Original Article

The effects of an exercise training program on body composition and aerobic capacity parameters in Tunisian obese children

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ABSTRACT

Background: The prevalence of children obesity is rising alarmingly in both developed and developing countries. Developing effective exercise programs is a strategy for decreasing this prevalence and limiting obesity-associated long-term comorbidities. **Objectives:** To determine whether a 16-week training program; in addition to the school physical education and without dietary intervention; could have beneficial effects on body composition and aerobic capacity of obese children. **Materials and Methods:** Twenty-eight obese children (16 boys, 12 girls; aged 12-14 years) were enrolled and were divided into either the exercise group (EG, $n = 14$) or the control group (CG, $n = 14$). EG participated in a 16-week aerobic exercises (four 60-min sessions per week at 70-85% of HRmax (maximum heart rate)), in addition to the school physical education. Fat-Free Mass (FFM) and Fat Mass (FM) were assessed with bioelectrical impedance equipment. To assess aerobic capacity, maximal metabolic equivalent of task (METmax) and maximal workload (Wmax) were estimated with an electronically braked cycle ergometer (type Ergoline 500®). **Results:** At baseline, there were no differences between the two groups. After the training program, only the EG showed significant reduction in BMI (body mass index) and waist circumference compared with the baseline values ($P < 0.001$). Exercise training significantly decreased FM only in the EG. A significant increase in FFM was seen in both groups; more marked in the EG. There was a significant increase in METmax ($P < 0.05$) and Wmax ($P = 0.02$) in the EG, and no significant changes in these parameters were seen in the CG. HRmax significantly decreased only in the EG ($P < 0.05$). **Conclusion:** This training program has beneficial effects on body composition and aerobic capacity parameters in obese children. Our intervention has the advantage of providing a sustainable and reproducible school and community approach for the management of children obesity.

Key words: Aerobic capacity, body composition, children obesity, physical exercise

Introduction

The prevalence of childhood and adolescent obesity is rising alarmingly in both developed and developing countries,[1,2] and this trend is also found in Tunisia.[3,4] Excess body weight in children is associated with negative impact on self-esteem and increases the risk of cardiovascular diseases and type 2 diabetes mellitus (T2DM), affecting the quality of life (QoL) and reducing the average life expectancy.[5]

Access this article online	
Quick Response Code:	Website: www.ijem.in
	DOI: 10.4103/2230-8210.122619

One of the most interesting possibilities for the management of obesity is the engagement in a regular physical activity (PA).[6,7] The latter contributes to an increase in both energy expenditure and maximum oxygen consumption (VO_2 max), with a significant impact on the QoL.[8-10]

Developing exercise programs is a strategy for decreasing obesity prevalence and is expected to help in eventually

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limiting obesity-associated long-term health and societal impact.[11,12] However, it is noted that the obese child is reticent to PA. Moreover, childhood obesity has been associated with reduced exercise capacity and poorer motor performance.[13] Current data suggest that self-efficacy, motivation, and physical competence are key factors to initiate a PA and to achieve its sustainability and continuity by obese children.[14-16]

Despite a growing literature on the problem of childhood obesity in the world, there are less randomized controlled studies investigating the efficacy of independent effect of exercise training in childhood obesity. There is a need to develop a modular aerobic exercise program which is suitable, individualized, attractive, and easily reproducible by others for these obese children.

The purpose of this study was to evaluate the effectiveness of a 4-month PA program for obese children without dietary intervention. We hypothesize that children randomized to the intervention group will demonstrate a significant improvement in both body composition and aerobic performance compared with those in the control group.

Materials and Methods

Patients

Twenty-eight obese children (16 males, 12 females; aged 12-14 years) were enrolled in the study [Table 1]. They were selected following an epidemiological study which considered 11 elementary schools in the city of Sfax, Tunisia.

After obtaining permission from school authorities and verbal informed consent from the children and parents, participants were randomly assigned into two groups: Exercise group (EG, *n* = 14) and control group (CG, *n* = 14).

Table 1: Anthropometric data and body composition of the participants before and after training exercise

	EG		CG	
	Pre-training	Post-training	Pre-training	Post-training
Age (years)	10.92±0.61	-	10.64±0.72	-
Weight (kg)	58.5±8.8	59.2±9.1	53.2±11.9	55.8±11.9***###
BMI (kg/m^2)	25.4±3.1	24.8±3.2***	24.2±3.8	24.7±3.9###
WC (cm)	81.5±6.4	79.8±6.2***	77.9±8.5	78.6±8.5###
FM (%)	33.1±6.5	28.8±6.9***	29.7±6.7	29.5±8.4##
FFM (kg)	38.7±4.5	41.8±5**	37±7.4	38.7±6.8*

Values are given as mean±standard deviation. EG: Exercise group, CG: Control group, BMI: Body mass index, WC: Waist circumference, FM: Fat mass, FFM: Fat free mass. Difference from baseline (paired *t* test): **P*<0.05, ***P*<0.01, ****P*<0.001. Difference between EG and CG (unpaired *t* test): #*P*<0.05, ##*P*<0.01, ###*P*<0.001

Inclusion criteria were as follow: A body mass index (BMI) greater than 97th percentile according to the French curves,[17] no history of heart or metabolic diseases, and no history of any medication that could influence body composition or energy metabolism.

Methods

All children were evaluated during two special consultations: In the Department of Physical and Rehabilitation Medicine, Habib Bourguiba Hospital and in the Department of Endocrinology, Hedi Chaker Hospital, Sfax, Tunisia. Subjects were advised not to change dietary habits during the study period. It was also recommended that they avoid ingestion of stimulants such as food, coffee, tea, and chocolate in the 24 h prior to the assessment.

Anthropometric parameters and body composition

Weight was measured without shoes and heavy clothes, using an electronic scale to the nearest 0.1 kg. (Seca 709, France). Height was measured to the nearest 0.5 cm by using a wall-mounted stadiometer. BMI was defined as weight (kg) divided by height squared (m^2). A child was defined as obese when his BMI was greater than 97th percentile according to the French curves.[17]

Waist circumference (WC) was measured to the nearest 0.5 cm with a nonelastic tape applied at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. The pubertal stage was assessed using the references suggested by Tanner.[18]

Fat-free mass (FFM) and fat mass (FM) were assessed with bioelectrical impedance equipment (TANITA, TBF-300, France). The measurements were performed in a standing position, with electrodes in contact with soles and heels of both feet.

Evaluation of the aerobic capacity

Exercise testing

Aerobic exercise tests were performed on an electronically braked cycle ergometer (type Ergoline 500®), under the supervision of a cardiologist. Standardized verbal encouragement was given throughout the test to stimulate maximal performance.

Aerobic fitness was assessed by a standard progressive incremental exercise test. The progressive exercise test consisted of step increments in work rate of either 10 or 15 W/min (according to the subject's height and age).[19] The exercise test was considered acceptable if it met any one of following criteria: Heart rate (HR) >195 beats/min; signs of intense effort such as facial flushing, hyperpnoea, and exhaustion of the child; and/or the inability to maintain the required pedaling speed despite strong verbal encouragement.[20]

To assess aerobic endurance capacity, maximal metabolic equivalent of task (METmax) and maximal workload (Wmax) were estimated for each participant under maximal exercise testing.

Exercise training program

Both groups participated in their habitual physical education courses in schools (1 session of 60-min physical education per week), but only the EG participated in an additional 4 sessions per week of 60 min per session of exercise training for 4 months.

The sessions were conducted as follow: Two sessions on weekdays, right after school courses and two other on weekends.

Various activities were incorporated in our exercise training program. This exercise program comprised a combination of games and sports activities involving continuous bouts maintained on an average at 70-85% of maximum HR (HRmax) which was calculated during a maximal progressive exercise test.

The intensity and duration of the exercise program were gradually and progressively increased, as individually tolerated, to induce a training effect throughout the 4 months. During the training sessions, HR was measured continuously with a HR monitor (Polar Electro, Kempele, Finland) and was checked and recorded every 15 min. The participants were instructed to adjust their movement speeds according to the target HR training zone.

The training program consisted of warm up exercise, main exercise, and cool down exercise. During the warm up phase, the children were directed to jog and stretch for 5 min.

Circuit training, racing games, and sport games were included in the main exercise program. The main exercise phase consisted of various items that would trigger the interest of children, such:

- Circuits: 1-2 sets; 3-4 exercises; period 5-10 min, depending on type of circuit; work-rest ratio between exercises 1:1/2 or 1/3 depending on exercise period and/or level of aerobic fitness; rest between sets 1-2 min; passive rest recovery (standing or walking at a slow pace)
- Racing games (relay and other recreational activities): 1-2 games; 2-4 sets; distance to run 10-15 m, exercise period 5-7 min, rest between sets 1-2 min; passive rest recovery (standing or walking at a low pace)
- Sport games such as football, handball, and basketball: 20-25 minutes, two teams, adapted rules to ensure an adequate and substantial aerobic challenge
- Two teams, comprised of different members each session, were formed and these games would last between 10-15 min play time with 2 min rest between sets with modified rules to suit the average skill level of the participants, achieve successful and ensure aerobic benefits. Brief passive rest recovery (<30 s) was incorporated intermittently to allow the instructor to provide specific instructions or tactical tips on how their play could be improved.

Statistical analysis

Descriptive statistics were used with means ± standard deviations (SD). Changes within and between the EG and the CG pre- and post-training for anthropometric, body composition, and aerobic fitness variables were analyzed using using the SAS statistical software package, version 9.1 (SAS Institute, Cary, NC). A $P \leq 0.05$ was considered as statistically significant. Unpaired Student's *t*-test was used to examine for significant differences in selected variables between these two groups. Comparison between measures before and after the training period was carried out using paired *t*-tests.

Results

Training program

All participants were able to complete the intervention during the experimental period. They were able to exercise at HR equal to or above the prescribed training HR (mean HR maintained during training sessions: 148.8 ± 2.7 beats/min).

Anthropometric data and body composition

At baseline, there were no differences between the two groups in anthropometric and bioelectrical impedance analysis characteristics [Table 1]. The mean age was 10.92 ± 0.61 years in the EG and 10.64 ± 0.72 years in the CG ($P = 0.72$). Mean BMI was 25.4 ± 3.1 kg/m^2 and 24.8 ± 3.2 kg/m^2 in the EG and CG, respectively ($P = 0.07$). In the EG (six girls and eight boys), nine were prepubertal (stage 1) and five were at the beginning of puberty (stage 2). In the CG (six girls and eight boys), ten were prepubertal (stage 1) and four were at the beginning of puberty (stage 2).

Changes in anthropometric parameters and body composition after the training program are summarized in Table 1.

Both groups showed weight increase after the training program, but this increase was significant only in the CG (EG: + 0.7 kg, $P = 0.07$; CG: + 2.6 kg, $P < 0.001$).

After training program, the EG showed significant BMI reduction compared with their baseline values (25.4 ± 3.1 vs 24.8 ± 3.2 kg/m^2, P < 0.001). No significant change in BMI was observed in the CG between pre- and posttesting (24.2 ± 3.8 vs 24.7 ± 3.9 kg/m^2, P = 0.07).

The training program induced a significant decrease of the WC in the EG (−1.6 ± 0.2 cm, P < 0.001) and a not significant increase of the WC in the CG (+0.7 ± 0.3 cm, P = 0.11).

A significant decrease in the percentage of body fat mass in the EG (−4.3 ± 3.1%, P < 0.001) was seen after completion of the 4-month intervention. For the CG, there was a decrease in the body fat mass with no significant difference compared with baseline measures (−0.2 ± 2.1%; P = 0.03).

There were significant increases in FFM in both groups; more marked in the EG (+3.1 ± 1.7%, P < 0.01) than the CG (+1.7 ± 1.1%; kg, P = 0.04).

Aerobic capacity parameters

The results of the exercise tests before and after intervention are shown in Table 2. After program, maximal aerobic capacity became significantly higher in EG than in CG. In fact, a significant increase was found for METmax in the EG (7.2 ± 1.5 vs 7.6 ± 1.4, P < 0.05), while the CG showed no significant change in measures of METmax before and after the protocol study (7.9 ± 1.1 vs 7.8 ± 1.1; P = 0.72). Wmax was significantly increased in the EG (102.9 ± 21 vs 109.3 ± 17.6 W; P = 0.02) and showed no significant change in the CG after study (110.4 ± 21 vs 107.8 ± 22.3 W, P = 0.1). However, maximal workload value per FFM (Wmax/FFM) after intervention did not mark any difference between the EG and CG (2.6 ± 0.4 vs 2.8 ± 0.6 W/kg; P = 0.84).

HRmax decreased in the EG from 179.9 ± 11.4 beats/min to 175.3 ± 7.9 beats/min (P < 0.05) and in the CG from 181.3 ± 8.3 beats/min to 180.9 ± 8.1 beats/min (P = 0.91).

Table 2: Aerobic capacity parameters of the participants before and after training exercise

	EG		CG	
	Pre-training	Post-training	Pre-training	Post-training
METmax	7.2±1.5	7.6±1.4*	7.9±1.1	7.8±1.1#
Wmax (watts)	102.9±21	109.3±17.6*	110.4±21	107.8±22.3#
Wmax/FFM (watts/kg)	2.7±0.4	2.6±0.4	2.8±0.6	2.8±0.6
HRmax (beats min^{-1})	179.9±11.4	175.3±7.9*	181.3±8.3	180.9±8.1#

Values are given as mean±standard deviation. EG: Exercise group, CG: Control group, METmax: Maximal metabolic equivalent of task, Wmax: Maximum workload, FFM: Free fat mass, HRmax: Maximum heart rate. Difference from baseline (paired *t* test): **P*<0.05, ***P*<0.01, ****P*<0.001. Difference between EG and CG (unpaired *t* test): #*P*<0.05, ##*P*<0.01, ###*P*<0.001

Discussion

The present study investigated the effect of a training program without diet intervention on body composition and aerobic fitness, in an EG compared to a CG with similar general and anthropometric characteristics recruited at baseline over a 4-month period. Its main findings are that our physical training program was able to improve both body composition and aerobic capacity parameters in the obese children.

In order to keep the program varied, interesting and fun, yet able to provide adequate aerobic benefits and to improve adherence by the children, we incorporated short duration games and different sporting activities. Obese children may find lack of variety in the long duration aerobic-based activities, and therefore reluctant to continue exercising on a routine basis in effect.[14,15] Since we conducted a feasibility study, we assured that all children participating in the training program had been exposed to a substantial physical training dose.

In this study, there was significant decrease in BMI and WC in the EG after intervention without diet intervention. Observational studies consistently showed that greater activity is associated with lower BMI and girth.[21-24] In contrast, other interventions were unable to improve such parameters.[25,26] One reason for this failure is that more activity leads to higher calorie consumption, offsetting any gains in energy expenditure.[27] Therefore, BMI improvement may be attained through a combined approach or with the interventions that aim to improve diet rather than physical training alone.[28] However, this hypothesis seems inconsistent with our results, given that our participants were advised not to change their dietary habits during the study period. Alternative explanations could be lack of adherence to the intervention or that exercise intervention may simply replace an equally habitual activity spent by children.[29]

BMI; as a measure of body composition; has well-known limitations, given that it reflects both fat and fat-free components of body weight.[30] It is possible that PA could increase lean muscle mass and decrease fat component with no overall change in BMI. Despite these limitations, BMI is the most consistently reported measure of body composition. In addition, elevated BMI in children is associated with increased metabolic abnormalities, as well as development of coronary artery disease and increased all-cause mortality later in life.[28,30,31]

Our exercise program resulted in a significant decrease in FM and a significant increase in FFM in the EG. Similarly, other studies concluded that reduction in adiposity can occur while maintaining or even increasing FFM of children.[32,33] Increasing FFM, or at last avoiding its decrease, seems to be of interest. The treatment of obese children should aim at decreasing FM, avoiding loss of FFM, ensuring adequate growth and development, and preventing cyclic weight regain. Notably, a decrease in FFM can result in subsequent reduction in basal metabolic rate, which then becomes a major risk factor for weight gain.[11,34]

In contrast, Treuth *et al*.,[35] demonstrated significant increases in weight, FFM, FM, and subcutaneous abdominal adipose tissue in growing obese prepubertal girls undergoing a strength training program, whereas intra-abdominal adipose tissue remained unchanged.[35]

Similarly, a recent study showed that a 12-week controlled resistance exercise program; increased weight, lean body mass, and hepatic insulin sensitivity in 12 obese adolescents, with no effect on the metabolically active fat tissue (visceral, hepatic, and intramyocellular).[36] Therefore, body fat distribution, rather than total fat mass or fat excess should be of importance in obese children.

Reduced values of cardiopulmonary exercise performance and lower aerobic fitness have been reported in obese children.[37] Our results showed significant improvement in the METmax, Wmax, and HRmax in the EG. Interestingly, Kodama *et al*.,[38] showed in a recent meta-analysis that 1-MET higher level of maximal aerobic capacity was associated with a 13 and 15% risk reduction of all-cause mortality and coronary heart disease/cardiovascular disease, respectively.[38]

Our training program has beneficial effects on aerobic capacity parameters without dietary intervention, illustrated by a significant increase in METmax and Wmax and a significant decrease in HRmax in the EG. Our results are in line with those of previous reports.[39] Nevertheless, such beneficial effects still not clearly established.[40] A recent meta-analysis demonstrated that aerobic exercise have a moderate positive effect on aerobic fitness; the programs with total durations of more than 12 weeks; three sessions per week (more than 60 min per session) showed better results; and combined programs (both aerobic activities and strength training) failed to achieve improvements in aerobic fitness.[40] Our protocol study meets all these criteria (16-week duration, four 60-min sessions per week).

Conclusion

It has been extensively demonstrated that low PA levels is a cause and a consequence of overweight. In this study, we demonstrated that varied aerobic activities, comprising of a combination of sports and games activities (suitable, individualized, attractive, and to suit the average skill level of the participants) provided improvement in body composition and aerobic fitness. This intervention has the advantage of providing a sustainable and reproducible school and community approach for the management of children obesity.

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Cite this article as: Regaieg S, Charfi N, Kamoun M, Ghroubi S, Rebai H, Elleuch H, *et al*. The effects of an exercise training program on body composition and aerobic capacity parameters in Tunisian obese children. Indian J Endocr Metab 2013;17:1040-5.

Source of Support: Nil, **Conflict of Interest:** None declared.