EFFECTS OF A SMALL-SIDED SOCCER PROGRAM ON HEALTH PARAMETERS IN OBESE CHILDREN

EFEITOS DE UM PROGRAMA DE FUTEBOL REDUZIDO SOBRE OS PARÂMETROS DE SAÚDE DE CRIANÇAS OBESAS

EFECTOS DE UN PROGRAMA DE FÚTBOL REDUCIDO EN LOS PARÁMETROS DE SALUD DE NIÑOS OBESOS

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Carolina Dertzbocher Feil Pinho[1]
(Physical Education Professional)
Juliano Boufleur Farinha[1]
(Physical Education Professional)
Salime Donida Chedid Lisboa[1]
(Physical Education Professional)
Natália Carvalho Bagatini[1]
(Physical Education Professional)
Gabriela Tomedi Leites[2]
(Physiotherapy)
Rogério da Cunha Voser[1]
(Physical Education Professional)
Anelise Reis Gaya[1]
(Physical Education Professional)
Alvaro Reischak-Oliveira[1]
(Physical Education Professional)
Giovani dos Santos Cunha[1]
(Physical Education Professional)

1. Universidade Federal do Rio Grande do Sul, Escola de Educação Física, Fisioterapia e Dança, Exercise Physiology Laboratory, Porto Alegre, RS, Brazil.
2. Universidade Federal de Ciências da Saúde de Porto Alegre, Porto Alegre, RS, Brazil.

Correspondence:
Carolina Dertzbocher Feil Pinho
Rua Felizardo, 750, Jardim Botânico, Porto Alegre, RS, Brazil. 90690-200.
cacadfpinho@gmail.com

ABSTRACT

Introduction: Childhood obesity is increasing and, as a consequence, it generates health complications resulting from sedentary behavior and low levels of physical fitness. There are few studies involving children, metabolic and cardiorespiratory profiles, and soccer. Objective: The purpose was to measure the effects of a 12-week recreational small-sided soccer program on cardiometabolic risk and individual responses to cardiometabolic risk factors in overweight or obese boys. Methods: Thirteen boys aged 8-12 years (34.9±11.6% body fat) participated in a 12-week recreational small-sided soccer training program with two 80-minute sessions per week at intensities over 80% of the maximal heart rate. Anthropometric characteristics, cardiorespiratory fitness, metabolic profile, individual responses to peak oxygen uptake (VO_2peak), maximal workload (Wmax), fasting blood glucose, insulin, HOMA-IR, LDL-C, HDL-C, TC, and TG were measured both pre- and post-training. Results: Considering the individual responses of the participants, recreational soccer training was effective in improving variations in maximum power and exhaustion time, as well as promoting at least one beneficial change in cardiometabolic risk factors in 84% of the overweight or obese children. There were no differences between pre- and post-program anthropometric characteristics, metabolic profiles, or VO_2peak values. Conclusion: Twelve-week recreational small-sided soccer programs were able to improve maximal power and anaerobic capacity and maintain cardiometabolic risk factor levels in overweight and obese boys. ***Level of evidence I; High-quality prospective study (all patients were enrolled at the same stage of disease, with >80% of patients enrolled).***

Keywords: Obesity; Soccer; Physical fitness; Health; Children.

RESUMO

Introdução: A obesidade infantil está aumentando e, como consequência, gera complicações de saúde decorrentes do comportamento sedentário e baixos níveis de aptidão física. Existem poucos estudos que envolvem crianças, perfis metabólicos e cardiorrespiratórios e futebol. Objetivo: O objetivo foi medir os efeitos de um programa de futebol recreativo reduzido de 12 semanas sobre o risco cardiometabólico e respostas individuais em meninos com sobrepeso ou obesos. Métodos: Treze meninos de 8 a 12 anos (34,9 ± 11,6% de gordura corporal) participaram de um programa de treinamento de futebol recreativo reduzido de 12 semanas com duas sessões de 80 minutos por semana em intensidades acima de 80% da frequência cardíaca máxima. As características antropométricas, a aptidão cardiorrespiratória, o perfil metabólico e as respostas individuais do pico de consumo de oxigênio (VO_{2pico}), carga máxima de trabalho ($W_{máx}$), glicemia e insulina em jejum, HOMA-IR, LDL-C, HDL-C, CT e TG foram medidos pré e pós-treinamento. Resultados: considerando as respostas individuais dos participantes, o treinamento recreativo de futebol foi eficaz para melhorar as variações da potência máxima e do tempo até a exaustão, bem como promover pelo menos uma alteração benéfica nos fatores de risco cardiometabólico em 84% das crianças com sobrepeso ou obesidade. Não houve diferenças entre as características antropométricas pré e pós-programa, perfis metabólicos ou VO_{2pico}. Conclusões: Doze semanas de programas de futebol recreativo reduzido foram capazes de melhorar a potência máxima e a capacidade anaeróbica, bem como manter os níveis de fatores de risco cardiometabólicos em meninos com sobrepeso e obesos. ***Nível de evidência I; Estudo prospectivo de alta qualidade (todos os pacientes foram inscritos no mesmo estágio da doença, com > 80% dos pacientes inscritos).***

Descritores: *Obesidade; Futebol; Aptidão física; Saúde; Crianças.*

RESUMEN

Introducción: La obesidad infantil está aumentando y, como consecuencia, genera complicaciones de salud derivadas del comportamiento sedentario y de los bajos niveles de aptitud física. *Existen pocos estudios sobre niños, perfiles metabólicos, cardiorrespiratorios y fútbol. Objetivo: El objetivo fue medir los efectos de un programa de fútbol recreativo reducido de 12 semanas sobre el riesgo cardiometabólico y respuestas individuales en niños con sobrepeso u obesos. Métodos: Trece niños de 8 a 12 años (34,9 ± 11,6% de grasa corporal) participaron en un programa de entrenamiento de fútbol recreativo reducido de 12 semanas con dos sesiones de 80 minutos por semana a intensidades superiores al 80% de la frecuencia cardíaca máxima. Se midieron las características antropométricas, la aptitud*

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cardiorrespiratoria, el perfil metabólico y las respuestas individuales del consumo máximo de oxígeno (VO_{2pico}), la carga de trabajo máxima (Wmax), la glucemia y la insulina en ayunas, HOMA-IR, LDL-C, HDL-C, CT y TG antes y después del entrenamiento. Resultados: Teniendo en cuenta las respuestas individuales, el entrenamiento de fútbol recreativo fue eficaz para mejorar las variaciones de potencia máxima y el tiempo hasta el agotamiento, así como para promover al menos un cambio beneficioso en los factores de riesgo cardiometabólico en el 84% de los niños con sobrepeso u obesidad. No hubo diferencias entre las características antropométricas, los perfiles metabólicos o el pico de VO2 antes y después del programa. Conclusiones: Doce semanas de programas de fútbol recreativo reducido fueron capaces de mejorar la potencia máxima y la capacidad anaeróbica, así como de mantener los niveles de factores de riesgo cardiometabólicos en niños con sobrepeso y obesidad. ***Nivel de evidencia I; Estudio prospectivo de alta calidad (todos los pacientes se inscribieron en la misma etapa de la enfermedad, con> 80% de los pacientes inscritos).***

Descriptores: *Obesidad; Fútbol; Aptitud física; Salud; Niños.*

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INTRODUCTION

The global obesity epidemic has been considered a major public health concern, mainly due to the increased risk of several serious chronic diseases, such as diabetes, hypertension, cancer, and dispinea.[1] Childhood obesity arises from a combination of factors, including insufficient physical activity (PA).[2] Because of that, group sports have emerged as a potential intervention to increase the PA.[3,4] However, little is known about the benefits of group sports on cardiometabolic risk factors (high blood pressure, lipemia, glycemia, insulin resistance, and low physical activity and fitness) and health-related physical fitness (cardiorrespiratory and muscular fitness) in children with overweight or obesity.

Inadequate physical activity has been linked to an increased risk of childhood obesity,[2] and soccer is one of the most popular sports in the world, and it can improve body composition,[3,5] biochemical markers[3,4] handgrip strength,[6] and cardiorespiratory responses.[3-7] Likewise, soccer training is considered all-in-one training with broad-spectrum fitness and can provide an important alternative for the treatment of childhood obesity.[8]

Obesity has multifactorial causes, and individual responses to training programs should be considered even when exercise is performed in groups. In the era of personalized medicine, interindividual differences in the magnitude of response to an exercise training program (individual response) have received increasing scientific interest.[9-12] Individuals under similar stimulus may achieve different benefits after an exercise training program and are considered responders (R), while those whose responses remain unchanged or worsen are considered non-responders (NR).[11] For this reason, the aim of the present study was to measure the effects of a 12-week period recreational soccer program on cardiometabolic risk factors (fasting lipemia, fasting blood glucose, fasting insulin, homeostatic model assessment for insulin resistance (HOMA-IR), VO_2peak, and maximal workload (Wmax) factors and individual responses in boys with overweight or obesity.

MATERIALS AND METHODS

Thirteen boys aged between 8 and 12 years were recruited for this quasi-experimental study investigating the effects of a 12-week recreational small-sided soccer program. All subjects performed only physical education at school and were instructed to maintain their daily habits during the intervention. The study was approved by the University Research Ethics Board (Case Project ID #: 53943116300005347) and was conducted in compliance with the standards set by the Declaration of Helsinki. Boys and their legal guardians were informed of the experimental protocol and the potential risks and provided written informed consent prior to participation.

Inclusion and exclusion criteria

The study included boys with overweight or obesity defined by the criteria: body mass index Z-score (BMI Z-score) ≤ 2 standard deviation (SD) were classified as overweight (four boys) and BMI Z-score > 2 SD were classified as obese (nine boys)[13,14] and who were enrolled in the school system. Boys who had some incapacity to perform physical exercise or who used medication that could influence the study results were excluded.

Anthropometric Measures and Maturity Status

Body mass, height, and sitting height were assessed using a digital scale and a stadiometer (Urano PS 180A, 0.1 kg and 0.01-m resolution; Rio Grande do Sul, Brazil), respectively. These values were used to calculate the BMI using the following equation: body mass (kg)/height^2(m). A total of eight skinfolds (mm) were measured: triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, and medial calf (Skinfold Caliper Mitutoyo-CESCORF, Porto Alegre-RS, Brazil).[15] Landmarks for each skinfold and waist-circumference measurement were in accordance with previously described procedures.[15] The equations proposed by Slaughter et al.[16] were used to estimate the body fat and fat free mass percentages. The sitting height was used to estimate years of peak height velocity according to Mirwarld et al.[17]

Cardiorespiratory Fitness

An incremental exercise test was performed, using the McMaster All-Out Progressive Continuous Cycling Test.[18,19] The test began at 25 W and had 25-50-W increments every 2 min, according to the participant's height, while maintaining a cadence between 60 and 80 rpm. Measurements of expired VO_2 and VCO_2 were made continuously using calibrated metabolic equipment (Quark CPET, Cardio Pulmonary Exercise Test, COSMED-Italy). Peak was considered the greatest oxygen uptake (VO_2) value in the whole protocol. The participants were verbally encouraged during the test to achieve their maximal performance. To be considered an exhaustive effort, each participant had to satisfy at least two of the following criteria upon termination of the cycle ergometer test due to volitional exhaustion: (1) VO_2 plateau, defined as an increase in VO_2 of less than 2.1 $mL \cdot kg^{-1} \cdot min^{-1}$ accompanied by an increase in exercise intensity.[20] (2) At the end of the test, the heart rate was 95% of the predicted maximal heart rate. [208 – (0.7 x age)] = HRmax,[21] (3) respiratory exchange ratio (RER) ≥ 1.0,[22] (4) despite strong verbal encouragement, inability to maintain a cycling cadence above 60 rpm.[18] Heart rate was measured using a heart rate monitor (Polar, S610 USA). Participants should have demonstrated overt signs of extreme physical exertion, such as facial flushing and grimacing, sweating, hyperpnea, and unsteady gait, at the end of the test.[22] The Wmax was considered as the workload correspondent to the last stage completed of the incremental exercise test. W_{max} was considered an indicator of muscular fitness.

Metabolic measures

For the biochemical analysis, fasting blood glucose, fasting insulin, triglycerides (TG), total cholesterol (TC), HDL cholesterol (HDL-C) and LDL cholesterol (LDL-C) were collected after 10 to 12 hours of fasting. An 8 mL sample of blood was collected by venipuncture and stored in tubes with specific anticoagulant gel (EDTA). After this procedure, the samples were centrifuged at 3.500 rpm for 10 min, and the aliquots of plasma were stored at -80°C for posterior analysis. Blood glucose, TG, TC, and HDL-C were determined by enzymatic colorimetric tests (Cobas C111, Roche, Diagnostics, Basel, Switzerland). The fasting insulin was evaluated by kits for humans (DRG International, Springfield, USA) and determined by an enzyme linked immunosorbent assay (ELISA). The insulin resistance was estimated using the homeostasis model assessment of insulin resistance: HOMA-IR is an abbreviation for [fasting blood glucose (mmol·L^{-1}) fasting insulin (uU·ml^{-1})] 22.5. The LDL-C was estimated using the equation by Friedewald: (LDL-C: CT HDL-C TG 5).

Responders and non-responders' classification

The percentage of responders and non-responders was obtained according to previous studies, considering Δ% effect (% of the after *minus* the before value).[9,10,12] To consider acceptable clinical and individual effects, we used the Δ% values obtained in previously published studies with public and metabolic parameters similar to the present study, defining cut off points such as: TG (the cut-off points – 10.1 mg·dL^{-1}, R>10%), TC (change of the cut points – 7.7 mg.dL^{-1}, R>5%), HDL-C (change of the cut-off points 4.2 mg·dL^{-1}, R>10%), LDL-C (change of the cut-off points – 12.4 mg·dL^{-1}, R>10), and HOMA-IR (change of the cut-off points – 1.0, R>30%).[12]

Recreational Small-Sided Soccer Training Program

Thirteen boys participated in a 12-week recreational small-sided soccer training program with two sessions per week. The training lasted 90 minutes and was divided into the following sections: warm-up (10 minutes) with playful games; technical drills (15 minutes) to learn specific fundamentals (pass, kick, ball control, etc.); small-sided soccer games (20 to 40 minutes) with adapted games beginning with [2 vs. 2, 3 vs. 3, 4 vs. 4, 5 vs. 5] and its variations with changes in the size of the court to give the game dynamics; and a cool-down (5 minutes). For the main part, there was an increase in the volume of free game time, with intervals of 1 to 3 minutes for recovery every 5 minutes of game. During the first four weeks, there were 20 minutes of small-sided soccer games, increasing to 30 minutes the following four weeks and then to 40 minutes the last four weeks. The intensity of training was monitored at the end of each activity (warm-up, technical drills, small-sided soccer games) using a heart rate monitor. During small-sided soccer games, boys were monitored to maintain a heart rate of over 80% of their HRmax obtained in the maximal incremental exercise test. All participants had to complete 80% of the training sessions. Those subjects with three consecutive absences did not have their data computed. All participants were instructed not to change their regular physical activity habits during the experiment.

Statistical analysis

Data normality and data homogeneity were verified through Shapiro--Wilk and Levene's tests, respectively. Paired T-tests were used to compare the pre-test with the post-test results. The data are presented as mean standard deviation.Measures of the effect size were calculated by Cohen´s *d* test, and the magnitude of the effect size was classified according to the following criteria: $d < 0.2$ was considered "trivial," 0.2-0.59 was considered "small," and 0.6-1.19 represented "moderate," 1.2-1.99 was considered "high", 2.0-3.9 was considered "very high" and > *4* constituted "close to perfect".[23] A significance level of 0.05 was adopted for all statistical tests, and the Statistical Package for the Social Sciences (SPSS) version 20.0 was used.

RESULTS

Anthropometric characteristics pre- and post-training are described in Table 1. A higher W_{max} and an increased time to exhaustion in cardiorespiratory fitness test were significant after 12-week period. No significant differences were found between pre-and post-recreational program for fasting blood glucose, fasting insulin, HOMA-IR, TC, TG, LDL-C, HDL-C and VO_2peak. The data are described in Table 2.

Figure 1 depicts individual responses for cardiometabolic risk factors. In this study, 46% boys were considered responders for CT; 38% for LDL-C; 23% for HDL-C, TG and HOMA-IR, respectively. Figure 2 shows the individual responses for each participan on HOMA and lipemic profile.

DISCUSSION

Recreational soccer training was effective after 12 weeks in improving maximum power and exhaustion time, as well as promoting at least one beneficial change in cardiometabolic risk factors in 84% of children with overweight or obesity, when individual responses were taken into account.The percentage of individuals considered responders was 46% for TC, 38% for LDL-C, 23% for HDL-C, TG, and HOMA-IR, respectively. Understanding individual responses is important due to the complexity of obesity treatment, and we can propose a beneficial approach to controlling childhood obesity as there is a lack of studies reporting the effects of individual and group sports interventions on cardiometabolic risk factors in preschool boys with overweight or obese pubescents.

We found a moderate and significant effect size in the time to exhaustion and maximum load in the maximum cycle ergometer test, indicating a greater tolerance to fatigue. Children showed significant gains with an increase of 1 min 21 sec in the total test time and reached a maximum load greater than 20w compared to the pre-training period. The answers can be linked to peripheral improvements. The activities performed by soccer training, such as sprints, kicking, and changes of direction, are related to mitochondrial adaptations, muscle capillarization, enzymatic activity, and neuromuscular adaptations, movements that create power and improve peripheral adaptations that seem to precede central adaptation.[24]

Table 1. Anthropometric measures pre- and post-recreational soccer training program.

Variables	Pre-training	Post-training	Δ%	*P*	Cohen d	Qualitative Cohen d
Age (years)	9.6 ± 1.3	9.8 ± 1.3	-	-	-	-
Body weight (kg)	55.1 ± 14.8	55.9 ± 14.6	1.5	0.203	0.05	Trivial
Height (m)	1.43 ± 0.1	1.45 ± 0.1	1.4	0.02*	0.1	Trivial
∑DC (mm)	212 ± 78	219 ± 75	3.2	0.384	0.09	Trivial
Years from PHV	-4.1 ± 0.9	-3.9 ± 1.1	-	-	-	-
BMI (kg/m^2)	26.5 ± 6.1	26.3 ± 6.01	-0.7	0.955	0.03	Trivial
Body fat (%)	34.9 ± 11.6	36.8 ± 12.6	5.1	0.248	0.1	Trivial
FFM (%)	65.1 ± 11.6	63.1 ± 12.6	-3.0	0.295	0.1	Trivial
Body fat (kg)	20.6 ± 11.9	22.0 ± 12.0	6.4	0.303	0.1	Trivial
FFM (kg)	34.6 ± 4.5	33.8 ± 4.7	-2.3	0.352	0.1	Trivial

Data from paired t-tests are expressed as means ± standard deviation. *Significant differences (p<0.05). Abbreviations: Δ%: Delta changes; ∑DC: Skinfolds sum; BMI: body mass index; FFM: Fat free mass; PHV = Peak height velocity.

Table 2. Glucose, insulin, lipemia, HOMA-IR and VO_{2peak} pre- and post-recreational soccer training program.

Variables	Pre-training	Post-training	*P*	Δ%	ES	Qualitative ES
Glucose ($mg.dL^{-1}$)	97.8 ± 7.1	95.3 ± 7.9	0.33	-2.5	0.33	Small
Insulin ($\mu IU.mL^{-1}$)	20.8 ± 7.8	20.2 ± 5.9	0.81	-2.8	0.08	Trivial
HOMA-IR	4.9 ± 1.7	4.7 ± 1.2	0.06	-4.0	0.13	Trivial
CT ($mg.dL^{-1}$)	147.2 ± 30.3	147.3 ± 29.6	0.98	0.06	0.003	Trivial
TG ($mg.dL^{-1}$)	88.1 ± 25.3	99.6 ± 31.6	0.28	13.1	0.4	Small
LDL-C ($mg.dL^{-1}$)	93.7 ± 34.5	91.3 ± 31,1	0.70	-2.5	0.007	Trivial
HDL-C ($mg.dL^{-1}$)	45.0 ± 11.4	46.4 ± 11.5	0.23	3.1	0.1	Trivial
VO_{2peak} ($mL.kg^{-1}.min^{-1}$)	27.9 ± 8.8	27.2 ± 6.3	0.52	-2.5	0.09	Trivial
VO_{2peak} ($mL.min^{-1}$)	1412 ± 347	1473 ± 293	0.32	4.1	0.18	Trivial
W_{max} (Watts)	67.6 ± 31.13	87.6 ± 20,8	0.004*	22.8	0.75	Moderate
Time of test (sec)	495 ± 186	576 ± 150	0.02*	14.0	0.40	Moderate

Data are expressed as means ± standard deviation. Abbreviations: Δ%: Delta changes; HOMA-IR: homeostasis model assessment of insulin resistance; TC: total cholesterol; TG: triglycerides; HDL-C: HDL cholesterol; LDL-C: LDL cholesterol; VO_{2peak}: peak oxygen uptake; W_{max}: maximal power output; ES = Cohen d effect size; sec: seconds.

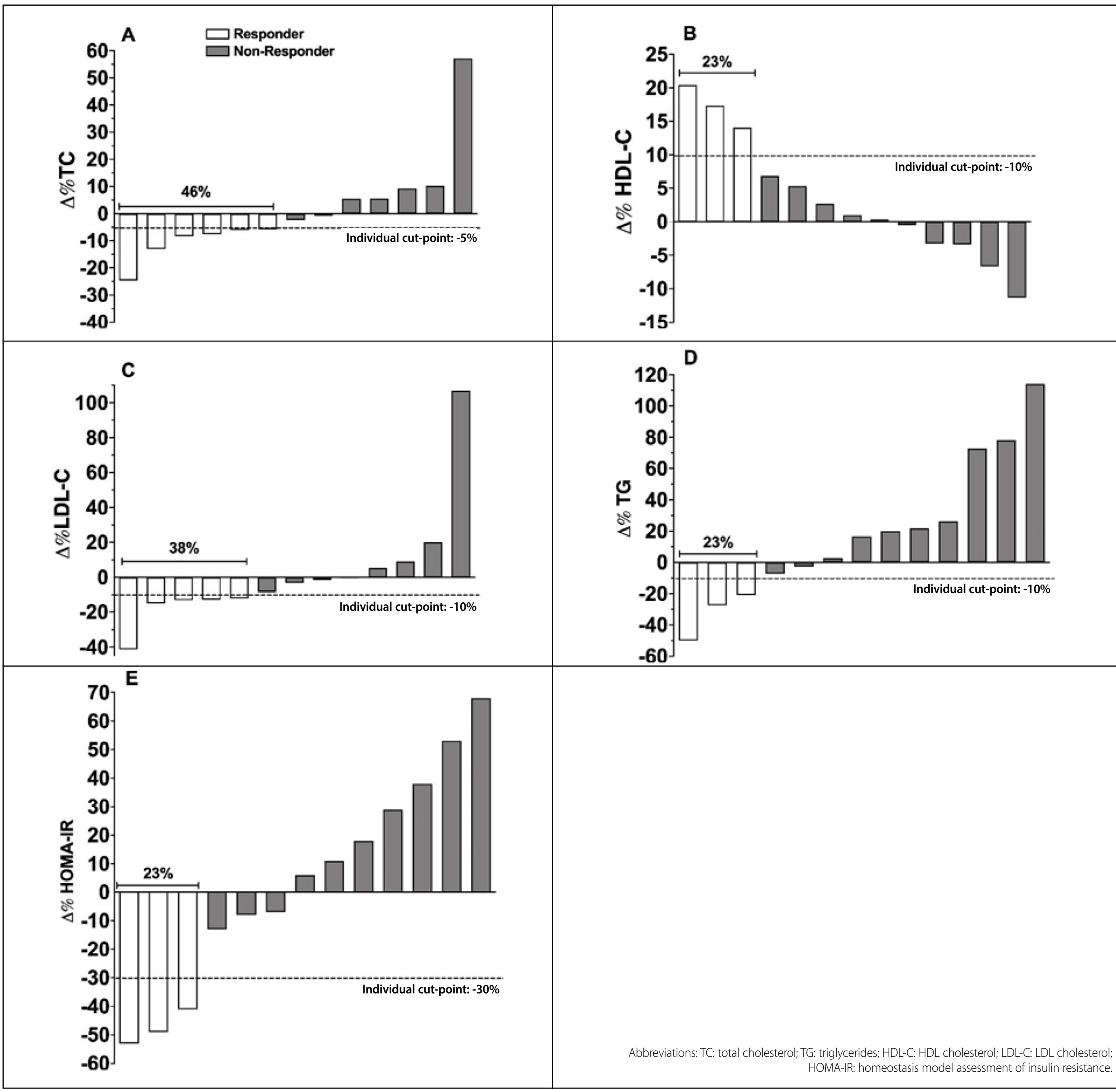

Figure 1. Percentage of responders for TC (A), HDL-C (B), LDL-C (C), TG (D) and HOMA-IR (E) after recreational small sided soccer training program.

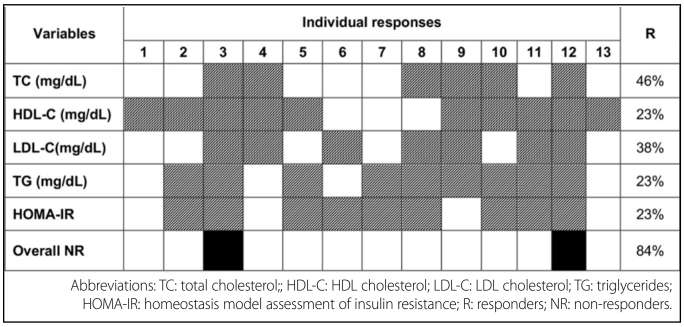

Figure 2. Individual responses of lipemic profile and HOMA after 12-week of recreational small sided soccer program. White box: Denote cases that changed positively (responders). Horizontal list box: Denote cases that did not change positively after soccer training (non-responders). Black box: Denotes individuals who were unable to improve any variable for both the lipemic profile and HOMA (Overall non-responders).

The increase in anaerobic metabolic pathway and muscular fitness is in accordance with the literature, where it has been seen that soccer intervention stimulates and increases the resistance of children by 22% after six weeks, while activities of low-moderate intensity and without training structure seem not to induce positive adaptations.[25] In the present study, we found an increase of 29% in Wmax achieved during cardiopulmonary exercise testing. In a similar group to the present study (children with obesity), after six months of training, Faude et al.[26] also found a 7% increase in Wmax achieved after soccer training, whereas the group that performed aerobic exercise increased 6%. These responses seem to be independent of the weekly training frequency since both the present study and Faude et al.[26] led to increased muscular fitness with two and three times a week.

In the present study, no significant differences among pre-and post-recreational small-sided soccer programs were found for HOMA-IR, lipemia, and VO_2peak average. It is important to note that boys already had lipemia values considered normal for their age prior to soccer training. In that regard, obesity is a progressive, chronic inflammatory process and the results indicate that a recreational soccer program was able to prevent changes in cardiometabolic risk factors.

In relation to individual response, our findings indicate that 23% of boys were responders to HOMA-IR and improved insulin sensitivity, indicating that interventions with high exercise intensity (85%HRmax) can contain the progress of the inflammatory process.[3,9,12] Regarding body fat, subjects who showed greater adiposity reductions were those who improved insulin sensitivity and HOMA-IR, indicating that interventions with high exercise intensity can improve body composition, promoting health benefits.[3,27]

For children with overweight or obesity, poor cardiorespiratory fitness is related to poor physical fitness values, high rates of chronic diseases, and mortality.[28] There were no significant differences in cardiorespiratory fitness measured by VO_2peak before and after the soccer program. A possible explanation is that even with a high intensity close to the anaerobic threshold, the soccer program duration and weekly frequency may have been insufficient to improve health indicators more effectively.[2] Seabra et al.[4] found a 11.3% increase in VO_2peak in boys (11 years) and Vasconcellos et al.[3] found an increase of 31% in adolescents (13 years) with intervention three times a week.

In relation to the children's responses to VO_2peak, the results are still controversial because, many factors, such as chronological age, biological maturation, body composition, as well as genetic and environmental factors, can influence cardiorespiratory fitness,[29] and we are not aware of studies that have evaluated individual cardiorespiratory responses (responders and non-responders) in children after participating in a recreational soccer program.

This study presents strengths, such as a small 12-week soccer recreational program, twice a week, that could improve anaerobic capacity and present beneficial responses for the control of obesity. In addition, it highlights that some individuals need a greater load or training volume to reduce cardiometabolic risks. However, the study has some limitations, such as the absence of a control group that could bring more effective responses regarding training responses and the relatively small sample size, in which even after performing a sample calculation, the study sample loss was significant and limited the answers found.

It was concluded that twelve weeks of small-sided recreational soccer programs were able to improve maximal power, anaerobic capacity, and maintain cardiometabolic risk factor levels in overweight and obese boys.

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