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Original article

Effects of an exercise program with or without a diet on physical fitness in obese boys: a three-year follow-up

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Summary. Childhood obesity is a global epidemic, and understanding the relationship between physical fitness and various forms of intervention in obese children is essential to implementing effective exercise programs. The objective of the present study was to conduct a long-term follow-up (three years) of how an exercise program with or without diet affects the physical fitness components of obese boys. The participants were 18 boys, ages between 8 and 11, divided into two groups according to the program they followed. The exercise group (E group) followed a physical exercise program (three 90-minute sessions per week), and the exercise plus diet group (E+D group) this physical exercise program plus a low calorie diet. Physical fitness was assessed by the European physical fitness test battery including flamingo balance, plate tapping, sit-and-reach, handgrip strength, standing broad jump, sit-ups, bent-arm hang, 10×5-metre shuttle run, and 20-metre endurance shuttle run. Kruskal-Wallis test was applied to reveal overall intergroup differences (E and E+D group), and measurements showing significant differences were further analysed for differences between individual groups by the Mann-Whitney U-test. In both groups, changes were observed in various physical fitness parameters, especially limb speed, agility, aerobic fitness, and muscular strength in absolute and relative terms (which improved in more than one evaluation). Differences between the two programs were observed only in the short term. It was found that long-term longitudinal interventions based on exercise programs with or without diet produce improvements in obese children's physical fitness.

Key words: aerobic fitness, agility, balance, body mass index, strength

Introduction

The prevalence of childhood obesity is increasing (1). Associated with this pathology are numerous other disorders – cardiovascular, metabolic, gastrointestinal, pulmonary, orthopædic, neurological, psychological and social, among others. In addition, childhood obesity is a predictor of cardiovascular disease morbidity and mortality in adulthood (2). Recommendations regarding the treatment of childhood obesity focus typically on lifestyle changes, including the promotion of healthy eating habits and increased physical activity (PA) (3). PA plays an important role in the prevention of overweight and obesity in childhood and adolescence (4). However, the PA levels of youngsters are today very low (5). In this sense, research on overweight children's habitual PA patterns suggests that they are less active (6) and have poorer movement skills (run, vertical jump, throw, catch, kick, and strike) (7) than normal-weight children. Other studies have shown that, compared with normal weight children, obese children had poorer performances on weight-bearing tasks, but not on all fitness components (8,9).

A sedentary lifestyle leads to poor physical fitness (PF), and this together with elevated body fatness is considered to be a strong predictor of cardiovascular disease in youth (10). Indeed, PF is considered a important marker of health throughout life (11). PF includes several components: cardiorespiratory fitness, muscular endurance, muscular strength, flexibility, coordination, and speed (12). Several studies have analyzed PF in obese children after an exercise program (13) or an exercise program plus diet (14,15). Most primarily looked at cardiorespiratory fitness through effort tests (13-15), although other PF parameters such as strength (13,14) and flexibility (14) have been included. These studies showed that exercise, both in isolation and in combination with diet, appeared to be beneficial by generating short/medium term (3-9 months) improvements of these parameters. In this regard, a recent meta-analysis of results on the obese pædiatric population has shown that programs based on aerobic exercise have a moderate positive effect on aerobic fitness (16). Often, the studies conduct interventions in the short to medium term, even though international recommendations propose longitudinal studies of the prevention and treatment of obesity (17,18). While there is a need to develop early interventions to improve PF in obese children (19), there have been no longitudinal studies to analyze the influence of exercise programs with or without diet on PF (17). Therefore, the aim of the present study was to track over the long term (three years – four evaluations) the influence of an exercise program with or without diet on the physical fitness components of obese boys.

Material and Methods

Participants

A total of 105 boys were invited to participate through the collaboration of various schools in the town of Caceres (Spain). The inclusion criteria were: (i) age between 8 and 11 years, and (ii) a body mass index (BMI) equal to or greater than the 97th percentile for the age and sex (male) of the subject as defined by Spanish population curves (20). Subjects were excluded if they were: (i) regularly practising PA, or following an exercise program or some other therapy (n=65); (ii) involved in any weight control program (n=18); (iii) were taking any medication (n=8); (iv) had any type of dysfunction limiting their PA (n=2); and other reasons (n=9). The final sample consisted of 18 Caucasian boys (10.7±0.9 years). They were divided into two groups (several subjects ate at the school's refectory, making it impossible to randomly assign membership to one or the other group): the exercise group (E group) who followed a multi-sports exercise program (n=8, 10.9±1.0 years), and the exercise plus diet group (E+D group) who followed a combination of two programs – the exercise program and a low calorie diet (n=10, 10.5±0.85 years). All the children's parents completed a prior informed consent form. The study was approved by the Bioethics and Biosecurity Committee of the University and respected the principles of the Declaration of Helsinki.

Interventions

Exercise program

The exercise program was carried out in a multisports hall, supervised by two PhD students in Sports Sciences (AGH, AMD) under the overall supervision of two PhD's in Sports Sciences (JMS, YE). The program design was based on previous studies (13) and on the more than 15 years experience in implementing this type of health-related exercise program of two of the authors (JMS, YE). The program was of three weekly 90-minute sessions. During the three years of the study, the participants carried out 230 session of 90 minutes each (20 700 minutes). Each session comprised a warm-up (15-20 min), a main part consisting of pre-sports and multi-sports games (soccer, basketball, baseball, hockey, among others) with a moderate to vigorous intensity aerobic component (60-65 min), and a cool-down (5-10 min). In the team games, the participants were asked to maintain the desired intensity throughout the activity. A progression was established to steadily ramp the subjects up to 60-65 minutes of moderate to vigorous intensity. The intensity of the session was monitored by accelerometry to ensure that all the subjects performed the activities with the same intensity. A Caltrac accelerometer (Hemokinetics, Madison, WI, USA) was used to this end, programmed to function as a PA monitor (21). This uniaxial accelerometer contains a piezoelectric bender element which assesses the intensity of movement in the vertical plane. Its validity has been demonstrated as a method for estimating energy expenditure in children (22), and it has been used in other studies (21, 23). Although it is unable to monitor such activities as rowing or swimming, no activity of this type was used either in the exercise program or in the subjects' daily PA for the duration of the study. The intensity of exercise was also estimated by Rate of Perceived Exertion Scale (6-20 RPE Scale). Levels 9-11 were considered light activity, levels 13-15 were considered light to moderate activity, and levels 17-19 were considered vigorous activity (24). However, it must be noted that quantifying exercise intensity is one of the most complex aspects of the sport science in general (25), and of physical exercise and health especially.

Compliance was assessed as percentage of exercise sessions attended. Compliance with the exercise program was good, with the children attending more than 78% of the total exercise sessions. Quantifying the intensities of 13 of the sessions/year selected at random showed no significant differences between the E and the E+D groups in any session, with a mean of 79 and 81 motion counts per session, respectively (Figure 1). Not all the sessions were quantified since the programming and placement of the accelerometers meant taking time away from the physical exercise program. The use of accelerometers allows one to objectively quantify the subjects' PA, ensuring that the intensity was similar in the two groups. In developing treatment strategies for obesity, one requires quantitative information on PA to provide more effective goals (26).

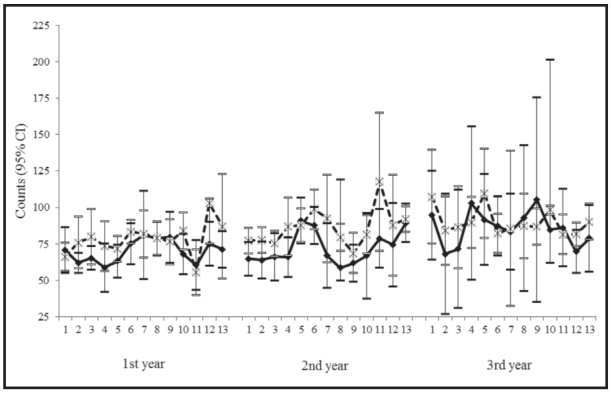

Figure 1. Representation of the means and confidence intervals of the intensity of the sessions of the physical exercise program as evaluated by accelerometry in the first, second, and third years. There were no differences between the E (solid line) and E+D (dashed line) groups

Diet program

The low-calorie diet consisted of five balanced meals spread throughout the day, with an energy intake of 1500 kcal/day. In this sense, there have been studies that recommend diets of between 1500 and 1800 kcal/day in obese children who are still growing, since in this way their growth and development are not compromised (27). Thus the diet prescribed was of 1500 kcal/day, similar to that of other studies (28). The diet consisted of 57% carbohydrates, 17% proteins, and 26% fats. Foods were selected according to the subject's dietary habits. A series of general recommendations were established focused on basic healthy lifestyle eating: consume ≥ 5 servings of fruits and vegetables every day; minimize sugar-sweetened beverages such as soft drinks, sports drinks, and sugar-added fruit juices; have more meals prepared at home rather than purchasing take-away restaurant food, etc. Regular meetings were held with the children and their parents for the control and monitoring of the diet.

Measurements

Each subject was evaluated for the following parameters: eating habits, daily PA, pubertal status, kinanthropometry, and PF. The evaluations were made at the start (baseline), and at 7 (1st-year), 19 (2nd-year), and 31 (3rd-year) months into the program.

Eating habits

Nutrition was assessed with a self-reported 3-day food record (2 weekdays and 1 weekend day in succession – Thursday, Friday and Saturday) filled in by the parents. The weight of the food was estimated from the parents' records. The computerized database Nutriber was used to calculate the daily intake (29), with the program recording the average of the three days (kcal/day).

Daily PA

Daily PA was measured before, during, and after the intervention, using a validated uniaxial accelerometer (Caltrac), and covering a 3-day period (Thursday, Friday, and Saturday), except during bathing and swimming. During the intervention, the daily PA was evaluated once a month. All participants were instructed to record the amount of time spent cycling or swimming during the evaluation period. At the beginning and the end of the day, the children recorded the number of "motion counts" of the accelerometer, following previously published protocols (21). The data were collected by the children with the help of their parents. A once-a-term meeting was held with the parents to inform them of the program's evaluation. The final Caltrac score was recorded, as also was the average of the three days (motion counts per day).

Pubertal status and kinanthropometry

Pubertal stage was evaluated by a trained pædiatrician according to pubic hair development using the Tanner classification criteria (30). The kinanthropometric measurements followed the ISAK protocol (31): body height, body weight, and body fat percentage (bioimpedance). Standard equipment was used: a scale-mounted stadiometer (Seca, Berlin, Germany), a weight scale (Seca, Berlin, Germany), and a bioimpedance analyzer (Bodystat 1500, Bodystat Ltd, Douglas, Isle of Man, UK). BMI was calculated as weight divided by height squared (kg/m^2), and the BMI z-scores were determined (20).

Physical fitness

Physical fitness was assessed by the Eurofit Fitness Testing Battery (32). This standardized test battery was devised by the Council of Europe for children of school age, and it has been used in many European schools since 1988 and in literature studies on obese children (8). All tests were conducted according to standard procedures (32), in indoor sports facilities, by two PhD students (AGH, AMD). The tests evaluated were (with the better of two attempts being recorded): (i) 20-metre endurance shuttle run, measuring the maximum aerobic capacity of the subject, recording the number of shuttles completed (only one attempt); (ii) sit-ups, measuring trunk muscle strength by the number of sit-ups performed in 30 seconds; (iii) 10×5-metre speed shuttle run, measuring speed agility from the time taken in seconds; (iv) plate tapping, measuring limb speed in a task in which two 20-cm rubber discs were fixed horizontally onto an adjustable table, placed with edges 60 cm apart and a 10×20 cm rectangular plate equidistant between the discs, the subject was required to touch each disc alternately with a stylus until 25 cycles were completed and then repeated, the fastest 25 cycles being recorded as the score in seconds; (v) sit-and-reach, measuring flexibility according to the standard sit-and-reach test for range of movement, using equipment for the items of this test provided by Bodycare (Birmingham, United Kingdom); (vi) flamingo balance on a 50-cm-long beam, 4 cm in height and 3 cm wide, 4 cm off the floor, for 1 minute, recording the number of falls; (vii) handgrip test recorded on a grip dynamometer (Takei Kigi Kokyo, Tokyo, Japan), measuring the force of the grip in kilograms; and (viii) standing broad jump, measuring explosive power as the distance in centimetres that the subject jumped horizontally.

Finally, muscular strength parameters can be expressed in terms that are absolute (activities such as carry a suitcase, move a heavy object, handgrip strength test, etc.) or relative (activities in which the person has to lift, hold, or carry his/her own body weight, standing broad jump). In the analyses, the handgrip score was divided by the weight which implies a transformation from absolute strength to relative strength, and the standing broad jump score was multiplied by the weight so that it was transformed from relative strength to absolute strength (33). The bent-arm hang test from the originally planned battery could not be completed satisfactorily by a number of children. This item was therefore dropped from further consideration in the study.

Statistical analysis

All the variables satisfied the tests of homoskedasticity (Levene variance homogeneity test) and normality (Kolmogorov-Smirnov test) of their distributions. However, we used non-parametric tests as is recommended in the case of small sample sizes. The basic descriptive statistics (means and standard deviations) were calculated. The Kruskal-Wallis method was applied to test for overall intergroup differences (E and E+D group), and measurements showing significant differences were further analyzed for differences between individual groups by the Mann-Whitney U-test (baseline, 1st-year, 2nd-year, and 3rd-year). Finally we performed a bivariate correlation (Pearson's P) analysis for each group at the end of the program to determine the possible effects of the kinanthropometric variables on the physical fitness. The level of significance for all statistical tests was set at $p \leq 0.05$. All calculations were performed using SPSS (version 16.0).

Results

The variables satisfied the tests of normality (Kolmogorov-Smirnov: $0.407 \leq z \leq 1.021$, $p>0.05$) and variance homogeneity (Levene: $0.008 \leq F \leq 4.361$, $p>0.05$). There were no intergroup differences in eating habits, daily PA, pubertal status, kinanthropometric, or PF parameters at the start of the program (Table 1).

Intra-group differences

Figures 2, 3, and 4 show the changes and effects of the treatment at different moments of evaluation (baseline [B], 1st-year [F], 2nd-year [S], and 3rd-year [T]). Figure 2 shows the evolution over the three years of intervention of the height, weight, body fat percentage, fat-free mass, BMI, and BMI z-score. No changes were observed in either daily PA or pubertal status. In both groups, however, changes were observed in the height and BMI z-score from the B to the T evaluations, and in the body fat percentage from the B to the F evaluations.

Figure 3 shows the evolution of each of the PF parameters. For the E group, there were differences between different moments of evaluation in the endurance shuttle run (B<T), the 10×5-metre shuttle run (B>T), and the plate tapping test (B>S,T; F>S,T). For the E+D group, there were differences between moments of evaluation in the endurance shuttle run (B<S,T), the 10×5-metre shuttle run (B>F,S,T), and the plate tapping test (B>S,T; F>T).

Table 1. Eating habits, daily PA, pubertal status, kinanthropometric, and physical fitness parameters of the study participants at baseline.

	E group (n=8)	E+D group (n=10)	Intergroup differences
	Mean ± SD	Mean ± SD	*p*
Eating habits			
Energy intake (kcal/day)	1952.4 ± 202.8	1928.6 ± 257.4	0.673
Daily PA			
3-day physical activity (counts/day)	156.2 ± 36.7	149.9 ± 36.3	0.914
Pubertal status			
Tanner stage (pubic hair)	1.62 ± 0.52	1.80 ± 0.63	0.937
Kinanthropometric			
Height (m)	1.49 ± 0.07	1.47 ± 0.09	0.235
Weight (kg)	62.4 ± 11.1	60.5 ± 11.8	0.815
Fat mass (%)	32.2 ± 3.77	33.0 ± 2.92	0.622
Fat-free mass (kg)	38.1 ± 7.45	39.3 ± 6.99	0.815
BMI (kg/m^2)	27.7 ± 2.95	27.9 ± 3.90	0.674
BMI z-score	4.00 ± 2.85	4.19 ± 2.81	0.256
Physical fitness			
Endurance shuttle run (n)	1.69 ± 1.41	2.20 ± 0.79	0.115
Trunk strength (n)	11.9 ± 4.55	12.2 ± 4.80	0.947
Agility run (s)	23.2 ± 1.39	23.9 ± 1.91	0.158
Limb speed (s)	14.9 ± 0.90	15.3 ± 3.83	0.072
Flexibility (cm)	-3.44 ± 6.94	3.40 ± 3.56	0.184
Balance (falls/min)	4.86 ± 1.68	6.00 ± 4.50	0.062
Handgrip strength (kg)	42.0 ± 6.55	37.5 ± 10.2	0.315
Standing broad jump (cm)	112.0 ± 18.8	108.3 ± 15.8	0.771

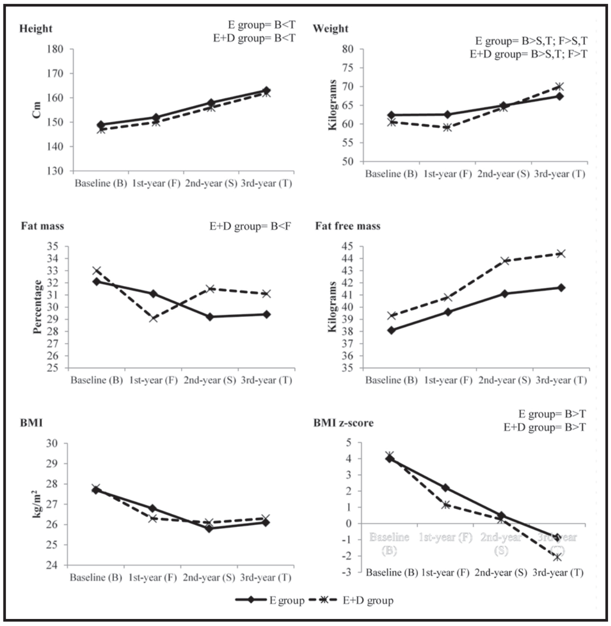

Figure 2. Changes in daily PA, pubertal stage, and kinanthropometric parameters at the baseline, first, second, and third year evaluations in obese boys; p<0.05.

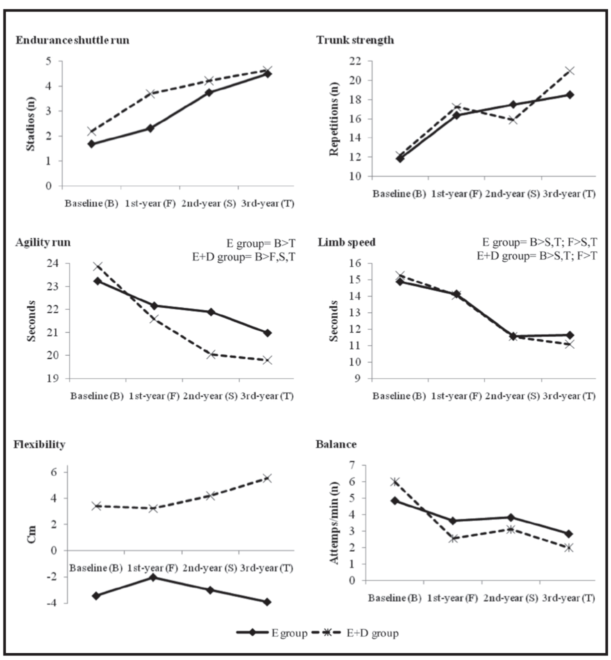

Figure 3. Changes in physical fitness parameters at the baseline, first, second, and third year evaluations in obese boys; p<0.05.

Regarding the relationship between the kinanthropometric variables and physical fitness, in the E group, relationships were found between height and

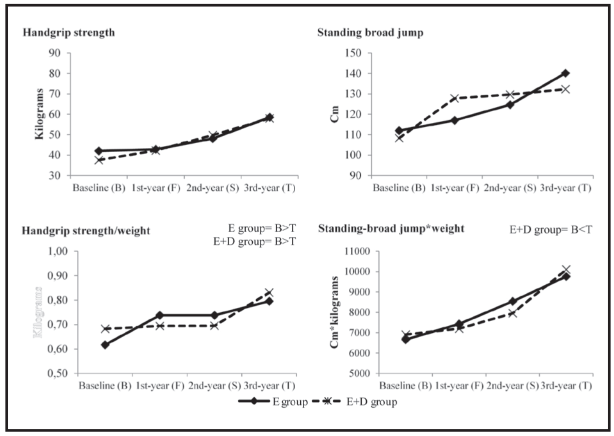

Figure 4. Changes in physical fitness parameters at the baseline, first, second, and third year evaluations in obese boys; p<0.05.

handgrip strength (r=0.850, p=0.032), and between BMI and endurance shuttle run (r=-0.922, p=0.009), trunk strength (r=-0.878, p=0.022), and flexibility (r=-0.855, p=0.030). In the E+D group, relationships were found between height and endurance shuttle run (r=0.608, p=0.047), handgrip strength (r=0.713, p=0.014), and standing broad jump (r=0.606, p=0.048), between weight and handgrip strength (r=0.847, p=0.001), and between BMI and handgrip strength (r=0.640, p=0.034).

Figure 4 shows the evolution of each of the muscular strength PF parameters. For the E group, there were differences between several moments of evaluation in the handgrip strength and in handgrip/weight (B<T). For the E+D group, there were differences between moments of evaluation in the handgrip strength (B<T), in handgrip/weight (B<T), and in standing broad jump×weight (B<T).

Intergroup differences

Table 2 presents the intergroup differences. One observes differences in weight change (E group 1st year<E+D group 3rd year; E group 3rd year>E+D group 1st year), body fat percentage change (E group>E+D group, both 1st year; E group 3rd year>E+D group 1st year), 10×5-metre shuttle run change (E group 2nd year>E+D group 1st year, and E group 3rd year>E+D group 1st year), and standing broad jump (E group<E+D group, both 1st year).

Table 2. Differences between groups for the changes in kinanthropometric and physical fitness parameters

	1st year		**2nd year**		**3rd year**		**ANOVA**		**Differences between groups**
	E group	**E+D group**	**E group**	**E+D group**	**E group**	**E+D group**			
	A	**a**	**B**	**b**	**C**	**c**	**F**	**p**	
Δ Weight (kg)	0.16 ± 1.35	-1.42 ± 3.06	3.10 ± 1.83	5.12 ± 3.82	8.25 ± 4.94	8.69 ± 3.80	12.372	0.000	A<c; a<C
Δ BMI z-score	-1.79 ± 0.69	-3.03 ± 2.11	-1.56 ± 0.92	-0.74 ± 1.23	-1.36 ± 2.23	-1.84 ± 3.53	1.339	0.268	
Δ Body fat (%)	-1.07 ± 0.85	-3.04 ±1.94	-2.35 ± 3.54	-0.14 ± 1.07	0.38 ± 2.60	-0.93 ± 0.90	2.494	0.047	A>a; a<C
Δ Endurance s huttle run (n)	0.62 ± 0.52	1.50 ± 0.62	1.25 ± 1.13	1.17 ± 1.00	0.50 ± 0.63	0.25 ± 1.13	2.643	0.037	
Δ Trunk strength (n)	4.50 ± 3.50	3.30 ± 3.16	2.00 ± 2.28	2.33 ± 3.39	1.17 ± 2.99	3.62 ± 6.63	0.659	0.656	
Δ Agility run (s)	-1.08 ± 0.91	-2.44 ± 1.05	0.22 ± 1.56	-1.05 ± 1.51	0.44 ± 1.08	-0.13 ± 1.23	6.102	<0.001	a<B; a<C
Δ Limb speed (s)	-0.73 ± 1.43	-1.51 ± 2.55	-0.45 ± 0.63	-0.17 ± 1.04	0.32 ± 1.54	-0.01 ± 0.89	1.436	0.232	
Δ Flexibility (cm)	1.41 ± 3.71	-0.50 ± 3.94	-0.58 ± 2.90	1.49 ± 3.48	-1.15 ± 3.23	0.08 ± 1.60	0.837	0.532	
Δ Balance (falls/min)	-2.50 ± 4.75	-3.60 ± 4.57	0.00 ± 4.82	-0.56 ± 4.50	0.17 ± 3.49	-0.57 ± 2.07	1.078	0.387	
Δ Handgrip strength (kg)	1.43 ± 10.17	4.15 ± 3.21	2.58 ± 2.87	1.22 ± 3.19	5.40 ± 3.24	4.24 ± 5.20	1.554	0.197	
Δ Standing broad jump (cm)	5.00 ± 12.8	18.7 ± 4.90	4.50 ± 10.8	5.55 ± 12.0	7.17 ± 9.19	3.71 ± 8.60	2.989	0.022	A<a

Results expressed as mean ± S.D.; E, exercise; E+D, exercise plus diet.

Discussion

We have described a long-term follow-up study (three years – four evaluations) of the effects of an intervention based on exercise programs with or without diet on the physical fitness parameters of obese boys. The results indicate that such long-term longitudinal intervention consisting of exercise programs both with and without a diet improves the fitness of these obese subjects, with a possible need for adjustments to fit the specific needs of the subjects according to their weight status (34). Differences between the two groups (with and without diet) were observed only in the short term.

Intra-group differences

Both groups showed reductions in plate tapping time from the baseline to a later evaluation. Improvements in the two groups were similar, perhaps because performance in this test is not influenced by excess fatness (35). These improvements may have been due to the inclusion of such sports as tennis and padel in the exercise program, with their need for major arm mobility. On the other hand, there were no improvements in balance, sit-ups, or flexibility, contrary to the findings of a randomized controlled trial (7). Maybe this indicates that specific programs may generate specific changes. With respect to the 10×5-metre shuttle run test, we observed time reductions in both the E group (baseline > third evaluation) and the E+D group (baseline > first, second, and third evaluations). Thus, both intervention strategies appear to be beneficial in the short and long term at improving the obese subject's agility. The exercise program was initially focused on simple aerobics combined with strength work (5). As the body fat percentage levels decreased and the fitness levels improved, the intensity of the sessions was increased (Figure 1). By the end of the study period, we observed improved performances on the endurance shuttle run test in both the E group (baseline > third evaluation) and the E+D group (baseline > second and third evaluations). These results are consistent with a meta-analysis and other studies indicating that both aerobic exercise-based intervention alone (4) and in combination with diet (14,15) lead to increased aerobic fitness. The improvement in this parameter is consistent with the reduction in body fat percentage since this reduction results in improved maximal aerobic power (36).

With respect to muscular strength parameters, the handgrip strength in absolute and relative terms increased in both groups from the baseline to the last evaluation (third year). In a similar study in the same line, but only with short term data (12 weeks), an exercise plus diet program produced improvements in the handgrip strength both intra-group (pre-test vs post-test, 9.4%) and inter-group (E+D vs D, 7.6%) (14). In the present study, the arm-specific activities and resistance weight-training incorporated into the exercise program could have favoured improvement in the handgrip strength (8). The improvements in this test, therefore, could be explained by changes in the neural mechanism and/or the quality of muscle contractile properties (37). This observation led us to introduce increased training of the upper body musculature (38). Finally, with respect to the standing broad jump relative to weight, this increased in the E+D group from the baseline to the last evaluation (third year). Such motor tasks as jumping which have to support the weight of the body's excess fat are probably among the most difficult exercises for obese people (39). For that reason, jumps or certain other activities involving sudden changes of direction were not implemented at the beginning of the program since obese young boys are limited in their ability to perform weight-bearing activities. Instead, the activities actually carried out were aimed at encouraging the continued participation of these obese individuals (40).

Intergroup differences

The results showed greater improvement in the E+D group than in the E group, especially in the short-term (Table 2). In particular, the E+D group improved their standing broad jump more than did the E group in the first year (1st year minus baseline in E group < 1st year minus baseline in E+D group; p=0.022). This could have been a reflection of the differences between the two groups in body fat percentage change recorded in the first evaluation period (1st year minus baseline in E group > 1st year minus baseline in E+D group; p=0.047) which confirmed that, in obese subjects, combined exercise plus diet programs generate greater improvements in body fat percentage than exercise alone. Similarly, since a higher BMI is associated with reduced performance in the standing broad jump (9), the downward trend shown by the BMI z-score would seem to favour improved performance on this test compared to the baseline. Furthermore, it is noteworthy that there was an increase in fat-free mass favoured by the exercise program, and this could have led to increased strength of these obese subjects (8). Finally, differences in favour of the E+D group were observed in the changes in the 10×5-metre run test (2nd year minus 1st year in the E group > 1st year minus baseline in the E+D group, p=0.002; and 3rd year minus 2nd year in the E group > 1st year minus baseline in the E+D group, p=0.001). This could be a consequence of a lack of experience in weight-bearing tasks, since obese young boys are limited in their ability to perform weight-bearing activities (41). In particular, although in both groups there was a downward trend as reflected in the long-term improvements in this parameter (Figure 3), the great improvement in the E+D group after the first year and the original scope for improvement in this group (at the baseline, they showed very little agility) could have favoured the differences with respect to the second and third evaluations of the E group (after the first year, the subjects were more agile, and there was less room for improvement).

Limitations

A number of limitations of this study need to be borne in mind. First, there was a lack of initial randomization of the groups. Several subjects ate at the school's refectory, or were unable to attend the exercise program, making it impossible to randomly assign membership to one or another group. Nonetheless, the homogeneity of the groups was verified by the absence of initial differences in any of the variables (Table 1). Second, the number of subjects in the study was small (n = 18), although the study's longitudinal character could make this limitation of only relative importance. In long-term longitudinal studies, it is difficult to achieve the participants' adherence to the program or to reduce the number of drop-outs (42). Indeed, the numbers of subjects in other studies of much shorter duration (between 2 and 6 months versus the 31 months of the present study) are similar to ours (43) or just slightly greater in the case of the very short duration programs. Third, there was no group that only had the diet without doing the Physical Education classes. Despite these limitations, the existing scientific evidence for the effectiveness of Physical Education classes in improving physical fitness in obese children is inconclusive because of the small number of weekly sessions (usually just one or two) when at least three 60-minute sessions of physical exercise are needed to achieve improvements in aerobic condition (16). However, even a small frequency of Physical Education classes may help reduce sedentary habits (44).

Conclusions

A long-term intervention based on an exercise program with or without a diet program in obese boys improved their physical fitness parameters, especially those related to limb speed, agility, aerobic fitness, and muscular strength in relative and absolute terms. The combined intervention (exercise program plus diet) was the more effective in the short-term for some of the fitness parameters. There were no differences in effectiveness between the two interventions in the long term. The results further confirm the importance of physical exercise in increasing obese children's fitness.

Refrences

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