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Can hepatic steatosis compromise the effect of physical exercise on body composition in obese children and adolescents?

Esteatose hepática pode comprometer o efeito do exercício físico sobre a composição corporal em crianças e adolescentes obesos?

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Abstract - Physical exercise is one of the forms of prevention and treatment of obesity and associated diseases such as hepatic steatosis. The aim of this study was to analyze whether hepatic steatosis interferes in the effect of physical exercise on the body composition of obese children and adolescents. The sample consists of 40 obese individuals, 13 children (8.17±1.33 years) and 27 adolescents (12.28±1.36 years). Total and segmental body composition was estimated by DEXA. Anthropometric measurements were performed, as well as ultrasound examination of the liver to measure intra-abdominal and subcutaneous fat, and to diagnose hepatic steatosis (HS). The intervention consisted of 20 weeks, with recreational/competitive activities being applied to children and, for adolescents, concurrent training (aerobic and resistance). The Levene's, repeated-measures ANOVA and effect size tests (ES) by Eta-Squared were performed. It was observed that, although not statistically significant, analyzing the effect size, physical activity in both children (body fat ES effect time= 0.210 and ES effect group= 0.208; fat mass ES effect group= 0.338; fat android ES effect Interaction= 0.267), and adolescents (intra-abdominal fat ES effect group= 0.230) regardless of whether or not HS was effective in reducing body fat. Therefore, exercise was effective in improving the body composition of obese children and adolescents, regardless of HS.

Key words: Adolescent; Child; Exercise; Fatty liver; Obesity.

Resumo – *O exercício físico é uma das formas de prevenção e tratamento da obesidade e doenças associadas como a esteatose hepática. Objetivou-se analisar se a esteatose hepática interfere no efeito do exercício físico sobre a composição corporal de crianças e adolescentes obesos. A amostra consiste em 40 indivíduos obesos, sendo 13 crianças (8,17±1,33 anos) e 27 adolescentes (12,28±1,36 anos). A composição corporal total e por segmento foi estimada pelo DEXA. Realizou-se medidas antropométricas, bem como, o exame de ultrassom do fígado para mensurar a gordura intra-abdominal e subcutânea, assim, diagnosticar a esteatose hepática (EH). A intervenção foi composta por 20 semanas, sendo aplicadas nas crianças, atividades lúdico-recreativas/competitivas e para os adolescentes, treinamento concorrente (aeróbio e resistido). Foram realizados os testes de Levene, ANOVA de medidas repetidas e o tamanho do efeito (TE) pelo Eta-Squared. Observou-se que, apesar de não obter significância estatística, analisando o tamanho do efeito, o exercício físico tanto nas crianças (gordura corporal TE efeito tempo= 0,210 e TE efeito grupo= 0,208; massa gorda TE efeito grupo= 0,338; gordura andróide TE efeito interação= 0,267), quanto nos adolescentes (gordura intra-abdominal TE efeito grupo=0,230), independentemente se tinham ou não a EH foi eficaz para reduzir a gordura corporal. Observa-se que o exercício físico foi eficaz na melhora da composição corporal de crianças e adolescentes obesos independente da EH.*

Palavras-chave: *Adolescente; Criança; Exercício; Fígado gorduroso; Obesidade.*

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INTRODUCTION

Obesity is a chronic disease characterized by excessive body fat accumulation, and has multiple causes related to genetics and life habits[1]. It is estimated that there are 170 million overweight young people worldwide, and in Brazil, the estimated incidence is 47.8%[2]. Among the complications associated with obesity, non-alcoholic fatty liver disease (NAFLD) has been investigated because it is a disease that is directly related to macronutrient metabolism[3], whereas liver impairment may delay and make it difficult to treat obesity and contribute to the onset of other diseases[4].

NAFLD is a clinical-pathological condition characterized by excessive accumulation of lipids in hepatocytes, ranging from simple hepatic steatosis (HS), non-alcoholic steatohepatitis (NASH), fibrosis, and can trigger hepatic carcinoma or even cirrhosis[5]. The literature characterizes NAFLD as a manifestation of the metabolic syndrome[6], and suggests the early diagnosis so that the disease is treated while reversible, as is the case of HS[7]. Non-medicated treatments for this disease in obese individuals are important contributors to reduce liver fat, practice of physical exercises associated with changes in eating habits[8].

Concerning the treatment of obesity and HS in young people, some peculiarities deserve attention; health experts indicate recreational exercises because they are attractive and motivational exercises capable of collaborating with the motor development of children, concomitantly providing benefits to the quality of life increasing daily energy expenditure[1]. Another way to promote body fat reduction is through systematized activities, indicated for adolescents who already have more refined physical abilities capable of performing activities that require greater motor coordination and body awareness.

Training protocols that combine aerobic exercises with resistance exercises (concurrent training) are alternatives that, according to literature, can help reduce the risk factors associated with obesity[1,9]. This is due to the fact that this training model stimulates different metabolic pathways in the same training session. Studies using young population with HS have shown improvements in body composition through different training protocols, whether systematized training occurring with adolescents, and even physical exercises through predominantly aerobic activities with children[10,11]. However, analyses were performed without adjustment for confounding factors, and the results found may have several explanations, not the effect of the exercise itself. In addition, it is still little investigated whether in children and adolescents, the result of physical exercise may be different between those with or without HS, and if excess fat in hepatocytes is responsible for hindering the metabolism of macronutrients, especially lipids, during physical exercise. Therefore, the aim of the present study was to analyze the possible interference of HS in the effect of concurrent training and recreational activities on body composition of obese children and adolescents.

METHODOLOGICAL PROCEDURES

Participants

The initial sample consisted of 65 individuals, 25 subjects were excluded because they did not perform all the proposed evaluations (n=16), intervention (n=3) or because they exceeded the allowed absences (25%) (n=6). Thus, the final sample consisted of 40 individuals, of which 13 were children aged 5-10 years (8.17±1.33), six girls and seven boys, and 27 adolescents aged 11-16 years (12.28±1.36), 13 girls and 14 boys. Participants were recruited through media resources. The inclusion criteria were: to be classified as obese according to criteria established by Cole et al.[12], to have between 5 and 16 years of age at the time of evaluation, do not present any clinical problem that prevented the practice of physical activity and to have the consent form signed by parents and/or guardians. This study was approved by the Ethics Committee of FCT / UNESP (Protocol: 07/2009). The effect of training on obese adolescents was analyzed based on the study by Monteiro et al.[13]. Regarding the risk factors of HS, the sample calculation was performed using the body fat percentage, with a difference to be detected of 3.4%, standard deviation of 5.3%, power of 80% and significance of 5 %, reaching a minimum sample is 38 children and adolescents. Therefore, the present study meets the minimum sample size.

Procedures

Weight and height were measured for the calculation of the body mass index (BMI), as well as trunk stature, for the calculation of the growth velocity peak (GVP) using formulas according to gender proposed by Mirwald et al.[14]. Body fat (BF) (%), trunk fat (TF) (%), android fat (AF) (%), gynoid fat (GF) (%), and total body mass (BM) (kg), lean body fat (LBF) and fat mass (FM) (kg) were estimated using dual energy x-ray absorptiometry (DEXA) and Lunar DPX-NT equipment.

In order to analyze the thickness of the intra-abdominal fat (IF), subcutaneous fat (SF) (cm) and the HS diagnosis, TOSHIBA ultrasound model Aplio was used. SF was measured from the distance between the skin and the face of the rectus abdominis muscle. IF was defined as the distance between the inner face of the same muscle and the anterior wall of the aorta. The HS diagnosis followed recommendations of Saadeh et al.[15]. Ultrasonography assessments, both pre- and post-intervention, were performed by the same radiologist, using recommendations of literature.

Interventions lasted 20 weeks, and were performed in three weekly sessions lasting 60 minutes each day. Activities were organized according to the age group for maximum utilization during activities, thus forming two groups: children aged 5-10 years and adolescents aged 11-16 years.

Children

- **Playful-recreational/competitive activities**

Children performed activities such as walking, racing and competitive games, immersed under the playful view as proposed by Neto[16], aiming at predominantly aerobic activities. Pre-sports activities and a variety of motor circuits were also performed, due to the systematic repetitions of certain movements, also improving physical capacity. The intensity of recreational/competitive activities was measured by means of Polar® S810 cardiac monitors placed in five children randomly selected, which should remain with an average of 65-85% of the maximum heart rate frequency.

- **Adolescents**

Adolescents performed concurrent training during 60 minutes / class, with approximately 30 minutes of resistance training and 30 minutes of aerobic training. The training was applied in the form of a circuit for 20 weeks in a bodybuilding gym under the guidance of experienced professionals. Initially, there was a period of adaptation and familiarization, both for aerobic activities and for strength exercises. Muscle stretching exercises were performed at baseline, and at the end of each session, participants were instructed to ingest water and wear appropriate clothing to perform activities.

- **Resistance Training**

After the two weeks of neuromuscular adaptation and familiarization, subjects were submitted to the maximal repetition prediction test (1RM) by means of the 10 maximal repetition test (10RM), with maximum load for the accomplishment of 10 repetitions in each exercise. For the 10 RM test, Leg Press 45º, Bench Press, Rowing and Biceps Curl exercises were performed in order to evaluate the four large muscle groups.

After the test to determine the training intensity, loads with 55% of MR were used, a series of 20 repetitions in the first month. From this, 5% of MR was incremented each month, and the number of sets and repetitions was adjusted so that there was adequate load increment, with increase in volume. Resistance training was performed in the form of a circuit and consists of the following exercises: Leg Press 45º, Rowing, horizontal bench press, rack squat, vertical high pull, flexor, Biceps Curl, Flying, triceps extension, extensor, abdominal and trunk extension.

- **Aerobic Training**

Adolescents underwent progressive and continuous maximal effort test in ATL model treadmill (Inbrasport, BR), based on the protocol adapted from Bruce. The effort test started at a speed of 3 km / h for one minute at a slope of 1%. At each minute, the speed was increased by 0.5 km / h keeping the inclination at 1%. Heart rate was monitored during the test using the Polar® S810 frequency meter to estimate peak oxygen consumption (VO_2peak).

VO_2peak, indirectly estimated, and heart rate of this moment were determined by means of the effort test to control the training intensity. Aerobic training consisted of running and walking on flat terrain. Exercise intensity was controlled using the Polar® S810 heart rate monitor, randomly placed in five distinct participants at each training session. The equipment was adjusted so that there was assurance that participants remained in the aerobic training zone. The increase in aerobic training intensity was initiated with 65% of VO_2peak, increasing 5% each month to 85% of VO_2peak.

Statistical analysis

The Levene test was performed to verify the homogeneity of variables and the analysis of variance (ANOVA) of repeated measures with Bonferroni *post hoc* to compare differences between groups with and without HS and pre- (M1) and post-intervention (M2), adjusted for age, GVP and gender, in which values were expressed as means and standard error, adjusted for age, gender and GVP. Delta values (Δ) were calculated by subtracting the mean of M2 minus the mean of M1. The effect size was calculated using Eta-Squared. The significance level was 5% and all analyses were performed in SPSS Software version 13.0.

RESULTS

Initially, the prevalence of HS in 40 obese individuals was 18.4% and, after intervention, these values decreased to 10.7%. When analyzing only the group of children, these values ranged from 25% to 11.1%, for adolescents, values ranged from 15.4% to 10.5%.

The characterization values at baseline are presented in Tables 1 and 2 for children and adolescents, respectively. Table 1 shows the body composition values before and after intervention, separated by absence and presence of HS in children. Children submitted to playful and recreational activities, although not statistically significant, had a group effect on BF with mean effect size (effect size = 0.208) and time (effect size = 0.210), as well as in FM, it had a group effect (effect size = 0.338) and only interaction in AF (effect size = 0.267). In Table 2, adolescents who performed concurrent training had a mean effect size on the difference between IF in the group (effect size = 0.230). When comparing A-HS and P-HS individuals, BF of A-HS group tended to decrease more than P-HS adolescents as can be observed according to deltas.

Table 1. Effect of intervention on the body composition of obese children with and without HS

	A-HS (n=9) M[a] (SE)	Δ	P-HS (n=4) M[a] (SE)	Δ	Effect	F	p-value	ES
BM (kg)					T	0.013	0.914	0.002
M1	51.5 (2.1)	1.4	56.7 (3.7)	1.8	G	1.675	0.237	0.193
M2	52.9 (2.0)		58.5 (3.5)		I	0.110	0.749	0.016
BF (%)					T	1.866	0.214	0.210
M1	46.9 (1.7)	-1.1	51.4 (3.1)	-1.1	G	1.840	0.217	0.208
M2	45.8 (1.4)		50.3 (2.6)		I	0.018	0.898	0.003
FM (kg)					T	1.021	0.346	0.127
M1	24.5 (1.3)	-0.1	29.3 (2.3)	0.2	G	3.580	0.100	0.338
M2	24.4 (1.2)		29.5 (2.2)		I	0.124	0.735	0.017
LBM (kg)					T	1.035	0.343	0.129

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	A-HS (n=9) Mª (SE)	Δ	P-HS (n=4) Mª (SE)	Δ	Effect	F	p-value	ES
M1	25.4 (1.2)	1.4	25.7 (2.1)	1.5	G	0.020	0.892	0.003
M2	26.8 (1.1)		27.2 (2.0)		I	0.063	0.810	0.009
TF (%)					T	0.470	0.515	0.063
M1	50.1 (1.9)	-0.8	55.3 (1.9)	-2.2	G	1.679	0.236	0.194
M2	49.3 (1.5)		53.1 (2.7)		I	1.707	0.233	0.196
AF (%)					T	0.397	0.549	0.054
M1	54.3 (2.0)	-0.4	58.5 (3.5)	-2.6	G	0.716	0.425	0.093
M2	53.9 (1.5)		55.9 (2.7)		I	2.552	0.154	0.267
IF (cm)					T	0.005	0.950	0.002
M1	3.8 (0.4)	-0.2	4.5 (0.7)	-1.7	G	0.002	0.970	0.001
M2	3.6 (0.8)		2.8 (1.2)		I	0.715	0.460	0.192
SF (cm)					T	0.249	0.652	0.077
M1	2.8 (0.6)	-0.4	2.3 (0.9)	0.5	G	0.012	0.918	0.004
M2	2.4 (0.4)		2.8 (0.6)		I	0.135	0.737	0.043

A-HS = absence of hepatic steatosis; P-HS = presence of hepatic steatosis; Ma = estimated mean; SE = standard error; Δ = delta; T = time; G = group; I = Interaction; ES = effect size; BMI = body mass index; M1 = initial moment; M2 = moment after 20 weeks intervention; BM= body mass; BF = body fat; FM = fat mass; LBM = lean body mass; TF = trunk fat; AF = android fat; GF = gynoid fat; IF = intra-abdominal fat; SF = subcutaneous fat; bold = p-value <0.05.

Table 2. Effect of intervention on the body composition of obese adolescents with and without HS

	A-HS (n=23) Mª (SE)	Δ	P-HS (n=4) Mª (SE)	Δ	Effect	F	p-value	ES
BM (kg)					T	0.001	0.973	0.000
M1	79.9 (2.3)	-1.8	87.6 (5.5)	-1.2	G	1.877	0.185	0.082
M2	78.1 (2.2)		86.4 (5.4)		I	0.048	0.829	0.002
BF (%)					T	2.493	0.129	0.106
M1	47.1 (0.7)	-2.5	48.3 (1.8)	-1.0	G	0.820	0.376	0.038
M2	44.6 (0.9)		47.3 (2.3)		I	1.041	0.319	0.047
FM (kg)					T	0.855	0.366	0.039
M1	37.5 (1.5)	-2.6	41.7 (3.7)	-1.6	G	1.236	0.279	0.056
M2	34.9 (1.7)		40.1 (4.2)		I	0.226	0.640	0.011
LBM (kg)					T	0.470	0.500	0.022
M1	39.8 (0.9)	0.9	43.6 (2.3)	0.3	G	2.520	0.127	0.107
M2	40.7 (0.7)		43.9 (1.7)		I	0.267	0.611	0.013
TF (%)					T	1.743	0.201	0.077
M1	49.9 (0.6)	-2.3	50.0 (1.5)	-1.1	G	0.180	0.676	0.008
M2	47.6 (0.8)		48.9 (2.0)		I	0.411	0.529	0.019
AF (%)					T	1.619	0.217	0.072
M1	53.1 (0.7)	-2.6	55.1 (1.7)	-0.8	G	1.921	0.180	0.084
M2	50.5 (1.0)		54.3 (2.4)		I	0.940	0.343	0.043
IF (cm)					T	0.101	0.756	0.008
M1	3.4 (0.3)	-0.4	4.9 (0.7)	-0.4	G	3.893	0.070	0.230
M2	3.0 (0.3)		4.5 (0.7)		I	0.000	0.995	0.000
SF (cm)					T	2.071	0.174	0.137
M1	2.8 (0.2)	-0.1	2.6 (0.5)	0.3	G	0.012	0.913	0.001
M2	2.7 (0.1)		2.9 (0.3)		I	0.687	0.422	0.050

A-HS = absence of hepatic steatosis; P-HS = presence of hepatic steatosis; Ma = estimated mean; SE = standard error; Δ = delta; T = time; G = group; I = Interaction; ES = effect size; BMI = body mass index; M1 = initial moment; M2 = moment after 20 weeks intervention; BM= body mass; BF = body fat; FM = fat mass; LBM = lean body mass; TF = trunk fat; AF = android fat; GF = gynoid fat; IF = intra-abdominal fat; SF = subcutaneous fat; bold = p-value <0.05.

DISCUSSION

Currently, incidence of HS is being observed in significant proportions of obese individuals. The results of the present study indicate a prevalence of 18.4%, similar to scientific studies in overweight and obese adolescents performed by Lira et al.[17], who obtained prevalence of HS of 27.7%. Araújo et al.[18] observed even more pronounced prevalence values, in which 40.1% of obese women in the state of Bahia had HS.

Estimates indicate that about 3-5% of people with HS progress to NASH, and 5% may develop cirrhosis[5]. The factors that determine this progression are still unclear[19]. However, it is known that obesity and its risk factors are directly associated with HS. Therefore, there is a need for proposals to reverse and prevent HS, preventing a possible evolution of NAFLD.

In the present study, intervention with playful and recreational exercises provided results for body fat, fat mass and android fat of obese children with and without HS in group and time, group and interaction effect, respectively. Studies such as that of Farpour-Lambert et al.[20], similar to the present study, demonstrate the possible potential of playful activities in improving body composition, since this intervention program when compared to the control group had a positive impact on adiposity indicators such as BMI (-0.1), abdominal obesity (-2.9) and body fat (-2.4) in obese children, representing an important tool against obesity and its risk factors.

The training models most used as a form of treatment of obesity are those that predominantly use aerobic activities. Belmonte et al.[21] suggest moderate aerobic activity as a means of preventing NAFLD, since, in addition to the function of lipoprotein metabolism, there is an increase in the mitochondrial transport of fatty acids in hepatocytes. On the other hand, Porto et al.[22] consider the resistance training program as an efficient tool in reducing body fat resulting from the negative energy balance, resulting from the energy consumed during and after strength training sessions, and increasing oxygen consumption and energy expenditure at rest, possibly due to an increase in muscle mass[23].

The results of the present study have shown that, in the group of adolescents, there was a reduction in IF in both with HS (-0.4) and without HS (-0.4), and group effect, showing that individuals with HS have higher IF values, which is already known according to literature, because this adiposity is a predictor of HS[13]. In addition, although not statistically significant, when analyzing the delta values, both groups, with and without HS, presented a reduction in body fat, but with a tendency for the group without HS to reduce more. Studies that also performed concurrent training protocols with obese adolescents obtained efficacy in greater proportions, such as significant decreases in total body fat and trunk fat, increase in lean mass and improvement of lipid profile[24,25].

Fat in the central region is associated with endocrine and metabolic disorders because it is close to the vital organs and has more vascularization and innervations[26]. Waist circumference is among the indicators of central obesity[27], as well as high fat concentration in the trunk region, which are considered risk factors for the development of HS[13]. In this context, it is extremely essential to reduce these variables in the treatment of HS, as occurred in the present study, although without statistical significance, but being equally effective from the clinical point of view.

In a study by Donnelly et al.[28], obese adults with HS were submitted to a low-fat diet aimed at directly quantifying hepatic biological sources, showing that almost 60% of hepatic triglycerides are derived from free fatty acids derived from adipose tissues, 26% of new lipogenesis and 15% from diet[28]. As one of the main functions of the liver is the uptake and release of lipids into the bloodstream, this organ promotes the supply of triglycerides in the formation and resynthesis of energy[29]. Based on this assumption, it is considered that the insufficient practice of physical activity is related to excess circulating triacylglycerol, whereas regular physical exercise shows benefits in the improvement of the lipid profile[30].

In short, in both children and adolescents, despite the different intervention models applied, they obtained important results, and, especially in adolescents, for individuals without HS, exercises caused significant improvements. According to Tiniakos et al.[30], HS may be deleterious to the hepatic tissue as a function of the oxidative stress generated by the excessive metabolism of fatty acids, and it may be responsible for activating inflammatory pathways[29]. This inflammatory process generated by the clinical state of children and adolescents may have compromised the greater reduction of body fat in HS groups.

Finally, it is necessary to point out some limitations such as reduced sample size, absence of food intake follow-up, and maturational control of participants, thus encouraging new studies to investigate the trend of results presented in this study.

CONCLUSIONS

According to the results of the present study, there was a tendency of HS to influence the effect of the exercise, since the improvement was greater in individuals without the disease mainly in adolescents. However, regardless of the presence or absence of HS, concurrent training and playful activities were able to provide benefits in the body composition of obese children and adolescents.

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