Effects of a long-term physical exercise program with and without diet on obese boys after six-month detraining

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Background: **Most studies on physical fitness and detraining have been conducted on normal-weight children. Their results indicate that any gains regress to the untrained control values during the detraining period. It, therefore, seems necessary to determine how detraining affects the different fitness parameters in obese children. The aim of the present study was to evaluate the effects of detraining (6 months) on kinanthropometry and the components of physical fitness after an intervention (31 months) consisting of a program of exercise and/or diet for obese boys.**

Methods: **The participants were 18 boys, aged between 8 and 11 years, divided into E and E+D groups according to the program they followed. The E group followed a physical exercise program (three 90-minute sessions/week), and the E+D group the same 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, standing broad jump, hand-grip strength, sit-ups, bent-arm hang, 10×5-metre shuttle run, and 20-metre endurance shuttle run. The Kruskal-Wallis test was applied to reveal overall intergroup differences (E and E+D groups), and measurements showing significant differences were further analysed for differences between individual groups by the Mann-Whitney *U* test.**

Results: **In both groups, changes were observed in various physical fitness parameters, especially limb speed (E group, *P*=0.001; E+D group, *P*=0.002), agility (E group, *P*<0.001; E+D group, *P*<0.001), and aerobic fitness (E group, *P*=0.009; E+D group, *P*=0.002).**

Conclusion: **Detraining after a long-term intervention based on the combination of exercise program and exercise program plus diet in obese boys does not affect the changes attained during the intervention.**

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Introduction

Globally, obesity is affecting a growing proportion of children, especially over the past three decades.[1] Thus, childhood obesity has been described as the principal childhood health problem in developed countries.[2] Exogenous obesity arises from a sustained energy imbalance and a variety of other factors involved in its development: genetic, behavioural, cultural, environmental, and economic.[3] Governments internationally are acting to implement strategies for the prevention of obesity, and behavioural changes relating to diet and physical activity are an integral component of any such strategy.[4] However, evidence about the most effective means of preventing the development of obesity in children is sparse. Thus, a recent Cochrane Library review points to the need for longitudinal studies. These would provide invaluable information about the sustainability of the beneficial effects of these interventions in overweight and obese children.[4]

Most studies have confirmed that obese children and teenagers have poorer physical fitness and motor coordination than their normal-weight counterparts.[5,6] There are several components to physical fitness: cardiorespiratory fitness, muscular endurance, muscular strength, flexibility, coordination, and speed.[7] There have been studies analysing these components following a program of exercise or exercise plus diet in obese children, but there seem to have been none which consider how detraining influences these parameters. Detraining has been defined as the partial or complete loss of training-induced anatomical, physiological, and performance adaptations as a consequence of training reduction or cessation.[8] A better understanding of the detraining phenomenon will provide educators, coaches, and clinicians with useful information for developing exercise guidelines, designing in-season conditioning programs, and rehabilitating injuries.[9]

A recent review has noted that the effects of detraining in cases of pediatric obesity have been studied insufficiently.[10] The few works that have been published on detraining analyze its influence on different kinanthropometric and blood parameters in obese children.[10,11] To date, most studies on physical fitness and detraining have been conducted on normal-weight children. Their results indicate that, after short training periods (8-12 weeks), any gains regress to the untrained control values during the detraining period. It therefore seems necessary to determine how detraining affects the different fitness parameters in obese children. The objective of the present study was to evaluate the effects of detraining (6 months) on kinanthropometry and the components of physical fitness after an intervention (31 months) of exercise program and exercise program plus diet in obese boys.

Methods

Subjects

A total of 135 subjects were invited to participate through the collaboration of various schools in the town of Cáceres, Spain. The inclusion criteria were: (1) a body mass index (BMI) equal to or greater than the 97th percentile for the age and sex (male) of the subject, and (2) age between 8 and 11 years as defined by Spanish population curves.[12] Subjects were excluded if they: (1) were regularly practising physical activity, or following an exercise program or some other therapy (*n*=65); (2) were involved in any weight control program (*n*=18); (3) were taking any medication (*n*=8); (4) had any type of dysfunction limiting their physical activity (*n*=2); (5) were due to other reasons (*n*=24). The principal motive for "other reasons" was when parents could only bring their children to the pavilion for one or two weekly sessions due to constraints of their work, instead of the three conforming the physical exercise program. The final sample consisted of 18 Caucasian boys (10.7±0.9 years). They were divided into two groups: the E group who followed a multi-sports exercise program (*n*=8, 10.9±1.0 years), and the 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). The parents of all children completed an informed consent form. The study was approved by the Bioethics and Biosecurity Committee of the Universidad de Extremadura (Spain) and followed the principles of the *Declaration* of *Helsinki*.

Exercise program

The exercise program was based in a multi-sports hall, supervised by two MSc's in sports sciences (García-Hermoso A and Dominguez AM), and under the overall supervision of two PhD's in sports sciences (Saavedra JM and Escalante Y). The program was of three weekly 90-minute sessions. It comprised a warm-up (15-20 minutes), a main part consisting of pre-sports and multi-sports games with a moderate to vigorous intensity aerobic component (60-65 minutes), and a cool-down (5-10 minutes). In so far as possible, we respected the sporting interests and tastes of the research subjects, giving them different activities per session to choose from, encouraging cooperative activities and interpersonal relationships. 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 physical activity monitor.[13] This uniaxial accelerometer contains a triple-layer piezoelectric bender which measures the intensity of movement in the vertical plane. Its validity has been demonstrated as a method for estimating energy expenditure in children,[14] and it has been used in various other studies.[13] Although it does not record such activities as rowing or swimming, no activity of this type was used either in the exercise program or in the subjects' daily physical activity for the duration of the study.

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 (230 sessions). Quantifying the intensities of 13 of the sessions per 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. 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' physical activity, ensuring that the intensity was similar in the two groups. In developing treatment strategies for obesity, one requires quantitative information on physical activity to provide more effective goals.[15]

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.[16] Thus, the diet prescribed was of 1500 kcal/day, similar

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to that of other studies.[17] 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's parents for the control and monitoring of the diet.

Measurements

Each subject was evaluated for the following parameters: eating habits, daily physical activity, pubertal status, kinanthropometry, and physical fitness. The evaluations were made at the start (baseline), at 31 months (3rd-year), and at 37 months (detraining) into the program.

Eating habits

Nutrition was assessed with a self-reported 3-day food record (2 week days 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. A computerized database Nutriber was used to calculate the daily intake.[18] Thus, the program recorded the average of the three days (kcal/day).

Daily physical activity

Daily physical activity was measured before the intervention, during the follow-up, and at detraining with a validated uniaxial accelerometer (Caltrac) covering a 3-day period (Thursday, Friday, and Saturday), except during bathing and swimming (Fig. A). 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 subjects recorded the number of "motion counts" of the accelerometer, following previously published protocols.[13] The final Caltrac score was recorded, as also was the average of the three days (motion counts per day).

Pubertal status

Pubertal stage was evaluated by a trained pediatrician according to pubic hair development using the Tanner classification criteria (Fig. B).[19]

Kinanthropometry

The kinanthropometric measurements followed the ISAK protocol:[20] body height, body weight, and body fat mass (bio-impedance). Standard equipments were used: a scale-mounted stadiometer (Seca, Berlin, Germany), a weight scale (Seca, Berlin, Germany) and a bio-impedance 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.[12]

Physical fitness

The Eurofit Fitness Testing Battery that was used contained a total of eight items. Each item was scored in the order established for the battery's validity and reliability.[21] This standardized test battery was devised by the Council of Europe for children of school age. It has been used in many European schools since 1988, and in literature studies on obese children. All tests were conducted according to standard procedures, in indoor sports facilities in the Faculty of Sports Science (Universidad de Extremadura, Spain) by two MSc's in sports science (García-Hermoso A and Domínguez AM). The tests evaluated were: flamingo balance, plate tapping, sit-and-reach, standing broad jump, hand-grip test, sit-ups in 30 seconds, bent-arm hang, 10×5-metre speed shuttle run and 20-metre endurance shuttle run. The bent-arm hang test from the originally planned battery could not be completed satisfactorily by a number of children. This item was therefore

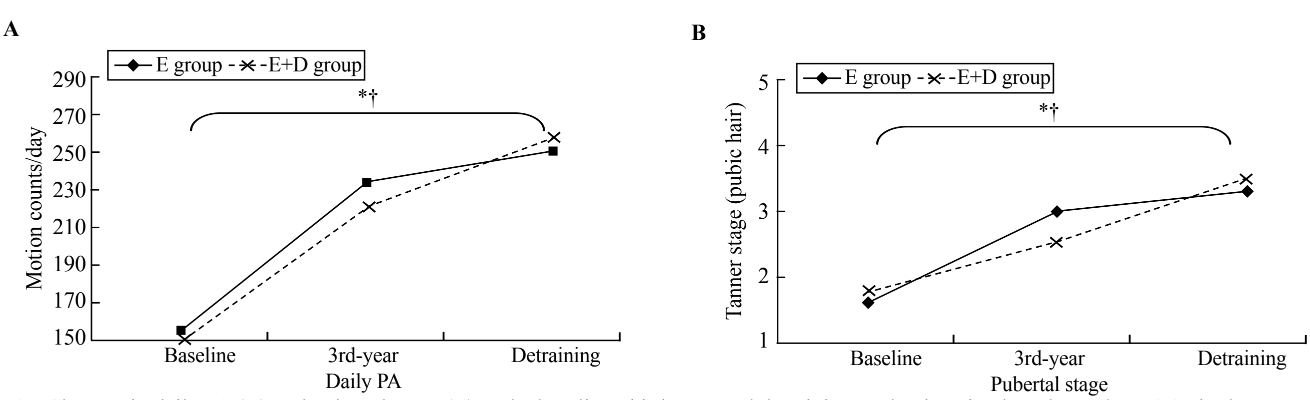

Fig. Changes in daily PA (**A**) and pubertal stage (**B**) at the baseline, third year, and detraining evaluations in obese boys. *: $P<0.05$ in the E group; †: $P<0.05$ in the E+D group. PA: physical activity; E group: exercise group; E+D group: exercise plus diet group.

dropped from further consideration in the study. One of the items evaluated in the study was to hold a one-leg balancing posture ("flamingo balance") for as long as possible on a beam 50 cm long, 4 cm deep, and 3 cm wide, at 4 cm above the ground, taking as the measure the number of attempts needed to complete one minute of balance. Limb speed was measured in a plate-tapping task. Two 20 cm rubber discs were laid horizontally on an adjustable table, placing the edges 60 cm apart with a 10×20 cm rectangular plate midway between the disks. With the non-preferred hand on the rectangle, the subject was required to tap the two discs alternately, passing the free hand over the hand on the rectangle until completing 25 cycles. The number of seconds needed to complete the 25 cycles was recorded. Flexibility was measured according to the standard sit-and-reach test for range of movement (cm). The equipment for these test items was provided by Bodycare (Birmingham, United Kingdom). Explosive power was measured in the standing broad jump test as the distance in centimetres that the subject jumped horizontally. Hand-grip strength was recorded on a grip dynamometer (Takei Kigi Kokyo, Tokyo, Japan), measuring the force of the grip in kilograms of force. Trunk muscle strength was measured by the number of sit-ups performed in 30 seconds. Lastly, two shuttle runs were included in the battery: a 10×5-metre run to indicate speed and agility in seconds (10×5-metre shuttle run), and a 20-metre shuttle run for cardiorespiratory endurance, recording the number of shuttles completed. This test battery is a reliable and valid instrument for the measurement of physical fitness in children, and is commonly used in Europe.[21]

Detraining

At the end of the 3-year intervention programs, the participants were encouraged to join sports activities independently. Thus, 72% of the E group subjects and 75% of the E+D group subjects performed regular physical exercise during detraining, thereby increasing their daily physical activity compared to the baseline (Fig. B). Following detraining, the subjects were invited back to undertake a re-evaluation of their kinanthropometric and physical fitness parameters. The same methods described previously were used in the re-evaluation.

Statistical analyses

All the variables satisfied the tests of homoskedasticity (Levene variance homogeneity test) and normality (Kolmogorov-Smirnov test) of their distributions.

Table 1. Mean and standard deviation in kinanthropometric and physical fitness parameters at the baseline, third year and detraining evaluations in obese boys

Variables	Groups	Intervention time		Detraining time	Kruskal-Wallis		
		Baseline (a)	3-year (b)	6 months (c)			
		Mean±SD	Mean±SD	Mean±SD	H	*P*	Differences
Kinanthropometry							
Weight (kg)	E	62.40±11.10	73.20±11.60	71.50±10.50	3.034	0.219	
	E+D	60.50±11.80	71.90±18.30	77.20±18.40	3.051	0.218	
Fat mass (%)	E	32.20±3.77	29.40±6.19	27.30±3.80	4.357	0.113	a>c
	E+D	33.00±2.92	31.40±3.94	33.00±4.26	1.450	0.484	
Fat free mass (kg)	E	38.10±7.45	44.40±8.47	45.30±8.38	2.008	0.366	
	E+D	39.30±6.99	41.60±9.17	42.30±9.53	1.329	0.514	
BMI (kg/m^2)	E	27.70±2.95	27.20±2.96	25.10±2.60	2.492	0.288	
	E+D	27.90±3.90	27.30±5.31	27.70±5.01	0.330	0.848	
BMI *z*-score	E	4.00±2.85	-0.86±1.70	-1.15±2.99	10.377	0.006	a>c
	E+D	4.19±2.81	-2.06±2.22	-0.98±2.53	15.444	<0.001	a>c
Physical fitness							
Balance (attempts/min)	E	4.86±1.68	2.83±2.86	1.60±0.55	6.343	0.042	a>c
	E+D	6.00±4.50	2.00±2.24	2.00±2.00	8.403	0.015	
Plate tapping (s)	E	14.90±0.90	11.60±1.01	10.50±0.23	14.744	0.001	a>c
	E+D	15.30±3.83	11.10±1.03	10.90±1.00	12.945	0.002	a>c
Sit-and-reach (cm)	E	-3.44±6.94	-3.90±8.57	-2.12±9.80	0.706	0.702	
	E+D	3.40±3.56	5.53±7.20	5.40±8.05	2.053	0.358	
Standing broad jump (cm)	E	112.00±18.80	140.20±28.70	150.20±35.40	7.076	0.029	
	E+D	108.30±15.80	132.30±26.30	146.20±22.90	9.902	0.007	a<c
Hand-grip strength (kg force)	E	42.00±6.55	58.50±9.39	64.50±12.20	13.056	<0.001	a<c
	E+D	37.50±10.20	58.00±21.70	62.70±21.50	7.608	0.022	a<c
Sit-ups (*n*)	E	11.90±4.55	18.50±5.82	20.80±6.68	6.326	0.042	a<c
	E+D	12.20±4.80	21.00±5.80	21.00±2.42	11.966	0.003	a<c
Speed shuttle run (s)	E	23.20±1.39	21.00±1.07	18.90±1.16	13.452	<0.001	a>c, b>c
	E+D	23.90±1.91	19.80±1.53	18.70±1.36	15.103	<0.001	a>c
Endurance shuttle run (*n*)	E	1.69±1.41	4.50±2.10	5.60±2.16	9.327	0.009	a<c
	E+D	2.20±0.79	4.64±1.21	4.50±1.67	12.713	0.002	a<c

E group: exercise group; E+D group: exercise plus diet group; BMI: body mass index; SD: standard deviation.

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

Variables	E	E+D	Mann-Whitney *U*	
	Mean±SD	Mean±SD	*U*	*P*
Kinanthropometry				
Δ Weight (kg)				
3 year-detraining	2.15±0.87	2.50±2.71	19.00	0.774
Δ Fat mass (%)				
3 year-detraining	-0.14±1.06	1.03±1.70	12.00	0.582
Δ Fat free mass (kg)				
3 year-detraining	0.90±1.14	0.69±0.85	20.50	0.943
Δ BMI (kg/m^2)				
3 year-detraining	-1.52±0.90	1.19±2.48	4.00	0.045
Δ BMI *z*-score				
3 year-detraining	-0.13±1.89	1.90±2.60	6.00	0.175
Physical fitness				
Δ Balance (attempts/min)				
3 year-detraining	-0.60±2.51	0.83±1.60	13.00	0.687
Δ Plate tapping (s)				
3 year-detraining	-1.34±1.13	-0.10±0.91	6.00	0.010
Δ Sit-and-reach (cm)				
3 year-detraining	1.60±1.67	0.33±1.04	6.50	0.119
Δ Standing broad jump (cm)				
3 year-detraining	9.60±8.62	12.30±11.10	12.00	0.583
Δ Hand-grip strength (kg force)				
3 year-detraining	9.72±7.73	4.75±6.43	7.00	0.286
Δ Sit-ups (*n*)				
3 year-detraining	1.00±2.55	-1.50±5.54	10.50	0.408
Δ Speed shuttle run (s)				
3 year-detraining	-1.83±1.15	-1.12±0.66	9.00	0.273
Δ Endurance shuttle run (*n*)				
3 year-detraining	0.90±0.65	-0.17±0.88	4.50	0.050

Δ: increase; E group: exercise group; E+D group: exercise plus diet group; BMI: body mass index; SD: standard deviation.

However, we used a non-parametric test which is recommended in cases of small samples.[22] The basic descriptive statistics (means and standard deviations) were calculated. The Kruskal-Wallis test was applied to reveal overall intergroup differences (between the E and E+D groups), and measurements showing significant differences were further analyzed for differences between individual groups by the Mann-Whitney *U* test (baseline *vs.* detraining, and 3rd year *vs.* detraining). 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 test) and homoskedasticity (Levene test). Also, there were no intergroup differences in eating habits, daily physical activity, kinanthropometry, or physical fitness parameters at the start of the program.

Intra-group differences

Table 1 shows the changes and treatment effects in the kinanthropometric and physical fitness parameters at different evaluations [baseline (a), 3rd-year (b), and detraining (c)]. No changes were observed in daily physical activity or pubertal status until detraining (Fig.), indicating that the changes caused by the intervention were not attributable to these variables. In kinanthropometric parameters, for the E group, there were differences between different moments of evaluation in fat mass (a>c), BMI *z*-score (a>c). In physical fitness parameters, for the E group, there were differences between different moments of evaluation in the balance test (a>c), plate tapping (a>c), hand-grip strength (a<c), sit-ups (a<c), 10×5-metre shuttle run (a>c, b>c), and endurance shuttle run (a<c). For the E+D group, there were differences between moments of evaluation in the plate tapping test (a>c), standing broad jump (a<c), hand-grip strength (a<c), sit-ups (a<c), 10×5-metre shuttle run (a>c), and endurance shuttle run (a<c).

Inter-group differences

Table 2 shows the intergroup differences in the kinanthropometric and physical fitness parameters. The results between the baseline and detraining were not included since there were no differences between the two groups. Differences were observed only in BMI (E group>E+D group between detraining and third year evaluations). In physical fitness parameters, there were differences only in plate tapping (E group<E+D group between the detraining and third year evaluations), and in the endurance shuttle run (E group>E+D group between the detraining and third year evaluations).

Discussion

The present study analyzed the effects of detraining (6 months) on kinanthropometry and the components of physical fitness after an intervention (31 months) of a program of exercise and exercise plus diet in obese boys. The results indicated that the changes in kinanthropometry and physical fitness parameters obtained after both interventions were maintained. Thus, it appears that, with long-term longitudinal interventions, the fitness and body composition values attained remain even after a de-conditioning period.

Intra-group differences

After detraining, differences were found in fat mass in the E group between baseline and detraining (32.2±3.77 *vs.* 27.3±3.80, P=0.040, ES=-1.29). In this regard, there have been studies with opposite results.[10,11,23] Two of them found no changes from the baseline after exercise in the short and medium term.[11,23] The other found an increase in fat mass after detraining (ES=0.81).[10] It would seem that short-term interventions are followed by a rebound effect in body composition.[24] Similarly, we found reductions in the BMI *z*-score after detraining compared to the baseline in the E group (4.00±2.85 *vs*. -1.15±2.99, *P*=0.013, ES=-1.76) and E+D group (4.19±2.81 *vs*. -0.98±2.53, *P*=0.003, ES=-1.93). These results agreed partially with a short-term intervention (12 weeks) in which, after 40 weeks of detraining, the subjects who had carried out a program of exercise plus diet reduced their BMI *z*-score compared to the baseline (ES=-0.46). In contrast, unlike the present study, the exercise group maintained no such differences. However, the mean of this group remained below the criterion considered as obese.[12] A study with a combined (aerobic and strength) medium-term (36 weeks) exercise program found a significant increase in BMI after 12 weeks of detraining, with values reached being even higher than those at the beginning of the program.[23] Although studies support the idea that exercise is very important in preventing the progression of obesity in children,[25] longitudinal intervention seems necessary to maintain these improvements in kinanthropometric parameters after application of the program.

Regarding fitness, both groups showed reductions in the plate tapping after detraining relative to the baseline: the E group 14.9±0.90 s *vs*. 10.5±0.23 s, *P*<0.001; and the E+D group 15.3±3.83 s *vs*. 10.9±1.00s, *P*=0.002. It seems that the plate tapping improvements could be due to the exercise program carried out which included such sports as tennis or paddle tennis involving major movements of the upper limbs. Similarly, despite the six months of detraining, this parameter improved over the baseline, perhaps reflecting that a number of the subjects had included racket sports in their everyday lives, or other activities involving the high levels of arm movement. The improvements were similar in the two groups because performance on this test is not influenced by excess fatness.[26] With respect to the standing broad jump, this improved in the E+D group between baseline and detraining (108.3±15.8 cm *vs*. 146.2±22.9 cm, *P*=0.007). The results thus suggest that the detraining did not affect the standing broad jump performance, even though other work has indicated that in children after 8 weeks of detraining there is a loss of strength (leg extension) of 3% per week.[9] Handgrip strength increased in both groups after detraining compared to the baseline: in the E group 42.0±6.55 kg to 64.5±12.2 kg, *P*=0.001; and in the E+D group 37.5±10.2 kg to 62.7±21.5 kg, *P*=0.022. This may be related to a trend of increasing fat-free mass, since obese individuals develop increased fat-free mass as they accumulate excess adiposity, with the increase possibly being to support this extra load.[27] Also, arm-specific activities and resistance weight-training initiatives were incorporated into the exercise program, which could have fostered improvement in this parameter.[5] Trunk strength also increased in both groups between baseline and detraining (E group: 11.9±4.55 rep to 20.8±6.68 rep, *P*=0.042; E+D group: 12.2 ±4.80 rep to 21.0±2.42 rep, *P*=0.003). Nonetheless, all the strength parameters must be considered while bearing in mind the maturational changes generated after the children's detraining.[28] In the 10×5 metre shuttle run test, there were improvements in times in both groups (E group: 23.2±1.39 s to 9.18±1.16 s, *P*<0.001; E+D group: 23.9±1.91 s to 18.7±1.36 s, *P*<0.001). Thus, both interventions appear to be beneficial in the long-term in improving the agility of obese subjects. Similarly, the results showed a significant improvement in the E group after detraining (21.0±1.07 s to 18.9±1.16 s, *P*=0.033). This could indicate that the healthy habits generated during the intervention, with the performance of increased physical activity, favours the subjects' agility. Finally, there was an improvement in the endurance shuttle run test in both groups (E group: 1.69±1.41 shuttles to 5.60±2.16 shuttles, *P*=0.005; E+D group: 2.20±0.79 shuttles to 4.50±1.67 shuttles, *P*=0.004). Such improvements have also been found in different programs of aerobic exercise in isolation[29] or in combination with diet.[30] On the other hand, programs of aerobic exercise improve the low-density lipoprotein cholesterol and total colesterol concentrations.[31] But with respect to detraining, a study in an obese pediatric population found no change in this parameter after 12 weeks of aerobic exercise and another 12 weeks of detraining.[10] The present results indicate that the improvements after both longitudinal interventions are maintained after detraining. This could be due to the tendency for fat mass to decrease in this period, which would go together with an improvement in cardiorespiratory fitness.[32]

Inter-group differences

The results showed a smaller change in BMI in the E group than in the E+D group during the period of detraining (-1.52±0.90 *vs*. 1.19±2.48; *P*=0.045; ES=-1.53). Thus, despite the analysis of the daily physical activity performed by the two groups during detraining no differences were found in this respect. Therefore, this finding suggests that detraining more acutely affected the subjects who followed the combined intervention program, and that in the long-term physical exercise alone may be more beneficial as an intervention to treat childhood obesity, even though another study[11] found no differences between the two interventions after the detraining period. Whichever the case, both interventions were followed by increased BMI after that time.

With respect to physical fitness, the results showed

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greater improvement in the E group than in the E+D group, particularly during the period of detraining. In particular, there was greater improvement in the E group in the endurance shuttle run test (0.90±0.65 shuttles *vs*. 0.17±0.88 shuttles, P=0.050). This is because the kinanthropometric and blood parameters could indirectly affect the physical condition of obese subjects.[11] For example, poorer cardiorespiratory fitness performance is related to higher BMI (the heavier a person is, the less likely he or she is to be physically fit). These positive differences could be seen in the E+D group because healthier habits had been generated in the E group. Thus, studies on the subjects have suggested that only those activities which are capable of improving cardiorespiratory endurance are able to generate changes in BMI, and vice versa.[33]

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. 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. Third, we did not record the type of activity performed by each subject during the course of detraining. Such information could have been useful in interpreting the results.

In conclusion, detraining after a long-term intervention based on the combination of exercise program and/or diet in obese boys does not affect the changes attained during the intervention. The exercise alone intervention was more effective in cardiorespiratory endurance after the detraining. These results highlight the importance of exercise itself in maintaining the benefits obtained in the PF parameters in obese children.

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