Original Article

RBAFS Revista Brasileira de Atividade Física & Saúde
SOCIEDADE BRASILEIRA DE ATIVIDADE FÍSICA & SAÚDE

rbafs.org.br

Effects of an exercise intervention in overweight or obese children

Efeitos de uma intervenção com exercício em crianças com sobrepeso ou obesidade

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DOI

10.12820/rbafs.31e0441

ABSTRACT

Objective: To evaluate the effects of a physical exercise intervention on anthropometric, biochemical, and cardiorespiratory fitness parameters in overweight and obese children. Methods: A randomized controlled trial was conducted with 45 schoolchildren aged 8–11 years from public schools in Uberaba, Minas Gerais, Brazil. Participants were allocated into a control group (n = 22) and two intervention groups: court-based (n = 11) and pool-based (n=12). The 21-week program included three weekly 60-minute sessions of aerobic, recreational, and game-based activities. Outcomes included body mass, body mass index, waist circumference, skinfolds, physical activity and sedentary behavior (accelerometers), VO2max (Shuttle Run), and biochemical markers (cholesterol, HDL-c, LDL-c, triglycerides, glucose, leptin, adiponectin). Analyses were performed using two-way repeated measures ANOVA (group × time) ($p < 0.05$). Results: The sample was mostly female (55.1%) with a mean age of 9.1 ± 1.0 years. No significant between-group differences were found for anthropometric, biochemical, or fitness outcomes ($p > 0.05$). The court-based group showed reductions in waist circumference and leptin, while both intervention groups showed reductions in triceps skinfold thickness, although these changes were not statistically significant. No significant group × time interaction effects were observed for physical activity or sedentary behavior variables. Conclusions: Short-term exercise-only interventions did not produce significant changes in the studied parameters. Future studies should investigate whether different intervention structures, durations, and complementary components may lead to different results in childhood obesity management.

Keywords: Pediatric obesity; Physical exercise; Biomarkers; Child health.

RESUMO

Objetivo: Avaliar os efeitos de uma intervenção com exercícios físicos sobre parâmetros antropométricos, bioquímicos e de aptidão cardiorrespiratória em crianças com sobrepeso e obesidade. Métodos: Um ensaio clínico randomizado foi realizado com 45 escolares de 8 a 11 anos da rede pública de Uberaba, Minas Gerais, Brasil. Os participantes foram alocados em um grupo controle (GC, n = 22) e dois grupos de intervenção: quadra (GIQ, n = 11) e piscina (GIP, n = 12). O programa teve duração de 21 semanas, com três sessões semanais de 60 minutos, compostas por atividades aeróbias, recreativas e jogos. As variáveis avaliadas incluíram massa corporal, índice de massa corporal, circunferência da cintura, dobras cutâneas, atividade física e comportamento sedentário (acelerômetros), VO_2máx (Shuttle Run) e marcadores bioquímicos (colesterol, HDL-c, LDL-c, triglicerídeos, glicemia, leptina, adiponectina). As análises foram realizadas por meio de ANOVA two-way com medidas repetidas (grupo × tempo) ($p < 0,05$). Resultados: A amostra foi composta majoritariamente por meninas (55,1%), com média de idade de 9,1 ± 1,0 anos. Não foram encontradas diferenças significativas entre os grupos para variáveis antropométricas, bioquímicas ou de aptidão cardiorrespiratória ($p > 0,05$). O grupo de intervenção em quadra apresentou reduções na circunferência da cintura e na leptina, enquanto ambos os grupos de intervenção apresentaram redução na dobra cutânea tricipital, embora essas mudanças não tenham sido estatisticamente significativas. Não foram observados efeitos significativos de interação grupo × tempo para as variáveis de atividade física ou comportamento sedentário. Conclusões: Intervenções de curto prazo baseadas exclusivamente em exercícios físicos não produziram mudanças significativas nos parâmetros avaliados. Estudos futuros devem investigar se diferentes estruturas de intervenção, durações e componentes complementares podem levar a resultados distintos no manejo da obesidade infantil.

Palavras-chave: *Obesidade pediátrica; Exercício físico; Biomarcadores; Saúde infantil.*

Introduction

Overweight and obesity consist of excessive body fat accumulation, a condition that can bring negative health implications in the short, medium, and long term, including cardiovascular, metabolic, and psychological risk[1]. These conditions are multifactorial, involving complex interactions between genetics, dietary behaviors, sedentary lifestyle, family environment, and

socioeconomic factors, which makes their treatment particularly challenging[2].

The prevalence of childhood obesity continues to rise alarmingly worldwide. A recent global survey reported that among children and adolescents aged 5 to 19 years, obesity has tripled since 1990, and overweight plus obesity has doubled during the same period, with estimates suggesting that more than 90 million children will be a affected by obesity alone by 2025 in the absence of effective measures[3]. In Brazil, recent systematic reviews estimate childhood obesity prevalence at approximately 12.2% for children under 12 years, with significant variations between states and regions, demonstrating geographic heterogeneity and challenges for local public policies[4].

Excess weight in childhood is associated with increased morbidity and premature mortality in adulthood. Childhood obesity raises the risk of insulin resistance, dyslipidemias, metabolic syndrome, arterial hypertension, among other comorbidities, in addition to adverse psychological effects and reduced quality of life at early ages[5]. Therefore, early diagnosis and intervention as soon as possible are essential to interrupt or minimize the progression of these consequences.

Among intervention strategies, physical exercise programs have received special attention. Regular physical activity promotes energy expenditure, improves body composition and cardiorespiratory capacity, and has beneficial effects on biochemical markers such as lipid profile and insulin resistance[6]. Interventions that incorporate playful, recreational, or sports components, or that take place in school settings, appear to enhance adherence in children, a critical factor for sustained impact[7,8].

In addition, programs that combine land-based playful exercises with aquatic activities have been identified as particularly suitable strategies for pediatric populations with obesity, as they promote greater adherence, reduce osteoarticular overload, and enhance engagement, while simultaneously providing distinct and complementary physiological stimuli[9-11]. In this context, interventions that integrate different exercise modalities and multiple health indicators[12,13] are essential for a more comprehensive understanding of the effects of physical exercise on childhood obesity.

The objective of this study was to analyze the effect of a physical exercise intervention program on anthropometric, biochemical, and cardiorespiratory fitness parameters in children with overweight or obesity, aiming to contribute to the understanding of the effects of physical exercise on clinically relevant outcomes in children with overweight or obesity.

Methods

Study Design

This was a Randomized Controlled Trial based on physical exercise involving children who were classified as overweight or obese.

Ethical aspects

This study was approved by the Research Ethics Committee with Human Subjects of the da Federal University of Triângulo Mineiro (CAAE: 63985317.9.0000.5154) and all parents or legal guardians signed the Informed Consent Form.

Participants

The study population included children aged 8 to 11 years with a body mass index (BMI) above the 85th percentile for age and sex, corresponding to a Z-score > +1 SD, according to the World Health Organization 2007 growth reference for children and adolescents aged 5–19 years, and were classified as overweight or obese[14].

Children were recruited from Municipal School in Uberaba, Minas Gerais, Brazil, between May and June 2017. After a physical assessment conducted by the school with all enrolled students, BMI was calculated, and all children classified as overweight or obese were invited to learn about the study.

Inclusion and exclusion criteria

- Inclusion: children with overweight or obesity, aged 8 to 11 years, enrolled in elementary school at Municipal School Professor José Geraldo Guimarães in Uberaba, Minas Gerais, residing in Uberaba, not on a caloric restriction diet, and not using medications continuously.
- Exclusion: initiating participants in any structured weight-loss program, missing more than 19 sessions during the intervention program (Participants rate <70%), or presenting any physical or mental disability that would prevent participation in the program. This criterion was defined a priori to ensure minimum exposure to the intervention and participants who did not meet it were considered losses due to low adherence.

Group Allocation

The 45 children who agreed to participants were allocated into a control group (CG) and two intervention

groups. One intervention group performed activities in the sports court (Court Intervention Group - CIG, n = 11) and the other in the swimming pool (Pool Intervention Group - PIG, n = 12), while the CG (n = 22) continued their usual daily activities.

Attrition between the beginning and end of the program totaled two children in CIG, one in PIG, and one in CG, resulting in four children dropping out. After the experiment, an intervention program was offered to the children in the CG.

Experimental protocol

Figure 1 illustrates the entire experimental protocol procedure of the study.

Intervention

The intervention program consisted of physical exercises with aerobic, recreational, and sports activities, conducted in an extracurricular setting over 21 weeks.

Location: Municipal School Professor José Geraldo Guimarães gymnasium and swimming pool.

Frequency and duration: Three times per week, 60 minutes per session, totaling 63 sessions.

Supervision: Physical Education teachers.

Session structure:

- Warm-up/stretching (5–10 min)
- Main part – aerobic activities (20–25 min)
- Station circuit (15–20 min)
- Recreational games (10–15 min)
- Cool-down (5–10 min)

Exercises included playful activities involving running, walking, circuits, pre-sport games, and various aquatic activities. Support materials included ropes, balls, hoops, cones, and floating equipment (kickboards, dumbbells, pool noodles).

Exercise intensity was monitored to reach moderate to vigorous levels using the Modified Borg Scale[15]. This visual scale associates values from 0 to 10 with textual effort descriptors and is adapted for children using illustrations.

Outcomes

Anthropometry:

- Body mass (BM): digital electronic scale (Wiso, model W-721, Brazil), maximum capacity 180 kg, precision 100 g.
- Height: portable stadiometer (Sanny, Personal Caprice, Brazil), 2 m range, 0.1 cm precision.
- BMI: calculated as BMI = BM (kg)/Height^2 (m), classified according to age and sex[14].
- Waist circumference (WC): flexible, inelastic tape measure, 2 m (TBW, São Paulo), measured at the midpoint between the iliac crest and the last floating rib[16].
- Skinfolds: triceps (SF-Tri), biceps (SF-Bi), subscapular (SF-Sub), and suprailiac (SF-Supra), measured using a Lange caliper (constant pressure 10 g/mm^2)[17].

Physical activity and sedentary behavior: ActiGraph GT3X-BT accelerometers (ActiGraphCorp, Pensacola, FL) were used to monitor light physical activity, moderate physical activity, vigorous physical activity, and sedentary behavior. Cut-off points were based on Evenson et al.[18]. For children, sedentary activity was defined as 0–100 counts per minute, light activity as 101–2,295 counts per minute, moderate activity as 2,296–4,011 counts per minute, and vigorous activity as ≥4,012 counts per minute, values widely used to classify physical activity intensity measured by accelerometers[18]. The device was worn on the waist us-

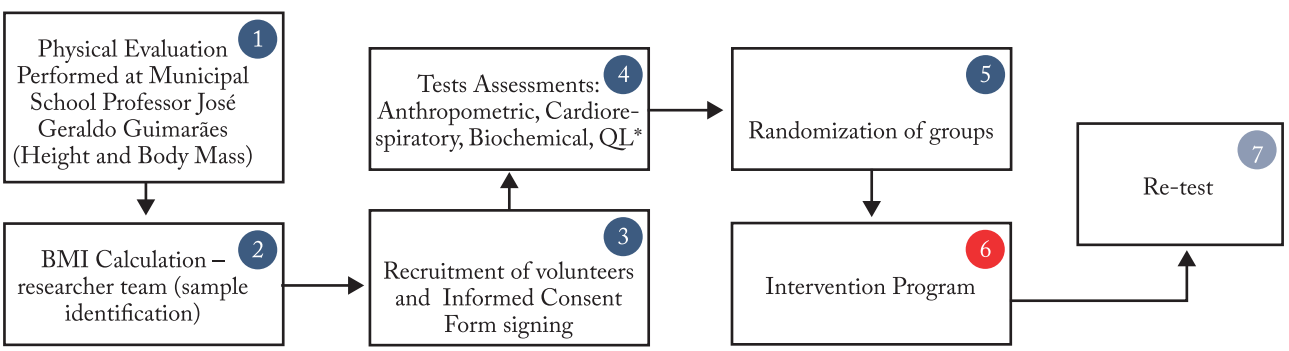

Figure 1 – Experimental protocol of the study. The diagram illustrates the sequence of participation identification, recruitment, baseline assessments, randomization, intervention program, and re-test. Anthropometric, cardiorespiratory, and biochemical assessments were performed. QL* = refers to the Quality of Life questionnaire[33].

ing an elastic belt aligned with the mid-axillary line for seven consecutive days (five weekdays and two weekend days), with a frequency of 80 Hz.

Cardiorespiratory fitness: was assessed by the 20 m Shuttle Run test was applied to estimate maximal oxygen consumption (VO_2max, $mL \cdot kg^{-1} \cdot min^{-1}$). The formula by Brito et al., validated for children[19], was used, considering age and the average speed achieved.

Biochemical variables: Blood samples were collected after 8–12 hours of fasting at the school by trained professionals using disposable materials. Samples were centrifuged for 8 minutes, and serum and plasma were used to determine total cholesterol, HDL-c, LDL-c, triglycerides, glucose, and leptin and adiponectin hormones. All analyses followed standardized methods and technical specifications of the reagents used.

Statistical analyses

Descriptive analysis of the studied variables was initially performed. Anthropometric, biochemical, and cardiorespiratory fitness characteristics were expressed as mean, standard deviation (SD), and 95% confidence intervals (95% CI). The delta (Δ) of each variable was calculated as the difference between post- and pre-intervention values (Δ = post – pre) and is presented for descriptive purposes only. Inferential analyses were performed using two-way repeated measures ANOVA. First, the intervention groups were combined (court-based + pool-based) and compared with the control group, with group as the between-subject factor and time (pre vs post) as the within-subject factor. Additional analyses were also conducted considering the three groups separately (court-based intervention, pool-based intervention, and control). In all models, the group × time interaction term was used to test the effect of the intervention. The significance level was set at $\alpha = 5\%$ ($p < 0.05$). All analyses were performed using SPSS version 24.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 45 children participated in the study, with 55.1% being female. Four children did not reach the minimum participation rate of 70% in the intervention sessions and were considered losses due to low adherence to the protocol. The mean age of the groups was: CIG 9.0 ± 0.5 years, PIG 9.3 ± 1.0 years, and CG 9.1 ± 1.2 years.

Table 1 presents the descriptive results of the anthropometric variables for the CIG, PIG, and CG groups. All groups showed increases in post-experiment values of body mass and BMI. However, no significant group × time interaction effects were observed, indicating that changes over time were similar between the intervention and control groups. For WC, skinfold thickness, and cardiorespiratory fitness, no significant group × time interaction effects were detected ($p > 0.05$). The pre- and post-intervention means for all variables are presented in Supplementary Table 4.

The results of physical activity levels and sedentary behavior are presented in Table 2. Although reductions were observed over time in physical activity levels and sedentary behavior across all groups, no significant group × time interaction effects were detected ($p > 0.05$), indicating that changes occurred similarly in the intervention and control groups. The pre- and post-intervention means for all variables are presented in Supplementary Table 5.

Regarding the biochemical data (total cholesterol, LDL-c, HDL-c, glucose, and triglycerides) and hormones (adiponectin and leptin) presented in Table 3, no significant group × time interaction effects were observed ($p > 0.05$). Although some variables showed significant time effects, these changes occurred similarly in both intervention and control groups. The pre- and post-intervention means for all variables are presented in Supplementary Table 6.

The ANOVA effects for each variable are presented in Supplementary Table 4.

Discussion

The main findings of this study indicate the absence of significant group × time interaction effects suggests that the physical exercise intervention program, by itself, was not sufficient to promote changes beyond those observed in the control group in anthropometric, biochemical, and cardiorespiratory fitness parameters in children with overweight or obesity. Although physical activity is recognized as a key component in the treatment and prevention of childhood obesity, the etiology of this condition is complex and multifactorial, involving genetic, behavioral, environmental, and sociocultural determinants that influence the response to interventions[21–23]. Thus, it is plausible that physical exercise, when applied in isolation, without dietary and/or sleep control and over a short period of time, has a limited impact on clinical and metabolic indicators, not being sufficient to modify overweight status or its associated comorbidities.

On the other hand, the literature has shown that

Table 1 – Anthropometric characteristics, waist circumference, skinfold thickness, and VO_2max (mean ± standard deviation and Δ) of overweight and obese children in the court, pool, and control groups.

Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)	Δ (Post–Pre)
Body mass (kg)			
Court Intervention Group	50.65 ± 11.70	53.97 ± 13.01	+3.32
Pool Intervention Group	46.75 ± 6.25	49.62 ± 6.86	+2.87
Control Group	48.25 ± 11.14	51.33 ± 10.44	+3.08
Body mass index (kg/m^2)			
Court Intervention Group	24.65 ± 4.19	24.80 ± 4.46	+0.15
Pool Intervention Group	23.44 ± 1.69	24.11 ± 1.92	+0.67
Control Group	23.86 ± 3.59	24.25 ± 3.18	+0.39
Waist circumference (cm)			
Court Intervention Group	85.00 ± 5.33	83.89 ± 5.33	−1.11
Pool Intervention Group	85.00 ± 3.94	87.48 ± 3.94	+2.48
Control Group	85.00 ± 5.70	85.62 ± 5.70	+0.62
Triceps Skinfold (mm)			
Court Intervention Group	28.95 ± 4.32	26.82 ± 3.09	−2.13
Pool Intervention Group	27.81 ± 3.75	26.50 ± 4.06	−1.31
Control Group	27.96 ± 4.70	27.55 ± 5.64	−0.41
Biceps Skinfold (mm)			
Court Intervention Group	24.50 ± 4.50	27.36 ± 5.32	+2.86
Pool Intervention Group	23.18 ± 3.41	26.25 ± 2.99	+3.07
Control Group	22.42 ± 3.76	24.64 ± 5.63	+2.22
Subscapular Skinfold (mm)			
Court Intervention Group	29.26 ± 6.49	28.27 ± 6.36	−0.99
Pool Intervention Group	26.06 ± 7.49	25.83 ± 4.80	−0.23
Control Group	26.73 ± 6.56	28.41 ± 8.78	+1.68
Supra-iliac Skinfold (mm)			
Court Intervention Group	31.45 ± 4.62	34.00 ± 4.96	+2.55
Pool Intervention Group	30.88 ± 5.93	35.58 ± 3.87	+4.70
Control Group	30.78 ± 4.10	35.68 ± 10.81	+4.90
Maximal Oxygen Uptake (mL·kg^{-1}·min^{-1})			
Court Intervention Group	34.90 ± 5.99	32.31 ± 5.99	−2.59
Pool Intervention Group	35.00 ± 3.55	36.29 ± 3.55	+1.29
Control Group	35.10 ± 5.75	36.07 ± 5.75	+0.97

Court Intervention Group (n = 11); Pool Intervention Group (n = 12); Control Group (n = 22). Values are presented as mean ± standard deviation. Δ = post–pre.

structured physical exercise programs, especially when combined with nutritional and health education strategies, are capable of generating positive effects in obese children and adolescents, including improvements in cardiometabolic profile and body composition[24,25]. For example, Cordellat et al.[24] demonstrated that a 16-week multicomponent program, combining playful physical training and nutritional counseling, promoted improvements in body composition, reduction of BMI z-score, increased muscle strength and aerobic capacity, as well as decreased blood glucose and lipid levels. Similarly, Nie et al.[25] reported that combined diet and exercise interventions in obese children reduced weight, BMI, body fat percentage, and blood lipids, increased basal metabolic rate and physical activity, and lowered inflammatory markers, reinforcing the effectiveness of multicomponent strategies in the treatment of childhood obesity. Therefore, although our initial hypothesis was not confirmed, the findings reinforce the relevance of integrated and long-term strategies, considering that childhood obesity requires a comprehensive management approach that goes beyond physical exercise as a stand-alone intervention.

Moreover, recent studies have shown that recreation-

Table 2 – Physical activity levels and sedentary behavior (mean ± standard deviation and Δ) of overweight and obese children in the court, pool, and control groups.

Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)	Δ (Post–Pre)
Light physical activity / weekdays (min)			
Court Intervention Group	1151.25 ± 439.81	1015.40 ± 298.04	−135.85
Pool Intervention Group	1458.85 ± 414.35	1154.60 ± 304.51	−304.25
Control Group	1217.39 ± 354.28	1102.91 ± 301.74	−114.48
Moderate physical activity / weekdays (min)			
Court Intervention Group	130.15 ± 57.40	76.30 ± 44.81	−53.85
Pool Intervention Group	205.46 ± 71.35	167.28 ± 57.35	−38.18
Control Group	151.52 ± 73.85	152.53 ± 65.86	+1.01
Vigorous physical activity / weekdays (min)			
Court Intervention Group	44.98 ± 23.65	27.40 ± 28.44	−17.58
Pool Intervention Group	63.13 ± 27.79	56.02 ± 29.48	−7.11
Control Group	47.22 ± 35.12	52.47 ± 28.72	+5.25
Light physical activity / weekend days (min)			
Court Intervention Group	462.63 ± 192.29	389.85 ± 136.79	−72.78
Pool Intervention Group	632.85 ± 142.01	574.08 ± 146.06	−58.77
Control Group	508.53 ± 173.39	427.19 ± 150.37	−81.34
Moderate physical activity / weekend days (min)			
Court Intervention Group	43.02 ± 25.83	21.30 ± 11.23	−21.72
Pool Intervention Group	79.04 ± 22.04	69.70 ± 45.55	−9.34
Control Group	55.95 ± 28.13	47.28 ± 32.33	−8.67
Vigorous physical activity / weekend days (min)			
Court Intervention Group	10.88 ± 8.18	5.90 ± 4.04	−4.98
Pool Intervention Group	23.08 ± 13.99	23.00 ± 16.29	−0.08
Control Group	16.32 ± 14.69	11.28 ± 8.88	−5.04
Total physical activity (min)			
Court Intervention Group	1842.90 ± 697.65	1536.15 ± 324.38	−306.75
Pool Intervention Group	2462.40 ± 561.35	2044.70 ± 501.06	−417.70
Control Group	1996.89 ± 572.99	1793.13 ± 471.34	−203.76
Average physical activity (min)			
Court Intervention Group	307.15 ± 116.28	256.03 ± 54.06	−51.12
Pool Intervention Group	410.40 ± 93.56	340.78 ± 83.52	−69.62
Control Group	332.82 ± 95.50	298.94 ± 78.43	−33.88
Sedentary behavior / weekdays (min)			
Court Intervention Group	4435.80 ± 3044.76	2245.00 ± 339.95	−2190.80
Pool Intervention Group	4515.13 ± 2480.01	2788.43 ± 853.49	−1726.70
Control Group	4099.02 ± 2619.73	2146.78 ± 691.74	−1952.24
Sedentary behavior / weekend days (min)			
Court Intervention Group	1402.43 ± 944.38	850.25 ± 318.86	−552.18
Pool Intervention Group	1566.27 ± 640.88	1009.88 ± 427.66	−556.39
Control Group	1423.61 ± 724.78	637.31 ± 289.54	−786.30
Total sedentary behavior (min)			
Court Intervention Group	5838.23 ± 3985.43	3095.25 ± 368.27	−2742.98
Pool Intervention Group	6081.44 ± 3106.96	3798.30 ± 1169.80	−2283.14
Control Group	5522.63 ± 3312.55	2784.09 ± 743.18	−2738.54
Average sedentary behavior (min)			
Court Intervention Group	2919.12 ± 1992.72	1547.63 ± 184.13	−1371.49
Pool Intervention Group	3040.70 ± 1553.50	1899.15 ± 584.90	−1141.55
Control Group	2761.32 ± 1656.27	1392.05 ± 371.59	−1369.27

Court Intervention Group (n = 11); Pool Intervention Group (n = 12); Control Group (n = 22). Values are presented as mean ± standard deviation. Δ = post–pre. min = minutes.

Table 3 – Biochemical and hormonal variables (mean ± standard deviation and Δ) of overweight and obese children in the court, pool, and control groups.

Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)	Δ (Post–Pre)
Total cholesterol (mg/dL)			
Court Intervention Group	144.73 ± 47.77	148.55 ± 46.14	+3.81
Pool Intervention Group	137.82 ± 16.53	147.00 ± 13.53	+7.90
Control Group	148.74 ± 31.85	150.33 ± 27.77	+6.57
Low-Density Lipoprotein Cholesterol-c (mg/dL)			
Court Intervention Group	93.14 ± 42.12	95.89 ± 38.85	+2.75
Pool Intervention Group	89.46 ± 16.88	95.01 ± 12.45	+3.88
Control Group	99.16 ± 31.17	95.75 ± 27.39	+2.06
High-Density Lipoprotein Cholesterol-c (mg/dL)			
Court Intervention Group	32.82 ± 7.26	35.91 ± 8.32	+3.09
Pool Intervention Group	32.45 ± 6.70	35.58 ± 3.85	+3.40
Control Group	34.33 ± 7.44	37.78 ± 6.73	+3.85
Glucose (mg/dL)			
Court Intervention Group	77.00 ± 7.40	72.36 ± 5.35	−4.63
Pool Intervention Group	80.09 ± 4.25	71.92 ± 5.88	−7.90
Control Group	78.58 ± 10.95	73.83 ± 6.84	−6.64
Triglycerides (mg/dL)			
Court Intervention Group	95.27 ± 48.14	76.73 ± 31.14	−18.50
Pool Intervention Group	71.27 ± 25.93	74.67 ± 17.16	+4.90
Control Group	73.89 ± 30.31	78.44 ± 32.91	+6.57
Adiponectin (ng/mL)*			
Court Intervention Group	2338.55 ± 824.21	1698.50 ± 837.37	−640.04
Pool Intervention Group	3461.14 ± 648.97	2632.60 ± 1038.52	−745.32
Control Group	2767.98 ± 880.70	2305.52 ± 1243.81	−411.36
Leptin (ng/mL)*			
Court Intervention Group	1069.50 ± 734.11	590.49 ± 701.04	−393.71
Pool Intervention Group	519.25 ± 538.31	701.85 ± 266.13	+83.51
Control Group	754.52 ± 769.65	614.96 ± 426.26	+140.44

Court Intervention Group (n = 11); Pool Intervention Group (n = 12); Control Group (n = 22). Values are presented as mean ± standard deviation. Δ = post–pre. *Variables assessed in a subsample.

al physical exercise programs implemented in school settings and combined with the promotion of healthy habits may generate benefits in cardiorespiratory fitness and cardiovascular risk factors, such as reductions in LDL-c, triglycerides, total cholesterol, and blood pressure[26,27]. Even when group differences do not reach statistical significance, these findings support the relevance of school-based interventions as accessible and potentially wide-reaching public health strategies. Thus, our results should be interpreted with caution, as they do not invalidate the potential benefits of physical exercise; however, they also do not demonstrate effectiveness under the conditions evaluated in the present study

Regarding anthropometric measures (BW, height, BMI, and WC), reductions associated with decreased cardiovascular risk were expected, since childhood obesity is a well-established risk factor for cardiometabolic diseases throughout life[28]. However, physiological factors inherent to childhood and adolescence, such as skeletal growth, hormonal changes, and the onset of the prepubertal period, may have influenced the lack of significant differences between groups[29]. Recent evidence shows that children undergoing obesity treatment may present distinct patterns of growth velocity and body composition, which directly interfere with the interpretation of anthropometric outcomes[30].

Regarding waist circumference and triceps skinfold thickness, no significant group, time, or group × time effects were observed, which was also observed for hormonal outcomes, such as leptin or adiponectin. These findings should be interpreted primarily in light of temporal changes common to the sample, rather than descriptive variations within a specific group.

The absence of statistically significant changes in

VO_2max observed in this study is consistent with previous evidence from interventions involving children with obesity, in which physical exercise programs do not always result in marked increases in cardiorespiratory fitness, particularly in short- to medium-term interventions and due to the high interindividual variability of this response[31]. Systematic reviews indicate that more consistent gains in VO_2max tend to occur in longer interventions or those with more specific training stimuli, whereas programs with a playful character prioritize adherence and may lead to more modest cardiorespiratory adaptations[32].

Among the strengths of this study are the implementation of 180 minutes per week of moderate-to-vigorous intensity physical exercise, the high adherence rate (91.8%), and the engagement of the children, particularly in aquatic activities, which represent a playful and inclusive strategy with the potential to encourage participation among traditionally less active groups. As limitations, it is important to highlight the absence of nutritional follow-up, the lack of direct monitoring of exercise intensity, and the relatively short duration of the intervention, factors that may have restricted the magnitude of observed changes. The sample size can be considered a limitation of the study, as no prior sample size calculation was performed. Furthermore, no additional physical activity or exercise recommendations or monitoring were implemented beyond the prescribed intervention, which also represents a limitation. Future research should prioritize multicomponent approaches combining physical exercise, dietary counseling, and greater family involvement, as well as using technologies for monitoring intensity to optimize the precision of results. Such strategies may maximize effects on body composition, metabolic parameters, and hormonal profiles, contributing more effectively to the prevention and management of childhood obesity.

In conclusion, the intervention based exclusively on physical exercise, even with a playful and recreational character, was not sufficient to promote significant changes in the anthropometric, biochemical, and cardiorespiratory fitness parameters of the children evaluated. These results indicate that, under the duration and conditions evaluated in the present study, the exercise program alone did not produce measurable effects beyond those observed in the control group.

Conflict of interest

The authors declare no conflict of interest.

Author's contributions

Viana RS: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Resources; Data curation; Supervision; Project administration; Visualization; Writing – original draft; Writing – review & editing; Approval of the final version. Sampaio BOA, Santos A and Lagoa MJ: Data curation; Writing – review & editing; Approval of the final version. Andaki ACR: Conceptualization; Methodology; Software; Validation; Formal analysis; Investigation; Resources; Data curation; Supervision; Project administration; Visualization; Writing – review & editing; Approval of the final version.

Declaration regarding the use of artificial intelligence tools in the article writing process

The authors did not use artificial intelligence tools for preparation of the manuscript.

Availability of research data and other materials

The content is now available.

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Received: 11/03/2025
Reviewed: 01/21/2025
Approved: 02/10/2026

Cite this article as:
Viana RS, Sampaio BOA, Santos A, Lagoa MJ, Andaki ACR. Effects of a physical exercise intervention program on overweight or obese children: assessment of anthropometric, biochemical, and cardiorespiratory fitness parameters. Rev. Bras. Ativ. Fis. Saúde. 2026;31:e0441. doi: 10.12820/rbafs.31e0441

Supplementary Tables

Supplementary Tables 1 – Anthropometric and fitness outcomes (mean ± standard deviation) of overweight and obese children in the Terrestrial, Aquatic, and Control intervention groups.

Variable	Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)
Height (cm)	Court Intervention Group	1.42 ± 0.08	1.47 ± 0.07
	Pool Intervention Group	1.40 ± 0.07	1.43 ± 0.07
	Control Group	1.41 ± 0.09	1.45 ± 0.08
Body mass (kg)	Court Intervention Group	50.65 ± 11.70	53.97 ± 13.01
	Pool Intervention Group	46.75 ± 6.25	49.62 ± 6.86
	Control Group	48.25 ± 11.14	51.33 ± 10.44
Body mass index (kg/m^2)	Court Intervention Group	24.65 ± 4.19	24.80 ± 4.46
	Pool Intervention Group	23.44 ± 1.69	24.11 ± 1.92
	Control Group	23.86 ± 3.59	24.25 ± 3.18
Waist circumference (cm)	Court Intervention Group	85.0 ± 5.33	83.89 ± 5.33
	Pool Intervention Group	85.0 ± 3.94	87.48 ± 3.94
	Control Group	85.0 ± 5.70	85.62 ± 5.70
Triceps skinfold (mm)	Court Intervention Group	28.95 ± 4.32	26.82 ± 3.09
	Pool Intervention Group	27.81 ± 3.75	26.50 ± 4.06
	Control Group	27.96 ± 4.70	27.55 ± 5.64
Biceps skinfold (mm)	Court Intervention Group	24.50 ± 4.50	27.36 ± 5.32
	Pool Intervention Group	23.18 ± 3.41	26.25 ± 2.99
	Control Group	22.42 ± 3.76	24.64 ± 5.63
Subscapular skinfold (mm)	Court Intervention Group	29.26 ± 6.49	28.27 ± 6.36
	Pool Intervention Group	26.06 ± 7.49	25.83 ± 4.80
	Control Group	26.73 ± 6.56	28.41 ± 8.78
Supra-iliac skinfold (mm)	Court Intervention Group	31.45 ± 4.62	34.00 ± 4.96
	Pool Intervention Group	30.88 ± 5.93	35.58 ± 3.87
	Control Group	30.78 ± 4.10	35.68 ± 10.81
Maximal oxygen volume (mL·kg^{-1}·min^{-1})	Court Intervention Group	35.0 ± 59.87	32.31 ± 59.87
	Pool Intervention Group	35.0 ± 35.49	62.87 ± 35.49
	Control Group	35.0 ± 57.51	60.71 ± 57.51

Descriptive data.

Supplementary Table 2 – Physical activity levels and sedentary behavior (mean ± standard deviation) of overweight and obese children in the Terrestrial, Aquatic, and Control intervention groups.

Variable	Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)
Light physical activity/week (min)	Court Intervention Group	1151.25 ± 439.81	1015.40 ± 298.04
	Pool Intervention Group	1458.85 ± 414.35	1154.60 ± 304.51
	Control Group	1217.39 ± 354.28	1102.91 ± 301.74
Moderate physical activity/week (min)	Court Intervention Group	130.15 ± 57.40	76.30 ± 44.81
	Pool Intervention Group	205.46 ± 71.35	167.28 ± 57.35
	Control Group	151.52 ± 73.85	152.53 ± 65.86
Vigorous physical activity/week (min)	Court Intervention Group	44.98 ± 23.65	27.40 ± 28.44
	Pool Intervention Group	63.13 ± 27.79	56.02 ± 29.48
	Control Group	47.22 ± 35.12	52.47 ± 28.72
Light physical activity/weekend (min)	Court Intervention Group	462.63 ± 192.29	389.85 ± 136.79
	Pool Intervention Group	632.85 ± 142.01	574.08 ± 146.06
	Control Group	508.53 ± 173.39	427.19 ± 150.37
Moderate physical activity/weekend (min)	Court Intervention Group	43.02 ± 25.83	21.30 ± 11.23
	Pool Intervention Group	79.04 ± 22.04	69.70 ± 45.55
	Control Group	55.95 ± 28.13	47.28 ± 32.33
Vigorous physical activity/weekend (min)	Court Intervention Group	10.88 ± 8.18	5.90 ± 4.04
	Pool Intervention Group	23.08 ± 13.99	23.00 ± 16.29
	Control Group	16.32 ± 14.69	11.28 ± 8.88
Total physical activity (min)	Court Intervention Group	1842.90 ± 697.65	1536.15 ± 324.38
	Pool Intervention Group	2462.40 ± 561.35	2044.70 ± 501.06
	Control Group	1996.89 ± 572.99	1793.13 ± 471.34
Sedentary behavior/week (min)	Court Intervention Group	4435.80 ± 3044.76	2245.00 ± 339.95
	Pool Intervention Group	4515.13 ± 2480.01	2788.43 ± 853.49
	Control Group	4099.02 ± 2619.73	2146.78 ± 691.74
Sedentary behavior/weekend (min)	Court Intervention Group	1402.43 ± 944.38	850.25 ± 318.86
	Pool Intervention Group	1566.27 ± 640.88	1009.88 ± 427.66
	Control Group	1423.61 ± 724.78	637.31 ± 289.54
Total sedentary behavior (min)	Court Intervention Group	5838.23 ± 3985.43	3095.25 ± 368.27
	Pool Intervention Group	6081.44 ± 3106.96	3798.30 ± 1169.80
	Control Group	5522.63 ± 3312.55	2784.09 ± 743.18

Descriptive data.

Supplementary Table 3 – Biochemical characteristics (mean ± standard deviation) of overweight and obese children in the Terrestrial, Aquatic, and Control intervention groups.

Variable	Group	Pre (mean ± standard deviation)	Post (mean ± standard deviation)
Cholesterol (mg/dL)	Court Intervention Group	144.73 ± 47.77	148.55 ± 46.14
	Pool Intervention Group	137.82 ± 16.53	147.00 ± 13.53
	Control Group	148.74 ± 31.85	150.33 ± 27.77
High-Density Lipoprotein (mg/dL)	Court Intervention Group	32.82 ± 7.26	35.91 ± 8.32
	Pool Intervention Group	32.45 ± 6.70	35.58 ± 3.85
	Control Group	34.33 ± 7.44	37.78 ± 6.73
Triglycerides (mg/dL)	Court Intervention Group	95.27 ± 48.14	76.73 ± 31.14
	Pool Intervention Group	71.27 ± 25.93	74.67 ± 17.16
	Control Group	73.89 ± 30.31	78.44 ± 32.91
Low-Density Lipoprotein (mg/dL)	Court Intervention Group	93.14 ± 42.12	95.89 ± 38.85
	Pool Intervention Group	89.46 ± 16.88	95.01 ± 12.45
	Control Group	99.16 ± 31.17	95.75 ± 27.39
Glucose (mg/dL)	Court Intervention Group	77.00 ± 7.40	72.36 ± 5.35
	Pool Intervention Group	80.09 ± 4.25	71.92 ± 5.88
	Control Group	78.58 ± 10.95	73.83 ± 6.84
Leptin (ng/mL)	Court Intervention Group	1069.50 ± 734.11	590.49 ± 701.04
	Pool Intervention Group	519.25 ± 538.31	701.85 ± 266.13
	Control Group	754.52 ± 769.65	614.96 ± 426.26
Adiponectin (ng/mL)	Court Intervention Group	2338.55 ± 824.21	1698.50 ± 837.37
	Pool Intervention Group	3461.14 ± 648.97	2632.60 ± 1038.52
	Control Group	2767.98 ± 880.70	2305.52 ± 1243.81

Descriptive data.

Supplementary Table 4 – Comparison of intervention and control groups over time

Variables	F	p	F	p	F	p	R^2
	Group	Group	Time	Time	Group×Time	Group×Time	
Height (m)	0.03	0.8651	6.16	0.0149**	0.01	0.9103	0.0652
Body mass (kg)	0.02	0.8782	2.13	0.1481	0.00	0.9838	0.0239
Body mass index (kg/m^2)	0.06	0.8119	0.37	0.5424	0.00	0.9713	0.0049
Waist circumference (cm)	0.10	0.75	2.30	0.14	0.009	0.93	0.02
Triceps skinfold (mm)	0.08	0.7811	1.25	0.2661	0.45	0.5019	0.0198
Biceps skinfold (mm)	3.68	0.0584	8.12	0.0054**	0.18	0.6695	0.1195
Subscapular skinfold (mm)	0.04	0.8361	0.15	0.6960	0.57	0.4538	0.0083
Supra-iliac skinfold (mm)	0.03	0.8556	9.76	0.0024**	0.19	0.6609	0.1005
Maximal oxygen uptake (mL·kg^{-1}·min^{-1})	0.50	0.48	3.10	0.09	0.55	0.46	0.03
Light physical activity / weekdays (min)*	0.33	0.5668	2.85	0.0962	0.27	0.6036	0.0577
Moderate physical activity / weekdays (min)*	0.02	0.8833	0.83	0.3648	0.93	0.3378	0.0354
Vigorous physical activity / weekdays (min)*	0.02	0.9017	0.05	0.8316	0.73	0.3967	0.0162
Light physical activity / weekend days (min)*	2.22	0.1411	1.96	0.1666	0.15	0.7008	0.0522
Moderate physical activity / weekend days (min)*	0.62	0.4340	1.12	0.2930	0.00	0.9476	0.0260
Vigorous physical activity / weekend days (min)*	1.04	0.3113	0.56	0.4550	0.39	0.5356	0.0207
Total physical activity (min)*	0.80	0.3752	2.80	0.0989	0.13	0.7154	0.0591
Average physical activity (min)*	0.79	0.3762	2.80	0.0992	0.14	0.7142	0.0591
Sedentary behavior / weekdays (min)*	0.52	0.4744	10.68	0.0017**	0.00	0.9465	0.1465
Sedentary behavior / weekend days (min)*	1.30	0.2583	14.95	0.0003**	0.52	0.4719	0.1886
Total sedentary behavior (min)*	0.68	0.4114	11.93	0.0010**	0.05	0.8272	0.1589
Total cholesterol (mg/dL)*	0.50	0.4828	0.32	0.5735	0.12	0.7337	0.0121
LDL-c (mg/dL)*	1.51	0.2222	4.65	0.0341**	0.01	0.9107	0.0737
HDL-c (mg/dL)*	0.39	0.5364	0.00	0.9559	0.33	0.5688	0.0093
Triglycerides (mg/dL)*	0.21	0.6465	0.05	0.8306	0.72	0.3975	0.0129
Glucose (mg/dL)*	0.27	0.6042	11.19	0.0013**	0.25	0.6182	0.1357
Leptin (ng/mL)*	0.03	0.8588	0.78	0.3802	0.00	0.9805	0.0138
Adiponectin (ng/mL)*	0.00	0.9789	6.55	0.0124**	0.30	0.5858	0.0861

p-values obtained from two-way repeated measures ANOVA comparing the combined intervention group (court-based + pool-based) versus the control group over time. F (Group) = F-statistic for the effect of group; p (Group) = significance of group effect; F (Time) = F-statistic for the effect of time (pre- vs post-intervention); p (Time) = significance of time effect; F (Group × Time) = F-statistic for the interaction between group and time; p (Group × Time) = significance of the interaction effect; R^2 = proportion of variance explained by the model. *Variables assessed in a subsample

Reviewers' assessment

The reviews of this article were originally conducted in Portuguese. This version has been translated using ChatGPT and subsequently reviewed by the Chief Editors.

Reviewer A

Anonymous

Format

- Does the article comply with the manuscript preparation rules for submission to the Revista Brasileira de Atividade Física e Saúde?
  Yes
- Regarding formal aspects, is the manuscript well structured, containing the sections: introduction, methods, results, and discussion (with the conclusion as part of the discussion)?
  Yes
- Is the language appropriate, and is the text clear, precise, and objective?
  Yes
- Was any indication of plagiarism observed in the manuscript?
  No

Suggestions/Comments:

- The manuscript is adequate.

Abstract

- Are the abstract and the abstract in English adequate (containing: objective, information about the study participants, variables studied, main results, and a conclusion) and do they reflect the content of the manuscript?
  Yes

Suggestions/Comments:

- This sentence in the conclusion should be omitted, as there was no statistical difference.
- And it's not in the article's conclusion either.
- "No entanto, reduções modestas em circunferência da cintura e dobras cutâneas indicam benefícios potenciais "
- ". Nonetheless, modest reductions in waist circumference and skinfolds indicate potential benefits. "

Introduction

- Was the research problem clearly stated and delimited?
  Yes
- Is the research problem adequately contextualized in relation to the existing knowledge, moving from the general to the specific?
  Yes
- Are the reasons justifying the need for the study (including the authors' assumptions about the problem) well established in the writing?
  Yes
- Are the references used to support the presentation of the research problem current and relevant to the topic?
  Yes
- Was the objective clearly presented?
  Yes

Suggestions/Comments:

- This sentence needs to be adjusted, as it refers to 2025 and the verb is in the future: "with estimates suggesting that more than 90 million children will be affected by obesity alone by 2025 if effective measures are not implemented3."

Methods

- Are the methodological procedures, in general, appropriate for studying the research problem?
  Yes
- Are the methodological procedures adopted for conducting the study sufficiently detailed?
  Yes
- Was the procedure adopted for selecting or recruiting participants appropriate to the problem studied and described in a sufficient, clear, and objective manner?
  Yes
- Were information provided about the instruments used for data collection, their psychometric properties (e.g., reproducibility, internal consistency, and validity), and, when relevant, about the operational definition of variables?
  Yes
- Is the data analysis plan appropriate and adequately described?
  Yes
- Were the inclusion and/or exclusion criteria for sample participants described and appropriate for the study?

Yes

- Did the authors provide clarification about the ethical procedures adopted for conducting the research?
  Yes

Suggestions/Comments:

- The figure 1 shows QL = Questionnaire applied for quality of life41, as available in: doi: 10.15602/1983-9480/cm.v22n43p103-112. These data are not shown in the manuscript.

Results

- Is the use of tables and figures appropriate and does it facilitate adequate presentation of the study results?
  Partly
- Is the number of illustrations in the article in accordance with the journal's manuscript submission guidelines?
  Yes
- Are the number of participants at each stage of the study, as well as the number and reasons for losses and refusals, presented in the manuscript?
  Yes
- Are the characteristics of the participants presented and sufficient?
  Yes
- Are the results presented appropriately, highlighting the main findings and avoiding unnecessary repetition?
  Partly

Suggestions/Comments:

- All tables have commas instead of points. Adjust!
- It is not necessary to indicate the "n" value for each variable. You can indicate the 'n' value for most variables in the table and indicate (*) the variable that had sample loss or a smaller number of samples evaluated, such as leptin. The information in the table would then be clearer.
- In the tables 5, 6 and 7, the abbreviation for the control group is incorrect. It should be CG, not OG.
- The abbreviation for the Court Intervention Group = CIG is incorrect. It should be CIG, not CIQ.
- The group means and standard deviations are in the supplementary material; it would be interesting to try adjusting the tables and putting the means and "deltas" values in the same tables.
- Table 5: VO2 data should be checked. The standard deviation (SD) is very high, and the control group almost doubled the value, while the intervention group (CIG) reduced, although not significantly.
- CIQ 35.0±59.87 32.31±59.87
- CPI 35.0±35.49 62.87±35.49
- CG 35.0±57.51 60.71±57.51

Discussion

- Are the main findings of the study presented?
  Yes
- Are the study limitations and strengths presented and discussed?
  Yes
- Are the results discussed in light of the study limitations and the existing knowledge on the topic?
  Partly
- Are the potential contributions of the main study findings to scientific development, innovation, or real-world intervention discussed by the authors?
  Yes

Suggestions/Comments:

- The sample size can be considered a limitation of the study, since no sample size calculation was performed.
- Were any additional physical activity/exercise recommendations or monitoring carried out beyond what was prescribed? This is also a limitation of the study.

Conclusion

- Was the study conclusion presented appropriately and is it consistent with the study objective?
  Yes
- Is the study conclusion original?
  Yes

Suggestions/Comments:

- The manuscript requires revision, as it contains some words in Portuguese.

References

- Are the references up to date and sufficient?
  Yes
- Is most of the reference list composed of original research articles?
  Yes
- Do the references comply with the journal's standards (quantity and format)?
  Yes
- Is citation in the text adequate, that is, do the statements in the text cite references that actually sub-

stantiate such statements?
Yes
Suggestions/Comments:

- The references used are current.

Comments to the authors

- I appreciate the opportunity to review this manuscript.
- The paper discusses an important topic and is well written.
- Some suggestions for improving the manuscript.
- Above all, check the VO2 data and the limitations regarding the control of extra physical activity/ physical exercise intervention.

Final Decision

- Substantial revisions required

Other reviews

One of the reviews was not authorized for publication by the reviewer.