could also be that the smaller body fat percentage of the group contributed to better body mass displacement as seen in the standing long jump test score during follow-up. This interaction effect is important because it indicates that body composition and physical fitness are interrelated and that a better body composition can also contribute to improved physical fitness. It is, however, clear from the relapse effect found in most results that children cannot themselves apply a home programme that addresses all the principles

of a controlled intervention appropriately. Consequently, one cannot expect young obese children to have the self-responsibility to effectively incorporate all the desired lifestyle changes in their lives without proper supervision and motivation.

These results unfortunately do not include subjects who did not take part in the follow-up evaluation. The researchers and the subjects who took part in the intervention formed close relationships during the period of the intervention. It is possible that the subjects who did not turn up for the follow-up testing, who had all been part of the intervention group, were shy about a possible relapse effect that had occurred in them, especially as far as their body composition was concerned. The control group, of whom nothing was expectated, all took part in the follow-up testing. If this were the case (although speculative), these subjects will have an even bigger problem in making the lifestyle adjustments that are expected of them. The relapse effect could also possibly, although the deduction is also speculative, be ascribed to the age of the subjects who took part in this study, since researchers are of the opinion that children older than 12 years often show greater comprehension of the information provided to them to make healthy lifestyle changes and thus a lower BMI is often found among them during a follow-up period compared to in younger children.[19] The children in this study were younger than 12 years and possibly did not have the necessary understanding of the information and commitment to make lasting lifestyle changes. It is, however, characteristic of intervention studies that a large relapse effect occurs; consequently, the results were to be expected.

The results of this study must be judged in the light of the relatively small number of subjects on whom the results, especially those of the follow-up testing, were based. The study did, however, bring to the fore important information regarding the value of a physical activity, diet, and behaviour modification intervention for overweight and obese children, and especially regarding the sustainability of its effects. The findings also provide new knowledge concerning the demands needed from intervention programmes to improve physical fitness parameters such as flexibility, muscular strength, muscular endurance, and aerobic capacity and how to maintain that improvement. It is recommended that researchers should, in future, make use of a bigger random sample; and that they should try to limit the dropping out of intervention subjects after completion of an intervention for further testing.

Conclusions

It appears that the immediate effect of participation in a multidisciplinary physical activity, diet, and behaviour modification intervention is positive as far as a favourable shift was found in body composition, fat utilization and metabolism as seen in a lowered fat percentage and smaller subscapular skinfold (which was also sustainable), and in most of the physical fitness parameters (flexibility, muscular strength, and abdominal muscular endurance) of overweight and obese children between the ages of nine and 12 years. The intervention did not succeed in significantly improving cardiorespiratory endurance necessary for effective cardiorespiratory functioning (Table II), although it brought about a significant improvement in the group who took part in the follow-up assessment. Adjustments are therefore suggested in the exercise prescription to address this shortcoming. This will also be the hardest part of an exercise programme for obese children to maintain; therefore enjoyment will be an important factor to build into activities that are chosen, in order to maintain the intensity that are needed for improvement.

The study further indicated stabilising effects, which indicate that there were sustainable effects on explosive muscular strength and for body fat percentage and the subscapular skinfold, while the other parameters worsened during a short follow-up period of only three months. This indicates health behaviour decay trends among obese children over a very short period of time. Consequently, young obese children face challenges in effectively addressing the lifestyle changes expected of them, and strategies must be sought to better support them in this process. Motivation to increase their physical activity by joining sport and recreation activities is particularly important, while parents need to provide behavioural reinforcement and reward their child's effort to building healthy fitness and nutrition habits, and in so doing contribute to the behaviour change that are needed to improve health outcomes. The researchers also suggest that intervention programmes for young overweight and obese children must be

sustainable, since the results show that they cannot be expected to meet the demands for improvement of particularly aerobic capacity, which is dependent on participation in regular, moderate to high-intensity physical activity, without guidance and support. The findings, as far as physical fitness parameters such as flexibility, muscular strength, and muscular endurance are concerned is especially important as it fills a gap in existing literature, since the intervention effect on these health related fitness parameters is unknown in nine- to 12-year-old children.

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