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Original Article

A HIGH-INTENSITY INTERVAL TRAINING PROGRAM IN AQUATIC ENVIRONMENT (HIITAQ) FOR OBESE ADOLESCENTS

PROGRAMA DE TREINAMENTO INTERVALADO DE ALTA INTENSIDADE NO AMBIENTE AQUÁTICO (HIITAQ) EM ADOLESCENTES OBESOS

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RESUMO
A saúde de adolescentes brasileiros tem sido comprometida pelo aumento da prevalência da obesidade. A prática de exercício físico regular e modificações no estilo de vida são ações recomendadas como prevenção e tratamento. No entanto, não há consenso quanto à dose resposta dos programas de exercícios. O objetivo deste estudo foi verificar a efetividade de um programa de treinamento intervalado de alta intensidade no ambiente aquático (HIITAQ) na aptidão física e fatores de risco cardiometabólicos em adolescentes obesos. A amostra foi composta por 18 adolescentes de ambos os sexos, com idade entre 12 e 17 anos, com diagnóstico de obesidade. Foram avaliadas, variáveis antropométricas, aptidão física, glicemia e perfil lipídico, antes e após 12 semanas de treinamento. O programa foi composto por duas séries de 4 a 8 repetições com 30 segundos de duração (80-95% da frequência cardíaca máxima) por 60 segundos de recuperação ativa. Após o programa de exercícios verificou-se redução do índice de massa corporal escore z IMCz ($p< 0,01$), do Colesterol Total ($p< 0,01$) e LDL-c ($p< 0,01$). Houve aumento da taxa metabólica basal ($p< 0,01$) e do VO_2 pico ($p< 0,01$). Não foram observadas diferenças após o treinamento no percentual de gordura, índice de massa corporal, IMC, relação cintura/estatura RCEst, glicemia em jejum, insulina e HDL-c ($p>0,05$). O programa de treinamento de alta intensidade no meio aquático foi efetivo na redução de fatores de risco cardiometabólicos.
Palavras-chave: Exercício aquático. Obesidade. Perfil lipídico. Risco cardiovascular. Aptidão física.

ABSTRACT
The increased prevalence of obesity has endangered the health of Brazilian adolescents. Regular physical activity and lifestyle changes are recommended as prevention and treatment. However, there is no consensus on the dose-response of training programs. This study aimed at assessing the effectiveness of a high-intensity interval training program in aquatic environment (HIITAQ) on physical fitness and cardiometabolic risk factors in obese teenagers. The sample consisted of 18 adolescents of both sexes, aged 12 to 17 years, diagnosed with obesity. Anthropometric variables, physical fitness, blood glucose, and lipid profile were evaluated before and after 12 weeks of training. The program consisted of two sets of 4-8 repetitions for 30 seconds (85%-95% of maximal heart rate) and 60 seconds of active rest interval. After applying the program, a reduction in body mass index was seen, that is, BMI z-score ($p <0.01$), as well as a reduction of Total Cholesterol, TC ($p <0.01$), and LDL ($p <0.01$). There was an increase in basal metabolic rate ($p <0.01$) and peak VO_2 ($p <0.01$). No differences were seen after the training with regard to fat percentage, body mass index (BMI) waist/height ratio (WHtR), fasting blood glucose, insulin, and HDL-c ($p>0.05$). The high-intensity training program in aquatic environment was effective in reducing cardiometabolic risk factors.
Keywords: Aquatic exercise. Obesity. Lipid profile. Cardiometabolic risk. Physical fitness.

Introduction

Obesity has been reported as a pandemic and its etiology is a result of a multifactorial process that involves genetic and environmental aspects[1]. It is a public health problem and has a strong association with chronic non-communicable diseases (CNCD) and cardiovascular diseases (CVDs), which are among the leading causes of death in the contemporary world[2]. Obesity affects all age groups and contributes to the development of cardiometabolic diseases[2].

Physical activity is indicated as part of a non-drug therapy for the treatment of obese adolescents. However, there is no consensus in the literature as to the type of physical activity and the appropriate dose-response for this population[3,4]. The recommendation for obese adults is of at least 150 minutes a week with moderate-to-vigorous intensity to prevent an increase in body mass, which may result in a slight reduction in weight and health risks. Considering long-term weight reduction, 150 to 300 minutes of moderate-to-vigorous intensity are recommended[5,6]. Regarding adolescents, programs with daily aerobic exercises are indicated, with at least two weekly sessions of endurance exercises complemented with flexibility and balance for sixty minutes[5,7].

Recent studies show the high-intensity interval training (HIIT) as a possibility of exercises to improve body composition and increase the cardiorespiratory capacity of populations, including obese people[8,9]. This model involves short periods of high-intensity physical activities with submaximal active intervals for recovery. As a result of these programs, the improvement in metabolic parameters[10] is evidenced, in addition to skeletal muscle adaptations capable of increasing both, fat oxidation and excessive post-exercise oxygen consumption[9,11].

However, overweight and obese people have functional limitations that can hinder their participation in activities practiced on land. The risks of musculoskeletal injuries, postural discomfort, lower back or hip pain are increased in these individuals[12]. In fact, a study carried out with 1856 schoolchildren showed that 74% of the obese children had postural deviations due to abdomen protrusion; lordosis and kyphosis were the most common ones. Considering the orthopedic complications found, knock-knees and flat feet were the most common[13].

Therefore, training programs that are practiced in aquatic environment are alternatives to minimize the overload of body weight, which provides greater safety[14] mainly regarding the reduction of the impact on the joints due to the apparent weight decrease resulting from flotation[15]. In addition, due to both, the fluid density and the body area projected, there is an increase in resistive forces (drag), which will require greater application of muscle strength to move a given body segment in water[16].

In addition, with immersion there is a redistribution of blood flow and an increase in blood volume in the central region and atrial distension. Such changes result in increased release of the atrial natriuretic peptide (ANP), which acts in the regulation of lipid metabolism. Water exercises with progressive loads have proved to provide the increase in ANP concentration, which contributes to the increase in lipolysis and fat oxidation[17]. Such findings are significant and can assist in the selection of the most appropriate exercise modality for the treatment of obesity[18].

These characteristics of the aquatic environment corroborate the recommendations for physical activities in the sense of obtaining reduced weight, decreased cardiovascular risks and improved health[19,20]. However, no proposal for the application of the HIIT method in the aquatic environment for obese adolescents is known up to date. Thus, the present study aimed at proposing and applying a HIIT program in the aquatic environment for this population, in addition to assessing its effectiveness on physical fitness and cardiometabolic risk factors.

Methods

Participants

A sample size estimate was performed based on the study by Lopes et al.[4] with 80% statistical power, a significance level (α) of 0.05 and an effect size of 0.5, which indicated a sample of 27 participants (G*Power Software, v. 3.1.9.2, Germany). Considering possible losses, a total of 38 pubescent individuals were submitted to convenience sampling to participate in this study. Sixteen adolescents did not start the program due to incompatible training schedules with other activities, thus, 22 were included in the training group. Two participants did not finish the training due to illness, and two of them did not complete all final assessments. Eighteen male and female obese adolescents, aged between 12 and 17 years, finished the program according to the cutoff points for classifying the nutritional status proposed by the World Health Organization (WHO). The statistical power calculated a posteriori, with 18 participants evaluated at the end of the study, was of 65% considering alpha of 0.05, effect size 0.5.

Procedures

The study was approved by the Committee on Ethical Research with Humans in accordance with Resolution 466/12 and deliberations of the National Health Council, Opinion Number: 2.623.226 and the Municipal Secretary for Sport and Recreation of Curitiba city, Protocol No. 01-049765/2018; number of the Brazilian Clinical Trials Registry (ReBec) RBR: 6343y7. The recruitment was published on the website of the Brazilian university referred to as *Universidade Federal do Paraná* (UFPR). This dissemination was extended to the media in local radio and television programs.

The meetings with parents, as well as the screening and evaluations of the participants took place in the University auditorium, at the Quality of Life Center (QLC) and in the Laboratory of Activity Physiology of the Physical Education Course at the UFPR, *Jardim Botânico* Campus, during four consecutive visits.

The first visit consisted of a public explanation of the purposes and procedures for participating in the HIITAQ project, as well as signing of the Free Informed Consent Form after detailed reading. The criteria for inclusion in the study consisted of having a Body Mass Index (BMI) above the 95th percentile for age and sex, according to the criteria by De Onis et al.[21], in addition to being able to practice physical activity, not having infectious skin diseases (chilblains, dermatitis, mycoses) that would contraindicate the practice of exercises in water, and not using medicines or treatments for weight loss. Participation in all assessments and at least 75% attendance at sessions were demanded.

Medical, anthropometric and biological maturation assessments were performed on the second visit. Height was measured by using a stadiometer attached to the wall with a resolution of 0.1 cm and amplitude of 220 cm, performed at the end of maximal oxygen consumption. The body mass was expressed in kilograms by using a digital platform scale calibrated according to INMETRO, with a maximum capacity of 200 kg and a resolution of 50 grams. The BMI was calculated based on the body mass and height squared ratio, and classified according to the criteria of the Growth reference data for 5-19 years[21]. In order to calculate the body mass index z-score (BMIz), the WHO Anthro Plus® program, version 1.0.4 (WHO, 2012) was used. Considering age and sex, classification was performed based on the following values: obesity $\geq +2$ (SD), according to the criteria by Onis et al.[21]. Regarding the abdominal circumference (AC) and waist circumference (WC), a fiber anthropometric measuring tape by Sanny (code TR4013) was used, which was flexible and inextensible (a resolution of 0.1 cm).

The AC measurement followed Fernandez et al.[22] criteria for measurement and classification, considering values equal to or greater than the 75th percentile as abdominal excess, categorized according to age, sex and ethnicity. The WC was measured in accordance with the criterion by Taylor et al.[23], and the waist/height ratio (WHtR) was obtained by the quotient between waist circumference (cm) and height (cm), and classified according to the criterion by McCarthy HD, Ashwell M. A[24].

Sexual maturation was assessed by a doctor who applied direct observation with the permission from the adolescent and/or parents. When not allowed, self-assessment was considered through drawings regarding the development of pubic hair, (P1-P5), based on the staging proposed by NM, Udry JR[25], Tanner JM.[26]. Girls and boys were classified as follows: pre-pubertal individuals - with no pubic hair (P1), pubertal individuals - with pubic hair between P2 and P4, and post-pubertal individuals – P5 stage. The girls who reported the occurrence of menarche were considered as post-pubertal[27].

The blood samples were collected on the third visit at the clinical analysis laboratory to evaluate the lipid profile and blood glucose. Body composition was measured by using

Bioelectrical Impedance Analysis (BIA) with the tetra polar Bioimpedance device by Biodynamics (Model 450). The following variables were assessed: fat percentage, lean mass, fat-free mass and basal metabolic rate. The procedure was performed in the morning after a 10-12 hour fasting. Muscle strength was measured according to the right and left handgrip strength (HGS) by using a handgrip dynamometer with the same specifications as those by JAMAR, with a scale ranging from 0 to 100 kilograms strength (kgf)[28].

On the fourth visit, cardiorespiratory fitness was assessed by applying a test on an ergometric treadmill (Inbramed, model ATL, Brazil), with a modified ramp protocol, starting at a speed of 4 kilometers per hour (km/h) and a progressive increase of 0.3 km/h every 30 seconds with a constant slope of 1% until maximal exertion, as recommended for the age group[29].

The maximal oxygen consumption (VO_2 max) was determined by the highest value obtained during the maximal test, when two of the following criteria were obtained[5]: a) exhaustion or inability to maintain the speed required; b) respiratory ratio (R) $\geq$ 1.09; c) difficulty in coordinating the movement; d) maximum heart rate (HRmax) predicted by the formula 208-(0.7x age)[30].

The metabolic analyzer (K4b2, Cosmed, Italy) was used for assessing the VO_2 max, which is capable of storing data in internal memory for later download; the BREEZESUITE® software was used to estimate the values obtained. During the test performance, the following parameters of physiological controls were recorded: heart rate (HR) monitored by means of a heart rate monitor (Polar®, model A300), a portable wireless reception system, and the participants' responses were evaluated by using the OMNI Perceived Exertion Scale (PES) (1-10), which has been validated in studies for children and adolescents[31].

The HIITAQ program

The High-Intensity Interval Training Program in Aquatic Environment (HIITAQ) was carried out for 12 weeks, three times a week (36 sessions) in a 25-meter pool, 1.40-meter depth, controlled temperature (28º-30º degrees C). A period of familiarization with the aquatic environment was performed, that is, adaptation with the pool and the movements, sequence of exercises and implements used, such as the perceived exertion scale, heart rate monitor, and resistance equipment (Aquafin). The exercise intensity was established according to the recommendations by ACSM, 2018[5] and controlled by using the OMNI scale 5 (moderate) and 8 (intense); the heart rate (HR) was monitored using the polar frequency meter A300 recorded at the end of each series. The determination of the training HR was based on the maximal HR obtained on the treadmill test, corrected by immersion bradycardia (-14 bpm) according to the study by Bento, Lopes and Leite[32].

During the execution of the exercises, the participants were verbally encouraged to maintain the recommended intensity. At the end of each series, they received feedback regarding HR and the rate of perceived exertion (RPE) for a possible adjustment of training intensity in the subsequent series. The following exercises were selected for the present study: stationary running, frontal kick, and ski. The stationary running was repeated in order to complete the movements of the series. The selection and option for these movements was based on the fact that they are commonly used in water aerobics classes and because of the good correlation between PES and peak VO_2 when tested through ergospirometry evaluation[33]. The sessions consisted of warm-up (10 min), main series of HIIT with active rest interval, followed by a period of calm down in a recreational way according to the age group. HIIT was determined based on previous studies detailed in Chart 1[34,35].

Weeks	1	2	3	4-5	6	7-9	10-12
Series	2	2	2	2	2	2	2
Repetitions	4	5	6	7	8	8	8
Training/rest interval	30/60 s	30/60 s	30/60 s	30/60 s	30/60 s	30/45 s	30/30 s
RPE	7-9	7-9	7-9	7-9	7-9	7-9	7-9
Training HR (% HRmax)	80-95%	80-95%	80-95%	80-95%	80-95%	80-95%	80-95%
HR in rest interval (% da HRmax)	(50%)	(50%)	(50%)	(50%)	(50%)	(50%)	(50%)
Active rest interval between series	4 min	4 min	4 min	4 min	4 min	4 min	4 min
Training duration (HIIT)	12 min	15 min	18 min	21 min	24min	20 min	16min

Chart 1. Planning of the High-Intensity Interval Training Program in Aquatic Environment
Note: RPE: rate of perceived exertion ; HR: heart rate
Source: The authors

Statistical analysis

Descriptive statistics, mean and standard deviation were used in order to assess the data collected. Shapiro-Wilk test was applied to evaluate the data normality, in addition to Levene's test for sample homogeneity. The t-test was used to compare the pre and post intervention means, and Wilcoxon test was applied when the data did not follow a normal distribution. The significance level of $p < 0.05$ was determined for assessing the results. The tests were performed by using IBM SPSS Statistics software version 25.

Results

Eighteen adolescents aged 12 to 17 years of both sexes were classified as obese (21). Considering the pubertal stage, they were classified as pubertal individuals (9 boys and 3 girls) and post-pubertal (4 boys and 2 girls). The general characteristics related to age, anthropometric measurements, body composition, cardiorespiratory fitness and handgrip strength are shown in Table 1.

Table 1. General characteristics of the participants

	Total (n=18)	Male (n=13)	Female (n=5)
Age (years)	13.26 ±1,27		
Body mass (kg)	8509 ±20.81	88.27 ± 21,97	76.8 ± 16.54
Height (cm)	164.61 ±8.85	166.61 ± 9.24	161.9 ± 5.14
BMI (kg.m^2)	31.25 ±6.35	31.68 ± 6.70	30.14 ± 5.89
BMIz	2.76 ±0.95	2.8 ± 1.05	2.63 ± 0.73
WC (cm)	107.28±14.10	109.84 ± 1.05	100.6 ±7.89
WHtR (cm)	0.65 ±0.08	0.66 ± 0.09	0.63 ± 0.05
FM (%)	36.99 ±5.19	37.09 ± 5.70	36.69 ± 4.05
FFM (kg)	52.99 ±10.54	33.48 ± 12.59	28.48 ± 8.23
Blood glucose (mg/dl)	89.48 ± 7.09	90.00 ± 6.98	88.12 ± 8.05
Insulin (uUI/ml)	21.86 ± 9.32	23.09 ± 10.08	18.7 ± 6.85
TC (mg/dl)	175.09 ± 25.95	179.33 ± 27.04	164.06 ± 21.40
HDL-c (mg/dl)	40.89 ±6.45	40.75 ± 5.62	41.24 ± 9.05
LDL-c (mg/dl)	107.47 ± 21.79	110.03 ± 22.81	100.8 ± 19.54
TAG (mg/dl)	133.66 ± 41.8	142.71 ± 41.36	110.14 ± 36.54
Non-HDL-c (mg/dl)	134.28 ± 26.70	138.62 ± 28.12	123.00 ± 20.89
VO_2 peak (ml/kg. Min)	32.18 ±5.24	33.08 ± 6.02	30.27 ± 3.48
RHGS (kgf)	24.33 ±5.26	24.84 ± 5.45	23.00 ± 2.23
LHGS (kgf)	23.94 ±6.23	24.00 ± 7.14	23.8 ± 3.50
BMR (kcal/dia)	1644.22±341.16	1696.76 ± 356.63	1507.6±284.28

Note: BMI: body mass index; BMIz: body mass index z-score; WC: waist circumference; WHtR: waist/height ratio; FM: fat mass; FFM: fat-free mass; TC: total cholesterol ; TAG: triglycerides; Peak VO_2: peak oxygen consumption; RHGS: right handgrip strength; LHGS: left handgrip strength; BMR: basal metabolic rate
Source: The authors

Table 2 shows the variables related to the intensity of the HIITAQ program, which was carried out for twelve weeks and consisted of 36 sessions. Regarding the analysis, the means were considered at the end of each training cycle separated according to sex.

Table 2. Workout intensities, mean values (± standard deviation) related to the final weeks of each training cycle

Variables	Male			Female		
	4th week	8th week	12th week	4th week	8th week	12th week
THR	167.6±11.2	163.9±9.7	164±9.1	170.16±7.7	166.03 ±6.6	163.75±9.2
%HRmax.	94.9±8.2	92.6±9.7	93.0±4.5	99.5±5.8	99.3±4.8	97.6±2.6
% RHres	83.4±13.0	79.6±10.3	79.7±9.3	86.77±10.0	82.64±6.9	80.36±10.7
RPE	5.7±0.9	6.4±1.8	7.4±0.6	5.69±0.9	6.0±2.1	7.4±0.7

Note: THR: Training heart rate; % HRmax: percentage of the maximal heart rate; % HRres: percentage of the heart rate reserve; RPE: rate of perceived exertion
Source: The authors

Table 3 shows the results related to the analysis of pre and post intervention data, anthropometric variables and body composition. After the training period an increase in BM, height, waist circumference and fat-free mass was seen. There was a reduction in BMIz with no changes regarding the other variables.

Table 3. Anthropometric and body composition data before and after 12 weeks of training (mean ± standard deviation)

	Pre	**Post**	***p***
Body Mass (kg)	85.08± 20.80	87.41± 21.37*	< **0.01**
Height (cm)	164.61± 8.85	167.81± 8.80*	< **0.01**
BMI (kg/m²)	31.25± 6.35	30.87± 6.17	0.24
BMIz	2.75± 0.95	2.62± 0.95*	< **0.01**
WC (cm)	107.27± 14.10	109.48± 14.95*	< **0.01**
WHtR (cm)	0.65± 0.08	0.65± 0.08	0.94
FFM (kg)	52.99± 10.54	55.17± 12.45*	**0.04**
% fat	36.98± 5.19	36.37± 6.80	0.61

Note: BMI: body mass index; BMIz: body mass index z-score; WC: waist circumference; WHtR: Waist/height ratio; FFM: fat-free mass. *time effect p <0.05
Source: The authors

Table 4 shows the variables related to physical fitness and basal metabolic rate before and after the HIITAQ program. There was an increase in the basal metabolic rate and peak VO_2 after the training program (p<0.05). The other variables showed no change (p>0.05).

Table 4. Variables related to physical fitness and basal metabolic rate before and after 12 weeks of training (mean ± standard deviation)

	Pre	**Post**	***p***
VO_2 peak (ml.kg.min^{-1})	32.2 ±5.24	33.90± 4.93*	**0.03**
RHGS (kgf)	24.33± 5.26	24.83± 5.00	0.31
LHGS (kgf)	23.94± 6.23	24± 5.05	0.94
BMR (kcal/dia)	1644.22± 341.16	1765.94± 356.87*	< **0.01**

Note: Peak VO_2: peak oxygen consumption; RHGS: right handgrip strength; LHGS: left handgrip strength; BMR: basal metabolic rate.
Source: The authors

The results showed a reduction in total cholesterol and LDL cholesterol after 12 weeks of training (p <0.05). The other variables did not differ after the physical activity program (Table 5).

Table 5. Metabolic and lipid profile variables before and after 12 weeks of training (mean ± standard deviation)

	Pre	**Post**	***p***
Glucose (mg/dl)	89.48±7.09	91.03±7.35	0.53
Insulin (mg/dl)	21.86±9.32	20.52±9.83	0.60
TC (mg/dl)	175.08±25.95	163.97±22.71*	**0.01**
HDL-C (mg/dl)	40.88±6.45	41.98±5.55	0.43
LDL-C (mg/dl)	107.46±21.79	97.29±23.80*	**<0.001**

Note.: CT: total cholesterol; * time effect p<0.05
Source: The authors

Discussion

The present study is the first to propose and apply a high-intensity interval training program in aquatic environment for obese adolescents, in addition to assessing its effectiveness in terms of the anthropometric parameters of physical and cardiometabolic fitness.

The intensity of 80-95% maximal heart rate was suggested based on a previous study applied to this population on land with 70-95% maximal heart rate[35], and on another study with adults carried out in aquatic environment with an intensity of 80-95% maximal heart rate[36]. The intensity proposed for the HIITAQ program was reached and varied from 92% to 94% of the maximal HR in men, and 97% to 99% in women. Regarding the heart rate reserve, it was from 79% to 83% for men, and 80% to 86% for women. However, considering the rate of perceived exertion, the values found were lower than expected, considering the training proposal that should be 8 points on the OMNI scale.

The results showed that the physical activity program was effective in reducing the BMI z-score ($p < 0.01$). The decrease in this measure may represent a possible decrease in the classification of the obesity degree[21], which indicates an improvement in the metabolic parameter when the reduction is equal or greater than 0.5 BMI z-score. There was an increase in height ($p < 0.01$) and lean body mass ($p < 0.048$), which might justify the increase in total body mass.

The fat percentage showed no change. This result corroborates the findings shown in a study by Dias et al[37]. The waist-height ratio has been a marker of cardiometabolic risk[24], however, no change was seen. The water density works as a factor to increase resistance to movement, which can generate an increase in energy expenditure[38]. However, flotation is a protective factor for the ankle and knee joints, and at the same time it seems to result in less total energy expenditure when compared to physical exercises that demand total body weight lift[39]. This occurs especially when a large part of the body is immersed, as in the present study, in which the participants had the water level between the xiphoid process and the shoulder line. Thus, the apparent weight reduction might have resulted in less total energy expenditure, which may partially explain the absence of changes in both, the waist/height ratio and fat percentage.

HIIT has received attention as a training method with efficient and effective use of time to improve physical fitness with increased cardiorespiratory capacity, even in obese individuals[8,9]. In fact, the present study showed an increase in peak VO_2, which is quite significant, since the improvement of aerobic fitness with a short-term physical activity program favors obese people. Usually, this group has low cardiorespiratory fitness and, thus, it is not always able to engage in traditional long-term programs, even if the intensity is moderate. It is also noteworthy that the improved aerobic fitness is related to cardiovascular protection and prevention of metabolic diseases[10].

In addition, there was an increase in the basal metabolic rate ($p < 0.01$), which might prove to be a response of the physical activity to skeletal muscle adaptations that increase fat oxidation and oxygen use[8,9,11]. However, there was no increase in muscle strength, which was assessed by means of handgrip strength. This is likely to due to the training specificity that emphasized lower limb muscle groups.

It is well established that blood markers, that is, glucose, total cholesterol, triglycerides, LDL, HDL are metabolic risk indicators[10]. On the other hand, regular physical activity has been recommended to reduce these risk factors.

The results of the present study showed that HDL, glucose and insulin did not change. However, there was a reduction in total cholesterol and LDL-c, which indicates a positive response of the program herein proposed with regard to the modification of the lipid profile in obese adolescents. Obesity is associated with changes in the concentrations of TC and LDL-c that are determinant in the cardiovascular complications observed in obese adolescents and that can persist throughout adulthood[40]. Thus, the reduction related to these variables shown in this study indicates the effectiveness of the program and its significance for health.

Therefore, the proposal of the present study is innovative as a high-intensity training methodology for obese adolescents in aquatic environment. The program proved to be viable, since the intensities suggested were achieved, even in a group of participants with low physical fitness.

One of the limitations of this study is the absence of a control group. However, considering that the participants were classified as pubertal (final stage) or post-pubertal individuals, the effects of the growth process, development and maturation might have been less evident. Thus, the morphological and physiological changes shown can be largely attributed to the physical training proposed. Further studies are suggested in order to compare the effectiveness of a high-intensity water training with moderate-intensity aerobic exercises in aquatic environment, which are traditionally recommended for reducing and controlling body weight.

Conclusions

In conclusion, the high-intensity interval training program in aquatic environment carried out for 12 weeks was effective in the sense of reducing the cardiometabolic risk and improving physical fitness of the obese population. The reduction in BMI, LDL-c and total cholesterol is highlighted, in addition to the increase in fat-free mass, basal metabolic rate and cardiorespiratory fitness. Thus, HIITAQ meets the high-intensity interval training (HIIT) methodology and can be considered an alternative as part of non-drug therapy for the treatment of obesity in adolescents.

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