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ORIGINAL ARTICLE

Hospitalary concurrent exercise program in overweight and obese school students and adolescents during COVID-19 pandemic

Programa de ejercicio concurrente hospitalario en escolares y adolescentes con sobrepeso y obesidad durante la pandemia COVID-19

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What do we know about the subject matter of this study?

The COVID-19 pandemic generated deleterious effects on anthropometric values, aerobic capacity, muscle function, and metabolic control in overweight and obese schoolchildren and adolescents.

What does this study contribute to what is already known?

A 12-week concurrent training program at the hospital level during the COVID-19 pandemic successfully maintained or improved anthropometric values, aerobic capacity, muscle function, and metabolic control in overweight and obese schoolchildren and adolescents.

Abstract

The COVID-19 pandemic reduced daily physical activity in the pediatric population, with deleterious effects on anthropometry, muscle function, aerobic capacity, and metabolic control. **Objective:** Determine the changes in anthropometry, aerobic capacity, muscle function, and metabolic control of a 12-week concurrent training protocol in overweight and obese children and adolescents during the COVID-19 pandemic. **Patients and Method:** 24 patients participated and were divided into groups once a week (12S; n = 10) and twice a week (24S; n = 14). Anthropometry, muscle function, aerobic capacity, and metabolic biochemical tests were evaluated before and after the application of the concurrent training plan. Two-way ANOVA, Kruskal-Wallis test, and Fisher's post hoc test were used. **Results:** Only the twice times week training improved the anthropometrics parameters (BMI - z, waist circumference and waist to height ratio). The muscle function tests (push up, standing broad

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jump and prone plank), improved in both groups such as the aerobic capacity measured by $VO_{2maximo}$ and the runned distance in Shuttle 20m run test. The HOMA index only improved with twice times week training without changes in lipid profile in both groups. **Conclusions:** The 12S and 24S groups improved aerobic capacity and muscular function. Only the 24S improved anthropometric parameters and the HOMA index.

Introduction

The COVID-19 pandemic negatively impacted the amount of daily physical activity in the pediatric population, reporting a 50-60% reduction in children and adolescents in North and South America[1-3]. Pre-pandemic evidence showed that those children and adolescents with a higher amount of daily physical activity had better aerobic capacity[4], lipid profile, and glycemic control[5]. In contrast, those with less physical activity showed negative values of body mass index (BMI) and muscle function[6]. Similarly, literature before COVID-19 concluded that high-intensity interval training (HIIT)[7] improved aerobic capacity, as well as strength training programs improved muscle function[8]. At the same time, the concurrent training program[9] has demonstrated improvements in aerobic capacity, strength, and metabolic control. Evidence on the impact of exercise planning on overweight and obese children and adolescents during the COVID-19 pandemic is scarce[10]. The objective was to determine the effects of the concurrent training program on anthropometry, muscle function, aerobic capacity, lipid profile, and glycemic control in overweight and obese children and adolescents in a COVID-19 pandemic context.

Patients and Method

Population and selection criteria

This study was approved by the Ethics Committee of the South Metropolitan Health Service (31-25042022) following the guidelines of the Helsinki Declaration. Through an anonymous database, data were collected from patients who underwent surgery during the period from June 25, 2020, to February 17, 2021. Inclusion criteria were overweight (body mass index by z-score [BMI-z] > 1 standard deviation [SD]), obese (BMI-z > 2 SD), severely obese (BMI-z > 3 SD), and ages between 7 and 17 years. For definitive selection, patients with normal pre-participation cardiovascular evaluation (*Vide Infra*) were selected. Exclusion criteria were moderate to severe cognitive impairment, traumatological condition preventing exercise similar to their baseline condition, severe cardiac disease, and non-completion of the concurrent training program. Patients were divided into two groups according to their availability to attend 1 or 2 times per week to perform the concurrent training program for 12 weeks: 12 and 24 sessions (12S and 24S).

Study design

The selected patients were evaluated for 3 consecutive days before and after the concurrent training program as follows:

Day 1: Cardiovascular[11] and anthropometric (weight, height, BMI, BMI-z, waist circumference (WC), and waist-to-height ratio (WHtR) pre-participation assessment.

Day 2: Muscle function (elbow flexion/extension, standing long jump, prone plank) and aerobic capacity (20m shuttle run test).

Day 3: Measurement of lipid profile, glycemia, insulin, and HOMA index (homeostasis model assessment) during a fasting period of 8-12 hours.

Training program

The 12S and 24S group performed a 12-week concurrent training program, which was derived from a plan reported by Gálvez-Mazuela et al.[12]. In both plans, the session lasted one hour, divided into 30 min of aerobic exercise and 30 min of strength exercise. The aerobic exercise program was performed with functional exercises: jogging, skipping, jumping jacks, side shuffles, and modified burpees. In the first two weeks, 2 sets of 15 min were performed with 5 min rest between sets at a 5-6 score on the children's rating of perceived exertion scale[13]. From week 3 to week 12, HIIT was performed in circuit mode with the verbal command to perform the exercises at maximum capacity [e.g., week 4, day 1, objective: 20 rounds of HIIT, divided into 4 rounds for each of the movements (jogging, skipping, jumping jacks, side shuffles, and modified burpees)] with a perceived exertion rating of 8-9 for the work phase and 5-6 for the active pause. The strength exercise consisted of 6 types of isotonic exercises: squats and lunges at 90°, long and vertical jumps, elbow flexion/extension with knee support and triceps dips with elbow and knee flexion at 90°, and one trunk exercise (isometric): prone plank, performed with body weight at an intensity of 5-6 according to the perceived exertion scale for strength exercise. Table 1 shows the details of both exercise plans.

Measurements

Anthropometry

Weight and height were measured using a beam balance scale and a SECA® stadiometer, and BMI and BMI-z were calculated with the data collected. The WC was measured with an inextensible tape measure, according to the protocol of Ruiz et al.[14], and the WHtR was obtained by dividing the WC by the height. Anthropometric measurements were performed by the sports medicine physician.

Muscle function

Elbow flexion/extension: Patients were placed on a mat, supporting only feet and hands shoulder-width apart and performed maximum repetitions of trunk lift with 90° arm flexion[15]. The maximum number of repetitions (rep) was considered for data analysis.

Table 1. Concurrent exercise schedules for schoolchildren and adolescents according to 12- or 24-session training schedules

Aerobic exercise planning

12S Group

Weeks	1	2	3	4 - 5 - 6	7 - 8 - 9	10 - 11 - 12	
Frequency (days)	1	1	1	1	1	1	
Work RPE	5-6	5-6	8-9	8-9	8-9	8-9	8-9
Active pause RPE	/	/	5-6	5-6	5-6	5-6	5-6
HI:MI Relationship	/	/	1:4	1:3	1:2	1:2	1:1
WTT (min)	30	30	20	20	20,25	9,75	10
Bouts EIAI	/	/	16	20	27	13	20
Active TT (min)	30	30	4	5	6,75	3,25	5
Active pause TT (min)	/	/	16	15	13,5	6,5	5

24S Group

Weeks	1		2		3		4 - 5 - 6		7 - 8 - 9		10 - 11 - 12			
Frequency (days)	1	2	1	2	1	2	1	2	1	2	1		2	
Work RPE	5-6	5-6	5-6	5-6	8-9	8-9	8-9	8-9	8-9	8-9	8-9	8-9	8-9	8-9
Active pause RPE	/	/	/	/	5-6	5-6	5-6	5-6	5-6	5-6	5-6	5-6	5-6	5-6
HI:MI Relationship	/	/	/	/	1:4	1:4	1:3	1:3	1:2	1:2	1:2	1:1	1:2	1:1
WTT (min)	30	30	30	30	20	20	20	20	20.25	20.25	9.75	10	9.75	10
Bouts EIAI	/	/	/	/	16	16	20	20	27	27	13	20	13	20
Active TT (min)	30	30	30	30	4	4	5	5	6,75	6,75	3,25	5	3,25	5
Active pause TT (min)	/	/	/	/	16	16	15	15	13,5	13,5	6,5	5	6,5	5

Strength exercise planning

Group 12S

Weeks	1 - 2 - 3 - 4	5 - 6	7 - 8	9 - 10 - 11 - 12
Frequency (days)	1	1	1	1
Work RPE	5-6	5-6	5-6	5-6
Isotonic volume exercises (series x repetitions)	2 x 10	3 x 8	3 x 10	3 x 12
Isometric volume exercises (series x seconds)	2 x 30	2 x 45	2 x 60	2 x 60

24S Group

Weeks	1 - 2 - 3 - 4		5 - 6		7 - 8		9 - 10 - 11 - 12	
Frequency (days)	1	2	1	2	1	2	1	2
Work RPE	5-6	5-6	5-6	5-6	5-6	5-6	5-6	5-6
Isotonic volume exercises (series x repetitions)	2 x 10	2 x 10	3 x 8	3 x 8	3 x 10	3 x 10	3 x 12	3 x 12
Isometric volume exercises (series x seconds)	2 x 30	2 x 30	2 x 45	2 x 45	2 x 60	2 x 60	2 x 60	2 x 60

RPE: Rated Perceived Exertion; HI:MI: High Intensity / Moderato Intensity; WTT: Work Total Time; HIIE: Hight Intensity Interval Exercise; TT: Total Time; 1:4: 15 seconds of high intensity by 60 seconds of moderate intensity; 1:3: 15 seconds of high intensity by 45 seconds of moderate intensity; 1:2: 15 seconds of high intensity by 30 seconds of moderate intensity; 1:1: 15 seconds of high intensity by 15 seconds of moderate intensity.

Prone plank: Only elbows and toes were allowed to be in contact with the mat, maintaining the isometric position for as long as possible. The total time recorded in seconds (s) was used for data analysis[16].

Standing long jump: The patient stood behind the jump line, with feet shoulder-width apart. From that position, the patient jumped as far as possible, landing with both feet at the same time. Three attempts were performed and the best score in centimeters (cm) was considered for data analysis[14].

Aerobic capacity

20m shuttle run test (20m SRT): it consisted of running 20 meters round trip at an initial incremental speed of 8.5 km/hr, increasing by 0.5 km/hr per minute[1]. Maximal oxygen consumption (VO2max) was estimated using the Leger et al equation[17]. VO2max in ml/kg/min and distance covered (m) during the test were used for data analysis.

Nutritional biochemical examinations

Venous blood samples were collected after fasting between 8-12 hours. Lipid profile and glycemic control analyses were performed by a medical technologist specialized in the area, using the following techniques:

Lipid profile: enzymatic determination method for total serum cholesterol and triglycerides: Friedewald equation for LDL cholesterol and direct polyethylene glycol measurement for HDL cholesterol.

Glycemic control: electrochemiluminescence for basal insulin and hexokinase for basal glycemia. The HOMA index was calculated [(fasting insulin (mU/L) x fasting glycemia (mg/dL)/405].

Children's Perceived Exertion Scale

The perceived exertion scale was used to quantify the sensation of physical exertion caused by aerobic exercise. It has numerical descriptors (0 to 10), verbal descriptors, and a set of illustrations depicting a child running at increasing intensities along a bar scale of incremental height[13].

Perception of exertion scale for strength exercise

Perception of exertion scale applied to strength exercises. It has numerical descriptors (0 to 10), verbal descriptors, and a set of illustrations depicting a child lifting weight at increasing intensities along a bar scale of incremental height[18].

Statistical analysis

Sample normality was determined using the Shapiro-Wilk test. Student's t-tests and Mann-Whitney tests were used to determine possible differences in baseline characteristics of normally and non-normally distributed variables between the 12S and 24S groups. Intra-group changes experienced by both 12S and 24S from baseline and post-exercise were compared by two-way analysis of variance (ANOVA) or the Kruskal-Wallis test depending on the assumption of normality. If the ANOVA or Kruskal-Wallis test showed a significant difference, a Fisher's LSD *post hoc* test for multiple comparisons was used to determine whether there were changes between the 12S and 24S groups after exercises. Effect size (ES) analysis was performed for normally and non-normally distributed variables[19,20], interpreted as < 0.1 trivial, ≤ 0.1 to < 0.3 small, ≤ 0.3 to < 0.5 medium, and ≥ 0.5 as large. Statistical analysis was performed using the PRISM 8.0 software (GraphPad®, California). Statistical significance was set at $p \leq 0.05$. Data are presented as means and standard deviation (mean ± SD) or median and interquartile range (IQR).

Results

There were no differences in baseline characteristics between patients in the 12S and 24S groups the before concurrent training program (Table 2). The 12S group initially consisted of 17 patients, of whom 10 completed the program (11.7 ± 1.6 years; 4 female and 6 male), showing 58.5% of adherence and an attendance of 85 ± 14.3 sessions. The 24S group initially consisted of 23 patients, of whom 14 completed the program (11.7 ± 2.2 years; 8 female and 6 male) and showed 60.8% of adherence and attendance of 74.7 ± 13.1 sessions. Of the 12S group, 5 participants dropped out of the study during weeks 1-6 and 2 during weeks 7-12 due to parental inability to take the patient to the exercise program (4), re-exacerbation of mental health pathology (2), and infection with COVID-19 in the community (1). Of the 24S group, 9 patients dropped out of the study during weeks 1-6 and 2 during weeks 7-12 due to the inability to take the patient to the exercise program (3), re-exacerbation of mental health pathology (1), urinary tract infection (1), COVID-19 infection in the community (1), and no dropout data (3).

Anthropometry

There were no differences in multiple comparisons of the 12S versus 24S group for changes in weight, height, BMI, BMI-z, WC, and WHtR. Weight increased in the 12S group compared with the 24S group (3.2 ± 2.1 kg vs. 0.8 ± 2.1 kg; $p = 0.001$; ES: 0.2); height increased in the 24S group compared with the 12S group (1.4 ± 1.3 cm vs. 0.6 ± 0.8 cm; $p = 0.001$; ES: 0.1); BMI increased in the 12S group compared with 24S (1.1 ± 0.8 kg/m2 vs -0.1 ± 0.8 kg/m2; $p = 0.002$; ES: 0.4); BMI-z increased by 0.09 ± 0.10 (SD; $p = 0.02$; ES: 0.05) in the 12S group and decrease by -0.07 ±

0.13 (SD; p = 0.033; ES: 0.1) in the 24S group; WC decreased in the 24S group compared with 12S group (-3.0 ± 2.8 cm vs -0.6 ± 3.7 cm; p =0.0018; ES: 0.1), and WHtR decreased in the 24S group compared with the 12S group (-0.02 ± 0.01 points vs -0.01 ± 0.03 points; p = 0.0052; ES: 0.3).

Muscle function

There were no differences in the multiple comparisons of the 12S versus 24S group in the variables of elbow flexion-extension, prone plank, and standing long jump. The elbow flexion-extension test (Figure 1A) improved in the 12S group [3.0 rep (0.7 - 7.0 rep; ES: 0.8; P=0.0234)] as well as in the 24S group [8.2 rep (2.7 - 10.2 rep; ES: 1.0; P = 0.0001)]. The same occurred with the prone plank (Figure 1B), showing an increase in both the 12S group [37.0 s (28.1 - 63.2 s; ES: 1.0; P = 0.0005)] and the 24S group [58.7 s (46.5 - 109.7 s; ES: 1.0; p = 0.0001)]. Similarly, the standing long jump (Figure 1C) increased by 15.0 cm in the 12S group (0.0 - 31.0 cm; ES: 0.8; P = 0.0391) and by 22.0 cm in the 24S group (2.5 - 28.7 cm; ES: 0.9; P = 0.0005).

Aerobic capacity

There were no differences in the multiple comparisons of the 12S versus 24S group for VO2max estimated by the 20m SRT, nor for distance covered during the test. Both 12S and 24S groups increased VO2max by 0.9 ± 1.2 ml/kg/min; p = 0.037; ES: 0.4 vs 1.2 ± 1.8 ml/kg/min; p =0.029; ES: 0.3, respectively (Figure 2A). Distance covered during the test increased by 44.0 ± 30.7; p = 0.002; ES: 0.6 in the 12S group and 40.0 ± 58.1; p = 0.005; ES: 0.8 in the 24S group (Figure 2B).

Nutritional biochemical examinations

Lipid profile: No differences were observed in multiple comparisons for the 12S versus 24S group in the variables: total cholesterol, triglycerides, LDL choles-

Table 2. Baseline characteristics of schoolchildren and adolescents before the start of the concurrent exercise program

Characteristics	Group once a week (n = 10)	Group 2 times per week (n = 14)	p-value
Percentage of adherence to the program	58.8%	60.8%	-
Percentage attending sessions	85. 0 ± 14.3	74.7 ± 13.1	0.08
Age (years)	11.7 ± 1.6	11.7 ± 2.2	0.98
Anthropometry			
Weight (kilograms)	74.7 ± 15.8	74.0 ± 18.6	0.92
Height (centimeters)	156.9 ± 11.4	155.0 ± 12.21	0.70
BMI (kilograms/meter2)	29.9 ± 2.8	30.2 ± 4.4	0.83
BMI-z (standard deviation)	2.93 ± 0.42	2.89 ± 0.52	0.87
WC (centimeters)	93.6 ± 10.7	94.0 ± 11.0	0.91
WHtR	0.60 ± 0.04	0.60 ± 0.06	0.73
Muscle function			
Elbow flexion - extension (repetitions).	1.5 (0.0 - 3.0)	0.5 (0.0 - 3.0)	0.61
Prone plank (seconds)	30.4 (25.7 - 46.6)	20.0 (13.4 - 40.7)	0.13
Standing broad jump (centimeters)	115.0 (107.5 - 146.2)	139.0 (114.7 - 145.2)	0.24
Aerobic capacity			
VO_{2max} estimated by Shuttle 20m-run test (millimeters/kilogram/minute)	37.2 ± 1.8	37.6 ± 4.0	0.79
Distance runned in Shuttle 20m-run test (meters)	180.0 ± 74.3	200.0 ± 47.7	0.44
Lipid profile			
Total cholesterol (mg/dl)	151.6 ± 37.6	159.9 ± 40.4	0.62
Triglycerides (mg/dl)	108.4 ± 39.9	158.2 ± 76.4	0.07
LDL cholesterol (mg/dl)	85.8 ± 30.4	87.6 ± 34.8	0.90
HDL cholesterol (mg/dl)	44.2 ± 8.0	40.8 ± 7.9	0.33
Glycemic control			
Insulin (mU/L)	26.5 (18.8 - 35.5)	26.3 (18.5 - 34.6)	0.95
Glycemia (mg/dl)	95.5 (91.5 - 101.2)	96.0 (91.0 - 98.2)	0.55
HOMA index	6.1 (4.2 - 8.8)	6.2 (5.2 - 7.9)	0.97

Mean ± Standard Deviation; Median (Interquartile Range); BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist to Height Ratio; VO2max: Maximal Oxygen Consumption; mg/dl: milligrams/deciliter; LDL: Low-density lipoprotein; HDL: High-density lipoprotein; mU/L: milliunits/liter; BMI-z: Body mass index calculated by z-score; HOMA: Homeostasis assessment model.

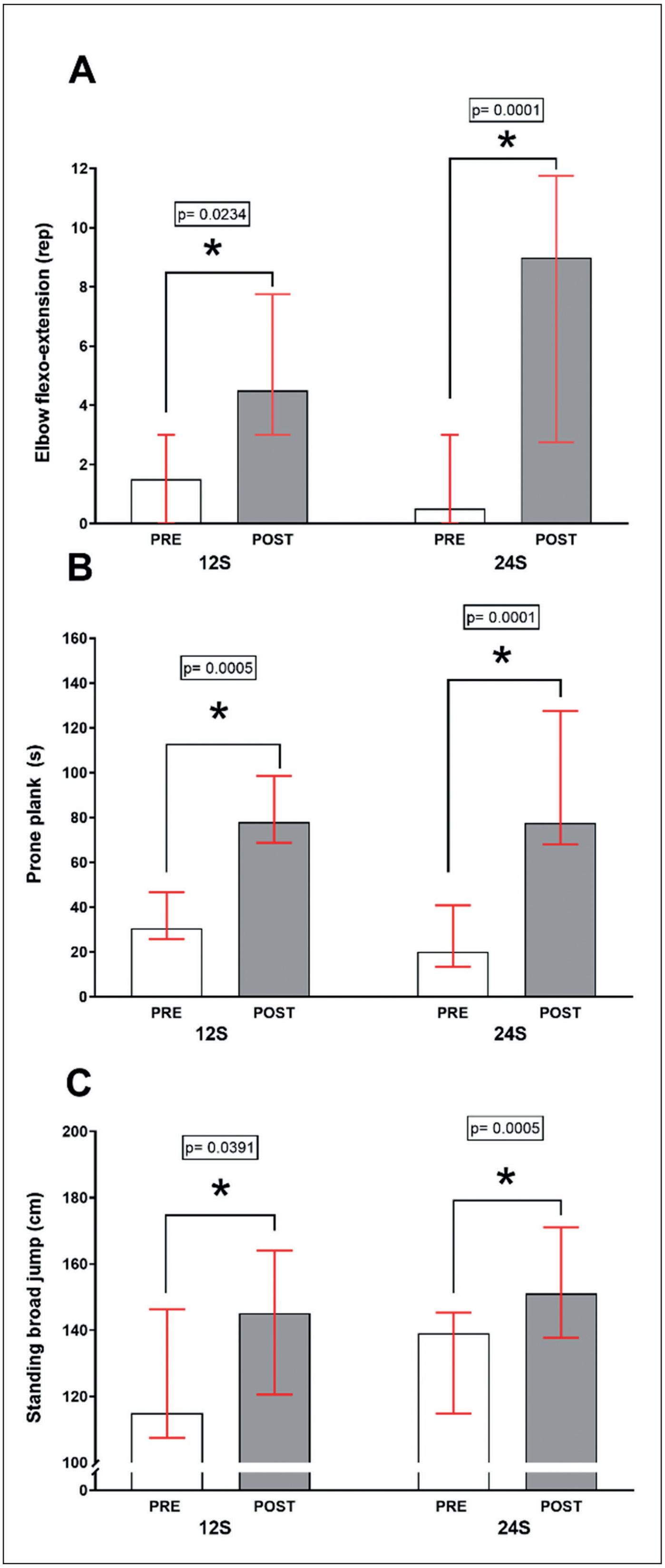

Figure 1. Muscle function measured as elbow flexion-extension (A), prone plank (B), and standing broad jump (C), after a concurrent exercise training program of 12 and 24 sessions (12S and 24S) (12 sessions). Results expressed as median (RIC). *P<0.05 concerning baseline.

terol, and HDL cholesterol. There were no changes in total cholesterol, triglycerides, LDL cholesterol, and HDL cholesterol for both the 12S and 24S groups (Table 3).

Glycemic control: There were no differences in multiple comparisons for the 12S versus 24S group for insulin, glycemia, and HOMA index variables nor changes in insulin and glycemia for both groups (Table 3). Besides, the HOMA index decreased in the 24S group compared with the 12S group [-0.2 (-1.1 - 0.0) vs -0.3 (-1.9 - 0.4), respectively; p = 0.01; ES: 0.8].

Discussion

Our main finding was that the concurrent training program improved aerobic capacity and muscle function after 12 and 24 weeks of training in overweight and obese schoolchildren and adolescents during the pandemic. Additionally, the 24S program improved multiple anthropometric parameters and glycemic control, which was not evidenced in the 12S program.

In relation to anthropometry, the 12S group showed negative changes in weight, BMI, and BMI-z, which coincides with other studies[21,22]; therefore, the 60 minutes of weekly physical exercise of the 12S group are not enough to have an impact on such characteristics. On the other hand, the 24S group did not generate changes in weight and BMI, showing positive changes in BMI-z, WC, and WHtR, similar to studies conducted before the COVID-19 pandemic[23]. Considering that the trend is toward worsening of the studied variables[21,22], the maintenance and improvement of cardiovascular risk variables (weight and BMI and BMI-z, WC, and WHtR, respectively) propose that a minimum amount of exercise is necessary to maintain cardiovascular health in this context.

After the concurrent training program, both the 12S and 24S groups achieved positive effects on muscle function. Our results are in line with those reported in the literature, supporting the idea that strength exercises performed twice a week will present greater improvements in muscle function than those performed once a week[24,25]. Both the 12S and 24S groups improved muscle function supported by the large ES. This could be due to the poor level of muscle function evidenced by both groups at baseline, with performances below the 10th percentile for sex and age in the elbow flexion-extension tests compared with the Spanish population[26], prone plank compared with a North American population[27], or standing long jump compared with the Spanish and South American population[26,28]. In addition, it has been shown that untrained subjects can achieve large gains in muscle function with small amounts of strength exercise[29,30].

Both concurrent training programs (12S and 24S) improved the aerobic capacity variables, such as VO-2max estimated by 20m SRT and distance covered during the test. The results of the 24S group are consistent with previous studies reported, where after 10 weeks, twice a week of concurrent training in an obese pediatric population, the VO2max estimated by 20m SRT increased by 1.3 ml/kg/min[31]. Interestingly, the frequency of concurrent training once a week in a pediatric population with similar characteristics did not achieve improvements in VO2max[32] which could be due to that researchers propose continuous aerobic exercise of moderate intensity, while our program contemplates HIIT, which has been shown to have a greater impact on the improvement of VO2max[7,33], in normal-weight, overweight, and obese children and adolescents.

The lipid profile did not show changes in the 12S and 24S groups in the variables of total cholesterol, triglycerides, LDL cholesterol, or HDL cholesterol, which agree with that reported in the meta-analysis of Escalante et al.[34], where three days a week or 180 minutes a week was determined as the minimum amount of exercise to achieve changes in the lipid profile of overweight and obese children and adolescents. Studies have reported increases of 9.5 mg/dl in total cholesterol, 39.9 mg/dl in triglycerides, and 8.9 mg/dl in LDL cholesterol during the COVID-19 pandemic[35], therefore, the non-existence of changes in the 12S and 24S groups in total cholesterol, triglycerides, and LDL cholesterol, evidenced a protective factor given by concurrent training program in overweight and obese children and adolescents during the COVID-19 pandemic.

After the intervention, the 12S group did not experience changes in insulin, glycemia, and HOMA index; in contrast, the 24S group showed positive changes in the HOMA index only. Review studies[36] showed that the minimum amount of exercise twice a week achieved changes in glycemic control, explaining the no variation found in the 12S group. Similarly, the 24S group did not achieve changes in glycemia, similar to results reported by other researchers[37], however, it improved the HOMA index. Our results are in line with those reported by Kim et al.[38] which, after 12 weeks of concurrent training, the HOMA index decreased from 1.5 (1.4-4.0) to 1.0 (0.8-1.4). Likewise, the evidence shows that insulin should have decreased[37,38] but, although in our study insulin decreased and has a moderate effect size, it does not reach statistical significance. There is strong evidence that glycemic control was negatively impacted during the COVID-19 pandemic[35,39], which explains why the results of both the 12S and 24S groups on glycemia, insulin, and HOMA index demonstrate

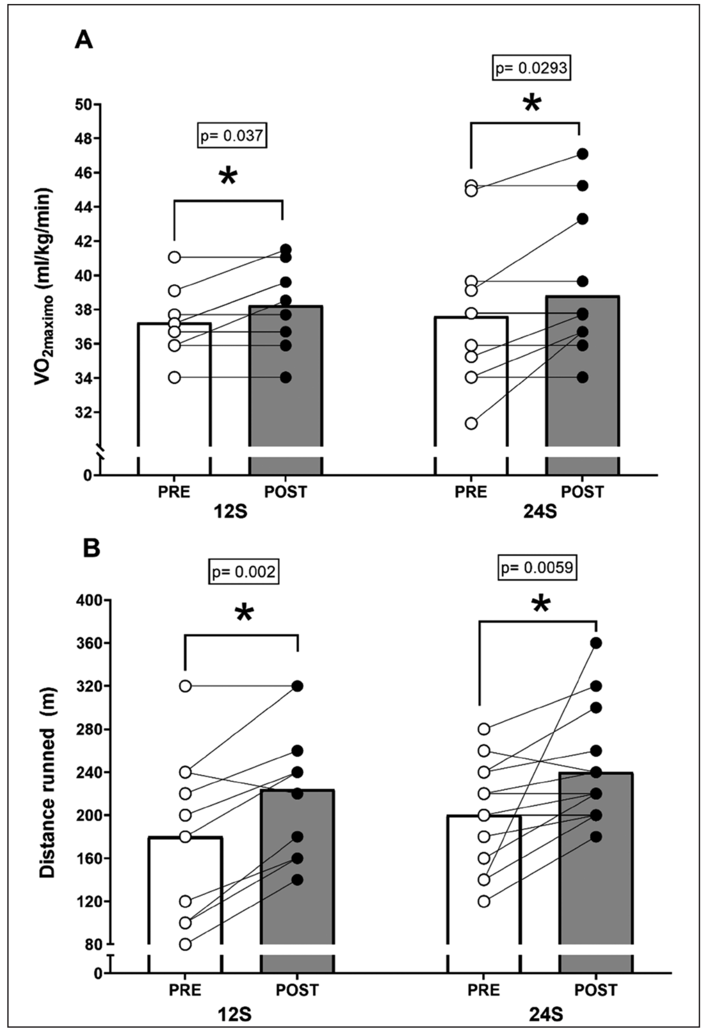

Figure 2. Individual temporal changes in aerobic capacity measured as maximal oxygen consumption estimated by Shuttle 20m run test (A) and distance runned in Shuttle 20m run test (B), after a concurrent exercise training program of 12 and 24 sessions (12S and 24S) (12 sessions). *P < 0.05 concerning baseline.

that the 12-week concurrent training program had a protective effect on these variables in overweight and obese children and adolescents.

It should be noted that our study determined that a minimum amount of concurrent training was a protective factor in cardiovascular risk variables in overweight and obese children and adolescents, even in the context of increased sedentary time and minimal physical activity. We believe it is essential to implement concurrent training programs as part of a process of innovation in the country's public health centers for the management of overweight and obesity in children and adolescents.

As limitations, we can mention that we used chronological age and not biological age since during the pubertal transition, there are musculoskeletal, en-

Table 3. Results of the application of a 12- and 24-week concurrent exercise protocol on anthropometry, aerobic capacity, muscle function, lipid profile, and glycemic control

	12S Group				24S Group			
Characteristics	Pre Intervention Values	Post Intervention Values	Pre-post difference	p-value	Pre Intervention Values	Post Intervention Values	Pre-post difference	p-value
Anthropometry								
Weight (kilograms)	74.7 ± 15.8	78.0 ± 15.9	3.2 ± 2.1	**0.001**	74.0 ± 18.6	74.9 ± 18.6	0.8 ± 2.1	0.15
Height (centimeters)	156.9 ± 11.4	157.6 ± 11.7	0.6 ± 0.8	0.06	155.0 ± 12.2	156.5 ± 11.9	1.4 ± 1.3	**0.001**
BMI (kilograms/meter2)	29.9 ± 2.8	31.0 ± 2.7	1.1 ± 0.8	**0.002**	30.2 ± 4.4	30.1 ± 4.6	-0.1 ± 0.8	0.54
BMI-z (standard deviation)	2.93 ± 0.42	3.01 ± 0.38	0.09 ± 0.10	**0.02**	2.89 ± 0.52	2.82 ± 0.60	-0.07 ± 0.13	**0.03**
WC (centimeters)	93.6 ± 10.7	92.9 ± 8.2	-0.6 ± 3.7	0.30	94.0 ± 11.0	91.0 ± 9.7	-3.0 ± 2.8	**0.001**
WHtR	0.60 ± 0.04	0.59 ± 0.02	-0.01 ± 0.03	0.73	0.60 ± 0.06	0.58 ± 0.05	-0.02 ± 0.02	**0.005**
Muscle function								
Elbow flexion - extension (repetitions)	1.5 (0.0 - 3.0)	4.5 (3.0 - 7.7)	3.0 (0.7 - 7.0)	**0.02**	0.5 (0.0 - 3.0)	9.0 (2.7 - 11.7)	6.0 (2.7 - 10.2)	**0.0001**
Prone plank (seconds)	30.4 (25.7 - 46.6)	77.8 (68.7 - 98.6)	37.0 (28.1 - 63.2)	**0.0005**	20.0 (13.4 - 40.7)	77.6 (67.9 - 127.5)	58.7 (46.5 - 109.7)	**0.0001**
Standing broad jump (centimeters)	115.0 (107.5 - 146.2)	145.0 (120.5 - 164.0)	15.0 (0.0 - 31.0)	**0.03**	139.0 (114.7 - 145.2)	151.0 (137.7 - 171.0)	22.0 (2.5 - 28.7)	**0.0005**
Aerobic capacity								
VO_{2max} estimated by Shuttle 20m-run test (millimeters/kilogram/minute)	37.2 ± 1.8	38.2 ± 2.2	0.9 ± 1.2	**0.03**	37.6 ± 4.0	38.8 ± 3.9	1.2 ± 1.8	**0.02**
Distance runned in Shuttle 20m-run test (meters)	180.0 ± 74.3	224.0 ± 61.1	44.0 ± 30.7	**0.002**	200.0 ± 47.7	240.0 ± 52.6	40.0 ± 58.1	**0.005**
Lipid profile								
Total cholesterol (mg/dl)	151.6 ± 37.6	150.6 ± 30.0	-1.0 ± 20.0	0.88	159.9 ± 40.4	160.5 ± 42.0	0.5 ± 25.0	0.93
Triglycerides (mg/dl)	108.4 ± 39.9	114.0 ± 46.0	5.6 ± 22.9	0.48	158.2 ± 76.4	157.8 ± 59.2	-0.3 ± 53.7	0.97
LDL cholesterol (mg/dl)	85.8 ± 30.4	85.4 ± 25.2	-0.4 ± 16.7	0.94	87.6 ± 34.8	83.5 ± 36.3	-4.1 ± 15.0	0.34
HDL cholesterol (mg/dl)	44.2 ± 8.0	42.4 ± 6.8	-1.8 ± 3.8	0.19	40.8 ± 7.9	42.2 ± 8.8	1.3 ± 4.9	0.32
Glycemic control								
Insulin (mU/L)	26.5 (18.8 - 35.5)	26.1 (20.0 - 31.2)	-0.6 (-7.0 - 1.8)	0.49	26.3 (18.5 - 34.6)	24.4 (17.3 - 31.6)	-4.0 (-10.1 – 2.8)	0.17
Glycemia (mg/dl)	95.5 (91.5 - 101.2)	92.5 (87.2 - 99.2)	-1.00 (-8.7 - 3.0)	0.28	96.0 (91.0 - 98.2)	93.0 (89.0 - 98.0)	-1.5 (-4.5 - 3.2)	0.67
HOMA index	6.1 (4.2 - 8.8)	5.6 (4.7 - 7.9)	-0.3 (-1.9 - 0.4)	0.32	6.2 (5.2 - 7.9)	5.4 (4.0 - 7.1)	-0.2 (-1.1 - 0.0)	**0.01**

Mean ± Standard Deviation; Median (Interquartile Range); BMI: Body Mass Index; WC: Waist Circumference; WHtR: Waist to Height Ratio; VO_{2max}: Maximal Oxygen Consumption; mg/dl: illigrams/deciliter; LDL: Low-density lipoprotein; HDL: High-density lipoprotein; mU/L: milliunits/liter; BMI-z: Body mass index calculated by z-score; HOMA: Homeostasis assessment model.

docrine, and metabolic changes that affect the responses to exercise, and there was no nutritional control of the patients during the intervention.

Conclusions

Attending 12 sessions of a concurrent training program improves aerobic capacity and muscle function and attending 24 sessions additionally improves anthropometry and HOMA index in overweight and obese children and adolescents.

Ethical Responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: This study was approved by the respective Research Ethics Committee. The authors state that the information has been obtained anonymously from previous data.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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