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Longitudinal data from a school-based intervention - The ACORDA project

Datos longitudinales de un programa intervención en la escuela - proyecto ACORDA

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Abstract. The aim of this study was to analyse changes over 8-months of a multidisciplinary school-based intervention program (ACORDA-Project), in body fat, metabolic profile and physical activity (PA). 40 children [22 girls (55%), and 18 boys age=8.4±1.2] of 6 schools participated in a multidisciplinary program during a school year. Blood pressure (BP), physical activity (PA) by accelerometers, percentage of body fat (%BF) and of trunk fat (%TF) by DXA, and plasmatic total cholesterol (TC), triglycerides, HDL-cholesterol, LDL-cholesterol, insulin and glucose were taken at the baseline (Time point 1, TP1) and at the end of the intervention (Time point 2, TP2). General Linear Models (Repeated Measures Analysis of Covariance) was carried out comparing values at baseline vs. final evaluation, with adjustments for gender and age at baseline. Further adjustments were made to relative changes (increase$\%_X$) in height, weight, total PA through steps.day^{-1}, sedentary (SEDPA), light (LIGPA) and moderate to vigorous (MVPA) intensities. Relative changes were calculated as: increase$\%_X = (X_{final} - X_{baseline}) / X_{baseline}$. Statistical significance was set at 5%. Eta squared (n^2) was used as an indicator of effect size. There was a significant increase of LIGPA and MVPA, (P<0.05), and significant reduction in systolic blood pressure (P<0.05), but not in diastolic blood pressure. For TC and fasting glucose, significant reductions were also found P<0.05). No changes were observed for other traditional cardiovascular risk factors. The present study found that 8-months of multidisciplinary intervention provided a significant increase in PA levels and reduced cardiovascular risk factors in school children, highlighting the importance of this type of intervention through promotion of PA and the positive impact on children health.
Keywords. Metabolic diseases, Children, DEXA, Accelerometers, Body composition.

Resumen. El objetivo de este estudio fue analizar los cambios en la grasa corporal, el perfil metabólico y la actividad física (AF) en jóvenes escolares que han participado en un programa de intervención multidisciplinario (ACORDA-Project). 40 niños [22 niñas (55%), y 18 niños de edad = 8,4 ± 1,2] de 6 escuelas participaron en un programa multidisciplinario durante un año escolar. La presión arterial (PA), AF por acelerómetros, la porcentaje de grasa corporal (% GC) y de la grasa del tronco (% TF) por DXA, y el colesterol total plasmático (CT), triglicéridos, HDL-colesterol, LDL-colesterol, insulina, la glucosa se tomaron a la línea de base (punto de tiempo 1, TP1) y al final de la intervención (punto de tiempo 2, TP2). Modelos lineales generales (medidas repetidas análisis de covarianza) se utilizaran para la comparación de los valores al inicio del estudio vs. evaluación final, con ajustes para el género y la edad al inicio del estudio. Se hicieron nuevos ajustes a los cambios relativos (incremento$\%_X$) de altura, el peso, actividad física total (PA) a través de pasos por día, sedentaria (SEDPA), leve (LIGPA) y de moderada a (MVPA) intensidades vigorosas. Se calcularon los cambios relativos como: incremento$\%_X$ = (xfinal - Xbaseline) / Xbaseline. La significación estadística se fijó en 5%. Eta cuadrado (n^2) se usó como un indicador del tamaño del efecto. Se observó un aumento significativo de LIGPA y MVPA, (P <0.05) y una reducción significativa de la presión arterial sistólica (p <0,05), pero no en la presión arterial diastólica. Para el CT y la glucosa en ayunas, también se encontraron reducciones significativas (P<0.05). No se observaron cambios en otros factores de riesgo cardiovascular tradicionales. El presente estudio encontró que 8-meses de intervención multidisciplinaria proporcionaron un aumento significativo en los niveles de AF y reducción de factores de riesgo cardiovascular en niños en edad escolar. Se destaca la importancia de este tipo de intervención a través de la promoción de la AF y el impacto positivo en la salud de los niños.
Palabras clave. enfermedades metabólicas, niños, DEXA, acelerómetros, composición corporal.

Introduction

Obesity is one of the most spread diseases in developed and developing countries. Portugal has one of the highest rates of children with overweight, along with other Mediterranean countries (Sardinha et al., 2011). According to current scientific evidence, high levels of physical activity (PA) during childhood and adolescence, particularly moderate to vigorous PA (MVPA), are associated to lower total and central adiposity (Franks et al., 2010) and other weight-related problems, such as hypertension (Gaya et al., 2009) and unfavourable lipid profile (Andersen, Riddoch, Kriemler, & Hills, 2011). Because childhood obesity clearly tracks into adulthood (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008) and after established in adulthood, obesity is difficult to treat (Leblanc, O'Connor, Whitlock, Patnode, & Kapka, 2011), interventions for prevention and treatment have been focused in early ages. Indeed, it seems easier to control and influence children rather than adults toward to healthy behaviours. Review studies suggest that treatment of childhood obesity can be efficient promoting positive behaviours, combining diet and increased PA levels, or reducing negative behaviours such as television viewing time (Brown et al., 2009; Katz, O'Connell, Njike, Yeh, & Nawaz, 2008; Khambalia, Dickinson, Hardy, Gill, & Baur, 2012; Vasques et al., 2013; Waters et al., 2011; Whitlock, O'Connor, Williams, Beil, & Lutz, 2010). Schools are one of our best venues for making these population-wide changes. However, there is no standard intervention profile that fits all schools and different populations and most results report some limitations on the effectiveness of interventions to achieve weight reduction in school settings (Khambalia et al., 2012). And despite the majority of studies being randomized controlled trials (RCT), they are, at a minimum, at moderate risk of bias (Dobbins, Husson, DeCorby, & LaRocca, 2013). In addition, several limitations can be found in methodology, as the use of different primary outcomes (such as BMI, waist circumference (WC), body fat, PA levels or metabolic variables), different times of intervention, different designs, hindering the comparison between studies. Furthermore, the long-term impact of interventions is still unclear.

Therefore, the aim of this study was to analyse changes in body fat, metabolic profile and habitual PA after 8 months of a school-based interdisciplinary intervention program (ACORDA-Project).

Methodology

Study design

The «ACORDA Project» (i.e. Obese Children and Adolescent Involved in PA and Diet Program) is a longitudinal intervention study, focused in young people with overweight and obesity. «ACORDA Project» is an 8-month interdisciplinary, school-based intervention program, aimed to change behaviours by providing easy access to PA.

Participants

The mean number of students per school was 152 (min 93; max 236). Initially, weight and height were taken to screen all children, and those above the cut points of overweight according Cole et al., (2000), were invited to participate. A letter was sent to all parents, acknowledging

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the mission of the project and inviting them to participate in a meeting where they would be informed in more detail about the aims, contents and evaluation to be accomplished.

All children were randomly selected from 6 schools in the Porto district from a deprived suburban area, with high prevalence of obesity and low socio-economic status: 56.6% of mothers or fathers were unemployed and over 60% of mothers and 70% of fathers concluded 9th grade or less. The prevalence of overweight and obesity was higher than the average in the rest of the country, with 46.4% for girls and 47% for boys. For ethical reasons, children with normal weight who showed interested in participate were accepted in the program. Fourteen children [22 girls (55%), and 18 boys age=8.4±1.2] including 37.7% with normal weight, 22.6% with overweight and 35.8% with obesity from 6 schools participated in a multidisciplinary program during a school year.

Intervention Program

All participants were asked to modify their lifestyle habits and to participate in a regular physical exercise classes. Attendance was in average of 85%. The ACORDA Project consisted in adding 2 extra hours of after-school sessions (1h each session) and took place from October to June. Classes/groups comprised a minimum of 6 and a maximum of 8 participants in each school. Two graduates in Sport Sciences, under the guidance of two researchers supervised sessions, ensuring that the type and variety of exercises would be performed according to previously planned to guarantee the equality in all schools. Sessions included 15 minutes of warm-up with aerobic endurance and flexibility, 30 minutes of working circuit for aerobics, strength endurance training, coordination and balance, with balls, bows, strings, and callisthenic exercises, 10 minutes of games to promote enjoyment, and 5 minutes of stretching. All activities were carried-out indoors in schools´ sports facilities. Exercises and games were progressively intensified as individually tolerated. Training intensity and compliance between individuals was defined to induce heart rate (HR) higher than 80% of each child's HR_{max}. To ensure this, 10 randomly selected children wore a portable HR monitor (Polar Team^2 Pro, Polar, Finland) and an accelerometer (MTI, model GTX3, as described below) during sessions.

To reduce dropout rates, at the end of the program, three bikes were offered to those children who attended all sessions and achieved higher PA levels. To maintain enthusiasm, activities outside school, such as surfing lessons, a camp during weekend and thematic classes (Christmas, Carnival and Easter) were organized. Parents could also participate in all sessions and extra-activities. A basket was raffled for parents who attended a workshop about healthy food habits with selected nutrients and recipes of low-cost meals. Evaluations were made at the beginning and at the end of the intervention, at the facilities of the University Of Porto Faculty Of Sports, under the same condition, using the same protocols, instruments, and evaluators. Blood samples were taken at school, avoiding children to wait many hours fasting.

At the end an individual report was delivered to children's' guardians including all test results and a brief interpretation. If abnormal values were observed, paediatricians and parents/guardians were informed and an appointment with a family doctor was encouraged for a follow-up evaluation.

The nature, benefits, and risks of the study were explained to the volunteers, and a parent's written informed consent was obtained before the study, consistent with the Helsinki Declaration. The experimental protocol was approved by the Review Committee of the Scientific Board of the Faculty of Sport - University of Porto as well as by the Foundation of Science and Technology. Nutritional, analytical and clinical data were collected at baseline (October 2012) and after the intervention program (June 2013). The participants were told to do a 12-hour fast, and could only drink water after dinner in the previous day.

Participants under regular medication or having any physical condition were excluded from the sample.

Procedures

Anthropometry

Height and weight were measured before starting the protocol with participants wearing shorts and t-shirts only. Height was measured using a Holtain stadiometer (Holtain Ltd., Crymmych, UK) and recorded in centimetres to the nearest millimetre. Weight was measured to the nearest 0.1 kg with the scale Tanita MC 180 MA. BMI was calculated by the ratio between weight and squared height ($kg.m^{-2}$). BMI categories were set using Cole et al. (2000) cut points.

WC was measured to the nearest mm with a metallic tape at the superior border of the iliac crest, according to the protocol of the NHANES (The Third National Health and Nutrition Examination Survey, 1996).

Blood Pressure

Systolic and diastolic blood pressures (SBP and DBP) were measured with an automated oscillometric sphygmomanometer (Colin Press Mate Non-Invasive Blood Pressure Monitor - model BP 8800p; Colin Medical Instruments Corporation – San Antonio, TX, USA), using a standard technique (Duarte, Guerra, Ribeiro, & Mota, 2000). A trained technician took the measurements. SBP and DBP were measured in the right arm, with the subjects in the fasting state. The subjects were in the sitting position (without their legs crossed), with the right arm at heart level. Three standard pressure cuffs of correct size (9x18, 12x22, 16x30 cm) were used according to the published guidelines for BP assessment in children (Pickering et al., 2005). The first and second measurements were taken after 5 and 10 min resting, the mean of these measurements being considered for statistical purposes. If these two measurements differed 2 mm Hg, the protocol was repeated (two new measurements that could not exceed 2 mm Hg).

Body composition

Whole body Dual-energy X-ray Absorptiometry (DXA) was performed using a Hologic Explorer configured with software version 12.1 (Hologic, Bedford, MA). Measurements were analysed using Hologic APEX 3.1 software (Hologic) according to standard procedures set forth in the users guide for the DXA instrument, and %BF and trunk fat (%TF) were reported.

Blood Samples

After an overnight fast of at least 12 hours, blood was collected by venepuncture into ethylenediaminetetraacetic acid (EDTA) containing tubes and processed within 2h. Aliquots of plasma were made and stored at – 80ºC until assayed.

Lipids and lipoproteins analysis were performed in an auto-analyser (Cobas Integra 400 plus, Roche) using commercially available kits. Total cholesterol (TC) and triglycerides (TG) concentrations were determined by enzymatic colorimetric tests (CHOD-PAP and GPO-PAP methods, Roche, respectively). High-density lipoprotein (HDL)-cholesterol was measured using enzymatic colorimetric tests (Direct HDL-Cholesterol, Roche). Low-density lipoprotein (LDL)-cholesterol was calculated using Friedwald formula (LDL-cholesterol = TC – HDL-cholesterol – (TG/5) (Friedewald, Levy, & Fredrickson, 1972). The determination of circulating levels of glucose and insulin were performed using routine automated technology (ABX Diagnostics). The homeostasis model assessment of insulin resistance ($HOMA_{IR}$) was calculated (Matthews et al., 1985).

Physical activity

The Manufacturing Technology Inc. (MTI), model GTX3, formerly known as the Computer Science Applications activity monitor (Shalimar, FL) was used to evaluate PA. Validation studies examining this accelerometer suggest that it provides a valid and reliable measurement of PA in children being strongly correlated (r = .86) with energy expenditure, assessed by indirect calorimetry, as well as a high degree of inter-instrument reliability (Brage, Wedderkopp, Andersen, & Froberg, 2003; Trost et al., 1998).

For the current study, the accelerometer was worn on the hip secured by an elastic waist belt. The epoch period (i.e., the duration of the sampling period) was set at 10 seconds and the output was expressed as counts per minute (counts·min^{-1}). Participants were provided with written instructions regarding care and placement of the accelerometers. A data sheet was given to each participant providing instructions to remove the accelerometers each time they performed any restricted activities like showering and swimming.

Table 1.
Participants characteristics at baseline

	All (n=40) Mean ± SD	Girls (n=22) Mean ± SD	Boys (n=18) Mean ± SD	Difference (Girls - Boys) Mean (95% CI)	η^2
Age (years)	8.4 ± 1.2	8.4 ± 1.2	8.4 ± 1.2	-0.03 (-0.80 to 0.75)	0.000
Height (cm)	131.4 ± 7.3	129.3 ± 6.5	133.9 ± 7.7*	-4.63 (-9.17 to -0.09)	0.101
Weight (kg)	34.8 ± 10.7	32.2 ± 9.6	38.1 ± 11.5	-5.95 (-12.67 to 0.78)	0.078
BMI (kg.m^{-2})	19.8 ± 4.4	18.9 ± 4.0	20.9 ± 4.8	-1.95 (-4.76 to 0.86)	0.049
WC (cm)	68.4 ± 12.4	65.2 ± 11.8	72.4 ± 12.3	-7.25 (-14.98 to 0.47)	0.087
Body Fat (%)	37.3 ± 7.0	36.7 ± 6.1	38.0 ± 8.0	-1.33 (-5.84 to 3.18)	0.009
Trunk Fat (%)	34.3 ± 8.4	33.8 ± 7.7	34.9 ± 9.4	-1.01 (-6.48 to 4.46)	0.004
SBP (mm Hg)	106.2 ± 11.0	102.5 ± 12.0	110.6 ± 7.9*	-8.12 (-14.79 to -1.45)	0.138
DBP (mm Hg)	55.9 ± 6.8	53.7 ± 7.3	58.6 ± 5.1*	-4.92 (-9.06 to -0.79)	0.133
TC (mg.dL^{-1})	172.6 ± 28.3	165.4 ± 28.8	181.3 ± 25.9	-15.84 (-33.56 to 1.89)	0.079
HDL-cholesterol (mg.dL^{-1})	54.9 ± 10.5	51.8 ± 9.1	58.8 ± 11.1*	-7.03 (-13.50 to -0.56)	0.113
LDL-cholesterol (mg.dL^{-1})	102.0 ± 23.7	97.5 ± 25.4	107.6 ± 20.7	-10.02 (-25.11 to 5.07)	0.045
TG (mg.dL^{-1})	78.2 ± 37.5	80.8 ± 40.8	75.0 ± 34.0	5.86 (-18.52 to 30.24)	0.006
Glucose (mg.dL^{-1})	81.8 ± 7.5	80.6 ± 7.4	83.4 ± 7.5	-2.74 (-7.53 to 2.06)	0.034
Insulin (μ U.mL^{-1})	9.11 ± 5.46	9.58 ± 6.64	8.55 ± 3.64	1.03 (-2.51 to 4.57)	0.009
HOMA$_{IR}$	1.87 ± 1.17	1.93 ± 1.40	1.78 ± 0.84	0.15 (-0.62 to 0.91)	0.004
Sedentary PA (min.day^{-1})	622.6 ± 62.2	615.1 ± 63.1	631.8 ± 61.4	-16.67 (-56.81 to 23.48)	0.018
Light PA (min.day^{-1})	347.4 ± 60.5	358.1 ± 65.7	334.3 ± 52.2	23.76 (-14.87 to 62.39)	0.039
Moderate PA (min.day^{-1})	38.0 ± 14.0	36.6 ± 10.6	39.6 ± 17.5	-3.07 (-12.72 to 6.58)	0.012
Vigorous PA (min.day^{-1})	12.1 ± 11.2	10.3 ± 5.9	14.3 ± 15.3	-4.02 (-11.98 to 3.94)	0.033
MVPA (min.day^{-1})	50.0 ± 23.3	46.8 ± 15.6	53.9 ± 30.3	-7.09 (-23.32 to 9.14)	0.024
Total PA (steps.day^{-1})	9652.7 ± 1837.5	9481.5 ± 1350.8	9862.0 ± 2325.4	-380.55 (-1653.06 to 891.96)	0.011
Total PA (counts.min^{-1})	561.8 ± 131.7	545.4 ± 87.3	581.9 ± 172.1	-36.49 (-128.61 to 55.62)	0.019
Motor Coordination (sum)	89.8 ± 32.7	87.1 ± 35.6	93.2 ± 29.5	-6.07 (-27.31 to 15.17)	0.009

Notes: Descriptive values are Mean ± Standard Deviation; Gender differences are Mean (95% Confidence Interval); Effect size for gender differences is represented as Eta Squared (η^2); * for P<0.05. BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HOMA$_{IR}$, homeostasis model assessment of insulin resistance; PA, physical activity; MVPA, moderate to vigorous PA.

Activity counts were summed for each hour that the accelerometer was worn between 7:00 h and 24:00 h to provide a representative picture of daily activity. Criteria for a successful recording were a minimum of 4 days of the week and 1 day of the weekend, and more than 600 minutes per day. Time periods of at least 10 consecutive minutes of zero counts were considered as periods when the monitor was not worn and thus disregarded before analysis. The data were processed with specific software «Actilife, version 6.8». Specific cut points from Evenson et al (2008) were used: for sedentary intensity d»100; Light, >100, moderate e» 2296; and vigorous e» 4012 counts.min^{-1}. Students filled out a diary indicating the activities performed from the awakening until sleeping time.

Motor Coordination Coefficient

Motor performance was assessed by the Koordinations Test für Kinder (KTK) as well as a test of throwing accuracy. The KTK is a product-oriented motor performance battery which consists of four age-adjusted movement ability tests: 1) a single-legged hop over obstacles, 2) a balance test on three different width beams, 3) a sideward jumping (ski jumping) test lasting 15 seconds, and 4) a lateral movement test lasting 20 seconds where the participant moves from one 6 x 6 inch footstool to another as many times as possible. A motor quotient for each participant was derived from the sum of the KTK age-adjusted scores from the four test items. The highest attainable score was thirty points. The test was first described in the Allgemeiner sportmotorischer Test für Kinder (AST) test battery (Bös & Wohlmann, 1987).

Statistical Procedures

Descriptive data for continuous variables are presented as Mean ± Standard Deviation or Mean (Standard Error) for adjusted analyses. The proportions for gender and weight status are described as percentages and Chi-squared test was used to analyse differences between groups.

At baseline, Student's T-test was carried out to analyse differences between boys and girls in anthropometric measurements, cardiovascular risk factors (CRF), PA and motor coordination.

To analyse longitudinal changes in anthropometric measurements, CRF, PA and motor coordination after 8-months PA intervention, General Linear Models (Repeated Measures Analysis of Covariance) was carried out comparing values at baseline vs. final evaluation, with adjustments for gender and age at baseline. For those anthropometric measurements and CRF that presented significant longitudinal changes, data were reanalysed adding relative changes (increase%$_X$) in height, weight, SEDPA, LIGPA, MVPA and total PA (steps.day^{-1}) as covariates. Relative changes were calculated as: increase%$_X$ = (X_{final} – $X_{baseline}$) / $X_{baseline}$. This approach was used to analyse whether longitudinal changes in dependent variables were independent variations related to growth or modifications in habitual PA.

Statistical significance was set at 5% for all analyses. Eta squared (n^2) was used as an indicator of effect size. All calculations and analyses were carried out in SPSS version 21.0 for Mac OSX.

Results

Participants' characteristics and data at baseline are presented in Table 1 for the total sample and according to gender. At the beginning of the study, there were differences (P<0.05) between genders for height, SBP, DBP and HDL-cholesterol, with greater values for boys. At baseline, 45% of children were normal-weight and 55% were overweight or obese. The proportions of subjects classified as overweight/obese were similar between genders (x^2 = 2.059; P=0.560).

Longitudinal changes for anthropometric measurements, traditional CRF and blood pressure with adjustments for age and sex are shown in Table 2. Results show significant (P<0.001) increases in height and body mass. No changes were found in BMI, %BF and %TF. There was a significant reduction in SBP (P<0.05), but not in DBP. For TC and fasting glucose, significant reductions were also found. No changes were observed for other traditional CRF.

Table 2.
Longitudinal changes in anthropometric measurements and cardiovascular risk factors

	Baseline Mean (SE)	Final Mean (SE)	Longitudinal Change (Final – Baseline) Mean (95% CI)	Partial η 2
Height (cm)	131.4 (0.8)	134.1 (1.0)**	2.65 (1.95 to 3.36)	0.595
Weight (kg)	34.8 (1.3)	36.1 (1.3)**	1.23 (0.69 to 1.77)	0.346
BMI (kg.m^{-2})	19.8 (0.6)	19.7 (0.6)	-0.10 (-0.40 to 0.20)	0.012
WC (cm)	68.4 (1.6)	70.6 (1.5)	2.15 (-0.16 to 4.46)	0.082
Body Fat (%)	37.3 (1.1)	37.0 (1.0)	-0.26 (-1.65 to 1.13)	0.004
Trunk Fat (%)	34.3 (1.3)	34.0 (1.2)	-0.34 (-2.08 to 1.41)	0.004
SBP (mmHg)	106.2 (1.6)	102.1 (1.3)**	-4.05 (-6.65 to -1.45)	0.201
DBP (mm Hg)	55.9 (1.0)	57.8 (0.8)	1.88 (-0.31 to 4.07)	0.071
TC (mg.dL^{-1})	172.6 (4.4)	165.6 (4.2)*	-7.00 (-12.65 to -1.35)	0.137
HDL-cholesterol (mg.dL^{-1})	54.9 (1.6)	52.9 (1.6)	-2.03 (-5.08 to 1.01)	0.044
LDL-cholesterol (mg.dL^{-1})	102.0 (3.7)	98.0 (3.4)	-4.09 (-9.00 to 0.82)	0.067
TG (mg.dL^{-1})	78.2 (6.0)	74.3 (4.4)	-3.94 (-14.22 to 6.34)	0.015
Glucose (mg.dL^{-1})	81.8 (1.2)	78.4 (0.9)**	-3.47 (-5.81 to -1.13)	0.186
Insulin (μ U.mL^{-1})	9.12 (0.85)	8.37 (0.71)	-0.74 (-2.06 to 0.57)	0.032
HOMA$_{IR}$	1.87 (0.18)	1.63 (0.14)	-0.23 (-0.53 to 0.06)	0.061

Notes: Descriptive values are Mean (Standard Error); Longitudinal Changes are Mean (95% Confidence Interval); Effect size for longitudinal changes is represented as Partial Eta Squared (η 2); * for P<0.05 and ** for P<0.001.
BMI, body mass index; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; TG, triglycerides; HOMA$_{IR}$, homeostasis model assessment of insulin resistance.

PA and motor coordination longitudinal changes with adjustments for age and sex are presented in Table 3. Data show significant decreases in SEDPA (P<0.001). Regarding PA there were significant increases of

Table 3
Longitudinal changes in daily physical activity

	Baseline Mean (SE)	Final Mean (SE)	Longitudinal Change (Final – Baseline) Mean (95% CI)	Partial η^2
Sedentary PA (min.day^{-1})	622.6 (9.3)	571.4 (9.4)**	-51.23 (-71.68 to -30.78)	0.395
Light PA (min.day^{-1})	347.4 (9.1)	383.4 (8.6)**	36.04 (18.01 to 54.07)	0.293
Moderate PA (min.day^{-1})	38.0 (2.2)	49.8 (2.3)**	11.84 (7.42 to 16.26)	0.427
Vigorous PA (min.day^{-1})	12.1 (1.8)	15.4 (1.5)*	3.35 (0.34 to 6.37)	0.114
MVPA (min.day^{-1})	50.0 (3.7)	65.2 (3.3)**	15.19 (8.50 to 21.89)	0.348
Total PA (steps.day^{-1})	9652.7 (293.4)	11178.4 (280.5)**	1525.7 (965.2 to 2086.1)	0.435
Total PA (counts.min^{-1})	561.8 (20.5)	637.7 (18.6)**	75.87 (38.13 to 113.61)	0.296
Motor Coordination (sum)	89.8 (5.3)	95.3 (5.8)**	5.43 (-4.17 to 15.04)	0.032

Notes: Descriptive values are Mean (Standard Error); Longitudinal Changes are Mean (95% Confidence Interval); Effect size for longitudinal changes is represented as Partial Eta Squared (η^2); * for P<0.05 and ** for P<0.001.
PA, physical activity; MVPA, moderate to vigorous PA.

LIGPA and MVPA, (P<0.05). Additionally, significant improvements (P<0.001) were detected in total PA (steps.day^{-1} or counts.min^{-1}). Finally, changes were not significant for motor coordination.

Finally, longitudinal changes in SBP, TC and fasting glucose were analysed adjusting also to relative changes in height, weight, SEDPA, LIGPA, MVPA and total PA (steps.day^{-1}). The above-mentioned adjusted longitudinal analysis is presented in Table 4. These data demonstrate that longitudinal changes in SBP, TC and fasting glucose remained significant (P<0.05) after adjustments for covariates of changes associated to growth and habitual PA.

Table 4
Longitudinal changes in systolic blood pressure, total cholesterol and fasting glucose

	Baseline	Final	Longitudinal Change (Final – Baseline)	Partial η^2
	Mean (SE)	Mean (SE)	Mean (95% CI)	
SBP (mm Hg)	106.2 (1.7)	102.1 (1.4)**	-4.05 (-6.73 to -1.36)	0.234
TC (mg.dL^{-1})	172.6 (4.4)	165.6 (4.2)*	-7.00 (-12.60 to -1.40)	0.173
Glucose (mg.dL^{-1})	81.8 (1.1)	78.4 (0.9)**	-3.47 (-5.39 to -1.56)	0.306

Notes: Descriptive values are Mean (Standard Error); Longitudinal Changes are Mean (95% Confidence Interval); Effect size for longitudinal changes is represented as Partial Eta Squared (η^2); Covariates are: sex, age=8.4, $\Delta\%_{height}$=2.0%, $\Delta\%_{weight}$=3.7%, $\Delta\%_{SEDPA}$=-7.5%, $\Delta\%_{LIGPA}$=12.2%, $\Delta\%_{MVPA}$=46.3%, $\Delta\%_{TotalPA\ Steps}$=17.9%; * for P<0.05 and ** for P<0.001.
SBP, systolic blood pressure; TC, total cholesterol.

Discussion

After 8-months of a multidisciplinary intervention program to increase PA, we tested the effect of time in several CRF. Our main results showed an overall tendency for improving most metabolic variables, body fat and PA, although with significant findings for all PA intensity levels, SBP, glucose and TC.

There are compelling evidences that PA brings many benefits to health at any age; and higher intensity levels, especially MVPA, through intervention programs can help in terms of promoting healthy weight in children and adolescents (Mark & Janssen, 2011; Strong et al., 2005). However there are mixed findings concerning PA as outcome. Some studies proved the efficacy of interventions to increase PA (Demetriou & Honer, 2012). Others provided strong evidence that PA interventions have had only a small effect (approximately 4 minutes more walking or running per day) on children's overall activity levels. These results can partially explain, why such interventions have had limited success in reducing the BMI or body fat (Metcalf, Henley, & Wilkin, 2012). However, our favourable results for PA did not result in significant decreases in body fat or trunk fat neither in BMI or WC. A meta-analysis of 11 randomized trials (Guerra, Nobre, Silveira, & Taddei, 2013) suggested that, regardless of the potential benefits of PA to reduce participants weight in school environments, the interventions did not have a statistically significant effect. However, it is difficult to generalize from these results because the duration, intensity and type of PA used in the interventions varied greatly. Mark and Janssen (2011) revealed an inverse relation between total, low, moderate and vigorous intensity PA with total body and trunk fat assessed by DEXA. Several authors (Sun et al., 2011), observed also a decrease in body fat, %TF and WC, related with exercise compliance, but did not significantly decrease body weight and BMI. In fact, most studies showed inconclusive evidences for WC (Sun et al., 2013), and BMI. Intervention effects on BMI appeared to be limited, with less than 30% of the studies achieving significant results (Harris, Kuramoto, Schulzer, & Retallack, 2009). To bring about reductions in BMI, WC or body fat, complex, multi-structured longitudinal interventions are required. The reason for the small influence of the intervention in our study may be explained by the fact that the target group was not exclusively of overweight children. However, important cardiometabolic outcomes as fasting glucose, TC and SBP have decreased significantly. Longitudinal changes in the mentioned risk factors remained significant after adjustments for covariates that could be related to growth or modifications in daily PA. These results are of most relevance, as they highlight the impact of this intervention in longitudinal terms beyond the increase of habitual PA. In other words, these favourable changes in SBP, TC and fasting glucose might be associated to the dose of PA/exercise inherent to the intervention program, and not exclusively related to the improvement in PA behaviours.

The regular practice of PA has proved to influence positively blood pressure, glucose and lipid profiles. Other studies showed that multidisciplinary interventions (i.e. diet, PA) were able to improve metabolic profile in obese (Bianchini et al., 2013) and among normal weight children (Eagle et al., 2013). Likewise, no significant effects of interventions on insulin sensitivity and early insulin release index were observed (Sun et al., 2011). Some large, higher quality RCTs provided strong evidence for interventions to increase HDL-cholesterol. However, blood pressure and TG, LDL-cholesterol and TC remained inconclusive and require additional higher quality studies with high dose of interventions to provide conclusive evidence (Sun et al., 2013).

Motor coordination (MC) is positively correlated with PA (Williams et al., 2008) and the development of these fundamental motor skills during childhood is of most relevance. Children with good object control skills are more likely to become fit and healthy adolescents (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2008). In our study the significant increase of PA levels was not accompanied by a significant increase in MC levels. The same results were found in 6- to 8-year-old Danish children, showing the complex interrelationships amongst PA, %BF, and motor performance (Morrison et al., 2012). Nevertheless, it is probable that fundamental movement skill competences can be maintained over time in children and adolescents (Lai et al., 2014), and that interventions can still be more effective than standard Physical Education curricula at improving motor skill performance (Boyle-Holmes et al., 2010).

Follow-up studies, have shown that it is likely that PA is a sustainable outcome from interventions in children and adolescents, and there is reasonable evidence that interventions longer than 1 year are effective in producing this sustained impact (Lai et al., 2014). Longitudinal data have shown that for each weekday that normal weight adolescents participated in certain extracurricular physical activities and physical education, the odds of becoming overweight in adulthood decreased by 5% (Menschik, Ahmed, Alexander, & Blum, 2008). It is therefore of primary importance to identify approaches that will be effective in increasing and sustaining activity levels of children and adolescents in a school setting. The same authors evidenced that the 2 main limitations observed were lack of assessment of adherence to study protocols, both at the school level and at the individual level, and lack of objective assessment of the «dose» of PA achieved with such interventions.

Several methodological limitations can be identified, such as not being a RCT design, small sample size, the lack of a control group and information about energy intake. However, the strength of this study is the robust and objective measures used to assess all variables, emphasizing DEXA, and accelerometers for PA. In fact there are very few school-based intervention studies including so many robust measurements as our study did.

Conclusions

In conclusion, the present study found that 8-montns of multidisciplinary intervention reduced risk factors in school children. These results highlight the importance of this type of intervention aiming to increase PA levels for the positive impact on children's health. Further studies, with a larger samples and longer follow-up periods would be valuable to construct solid evidences.

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