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Physical exercise, detraining and lipid profile in obese children: a systematic review

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ABSTRACT
Introduction. Detraining is the loss of improvements obtained through the participation in physical exercise/training after training cessation, an aspect that has been poorly studied in obese child population. Therefore, the purpose of this study was to assess the effects of detraining on the lipid profile (HDL, LDL, total cholesterol and triglycerides) of obese children.
Population and Methods. Studies were collected through a search across seven databases. The search was limited to physical exercise programs that lasted, at least, eight weeks and the corresponding detraining, with an assessment of obese children lipid profile. Effect size (ES), 95% confidence intervals and study heterogeneity were estimated using Cochran's Q test (random effects model).
Results. Five studies complied with the inclusion criteria and were selected for review (n= 330). In general, intra-group results (posttest versus detraining) indicated that, following detraining, blood levels of HDL cholesterol (ES= 0.12) and total cholesterol (ES= 1.41) were increased. Likewise, inter-group results (experimental group versus control group) confirmed the increase of HDL cholesterol following detraining (ES= 0.49).
Conclusions. The results of this systematic review suggest that detraining after a physical exercise program does not lead to a significant loss of the benefits gained in relation to the lipid profile of obese children. However, given the number of analyzed studies and the heterogeneity observed in the analyses and the period defined as detraining (12 to 48 weeks), a higher number of well designed studies is required to obtain more conclusive results.
Key words: *detraining, metabolic risk, healthy habits, obesity, children.*

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INTRODUCTION

The global prevalence of childhood obesity has drastically increased in the past three decades, and has been defined as the pandemic of the 21st century.[1] It has been described as the main health problem among children in developed countries.[2] Exogenous obesity is caused by an imbalance in sustainable energy and various factors that have an impact on its development: genetic, behavioral, cultural, environmental and economic factors.[3] This condition is associated with different cardiovascular risk factors in children and adults.[4] Therefore, governments worldwide are working on the implementation of comprehensive healthy strategies aimed at preventing childhood obesity and promoting healthy lifestyles.[5]

The effects of healthy habits and physical exercise on cardiovascular risk in children are well-known.[6] In this sense, several systematic reviews and meta-analyses have been conducted in obese children.[6-8] In fact, it is estimated that physical exercise is moderately effective as a preventive treatment for obesity,[6] although it seems to specifically reduce systolic and diastolic blood pressure at rest.[8] In relation to the lipid profile, aerobic physical exercise favors the reduction of different parameters (LDL and triglycerides [TG]).[7] In addition, physical exercise programs with an average duration combined with a hypocaloric diet have positive effects on the lipid profile.[9]

Despite existing evidence regarding physical exercise and lipid profile in the obese child population, yet no systematic review has analyzed the influence of detraining on these parameters. Detraining is defined as a partial or total loss of anatomical, physiological and performance improvements induced by training as the result of training/physical exercise reduction or cessation.[10] Information regarding the effects of detraining on younger populations is scarce and results have been controversial.[11-14] In the case of adults, the situation is similar, with negative effects on lipid metabolism[15] or no changes at all.[16,17] In this context, the objective of this study was to assess the effects of detraining (cessation of scheduled physical exercise) on the lipid profile (HDL, LDL, total cholesterol [TC] and TG) of obese children.

POPULATION AND METHODS

Design

Systematic review.[18]

Literature search

Included electronic bibliographic databases were CINAHL (from 1937 to August 3rd, 2013), Cochrane Central Register of Controlled Trials (CENTRAL) (from 2002 to August 3rd, 2013), EMBASE (from 1980 to August 3rd 2013), ERIC (from 1966 to August 3rd, 2013), MEDLINE (from 1965 to August 3rd, 2013), PsycINFO (from 1987 to August 3rd, 2013) and Science Citation Index (from 1900 to August 3rd, 2013). Manual searches were carried out. The search was conducted from July 20th to August 3rd, 2013. Firstly, five categorical searches were done using the following key words: (1) "exercise"; (2) "child"; (3) "obesity"; (4) "overweight"; (5) "detraining"; (6) "lipid profile." Secondly, categories were combined using "and" and excluding duplicate articles.

Study selection

Studies included in the systematic review met the following criteria: (1) Subjects: children (6-14 years old) diagnosed with obesity; (2) Study type: randomized controlled trial (RCT) or quasi-experimental study (QES), with or without a control group; (3) Intervention type: physical exercise program, predominantly aerobic; (4) Program duration: at least eight weeks; and (5) Assessment of, at least, one lipid profile parameter following physical exercise (posttest) and following detraining (no physical exercise program): HDL, LDL, TC and TG. Similarly to other studies, inclusion criteria were restrictive so as to obtain a homogenous study sample.[7,8,19]

Risk of bias

Study quality was assessed using the Physiotherapy Evidence Database (PEDro) scale.[20]The purpose of this scale is to quickly identify RCTs or QESs that are more likely to have sufficient internal validity, contain sufficient statistical information to obtain interpretable results, and determine their external validity. The PEDro scale rates the presence of evidence quality indicators (1 point) or the absence of such indicators (0 points), for a score of up to 10 points.

Data extraction process

Two authors (AG and JMS) separately reviewed study titles and abstracts of potentially eligible studies identified through the search strategy. The authors then extracted data from each selected article: (1) subject characteristics (number, age, gender, race and definition of overweight or obesity); (2) physical exercise program characteristics (type, duration, frequency and intensity); (3) lipid profile assessment and characteristics; and (4) results (posttest and detraining). Any disagreement between both authors was resolved by repeating data extraction and subsequently reaching consensus among authors (YE).

Statistical analysis

The primary result of the systematic review were changes in the different lipid profile parameters (milligrams versus deciliters). Effect sizes (ESs) and 95% confidence intervals (CIs) were estimated for each study using the *t*-statistics, number of subjects and standard deviation (SD) by means of a random effects model.[21] If SD was not available, the standard error was used for estimations (SE, SD= SE $\sqrt{n}$). Cohen's categories were used to assess the effect size (small if $0 \leq |d| \leq 0.5$; medium if $0.5 < |d| \leq 0.8$, and large if $|d| > 0.8$).[22] This way, intra-group changes (posttest versus detraining in the same physical exercise group) and inter-group (detraining in the intervention group versus control group).

Study heterogeneity was assessed using Cochran's Q test.[23] The percentage of the total variability among studies due to heterogeneity was determined using the I^2statistic test. I^2 values <25%, between 25% and 50% and >50% were used to account for small, medium and large inconsistencies, respectively.[24]

Finally, the impact of each study on overall results was assessed by means of a sensitivity analysis whereby each study was excluded from the model once, and then the various analyses corresponding to each lipid profile parameter were conducted.

RESULTS

Study selection

Four hundred and sixty-one articles were identified as potentially relevant. Of these, 420 were excluded because they did not meet inclusion criteria as per their abstracts. The whole text of the remaining 41 eligible studies was then assessed. Of these,36 studies were excluded. Finally, the systematic review included five studies *(Figure 1).*

Study and intervention characteristics

Table 1 shows the characteristics of the five studies (n= 330).[20,25-28]

Risk of bias

Only one study met, at least, 50% of methodological quality criteria proposed by the PEDro scale (*Table 1*).[20]

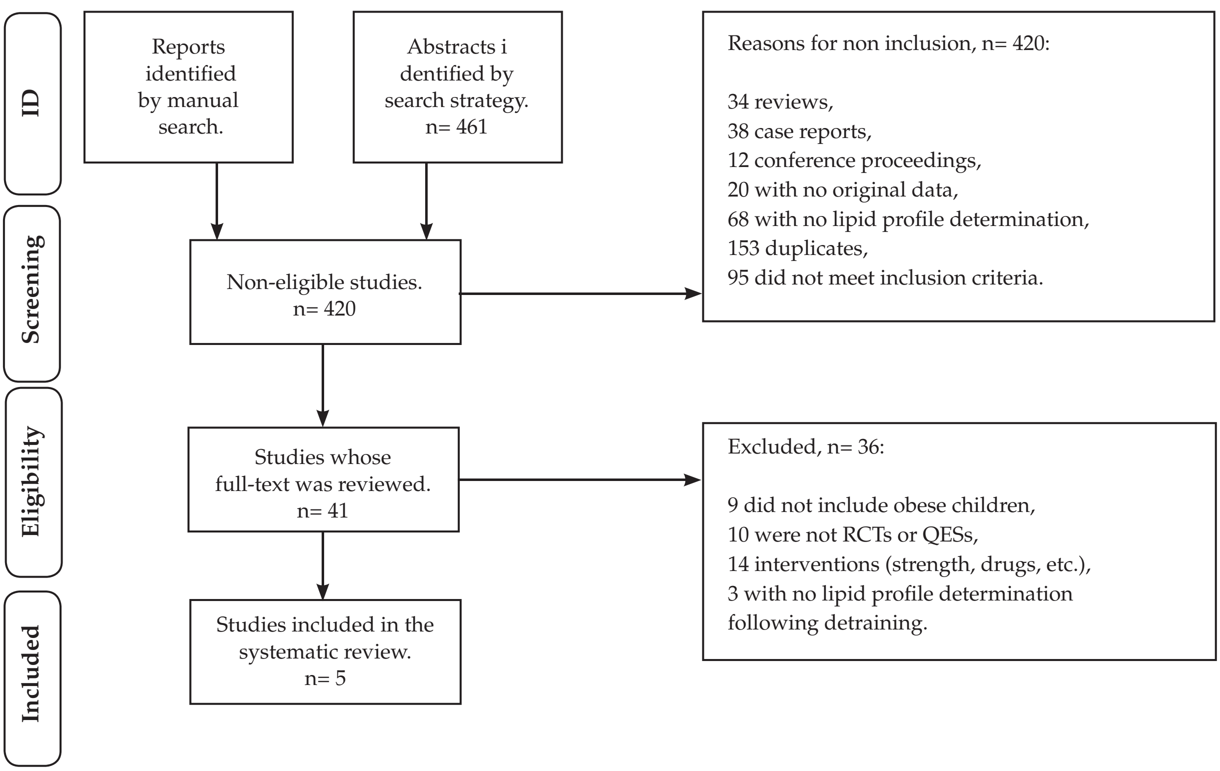
Subjects

A total of 330 children were included in the analysis. All studies included boys and girls in their design. Different classifications were used to define obesity in subjects: one of the studies used the 85th percentile of the tricipital skinfold thickness;[28] three studies used the national Germany classification criteria (≥97th percentile),[29] South Korea (>95th percentile)[26] and China (≥95th percentile);[27] while the remaining article did not clarify the classification used[25] (*Table 1*). Finally, in terms of child race, one study included Asian, Caucasian and African American children,[28] while two studies only included Asian children.[26,27] Such information was not included in the remaining studies.

Characteristics of the physical exercise program

The main workout was using machine-based exercises, e.g., bicycle ergometer, treadmill, elliptical trainer,[28] team sports, racing, jumping on a trampoline[25,29] and different games.[28] In two of the studies,[25,27] part of the workout session was made up of strength exercises, using mainly the subject's own body weight. Two of the studies did not report the type of aerobic exercise.[26,27] Program structure was heterogeneous; duration ranged between 12 weeks[25] and 48 weeks[20]; frequency was 2 to 5 days per week;[27] and duration of sessions ranged from 40 minutes[28] to 90 minutes.[20,25-27] In terms of physical exercise intensity, different parameters were applied for control (beats per minute and reserve heart rate) (*Table 1*). Likewise, only two of the analyzed studies reported on attendance to the physical exercise program,[25,28] with values over 70% in both cases. Finally, the design of two of the studies included an educational program

FIGURE 1. *Flow chart of studies included in the systematic review*



aimed at children[27] and parents,[29] with diet recommendations based on the "traffic light diet" (which classifies food as "green": recommended food; "orange": moderately recommended food; and "red": forbidden food)[29] and an optimal calorie intake as per the standards.[27]

Detraining

In terms of detraining duration, and similarly to what has been observed regarding physical exercise programs, there was great variability in the time elapsed following the exercise program. Such period ranged between 12 weeks[26,27] and 48 weeks[29] (*Table 1*).

Lipid test characteristics

Lipid and lipoprotein tests were performed in the morning with a 10[25,29] to 12 hour[26,28] fasting. However, such information was not provided by one of the studies.[27] Tests were done before and after the physical exercise program and after the scheduled detraining period.

Change in lipid parameters following detraining

Table 2 shows posttest and detraining values for each outcome measure (HDL, LDL, TC, TG) indicated in each study. The effect size and 95% confidence interval were estimated for each study using a random effects model. Following detraining, blood levels of HDL (intra-group: ES= 0.12; 95% CI 0.02-0.29; p= 0.049; inter-group: ES= 0.49;95% CI 0.18-0.81; $p < 0.001$) and TC were increased (intra-group: ES= 1.41; 95% CI 1.13-1.69; $p < 0.001$), although values were greatly heterogeneous (I^2= 65-78%).

Sensitivity analysis

Following the removal of each study in relation to the four assessed parameters, results did not differ only in terms of HDL cholesterol (omitting Chang., et al.'s study)[27] (*Table 3*).

DISCUSSION

This is the first systematic review that analyzed the evidence regarding the effect of detraining on physical exercise programs on the lipid profile of obese children. Results showed that, following detraining, blood levels of HDL cholesterol and TC were increased. This fact confirms the importance of physical exercise as an approach to improve the lipid profile since it does not seem to result in a significant loss of benefits gained in obese children. However, given the number of analyzed studies and heterogeneity observed in the analyses and the period considered detraining (12 to 48 weeks), caution should be exercised when interpreting these results.

Few studies have determined, through their interventions, the impact of detraining following physical exercise programs in children, and results observed in the literature have been controversial. A recent study on obese children

TABLE 1. *Characteristics of the studies included in the systematic review*

Study	Experimental group			Intervention characteristics							
	n	Age*	Type	BMI (percentile)	Duration (weeks)	Weekly frequency (times)	Session duration (min)	Intensity (%)	Detraining (weeks)	PEDro scale	Study type
Chang et al.[27]	25	12.5 (0.61)	Multiple sports	≥ p95	36	2-5	60-90	150-160†	12	3	ECA
Ferguson et al.[28]	40	7-11	Machines + sports	≥ p85‡	16	5	40	> 150†	16	5	ECA
Reinehr et al.[29]	203	6-14	Multiple sports	≥ p97	48	1	60	NI	48	4	ECE
Shalitin et al.[25]	52	8.21 (1.78)	Multiple sports + strength	≥ p95	12	3	90	NI	40	4	ECA
Woo et al.[26]	10	11.30 (1.70)	Aerobics	≥ p95	24	NI	NI	45-65§	12	4	ECE

RCT: randomized controlled trial; QES: quasi-experimental study; BMI: body mass index; p: percentile; NR: not reported; PEDro: Physiotherapy Evidence Database.

* Data are expressed as mean (standard deviation) or range; † beats per minute; ‡tricipital skinfold thickness; § reserve heart rate.

shows that, following a 3-year physical exercise program and a 6-month detraining period, fat mass and cardiorespiratory endurance (among other parameters) remained stable, and were even improved.[13] The situation in relation to lipid parameters is similar in the adult population: they are not modified following detraining.[16,17] On the contrary, other studies have reported losses of fitness benefits gained in children[11,12] and adolescents.[14] This systematic review showed that HDL cholesterol increased following detraining, and this is confirmed upon analyzing intra-group (ES= 0.12; 95% CI 0.02-0.29) and inter-group results (ES= 0.49; 95% CI 0.18-0.81). In addition, TC level was also increased following detraining (ES= 1.41; 95% CI 1.13-1.69). However, it is necessary to consider that the study with the highest number of subjects (n= 203)[22] was not included in this analysis because it did not assess this lipid parameter. At a first glance, it seems that physical exercise may have a positive impact on obese children by generating healthy habits, as reflected by the improvement of lipid parameters, even after detraining. This way, maintaining and/or improving physical exercise-induced benefits during detraining may be partially influenced by the size of initial benefits and the subjects' everyday habits. Therefore, this systematic review suggests that not all physical exercise-induced benefits in children are transient and reversible, which has been confirmed in the child population;[12] for example, this prevents an impairment in their lipid metabolism.[17]

Besides, HDL cholesterol results (sensitivity analysis) indicated that one of the studies included in the analysis[27] had a great impact on final results. The authors of that study[27] included an educational habits program in their design, which may have influenced on physical activity once it ended.[6] Therefore, it appears that this type of comprehensive program helps to maintain the benefits of physical exercise and avoid morbidities associated with obesity. However, the two articles included in the inter-group analysis[20,27] offered a long-term program (36-48 weeks). This may indicate the need to offer long-term physical exercise programs so that impairment following detraining is lower,[5] as confirmed in the obese child population.[13] This way, such proposal may help healthcare professionals to encourage an active lifestyle and physical activity habits so that their patients maintain such habits and their benefits into their adult life.

Finally, there are certain limitations in this systematic review. Firstly, the small number of included studies (n= 5). Secondly, the great heterogeneity in the period of detraining, which

Table 2. *Posttest, detraining (mean [SD]) and effect size values for the different lipis parameters*

	HDL (mg/dL)			LDL (mg/dL)			TC (mg/dL)			TG (mg/dL)		
	Posttest*	**Det.**	**ES**	**Posttest***	**Det.**	**ES**	**Posttest***	**Det.**	**ES**	**Posttest***	**Det.**	**ES**
Chang et al.[27]	45.5 (6.30)	56.0 (14.7)	0.93	84.0 (18.2)	94.5 (25.6)	0.47	136.2 (18.6)	175.9 (28.2)	2.16	79.7 (25.7)	132.9 (64.6)	1.08
Ferguson et al.[28]	41.7 (6.65)	41.6 (6.65)	-0.02	81.6 (17.8)	89.6 (17.5)	0.45	141.4 (17.9)	158.9 (19.7)	0.93	84.1 (5.31)	78.8 (5.31)	-1.00
Reinehr et al.[29]	49.0 (25.0)	49.5 (25.2)	0.02	113.0 (57.6)	112.9 (57.6)	0.00	NR	NR		119.9 (61.2)	116.3 (59.3)	-0.06
Shalitin et al.[25]	49.3 (10.4)	50.6 (12.1)	0.15	103.0 (25.7)	94.0 (29.6)	-0.69	107.7 (30.3)	166.4 (36.0)	1.76	91.7 (48.1)	107.9 (59.5)	0.30
Woo et al.[26]	NR	NR	-	NR	NR	-	165.7 (34.6)	183.9 (23.1)	0.62	154.5 (38.5)	163.5 (23.6)	0.28

* Results obtained following the physical exercise program; TC: total cholesterol; TG: triglycerides; ES: effect size; Det.: detraining; NR: not reported.

Table 3. *Sensitivity analysis for each lipid parameter*

Excluded study	HDL		LDL		TC		TG	
	ES (95% CI)	**p**	**ES (95% CI)**	**p**	**ES (95% CI)**	**p**	**ES (95% CI)**	**p**
Chang et al.[27]	0.03 (from -0.13 to 0.19)	0.70	-0.06 (from -0.22 to 0.11)	0.49	1.27 (from 0.96 to 1.57)	< 0.001	-0.10 (from -0.26 to 0.06)	0.23
Ferguson et al.[28]	0.13 (from 0.04 to 0.28)	0.04	-0.08 (from -0.25 to 0.09)	0.33	1.69 (from 1.34 to 2.04)	< 0.001	0.11 (from -0.06 to 0.28)	0.19
Reinehr et al.[29]	0.23 (from 0.01 to 0.49)	0.03	-0.04 (from -0.30 to 0.22)	0.76	-	-	0.05 (from -0.20 to 0.31)	0.68
Shalitin et al.[25]	0.12 (from 0.08 to 0.27)	0.05	0.11 (from -0.06 to 0.28)	0.21	1.19 (from 0.84 to 1.55)	< 0.001	-0.08 (from -0.25 to 0.09)	0.37
Woo et al.[26]	-	-	-	-	1.49 (from 1.20 to 1.79)	< 0.001	-0.03 (from -0.19 to 0.14)	0.75

TC: total cholesterol; TG: triglycerides; ES: effect size; CI: confidence interval.

ranged between 12 and 48 weeks. Such aspect may have an impact on results and be a major source of bias. Thirdly, results were analyzed at an intra-group level (posttest versus detraining) because not all included studies provided data that would allow to compare them to a control group. However, inter-group results (experimental group versus control group)[20,27] confirm general findings in terms of HDL cholesterol. Lastly, no study assessed daily habits during the study period (diet, physical activity, physical exercise, etc.), although they may have an effect on results following detraining. The main strength of this review is that its restrictive inclusion criteria may favor a greater study homogeneity.

CONCLUSIONS

The results of this systematic review suggest that detraining after a physical exercise program does not lead to a significant loss of the benefits gained in relation to the lipid profile of obese children. So much so that these physical exercise programs (36-48 weeks) seem to develop healthy habits that last following cessation and favor a subsequent increase in total cholesterol and HDL levels. More studies including longitudinal interventions are required on this topic and on their influence on detraining in relation to obesity-related metabolic parameters. Therefore, shorter participation periods or periods of inactivity due to injuries or school holidays may be studied as detraining periods. However, it seems necessary to reach a consensus on the minimum period that is considered detraining and conduct studies in this regard. ■

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