ORIGINAL ARTICLE

Lifestyle Intervention in Reducing Cardiometabolic Risk Factors in Students with Dyslipidemia and Abdominal Obesity: A Randomized Study

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Abstract

Background: The long incubation periods of cardiovascular diseases offer opportunities for controlling risk factors. In addition, preventive interventions in childhood are more likely to succeed because lifestyle habits become ingrained as they are repeated.

Objective: To investigate the effects of recreational physical activities, in combination or not with a qualitative nutritional counseling, in cardiometabolic risk factors of students with dyslipidemia and abdominal obesity.

Methods: Students (8-14 years old) were randomly divided into three groups (n=23 each): *i*) Control; *ii*) PANC, students undergoing Physical Activity and Nutritional Counseling, and *iii*) PA, students submitted to Physical Activity, only. Blood samples (12-h fasting) were collected for biochemical analysis and anthropometric markers were also assessed. Two-Way RM-ANOVA and Holm-Sidak's test, and Friedman ANOVA on Ranks and Dunn's test were applied. $P \leq 0.05$ was considered significant. Effect sizes were evaluated by Hedges' g and Cliff's δ for normal and non-Gaussian data, respectively.

Results: Compared to the control group and to baseline values, both interventions caused significant average reductions in total cholesterol (11%; $p < 0.001$), LDL-c (19%; $p=0.002$), and non-HDL-c (19%; $p=0.003$). Furthermore, students in the PANC group also experienced a significant decrease in body fat compared to baseline ($p=0.005$) and to control (5.2%; $g=0.541$).

Conclusions: The proposed strategies were effective to reduce cardiometabolic risk factors in children and adolescents. The low cost of these interventions allows the implementation of health care programs in schools to improve the students' quality of life.

Keywords: Child; Adolescent, Students; Exercise; Dyslipidemias; Obesity; Risk Factors; Lifestyle; Nutritional Orientation; Glycemic Profile.

Introduction

Despite remarkable advances in cardiovascular health promotion over the past decades, cardiovascular diseases (CVD) remain the leading cause of death worldwide.[1-3] It is estimated that behavioral risk factors may be responsible for about 80% of CVD and are associated with metabolic and physiological changes like overweight, hyperlipidemia, and hyperglycemia, which may have multiple effects.[1,2,4,5]

Over the last decades, the increased prevalence of overweight, obesity, and dyslipidemias in children and adolescents has placed concern on the health conditions of this population.[1-3] Additionally, the increased knowledge about the long-term effects of exposure to risk factors and concern about the epidemic of pediatric obesity led to the urgency of primordial and primary prevention strategies during childhood.[3,6] Therefore, in addition to the early detection of the metabolic disorders, it is important to establish preventive strategies for reducing these emerging epidemics.

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In this context, there are increasing evidences that physical inactivity in children and adolescents, which promote decrease in energy expenditure, is closely associated with the current prevalence of overweight, obesity, and dyslipidemias.[1,6-8] Therefore, in order to prevent and treat these disorders, there is a growing interest for approaches based on physical activity improvement.[1,6,9,10] According to the WHO, ideally, children and adolescents should accumulate 60 min of daily moderate to vigorous-intensity physical activity, and to improve biomarkers of cardiovascular health they should incorporate vigorous activities three times per week.[9,10]

In addition to physical activities, dietary patterns can modulate various aspects of cardiovascular risk, such as dyslipidemia, insulin resistance (IR), hyperglycemia, hypertension and inflammation.[8,11] Healthful dietary patterns are important for primary prevention of risk factors related to CVD from childhood through adulthood. Evidence of the effectiveness of dietary intervention for reducing risk factors in children is limited, but ample data suggest that changes in specific dietary macronutrients (e.g., fat and carbohydrates) and micronutrients (e.g., sodium and calcium) have a great positive impact.[2,8]

Herein, we hypothesized that recreational physical activities that are normally carried out in schools as obligatory curriculum, in combination or not with qualitative nutritional counseling, could promote the improvement of cardiovascular risk factors in children and adolescents with dyslipidemias and abdominal obesity. The primary endpoints were serum lipid profile and anthropometric parameters, while secondary endpoints were glycemic profile and subclinical inflammation markers.

Materials and Methods

Subjects

This is a parallel randomized with control group study. The Ethical Committee for Human Research of the Federal University of Santa Catarina approved the study (CAAE: 03626512.4.0000.0121). All participants and their legal guardians provided written informed consent before any procedure. Students (n=450; 8-14 y) of a public school in Guabiruba-SC, Southern Brazil, who were able to practice physical activities, were invited to participate. The studied school was chosen for having numerous students, an easy access location, and a number of children and adolescents with risk factors for CVD identified in our previous study.[12] Therefore, sampling for convenience or accessibility was used. Initially, blood samples were collected from 173 volunteers for biochemical analyses and waist circumference (WC) was measured. Based on the results, 114 students had abdominal obesity (WC cut off stratified by sex and age)[13] and dyslipidemias.[14] Volunteers were stratified according to sex and age, and were counterbalanced randomized (Website Research Randomizer®, 2008) into three groups (n=38 each): *i*) Control, whose members were not subjected to any intervention; *ii*) PANC (Physical Activity and Nutritional Counseling), whose students participate in a physical activity program and qualitative nutritional counseling; and *iii*) PA (Physical Activity), whose students participated in physical activities only.

The interventions were performed during 4 months and data were obtained in the beginning and at the end of study.

Lifestyle intervention

Physical activities were held at school in extracurricular period and consisted of soccer and basketball games or dance, which were developed during 1 h, twice a week, with the goal of approaching the WHO recommendation *i.e.*, 60 min of daily moderate to vigorous-intensity physical activities, three times per week.[9,10]

Qualitative nutritional counseling was performed by a nutritionist, without adopting specific or individualized diet and encouraging healthy eating based on increased consumption of fruits and vegetables and decreased consumption of sweets and fried food. The counseling was held collectively for student participants only, with meetings every three weeks, totaling four meetings, using videos, competitions, and practical activities in order to know and to give instruction about the amount of sugar, salt, and fat in foods regularly consumed by the students. In addition, the participants received instructions for preparing healthy snacks. Food consumption habits were assessed using a questionnaire for 24 h dietary recall (24HR), on two different days (one of which was a weekend day). The 24HR aims to report the intake of all foods and beverages consumed over a period of 24 h.[15] The 24HR was administered at the beginning and at the end of interventions and assessed using Avanutri® software, version 4.0 (Rio de Janeiro-RJ, Brazil).

Biochemical analysis

Blood sample was collected (12-h fasting) in tubes without anticoagulant and serum was obtained by centrifugation (750 x g, 10 min). Determinations of total cholesterol (TC), triglycerides (TG), glucose, uric acid, and high-density lipoprotein-cholesterol (HDL-c) were performed using routine methods (Labtest Diagnostic, Lagoa Santa-MG, Brazil) in automated Cobas Mira Plus® (Roche Diagnostics, Basel, Switzerland). The low-density lipoprotein-cholesterol (LDL-c) was estimated by the Martin equation [TC - (HDL-C - TG/×)], with "×" being the factor resulting from non-HDL-c and TG concentrations.[16] The non-HDL-c was estimated by the difference between TC and HDL-c. The Castelli I index [TC/HDL-c] and Castelli II index [LDL-c/HDL-c] were also evaluated.[17] The small, dense-LDL (sd-LDL) subclass was determined by procedure previously described for sd-LDL-cholesterol[18] and the LDL particle size was estimated using the equation [26.262 - 0.776 (TG $mmol.L^{-1}$/HDL-c $mmol.L^{-1}$)].[19] Quantification of insulin was carried out using chemiluminescence (Immulite 2000, Siemens Healthcare Diagnostics Inc. – USA) and the IR was identified by the homeostasis model assessment (HOMA-IR) index according to the equation [HOMA-IR = fasting insulin (μUI/mL) x fasting glucose (mg/dL)/405].[20] The levels of high-sensibility C-reactive protein (hs-CRP) and tumor necrosis factor-alpha (TNF-α) were measured by immunonephelometry (Nephelometer Behring BN, II Siemens Healthcare Diagnostics Products GMBH-Germany) and enzyme linked immune assay (BD OptEIA Human TNF ELISA Set, BD Biosciences-USA), respectively.

Anthropometric analyses

Weight (kg) and height (m) were measured (Welmy Equipment, São Paulo, Brazil), and the body mass index (BMI) was estimated by [weight/$height^2$]. Inelastic tape with a scale of 0.1 cm was used to the measurement of hip circumference and WC, that was performed at the midpoint between the last rib and the iliac crest.[13] Skinfolds were measured with adipometer (Scientific Cescorf, Porto Alegre-RS, Brazil) with a scale of 0.1 cm, amplitude of 88 mm and pressure of 10 g/mm^2. The measurement of triceps skinfold (TS) was performed on the posterior aspect of the arm, at the half distance between the superolateral border of the acromion and the olecranon. Subscapular skinfold (SS) was measured obliquely to longitudinal axis, following the costal arches, two inches below the scapula inferior angle. The percentage of body fat was estimated using TS and SS as described by Slaughter.[21]

Statistical analysis

We used sampling of convenience or accessibility. Results are presented as mean ± standard deviation or median and 25-75% interquartile interval (IQI). Data distribution was assessed by the Shapiro-Wilk test. Data that were not normally distributed were log-transformed whenever possible. Differences were detected by the Two-Way RM-ANOVA and Holm-Sidak's *post-hoc* test for normal (or normalized after log-transformed) data, and by the Friedman ANOVA on Ranks and Dunn's test for data with non-Gaussian distribution. The differences between variations in the three groups, based on the percentage changes (Δ%) to baseline values [((4-month x 100)/baseline) – 100], were analyzed using the One-Way ANOVA and Holm-Sidak's test for normal data and Kruskal-Wallis One-Way ANOVA on Ranks and Dunn's test for non-Gaussian data. When groups were stratified by sex, the differences in the percentage changes (Δ%) were detected by the Two-Way ANOVA and Holm-Sidak's test, and Kruskal-Wallis ANOVA on Ranks and Dunn's test for normal and non-Gaussian data, respectively. The chi-square test was used to compare baseline biodemographic features between the three groups. $P \leq 0.05$ was considered significant. All analyses were performed using SigmaPlot software v. 12.0 (Systat Software Inc., San Jose-California, USA).

To obtain a standardized measure of the magnitude difference between treatments for each variable, effect sizes were estimated. For normal distribution data, the effect size was calculated using Cohen's d statistic, with Hedges' g-average correction, and 95% confidence interval (CI), and interpreted as trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (> 0.80).[22] For non-Gaussian data, Cliff's delta (δ) effect size was calculated, which is classified as negligible (<0.147), small (0.148-0.32), medium (0.33-0.474), and strong (> 0.474).[23]

Results

During the study period, 40 students did not attend the final data collection for personal reasons and were thus excluded from the study. Therefore, 74 students effectively participated in the study (28 control, 23 PANC, and 23 PA groups). However, for appropriating paired statistical analysis, five students in the control group were additionally randomly (Website Research Randomizer®, 2008) excluded, retaining 23 participants per group (Supplemental File 1).

The main clinical and biodemographic features of students in the baseline period are shown in Supplemental File 2. The baseline values of lipid and glycemic profiles and anthropometric parameters are shown in Tables 1 and 2. Inflammatory marker levels are presented in Supplemental File 3. In spite of randomization, students of the control group had significantly lower levels of serum lipids (TC, LDL-c, non-HDL-c, and TG) and glucose (Tables 1 and 2).

Serum lipid profile

The physical activity intervention, with or without nutritional counseling, promoted similar and significant effects on serum lipid parameters (Tables 1 and 3). Students in the PANC and PA groups showed significant reductions in the absolute values of TC, LDL-c, and non-HDL-c, with a medium effect size for PA, in comparison to the respective baseline values (Table 1). Interventions did not change HDL-c and TG levels. Normalizing data to the respective baseline values, i.e., relative changes (Δ%), we also observed significant decreases in TC, LDL-c, and non-HDL-c of PANC and PA students in comparison to the control group, with medium and strong effect sizes (Table 3). Additional lipid parameters such as Castelli I and II indexes, and the small dense-LDL fraction (sd-LDL-cholesterol and LDL size) did not modify after interventions (results not shown).

Stratification by sex showed that male students in the PANC group experienced the most relevant, although not significant, relative reductions in TC, LDL-c, and non-HDL-c, with strong effect size, in comparison to male control (Table 4). Students in the PA group, regardless of sex, also showed percentage reductions in total- and lipoproteins-cholesterol in comparison to male and female controls, with strong effect size. On the contrary, male students in the control group had increased triglyceride levels after 4 months, with a strong effect size, in comparison to control females and to the male students in the PANC and PA groups (Table 4).

Anthropometric characteristics

After four months of intervention, all students maintained their BMI and WC values (Table 1). However, students in the PANC group showed a significant decrease in body fat, compared to the respective baseline values (Table 1) and to control students, with a strong effect size (Table 3).

Stratification by sex showed that female students in the PANC group had a significant decrease in body fat (in the percentage of baseline) compared to PANC male, with a large effect size (Table 4). Although not significant, a large effect size was also observed for a reduction in body fat of female PANC students in comparison to female students in the control group. Female students in the PA group also showed a significant body fat reduction in comparison to male students in this group, with a medium effect size (Table 4).

Glycemic profile

Regarding glycemic parameters, students in the control group showed a significant increase in the fasting glucose concentration, with a medium effect size in comparison to baseline values (Table 2). On the other hand, PANC and PA students showed no alterations in glucose levels. However, PA students experienced a significant and a medium effect size increase in the insulin and HOMA-IR values in comparison to baseline (Table 2), and the variation of insulin (Δ%) compared to the control group (Table 3). Taking into account the variation in relation to the respective baseline values (Δ%), the percentage reduction of glucose after the intervention was significant and with a strong effect size for PANC students, in comparison to control participants (Table 2).

Although not significant, the stratification by sex showed that male students in the PANC group showed a reduction in the fasting glucose levels, as a percentage of baseline (Δ%), that was more expressive than both female PANC and male control students, with strong effect sizes (Supplemental File 4). Male PA students also reduced glucose (in the percentage of baseline) compared to male control, with a strong effect size. On the other hand, male students in the PA group had increased levels of insulin compared to both female PA and male control, with medium and strong effect sizes, respectively (Supplemental File 4). Female PA students also showed increased percentage levels of insulin, with a medium effect size, in comparison to female control. Consequently, male PA students also experienced elevated HOMA-IR values, in the percentage of baseline, in comparison to male control students, with a medium effect size (Supplemental File 4).

Table 1 – Effect of physical activity and nutritional counseling on the serum lipid and anthropometric parameters of children and adolescents

Parameters	Control	Physical Activity and Nutritional Counseling		Physical Activity	
TC (mg/dL)			P^2		P^2
Baseline	158.5 ± 26.9[a]	206.3 ± 57.3[b]	0.009	197.4 ± 34.3[b]	**0.037**
4 months	164.4 ± 31.0[a]	184.3 ± 48.8[a]	0.229	176.1 ± 34.0[a]	0.517
P^1	0.961	0.007		0.009	
Effect Size	0.103	-0.399		-0.602	
LDL-c (mg/dL)*					
Baseline	99.5 ± 21.4[a]	137.1 ± 51.6[b]	**<0.001**	132.0 ± 30.4[b]	**<0.001**
4 months	103.9 ± 27.7[a]	117.6 ± 41.4[a]	0.362	114.1 ± 29.6[a]	0.358
P^1	0.455	0.004		0.002	
Effect Size	0.095	-0.391		-0.576	
HDL-c (mg/dL)					
Baseline	47.0 ± 12.6[a]	52.0 ± 17.5[a]	0.158	51.6 ± 10.4[a]	0.195
4 months	47.8 ± 10.2[a]	50.5 ± 15.9[a]	0.190	49.4 ± 10.6[a]	0.226
P^1	0.554	0.277		0.465	
Effect Size	0.067	-0.086		-0.202	
N-HDL-c (mg/dL)*					
Baseline	111.5 ± 22.8[a]	154.3 ± 56.0[b]	**0.001**	145.8 ± 32.1[b]	**0.001**
4 months	116.1 ± 29.2[a]	133.9 ± 45.8[a]	0.231	126.7 ± 31.4[a]	0.417
P^1	0.422	0.007		0.003	
Effect Size	0.161	-0.402		-0.597	
TG (mg/dL)*					
Baseline	60.1 ± 22.9[a]	85.8 ± 42.3[b]	**0.006**	68.7 ± 21.7[a,b]	0.418
4 months	63.4 ± 18.6[a]	81.5 ± 35.4[a]	0.165	63.2 ± 20.8[a]	0.435
P^1	0.502	0.429		0.398	
Effect Size	0.205	-0.060		-0.231	
BMI (kg/m²)					
Baseline		20.1 ± 3.6	0.874	18.9 ± 2.7	0.845
4 months		19.7 ± 3.7	0.901	19.1 ± 3.0	0.936
P^1		0.858		NS	
Effect Size		0.105		0.068	
Body fat (g%)*					
Baseline		19.3 ± 8.3	0.689	16.9 ± 5.0	0.594
4 months		17.8 ± 6.5	0.714	16.1 ± 4.4	0.908
P^1		0.005		0.964	
Effect Size		0.142		0.159	
WC (cm)*					
Baseline		70.6 ± 11.4	0.712	66.0 ± 7.2	0.893
4 months		70.7 ± 11.2	NS	66.1 ± 7.1	0.902
P^1		0.985		0.934	
Effect Size		0.008		0.013	

*Results are expressed as mean ± standard deviation (n=23 each group). TC: total cholesterol; HDL-c: high-density lipoprotein-cholesterol; LDL-c: low-density lipoprotein-cholesterol; BMI: body mass index; WC: waist circumference. *Log-transformed data. P^1 = Comparison to the respective baseline values and P^2 = Comparison between groups; different upper script letters in the same row mean significant differences (Two-way RM-ANOVA and Holm-Sidak post-hoc test). Effect size, comparisons between 4-month and baseline values of the same group. Hedges' g effect size for Gaussian paired-samples = trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (>0.80). Effect size between groups for baseline values were small or large, while effect size for 4-month values were trivial or small (not shown).*

Table 2 – The effect of physical activity and nutritional counseling on the glycemic profile of children and adolescents

Parameters	Control	Physical Activity and Nutritional Counseling		Physical Activity	
Glucose (mg/dL)			P^2		P^2
Baseline	81.9 ± 14.5 ^{a}	94.5 ± 11.9 ^{b}	**0.005**	90.9 ± 14.0 ^{a,b}	0.057
4 months	91.5 ± 15.1 ^{a}	91.8 ± 9.0 ^{a}	0.948	90.4 ± 11.4 ^{a}	0.951
P^1	**0.002**	0.297		0.874	
Effect Size^1	**0.626 (0.19 – 1.10)**	-0.244 (-0.20 – 0.71)		0.037 (-0.42 – 0.50)	
Insulin (µU/L)*					
Baseline	6.5 ± 5.1 ^{a}	7.3 ± 5.3 ^{a}	0.567	4.2 ± 2.6 ^{a}	0.199
4 months	6.6 ± 4.1 ^{a}	8.5 ± 4.6 ^{a}	0.449	7.4 ± 3.8 ^{a}	0.564
P^1	0.836	0.144		**0.001**	
Effect Size^1	0.021 (-0.32 – 0.28)	0.020 (-0.34 – 0.31)		**0.698 (0.62 – 1.34)**	
HOMA-IR*		7.3	8.5		
Baseline	1.4 ± 1.3 ^{a}	1.7 ± 1.3 ^{a}	0.343	1.0 ± 0.7 ^{a}	0.450
4 months	1.6 ± 1.4 ^{a}	1.9 ± 1.1 ^{a}	0.717	1.6 ± 0.9 ^{a}	0.133
P^1	0.256	0.257		**0.002**	
Effect Size^1	0.142 (-0.11 – 0.40)	0.158 (-0.19 – 0.52)		**0.679 (0.38 – 1.09)**	

*Results are expressed as mean ± standard deviation (n=23 each group). HOMA-IR, insulin resistance index; *Log-transformed data. P^1 = Comparison to the respective baseline values and P^2 = Comparisons between groups; different upper script letters in the same row mean significant differences (Two-Way RM-ANOVA and Holm-Sidak post-hoc test). Effect size^1, comparisons between 4-month and baseline values of the same group. Hedges' g for Gaussian paired-samples = trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (>0.80). Effect size between groups was trivial or small (not shown).*

Table 3 – Changes (Δ) in the serum lipid and glycemic parameters and body fat of children and adolescents after 4-month interventions

	Control (n=23)	PANC (n=23)		PA (n=23)		
Parameters	**Δ %**	**Δ %**	**Effect Size^1**	**Δ %**	**Effect Size^1**	**p**
Total Cholesterol	2.3 (-2.9 – 8.3) a	-11.2 (-20.6 – 0.0) b	**-0.537**	-13.2 (-22.6 – -1.4) b	**-0.586**	**< 0.001**
LDL-c	4.5 (-10.0 – 12.5) a	-19.5 (-29.8 – -4.8) b	**-0.490**	-16.8 (-26.5 – -9.2) b	**-0.573**	**0.002**
Non-HDL-c	5.3 (-10.2 – 12.0) a	-18.7 (-27.8 – 0.7) b	**-0.463**	-15.2 (-27.4 – -1.3) b	**-0.550**	**0.003**
HDL-c	-7,4 (-14,3 – 21,0) a	-2,9 (-13,3 – 2,4) a	0.004	-7,8 (-11,4 – 7,4) a	-0.066	0.905
Triglycerides	11.9 (-30.8 – 59.5) a	-4.5 (-15.4 – 50.9) a	-0.130	-0.0 (-37.0 – 15.4) a	-0.229	0.389
Glucose	5.4 (-1.3 – 15.6) ^{a}	-4.7 (-9.8 – 9.6) ^{b}	**-0.482**	-1.0 (-13.6 – 10.7) ^{a,b}	-0.291	**0.022**
Insulin	6.8 (-24.2 – 49.1) ^{a}	48.2 (-24.8 – 92.1) ^{a}	0.229	67.8 (12.6 – 156.2) ^{b}	**0.471**	**0.017**
HOMA-IR	11.9 (-30.8 – 59.5) ^{a}	-4.5 (-15.4 – 50.9) ^{a}	-0.108	0.0 (-37.0 – 15.4) ^{a}	**-0.353**	0.389
Body Fat	1.3 ± 12.6 ^{a}	-5.2 ± 10.3 ^{a}	**-0.541**	-3.0 ± 12.5 ^{a}	-0.328	0.178

Results are expressed as median (25-75% IQI) and mean ± standard deviation. Δ = 4 months minus the respective baseline values, in percentage. PANC: Physical activity and nutritional counseling; PA: Physical activity. LDL-c: low density lipoprotein-cholesterol, HDL-c: high-density lipoprotein-cholesterol; HOMA-IR: insulin resistance index. Different upper script letters mean significant differences (One-Way ANOVA and Holm-Sidak's test or Kruskal-Wallis One-Way ANOVA on Ranks and Dunn's test). Effect size: Hedges' g for normal data = trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (>0.80); Cliff's δ for non-Gaussian data = trivial (<0.147), small (0.148 – 0.32), medium (0.33 – 0.474), and strong (>0.474). Effect size^1, compared to the control group. The effect size between PANC and PA groups was trivial or small (not shown).

Table 4 – Changes (Δ) in serum lipid and anthropometric parameters of male and female students after 4-month interventions

	Control	Physical Activity/Nutritional Counseling		Physical Activity		
Parameters	**Δ %**	**Δ %**	**Effect Size[1]**	**Δ %**	**Effect Size[1]**	**P[2]**
Total Cholesterol						
Male	2.3 (-0.6 – 5.0)	-15.4 (-20.3 – 8.6)	**0.812 (0.26 – 0.96)**	-8.5 (-21.5 – -1.7)	**0.681 (0.08 – 0.92)**	NS
Female	0.6 (-6.6 – 19.3)	-4.4 (-24.3 – 8.6)	0.290 (-0.20 – 0.29)	-14.2 (-22.8 – -0.2)	**0.562 (0.11 – 0.82)**	NS
P[1]	NS	NS		NS		
Effect Size[2]	-0.052 (-0.49 – 0.40)	0.265 (-0.28 – 0.67)		-0.061 (-0.52 – 0.43)		
LDL-c						
Male	-1.9 (-5.1 – 11.8)	-20.7 (-30.3 – -11.5)	**0.810 (0.26 – 0.96)**	-16.8 (-25.6 – -2.2)	**0.587 (-0.03 – 0.88)**	NS
Female	6.3 (-11.3 – 22.1)	-5.1 (-29.8 – 20.2)	0.261 (-0.23 – 0.65)	-16,1 (-27.3 – -8.3)	**0.563 (0.12 – 0.82)**	NS
P[1]	NS	NS		NS		
Effect Size[2]	0.143 (-0.34 – 0.57)	0.333 (-0.20 – 0.71)		0.063 (-0.52 – 0.42)		
Non-HDL-c						
Male	5.3 (-0.92 – 17.8)	-19.9 (-30.0 – -6.1)	**0.786 (0.24 – 0.95)**	-14.9 (-26.4 – 1.4)	**0.683 (0.10 – 0.92)**	NS
Female	5.0 (-11.8 – 11.9)	-7.7 (-27.8 – 15.9)	0.239 (-0.25 – 0.63)	-16.9 (-28.1 – -5.4)	**0.491 (0.04 – 0.77)**	NS
P[1]	NS	NS		NS		
Effect Size[2]	-0.054 (-0.50 – 0.41)	0.242 (-0.26 – 0.64)		-0.048 (-0.51 – 0.43)		
HDL-c						
Male	-11.6 (-15.8 – 21.0)	-2.1 (-12.2 – 2.9)	-0.100 (-0.62 – 0.48)	-4.2 (-18.9 – 8.9)	0.050 (-0.52 – 0.59)	NS
Female	-3.6 (-13.8 – 18.8)	-3.0 (-13.3 – 0.1)	0.062 (-0.37 – 0.48)	-8.0 (-10.5 – 7.5)	0.081 (-0.33 – 0.47)	NS
P[1]	NS	NS		NS		
Effect Size[2]	0.210 (-0.32 – 0.63)	-0.08 (-0.52 – 0.39)		0.110 (-0.40 – 0.57)		
Triglycerides						
Male	59.4 (15.1 – 111.1)	-5.4 (-19.9 – 41.7)	**0.670 (0.12 – 0.90)**	0.1 (-23.3 – 6.3)	**0.650 (-0.01 – 0.92)**	NS
Female	1.6 (-31.7 – 26.9)	-4.5 (-14.0 – 52.4)	-0.100 (-0.51 – 0.35)	-8.1 (-39.8 – 22.7)	0.031 (-0.38 – 0.43)	NS
P[1]	NS	NS		NS		
Effect Size[2]	-0.610 (-0.86 – -0.11)	0.110 (-0.37 – 0.54)		-0.060 (-0.51 – 0.41)		

Results are expressed as median and (25%-75% IQI) and mean ± standard deviation. Δ = 4 months minus the respective baseline values, in percentage. Number of Male/Female = Control: 7/16; Physical activity and nutritional counseling: 12/11; Physical activity: 9/14. LDL-c: low-density lipoprotein-cholesterol, HDL-c: high-density lipoprotein-cholesterol; BMI: body mass index; WC: waist circumference. NS, not significant. P[1], comparison between sexes of the same group and P[2], comparisons between groups (Kruskal-Wallis ANOVA on Ranks and Dunn's test). Effect size (CI 95%): Hedges' g for normal distribution data = trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (>0.80). Cliff's δ = trivial (<0.147), small (0.148 – 0.32), medium (0.33 – 0.474), and strong (>0.474). Effect size[1], comparisons between intervention groups and control. Effect size comparisons between interventions groups were trivial or small. Effect size[2], comparisons between male and female students of the same group.

Inflammatory markers

The interventions did not promote significant changes in inflammatory markers, but an increase in the TNF-α level was observed in students in the control and PA groups in comparison to the respective baseline levels, with a medium effect size. In addition, a medium effect size was observed for hs-PCR decrease in students in the control group in relation to the baseline levels (Supplemental File 3).

Diet profile

Table 5 and Supplemental File 5 show the main nutritional parameters considered in this study at the baseline and 4-month periods. At baseline, students in the PANC group had a significantly increased intake of energy and total fat, in comparison to control participants with a large effect size. However, after a 4-month intervention, students in the PANC group significantly decreased the ingestion of total calories, total fat, and cholesterol, and increased the protein intake, with a large effect size. Although not significant, but with a large effect size, the PANC students also reduced the intake of SAT, PUFA, MUFA (Table 5). On the other hand, students in the control group significantly increased the intake of total fat, PUFA, and cholesterol, with a large effect size, while reduced the intake of protein, carbohydrates, and fiber (Table 5). Students in the PA group did not change their diet profile (Table 5 and Supplemental File 5). Similar results were found when data in the PANC group were normalized to the respective baseline values and the variation (in the percentage of baseline) was compared to control and PA groups (Supplemental File 5).

Discussion

Diet, physical activity, and sedentary behaviors should be considered simultaneously for preventing CVD. Herein, we showed that regular practice of recreational physical activities, associated or not with nutritional counseling for four months, promoted a significant decrease in TC (11.2%), LDL-c (19.5%), non-HDL-c (18.7%), and body fat (5.2%) in children and adolescents with dyslipidemia and abdominal obesity, with medium or large effect size. According to our results, male students were more prone to reduce serum cholesterol, while female students showed the most prominent decrease in body fat.

In general, lifestyle changes improved serum lipid profile at different extents, corroborating our findings.[24-28] Lifestyle changes had a significant impact on the total and LDL-c and triglycerides in the short-term (4-6 months) and long-term (1-2 years), without differences for HDL-c.[25] Interestingly, our results were contrary to those reported by Rosini et al. (2014),[29] where the authors found a significant reduction in triglycerides and an increase in HDL-c, but no change in total- and LDL-c. The type of physical activity applied, and the extent of dyslipidemias may play a role to explain the different results.

The sd-LDL subclass has been considered to be more atherogenic than the large, buoyant LDL particles.[29-32] Herein, our short-term interventions did not decrease the sd-LDL-c levels or increase the LDL particle size. However, previous studies showed improvement in the sd-LDL subclass after intervention with physical activities and nutritional counseling in obese adolescents.[24,28]

In general, physical activities when associated with dietary interventions promoted greater reductions in TC, LDL-c, and triglycerides, without effect for HDL-c.[33] However, in our study, nutritional counseling was not effective for superior benefits on serum lipid profile, despite the significantly decreased intake of total calories, total fat, SFA, PUFA, MUFA, and cholesterol, associated to increase the ingestion of fiber, which could improve the serum lipid profile.[34] Altogether, the controversial and inconclusive results are probably due to differences in study designs, sample size, exercise intensity, and type of nutritional counseling.[35] The underlying heterogeneity in the response to interventions in lifestyle and the fact that young people do not respond the same way, need to be further elucidated and will help to refine the interventions on target populations.[28-]

Low levels of physical activity are considered a fundamental factor for elevated glucose and insulin levels and, increased risk of diabetes mellitus.[35] In fact, in our study, students in the control group tended to increase glucose by 5.4%, in the median, with strong effect size, while those who were on physical activities and nutritional counseling reduced glucose by 4.7%, in the median, particularly male students in the PANC and PA groups. Poeta et al.[27] reported that glucose levels did not change in students on physical activities, while students in the control group showed a significant increase. Moreover, a significant decrease in fasting glucose was observed in obese children on physical activities.[36] Interestingly, for unknown reasons, insulin levels and IR increased in students who underwent physical activity, especially male students. Park et al.[37] did not observe changes in glucose and insulin in

Table 5 – Effect of physical activity and nutritional counseling on the diet parameters of children and adolescents

Parameters	Control	PANC		PA	
Energy (kCal)			P[2]		P[2]
Baseline	1747.6 ± 399.2[a]	1937.9 ± 237.0[b]	**<0.001**	1806.1 ± 192.4[a,b]	0.189
4 months	1663.7 ± 374.9[a]	1321.1 ± 590.7[a]	0.089	1819.2 ± 240.5[a]	0.219
P[1]	0.586	**<0.001**		0.884	
Effect Size	-0.198	**-1.229**		0.052	
Protein (%)					
Baseline	16.3 ± 4.2 [a,b]	12.8 ± 2.0 [a]	0.075	15.7 ± 5.9 [a]	0.056
4 months	13.5 ± 4.0 [a]	15.6 ± 3.4 [a]	0.358	17.9 ± 2.6 [a]	0.252
P[1]	**0.020**	**0.023**		0.513	
Effect Size	**-0.624**	**0.864**		0.392	
Carbohydrates (%)					
Baseline	49.7 ± 8.9 [a]	47.8 ± 5.4 [a]	0.578	51.6 ± 8.4 [a]	0.812
4 months	44.6 ± 4.3 [a]	48.6 ± 5.7 [a]	0.239	52.6 ± 6.7 [a]	0.068
P[1]	**0.004**	0.647		0.550	
Effect Size	**-0.589**	0.131		0.142	
Total Fat (%)					
Baseline	63.9 ± 22.4 [a]	84.9 ± 12.7 [b]	**0.002**	71.3 ± 18.2 [a]	0.792
4 months	76.0 ± 14.1 [a]	63.3 ± 13.2 [b]	**0.044**	67.6 ± 9.6 [a,b]	0.874
P[1]	**0.010**	**<0.001**		0.506	
Effect Size	**0.558**	**-1.524**		-0.210	
SFA (%)					
Baseline	14.8 ± 6.0 [a]	19.0 ± 3.8 [a]	0.069	16.7 ± 4.7 [a]	0.519
4 months	16.7 ± 4.6 [a]	15.3 ± 4.8 [a]	0.469	16.0 ± 2.1 [b]	0.802
P[1]	0.311	0.057		0.957	
Effect Size	0.324	**-0.756**		-0.166	
PUFA (%)					
Baseline	15.5 ± 7.3 [a]	17.8 ± 2.6 [a]	0.204	16.3 ± 2.5 [a]	0.487
4 months	21.9 ± 4.7 [a]	15.0 ± 2.9 [b]	**0.001**	16.9 ± 3.5 [a,b]	0.354
P[1]	**0.001**	0.113		0.771	
Effect Size	**0.939**	**-0.930**		0.177	
MUFA (%)					
Baseline	14.7 ± 6.4 [a]	15.9 ± 3.7 [a]	0.496	13.9 ± 4.5 [a]	0.221
4 months	16.8 ± 3.7 [a]	13.2 ± 3.4 [a]	0.107	14.8 ± 4.2 [a]	0.301
P[1]	0.196	0.080		0.451	
Effect Size	0.352	**-0.693**		0.189	
Cholesterol (mg)					
Baseline	145.6 ± 76.8[a]	155.1 ± 46.4[a]	0.730	135.3 ± 59.7[a]	0.093

4 months	189.9 ± 60.8[a]	126.2 ± 42.7[a]	0.086	152.3 ± 77.1[a]	0.334
P[1]	**0.005**	**0.051**		0.162	
Effect Size	**0.578**	**-0.587**		0.223	
Fiber (g)					
Baseline	21.8 ± 23.6 [a]	13.6 ± 8.8 [a]	0.274	23.1 ± 9.3 [a]	0.806
4 months	9.7 ± 9.0 [a]	15.8 ± 10.2 [a]	0.476	20.6 ± 7.0 [b]	0.159
P[1]	**0.003**	0.551		0.505	
Effect Size	-0.385	0.210		-0.273	

Results are expressed as mean ± standard deviation (n=23 each group). PANC, physical activity and nutritional counseling; PA, physical activity; SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids. P^1 = Comparison to the respective baseline values and P^2 = Comparison between groups; different upper script letters in the same row mean significant differences (Two-way RM-ANOVA and Holm-Sidak post-hoc test). Effect size, comparisons between 4-month and baseline values of the same group. Hedges' g effect size for Gaussian paired-samples = trivial (<0.20), small (0.20 to 0.49), medium (0.50 to 0.79), and large (>0.80). Effect sizes between groups were trivial or small (not shown), except for PANC vs. Control: Total Fat baseline (g = 1.046); Total Fat 4-month (g = -0.850); PUFA 4-month: (g = -1.631); and Cholesterol 4-month (g = -1.117).

adolescents doing exercises for 12 weeks. Physical activity was unassociated with glucose and IR, independent of nutritional status, sexual maturation, food intake, and sex.[35] One possible explanation for our results is the small number of students with blood glucose higher than reference values. Moreover, according to a meta-analysis, significant improvement in insulin levels was observed only after intervention exceeding 12 months, with no change in glucose levels.[25] However, a study with obese students found a reduction in glucose, insulin, and IR after 6 months of intervention with diet to reduce sugar and fat intake, instructions in physical exercise as part of everyday life, reducing screen time and doing behavioral therapy.[38] Improvement of IR was also found in obese students on aerobic and resistance exercises. Thus, improvement in glycemic profile seems to occur only in children and adolescents with high levels of these parameters, particularly in obese students.[39]

Although physical activity and diet adjustment separately promoted beneficial effects on inflammation markers, combined programs are the most promising approach.[40] However, herein we did not find changes in the hs-CRP, uric acid, and TNF-α levels after interventions. Similar findings were described by Poeta et al.[27] It is noteworthy that, in general, the students had normal levels of the inflammatory biomarkers. On the other hand, six months of combined intervention decreased hs-CRP in obese students, suggesting that the duration of activity and the type of nutritional counseling may be relevant.[38] It has been reported that decreasing intake of SFA, MUFA, and PUFA may also reduce hs-CRP concentration in children.[3] However, herein, regardless of a decrease in the intake of all fatty acids by students in the PANC group, a similar improvement of inflammatory markers was not observed. Thus, additional studies are needed to establish a better intervention to reduce subclinical inflammation in children and adolescents.

Abdominal obesity in childhood seems to be more related to CVD and diabetes mellitus in adulthood than general obesity.[41] In this study, physical activity and nutritional counseling did not promote significant changes in abdominal obesity measured by WC. Similarly, no reduction in abdominal obesity was seen in our previous study with participants of the same downtown.[29] Decrease of WC and WC/height ratio was observed and associated with improvement of insulin sensitivity in students after 40 weeks of a lifestyle intervention: individual nutritional counseling, with 60 min weekly training at school and 90 min weekly training with their families.[42] On the opposite, reports are suggesting that the absence of WC improvement after lifestyle interventions may be due to the intensity of physical activity and/or adherence to dietary modifications.[36,38,39] On the other hand, herein the physical activity associated with nutritional counseling was highly effective for body fat reduction by 5.2%, consistent with previous results.[36,38]

Despite the small number of individuals here studied, which might be considered a limitation of this study, we may suggest that the regular practice of recreational physical activities and qualitative nutritional counseling for children and adolescents with dyslipidemia and abdominal obesity promoted significant improvements in the serum lipid profile and body fat percentage.

Such benefits proved to be an effective and low-cost strategy for reducing risk factors in this population. Furthermore, the greatest strength of this study, which also differentiates it from other studies, was the presence of a control group, the absence of a specific or restrictive diet, and no vigorous physical activities nor parents' participation, proving that is an effective strategy to be applied in schools as a regular part of the curriculum.

Conclusion

Regular recreational physical activities at school associated with nutritional counseling reduced total cholesterol, non-HDL-cholesterol, and LDL-cholesterol, and body fat in children and adolescents with dyslipidemias and abdominal obesity. In addition, students also decreased the intake of total calories, total fat and saturated, monounsaturated, and polyunsaturated fatty acids, and cholesterol, and increased the ingestion of protein and fiber. It is suggested that early adoption of a healthy lifestyle should be considered as a basic component for prevention, reduction, and treatment of cardiometabolic factors for CVD in childhood and adolescence.

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Author contributions

Conception and design of the research: Pamplona-Cunha H, Rosini N, Caetano R, Silva EL. Acquisition of data: Pamplona-Cunha H, Rosini N, Caetano R, Silva EL. Analysis and interpretation of the data: Pamplona-Cunha H, Machado MJ, Silva EL. Statistical analysis: Pamplona-Cunha H, Machado MJ, Silva EL. Obtaining financing: Pamplona-Cunha H, Rosini N, Silva EL. Writing of the manuscript: Pamplona-Cunha H, Rosini N, Caetano R, Machado MJ, Silva EL. Critical revision of the manuscript for intellectual content: Pamplona-Cunha H, Silva EL.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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Ethics approval and consent to participate

This study was approved by the Ethics Committee of the *Universidade Federal de Santa Catarina* under the protocol number CAAE: 03626512.4.0000.0121. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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*Supplemental Materials

For additional information, please click here.