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%Δy in height, weight, total PA through steps/day1, sedentary (SEDPA), light (LIGPA) and moderate to vigorous (MVPA) intensities. Relative changes were calculated as: increase%Δy = (X2 – X1)/X1. Statistical significance was set at 5%. Eta squared (r2) 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.

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 (MPVPA), are associated to lower total and central adiposity (Frank 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, & Nawar, 2008; Kambalia, 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 (Kambalia 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
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 interest 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. To ensure this, 10 randomly selected children wore a portable HR monitor (Polar Team™ 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 showed interest in the project and invited them to participate in a meeting where they would be informed in more detail about the aims, contents and evaluation to be accomplished.

Procedures

Anthropometry

Height and weight were measured before starting the protocol with participants wearing shorts and t-shirts only. Height was measured using a Holttain stadiometer (Holttain 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 – 80°C 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 (HOMAIR) 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...
Relative changes were calculated as: increase% = (Xfinal - Xbaseline) / Xbaseline * 100; Light, >100, moderate e» 2296; and vigorous e» 4012.

The data were processed with specific software “Actilife, version 6.8” when the monitor was not worn and thus disregarded before analysis. 10 consecutive minutes of zero counts were considered as periods when recording were a minimum of 4 days of the week and 1 day of the hour that the accelerometer was worn between 7:00 h and 24:00 h to restrict activities like showering and swimming.

Motor performance was assessed by the Koordinations Test für Motor Coordination Coefficient (Trost et al., 1998).

Table 1. Participants characteristics at baseline.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Final</th>
<th>Longitudinal Change</th>
<th>Partial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>Mean</td>
<td>SE</td>
<td>Mean (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>14.3 (0.4)</td>
<td>0.61</td>
<td>14.4 (0.4)</td>
<td>-0.6 (0.6 to 2.6)</td>
</tr>
<tr>
<td>Female</td>
<td>14.5 (0.4)</td>
<td>0.51</td>
<td>14.4 (0.4)</td>
<td>1.2 (0.6 to 1.7)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>19.0 (0.6)</td>
<td>0.10</td>
<td>19.0 (0.6)</td>
<td>-0.0 (0.4 to 0.6)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>68.1 (1.6)</td>
<td>0.70</td>
<td>68.1 (1.5)</td>
<td>-1.2 (0.6 to 4.6)</td>
</tr>
<tr>
<td>Total PA (steps.day⁻¹)</td>
<td>10.6 (2.6)</td>
<td>0.10</td>
<td>10.2 (2.5)</td>
<td>-0.4 (0.3 to 1.8)</td>
</tr>
<tr>
<td>Trunk Fat (%)</td>
<td>35.4 (1.3)</td>
<td>0.10</td>
<td>35.0 (1.2)</td>
<td>-0.4 (0.2 to 4.1)</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>102.6 (2.0)</td>
<td>0.10</td>
<td>102.0 (2.0)</td>
<td>-0.6 (0.9 to 0.4)</td>
</tr>
<tr>
<td>HDL-cholesterol (mg.dL⁻¹)</td>
<td>55.9 (1.0)</td>
<td>0.10</td>
<td>57.4 (0.8)</td>
<td>1.9 (0.3 to 4.7)</td>
</tr>
<tr>
<td>TG (mg.dL⁻¹)</td>
<td>172.6 (6.0)</td>
<td>0.10</td>
<td>160.4 (4.7)</td>
<td>-12.0 (6.2 to 16.3)</td>
</tr>
<tr>
<td>LDL-cholesterol (mg.dL⁻¹)</td>
<td>90.9 (1.6)</td>
<td>0.10</td>
<td>92.9 (1.6)</td>
<td>-2.0 (0.5 to 3.6)</td>
</tr>
<tr>
<td>Glucose (mg.dL⁻¹)</td>
<td>81.8 (1.2)</td>
<td>0.10</td>
<td>78.4 (0.9)</td>
<td>-3.4 (0.7 to 2.5)</td>
</tr>
<tr>
<td>Inulin (mL.day⁻¹)</td>
<td>9.12 (0.8)</td>
<td>0.10</td>
<td>9.15 (0.8)</td>
<td>-0.2 (0.5 to 0.7)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Final</th>
<th>Longitudinal Change</th>
<th>Partial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>156.4 (0.4)</td>
<td>0.61</td>
<td>156.4 (0.4)</td>
<td>0.0 (2.3 to 0.5)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>19.0 (0.6)</td>
<td>0.10</td>
<td>19.0 (0.6)</td>
<td>0.0 (0.4 to 0.6)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>68.1 (1.6)</td>
<td>0.70</td>
<td>68.1 (1.5)</td>
<td>0.0 (0.6 to 1.4)</td>
</tr>
<tr>
<td>Total PA (steps.day⁻¹)</td>
<td>10.6 (2.6)</td>
<td>0.10</td>
<td>10.2 (2.5)</td>
<td>0.0 (0.3 to 0.7)</td>
</tr>
<tr>
<td>Trunk Fat (%)</td>
<td>35.4 (1.3)</td>
<td>0.10</td>
<td>35.0 (1.2)</td>
<td>0.0 (0.2 to 0.5)</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>102.6 (2.0)</td>
<td>0.10</td>
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<td>0.0 (0.5 to 0.7)</td>
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</table>

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 (x²=2.1, P=0.650).

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.

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%) in height, weight, SEDEPA, LIQGA, MVPDA and total PA (steps.day⁻¹) as covariates. Relative changes were calculated as: increase% = (Xfinal - Xbaseline) / Xbaseline * 100. 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 (η²) was used as an indicator of effect size. All calculations and analyses were carried out in SPSS version 21.0 for Mac OSX.
Finally, longitudinal changes in SBP, TC and fasting glucose were analysed adjusting also to relative changes in height, weight, SEDPA, changes were not significant for motor coordination. LIGPA and MVPA, (retalack, 2009). To bring about reductions in BMI, WC or body fat, studies achieving significant results (Harris, Kuramoto, Schulzer, & others (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 showing significant effects 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). 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).

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 BMI, 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 showing significant effects (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).

The 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-months 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.

Acknowledgments

This project was funded by FEDER through COMPETE and National Funds through Portuguese Foundation of Science and Technology (FCT), (PTDC/DTP-DES/1328/2012) (FCOMP-01-0124-FEDER-028619) and (FCOMP-01-0124-FEDER-028613 (PTDC/DTP-DES/0393/2012). The Research Centre on PA Health and Leisure (CIAEF) is supported by Pest-OE/SAU/UI0617/2014.

Table 4

| Variable | Baseline | Final | P | Partial η²
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</thead>
<tbody>
<tr>
<td>SBP (mm Hg)</td>
<td>102.3±1.7</td>
<td>102.1±1.9</td>
<td>-0.85</td>
<td>0.47 ± 0.56</td>
</tr>
<tr>
<td>TC (mg.dL⁻¹)</td>
<td>172.6±4.1</td>
<td>165.6±4.2</td>
<td>-7.00</td>
<td>12.00 ± 1.40</td>
</tr>
<tr>
<td>%MC</td>
<td>23.4±1.1</td>
<td>20.4±0.9</td>
<td>-3.47</td>
<td>5.30 ± 0.56</td>
</tr>
</tbody>
</table>

Note: Descriptive values are Mean ± Standard Error; Longitudinal Changes are Mean ± 95% Confidence Interval; Effect size for longitudinal changes is represented as Partial Eta Squared (%); Covariance are sex, age, 8-6, 5-11, 15, 7-9, 5-11, 15, 7-9. Δ%MC = -12.2%, Δ%TF = 0.0%, Δ%TF = 17.9%. P < 0.05 and **P < 0.001.

SBP: Systolic blood pressure; TC: Total cholesterol.
References


