Prevention of metabolic syndrome in obese children: a proposal of intervention

Prevenção da síndrome metabólica em crianças obesas: uma proposta de intervenção

Prevención del síndrome metabólico en niños obesos: una propuesta de intervención

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ABSTRACT

Objective: To analyze the effects of a 12-week intervention program based on physical activity practice, alimentary and psychological orientation on the risk factors for the development of metabolic syndrome in obese children and adolescents.

Methods: A longitudinal study was conducted with 23 obese children and adolescents, aged six to 16 years (12.0±3.2 years). Total body and trunk fat mass, glycemia, total cholesterol, triglycerides, systolic and diastolic blood pressure were measured. The children were submitted to physical activity three times a week during 12 weeks. Each session of 60 minutes consisted of recreational sports activities, gymnastics, circuits and track-walking. Chi-square test was used to compare categorical data for those patients who had values above the recommendations for each risk factor and Student's t-test for paired data was used to compare the two moments of the study.

Results: In subjects who had altered baseline values in the beginning of the study, the glycemia levels decreased 11.6% (from 105 to 93mg/dL; p=0.046) and the triglycerides decreased 24.9% (from 217 to 163mg/dL; p=0.013) after the intervention. On the other hand, no differences were noted for blood pressure and total cholesterol after the intervention.

Conclusions: The intervention was effective in improving blood glucose and triglycerides levels in children and adolescents enrolled in the study.

Key-words: metabolic syndrome X; obesity; risk factors; motor activity; child; adolescent.

RESUMO

Objetivo: Analisar o efeito de 12 semanas de intervenção envolvendo prática de atividade física, orientações alimentar e psicológica sobre fatores de risco para o desenvolvimento da síndrome metabólica em crianças e adolescentes obesos.

Métodos: Estudo longitudinal com 23 crianças e adolescentes obesos, com idade entre seis e 16 anos (12,0±3,2 anos). Foram mensurados: gordura corporal total e de tronco, glicemia, colesterol total e triglicérides, pressão arterial sistólica e diastólica. Os jovens foram submetidos a três sessões semanais de 60 minutos de exercício físico (atividades esportivas recreativas, ginástica, circuitos e caminhadas), durante 12 semanas. O teste do qui-quadrado foi usado para comparar dados categóricos daqueles que apresentaram valores acima das recomendações para cada fator de risco. O teste t para dados pareados foi aplicado para comparar os dois momentos do estudo.

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Resultados: Em indivíduos com alterações metabólicas no início do estudo, observou-se, após a intervenção, a diminuição de 11,6% na glicemia (105 para 93mg/dL; *p*=0,046) e de 24,9% no triglicérides (217 para 163mg/dL; *p*=0,013); porém, não houve diferenças na pressão arterial e no colesterol total.

Conclusões: O programa de exercício físico aplicado nas crianças e adolescentes foi eficiente para melhorar os valores de glicemia e triglicérides.

Palavras-chave: síndrome X metabólica; obesidade; fatores de risco; atividade motora; criança; adolescente.

RESUMEN

Objetivo: Analizar el efecto de 12 semanas de intervención implicando práctica de actividad física, orientación alimentar y psicológica sobre factores de riesgo respecto al desarrollo del síndrome metabólico en niños y adolescentes obesos.

Métodos: Estudio longitudinal con 23 niños y adolescentes obsesos, con edad entre seis y 16 años (12,0±3,2 años). Se midió: grasa corporal total y de tronco, glucemia, colesterol total y triglicéridos, presión arterial sistólica y diastólica Los jóvenes fueron sometidos a tres sesiones semanales de 60 minutos de ejercicio físico (actividades deportivas recreativas, gimnástica, circuitos y caminatas) durante 12 semanas. En el tratamiento estadístico, se realizó el análisis descriptivo, con promedio, desviación estándar y error estándar. La prueba de chi cuadrado fue usada para comparar datos categóricos con aquellos que presentaron valores por encima de las recomendaciones para cada Factor de Riesgo y la prueba t para datos pareados fue usada para comparar los dos momentos del estudio.

Resultados: En individuos con alteraciones metabólicas en el inicio del estudio, se observó, después de la intervención, reducción del 11,6% en la glucemia (1053mg/dL para 93mg/dL; *p*=0,046) y del 24,9% en los triglicéridos (217mg/dL para 163mg/dL; *p*=0,013); sin embargo, no hubo diferencias en la presión arterial y en el colesterol total.

Conclusión: El programa de ejercicio físico aplicado en los niños y adolescentes fue eficiente para mejorar los valores de glucemia y triglicéridos.

Palabras clave: Síndrome x metabólico; obesidad; factores de riesgo; actividad motora; niño y adolescente.

Introduction

Recent profound changes in lifestyle habits, including high-calorie diets and low levels of physical activity, are the principal determinant factors of the increase in obesity in the population, making this one of the most worrying problems in terms of Public Health[1].

The concerns are caused by the fact that obesity is a potential trigger factor for many different diseases[2], including the metabolic conditions that affect an ever-growing number of children and adolescents. The metabolic syndrome (MS) is one of these conditions[3]. The metabolic syndrome is characterized by the presence of cardiovascular risk factors such as arterial hypertension, insulin resistance, hyperinsulinemia, glucose intolerance, central obesity and dyslipidemia (which is an umbrella term for abnormal LDL, HDL-cholesterol and triglyceride levels)[1].

Treatment of obesity and, as a result, of the components of MS is more effective when there is a link between acquisition of healthy lifestyle habits[4] and participation in physical exercise, promoting improved glucose metabolism[5], a better lipid profile[6] and lower blood pressure[7]. The best strategy is therefore dependent on cooperative work by a multidisciplinary team made up of Physical Education professionals, Endocrinologists, Pediatricians, Nutritionists, Physiotherapists and Psychologists.

Although it is very clear that the prevalence of MS is increasing at a startling rate, in Brazil few studies have been conducted to investigate the effects on the components of MS in this population of interventions that include physical exercises and dietary guidance. The objective of this study was therefore to analyze the effects of 12 weeks' intervention in the form of physical activity and nutritional guidance on the risk factors for development of the metabolic syndrome in obese children and adolescents.

Method

This was a prospective study carried out during 2009. Potential recruits in the Brazilian city of Presidente Prudente, SP, were informed about the "Super-Action" obesity-control program for children and adolescents through advertisements in newspapers and on the radio and TV. All research activities were conducted at the Science and Technology Faculty, which is on the Presidente Prudente campus of the *Universidade Estadual Paulista* (FCT/Unesp).

After the initial phase of publicizing the program, people aged from five to 16 years who were interested in taking part underwent an initial triage designed to classify their nutritional status. Participants were invited to take part in the study during this phase. Inclusion criteria were as follows: a classification of obesity according to the criteria suggested by Cole *et al*[8]; authorization from a physician to take part in the practical activities; absence of problems that make motor activities impossible; willingness and availability to commit to attending the activities scheduled for the group; physical inactivity; and a formal consent form signed by participant plus parents or legal guardians. The multidisciplinary intervention involved a physician, a nutritionist, a psychologist and a physical education professional. The physician was a pediatric endocrinologist and was responsible for clinical assessment of participants and interpretation of test results. The nutritionist and psychologist supervised the nutritional guidance and psychological care, which was provided by the project monitors. These intervention sessions were each held once a week and lasted 60 minutes. Physical activities were scheduled for 3 days per week.

A total of 24 children and adolescents (nine boys and 15 girls) were enrolled. They were aged from six to 16 years (12.0±3.2 years). Data collection was conducted at the Motor Activity Assessment and Prescription Laboratory (CELAPAM), which is also at the Unesp Science and Technology Faculty (FCT/Unesp). Participants who failed to attend for more than 2 weeks running while the practical activities and psychological and nutritional guidance were being conducted were defined as drop-outs and removed from the program.

Each subject was invited to take part voluntarily in the study and was informed in detail about the study objectives and about how the data would be collected. Only subjects who provided a signed free and informed consent form were enrolled. This study was approved by the Research Ethics Committee at the FCT/Unesp.

Body mass was measured using a Filizola mechanical balance accurate to 0.1kg and with a maximum capacity of 150kg. Height was measured using a fixed, wooden stadiometer, accurate to 0.1cm and with a maximum capacity of two meters, in line with the methodology proposed by Freitas Jr. *et al*[9]. Body mass index (BMI) was calculated by dividing body mass in kg by the square of height in meters. Chronological age was calculated as years and fractions of years, on the basis of date of birth and day of assessment. Body mass indexes were used to classify nutritional status according to the reference values for age and sex proposed by Cole *et al*[8].

Total body and trunk fat were measured using a Lunar DPX-NT (Lunar/GE Corp, Madison, Wisconsin) Double Emission X-ray Absorptiometry machine. In accordance with the manufacturer's recommendations, assessments were conducted with the subject motionless in decubitus dorsal throughout the procedure. Results were ported out to a computer for future analysis. All measurements were made by investigators who had been trained in advance.

The cutoff points used to delineate metabolic syndrome risk factors were those proposed by the *Sociedade Brasileira de Cardiologia* (SBC) in its first directive on prevention of atherosclerosis in childhood and adolescence[10], with the exception of trunk fat, the cutoffs for which were taken from the reference values proposed by Taylor[11], since these provide reference values for the components analyzed here specific to Brazilian children and adolescents. Each risk factor (RF) for metabolic syndrome was classified as follows:

Trunk Fat: both total body fat and trunk fat were measured using DEXA. Trunk fat mass was classified according to the age and sex specific references proposed by Taylor[11].

Glycemia: venous blood sugar was measured after 4 hours' fasting using the reflectance method and expressed in mg/dL. A portable *One Touch Ultra 2* (Johnson & Johnson) machine and One Touch UltraSoft disposable lancets and reagent strips. The puncture site was sterilized in advance using cotton wool saturated with alcohol. The glycemia cutoff adopted was >100 mg/dL.

Total Cholesterol and Triglycerides: the same procedures were adopted as for the glycemia test, but the machine used was an *Accutrend* GCT (Roche Diagnostics, Mannheim, Germany), the reagent strips were *Accutrend* brand and results were expressed in mg/dL. Subjects were classified as having an unhealthy lipid profile when total cholesterol was >150 mg/dL and triglycerides were >100 mg/dL.

Arterial blood pressure: Systolic (BPS) and Diastolic (BPD) arterial blood pressure were measured using an Omron automatic digital blood pressure meter HEM742 INT (Omron Healthcare, Inc., Intellisense, Bannockburn, Illinois, USA) coupled to cuffs appropriate for the size of the subject's arm (6mm x 12mm [child size] for ages up to 13 and 9mm x 18mm for adolescents aged 14 to 18 years and for obese children with large arm circumferences). Measurements were taken at the right arm, after approximately 15 minutes

at rest in the supine position. Children were diagnosed as hypertensive if they had BPS and BPD≥95th percentile, for their sex, age and height percentile.

Physical training consisted of general physical activities with approximately 70% of the time engaged in aerobic effort and 30% working against loads and was conducted three times per week for 60 minutes per session and continued for 12 weeks. The activities were play-based and included cooperative and competitive games, walks, circuits and large games, with stretching at the start and end of each session. The intensity of effort was monitored by a POLAR S810 heart rate monitor which was used with ten children chosen at random during each training session. The monitor was set to guarantee that participants spent 70% of the time in the aerobic zone.

In addition to the physical activities, each group of children and adolescents took part in a weekly meeting of a psychological experiences group. At the meetings each subject was given the chance to express themselves freely and spontaneously about their difficulties, worries and anxieties, and also their enjoyment and successes resulting from their participation in the Super-Action project. These experiences were mediated by the project monitors and supervised by a Psychologist who was a professor at the FCT/Unesp Physical Education Department. Subjects also attended weekly nutritional guidance workshops run by the project monitors and supervised by the Super-Action project coordinator.

Results are presented in the form of descriptive statistics, with means, standard deviations and standard errors. The chi-square test was used to compare categorical data (the proportion of the sample that had test results over the recommended limits for each risk factor), and Student's *t* test for paired measurements was used to compare the results before and after the intervention, both for males and for females. An additional statistical analysis was run for those subjects whose test results were above the recommended levels at the start of the study. Analyses were performed using SPSS software, version 13.0.

Results

Twenty-four children were initially recruited to the project and began the program activities. There were 9 boys and 15 girls, aged 6 to 16 years and classified as obese. One of them, however, was excluded because she exceeded the absenteeism limit. The final sample was therefore made up of 23 children and adolescents: 9 boys and 14 girls with a mean age of 12.0±3.2 years.

Table 1 presents means and standard deviations for the general characteristics of the sample of male and female children and adolescents and for the risk factors for metabolic syndrome.

Table 2 lists the percentage of the sample who exhibited each of the risk factors for metabolic syndrome. It will be observed that trunk fat, triglycerides and total cholesterol had the largest percentages of children defined as abnormal by the SBC's first directive on prevention of atherosclerosis in childhood and adolescence[10].

Table 3 lists mean differences in study variables between measurements taken at the start and end of the study. Taking the sample as a whole, systolic arterial blood pressure increased and triglycerides decreased significantly. When broken down by sex, the boys had a difference in BPS and the girls had a difference in triglycerides.

Table 1 – Initial characteristics of the obese children and adolescents, expressed as means (standard deviations)

Indicators	Male	Female	*p*
Hemodynamic			
BPS (mmHg)	115±13	113±13	0.57
BPD (mmHg)	69±9	66±8	0.83
Adiposity			
TFM (kg)	17±9	14±3	0.56
TBF (%)	44±6	44±4	1.00
Blood tests			
GLY (mg/dL)	89±17	93±7	0.69
TG (mL/dL)	185±95	209±91	0.56
COL (mL/dL)	166±15	175±25	0.54

BPS: systolic arterial blood pressure; BPD: diastolic arterial blood pressure; TFM: trunk fat mass; TBF: total body fat; GLY: glycemia; TG: triglycerides; COL: total cholesterol.

Table 2 – Percentage of obese children and adolescents with abnormal results for risk factors for the Metabolic Syndrome

	TFM	BPS	BPD	GLY	TG	COL
Males	100	33	22	33	78	100
Females	93	36	7	21	93	100
p	1.00	1.00	0.54	0.66	0.54	1.00

TFM: trunk fat mass; BPS: systolic arterial blood pressure; BPD: diastolic arterial blood pressure; TBF: total body fat; GLY: glycemia; TG: triglycerides; COL: total cholesterol.

Table 3 – Mean (standard error) differences after 12 weeks' physical exercise intervention with obese children and adolescents

Indicators	Total	Male	Female
Hemodynamic			
BPS (mmHg)	5.9±(2.4)*	12.2±(3.8)*	2.1±(2.7)
BPD (mmHg)	1.9±(1.7)	0.4±(2.9)	2.8±(2.2)
Adiposity			
TFM (kg)	2.6±(0.3)	-0.6±(0.5)	0.5 (0.4)
TBF (%)	-0.43 (0.32)	-0.79 (0.51)	-0.16 (0.4)
Blood tests			
GLY (mg/dL)	5.18 (3.39)	10.1 (6.9)	1.8 (3.1)
TG (ml/dL)	-47.5 (17.1)*	-35.1 (26.7)	-55.1 (22.9)*
COL (ml/dL)	3.00 (4.06)	7.8 (6.0)	0.40 (5.4)

*$p<0.05$; BPS: systolic arterial blood pressure; BPD: diastolic arterial blood pressure; TFM: trunk fat mass; TBF: total body fat; GLY: glycemia; TG: triglycerides; COL: total cholesterol.

Table 4 - Mean (standard deviation) differences after 12 weeks' physical exercise intervention with subjects who had abnormal results for Metabolic Syndrome risk factors

Indicators	Before	After	p
Hemodynamic			
BPS (mmHg)	128±5	134±10	0.17
BPD (mmHg)	83±3	80±9	0.66
Adiposity			
TFM (Kg)	15±6	15±7	0.50
TBF (%)	44±5	44±6	0.22
Blood tests			
GLY (mg/dL)	105±5	93±8	0.05
TG (ml/dL)	217±85	163±61	0.01
COL (ml/dL)	172±23	175±21	0.33

TFM: trunk fat mass; BPS: systolic arterial blood pressure; BPD: diastolic arterial blood pressure; TBF: total body fat; GLY: glycemia; TG: triglycerides; COL: total cholesterol.

Table 4 lists the figures before and after intervention for those subjects who had abnormal results for metabolic syndrome components. When only the individuals with abnormal results for metabolic syndrome components were analyzed, figures for diastolic arterial blood pressure, glucose and triglycerides had all reduced after intervention. However, only the differences in glycemia and triglycerides were statistically significant between the two points in time.

Discussion

This study investigated obese children and adolescents in order to analyze the effects of 12 weeks' multidisciplinary intervention on risk factors for metabolic syndrome and found that, for those obese subjects who had abnormal test results for risk factors for the syndrome, the intervention resulted in discrete improvements in the parameters investigated. The intervention led to discrete reductions in total and trunk adiposity, but this difference was not statistically significant. This may be attributable to the intervention period or to the lack of more rigid control of both energy expenditure outside of the intervention period and nutritional intake. In a similar study conducted with adolescents, Dâmaso[12] stated that multidisciplinary intervention periods of at least 16 weeks were needed to achieve more significant results.

All of the boys and all but one of the girls had excess trunk fat, which is very worrying since excessive fat build up in this area is strongly associated with the development of cardiovascular disease and premature death[13]. Studies have shown that accumulated fat in the abdominal region (visceral fat) contributes to the physiopathogenesis of the metabolic syndrome[13] and is considered to be the variable that best predicts cardiovascular risk because of its associations with type 2 diabetes mellitus, hypertension and dyslipidemia, in addition to being the most prevalent factor among people with metabolic syndrome[14].

Although neither body mass nor trunk fat mass reduced during the intervention period, there were improvements in the lipid profile and in glucose metabolism, in common with a study published by Sudi[15], who observed serum lipid and insulin levels reduce in obese girls, irrespective of the quantity of subcutaneous and visceral fat. It was found that all of those assessed had abnormal triglycerides and total cholesterol levels. With regard to total cholesterol, all of children and adolescents had elevated test results, both before and after the intervention. The slight increase in total cholesterol that was observed after the intervention is in agreement with findings published by Chang[16], who observed an increase in cholesterol after 3 months' supervised sporting activity, but with no statistical difference between the two points in time. The failure to reduce total serum cholesterol is probably due to the fact that, in practice, the children and adolescents did not reduce their fat intake or began to eat more carbohydrates. Furthermore, studies of the body's response to intake of foods rich in cholesterol indicate that the plasma response to cholesterol has a threshold which is controlled endogenously by the transcription factor Sterol Regulatory Element–Binding Proteins - SREBP[17], in addition to other external factors related to cholesterol homeostasis , such as circadian rhythm, body weight and drug treatments[18].

With reference to triglyceride levels, at the start of the intervention, 79.1% of the sample had TG over the

recommended level[10], with greater prevalence among the girls (92.9%) than the boys (77.8%). At the end of the intervention, 77.8% of the boys and 71.1% of the girls had abnormal levels, suggesting that the intervention promoted improvements in this component among girls. These figures indicate that a longer period may be needed for significant improvements to occur. Taking just those subjects whose results were elevated at the start of the program, mean triglycerides underwent an impressive reduction from 217.4mg/dL to 163.1mg/dL. This difference was statistically significant (p<0.013).

It is very well-documented that a hyperglycemic state is a strong indicator of reduced sensitivity to insulin. Studies have shown that people with abnormal blood glucose levels may develop diabetes mellitus type II over a period of 5 to 10 years[19]. Serum glycemia was abnormal in 33.3% of the boys and 21.4% of the girls and after intervention there were significant reductions only among subjects who had had abnormal results for this component at the start of the study (p=0.046). Only one of the six participants who had had abnormal glycemia before the intervention still had abnormal results after it. The response to the intervention is in agreement with results observed by Chang[16], who found improved glycemia after 3 and 9 months' supervised sporting activities, with the difference being more significant after 9 months.

Arterial hypertension is another component of the metabolic syndrome and is well-established as a risk factor for coronary events among adults[20]. Excess body fat in children is associated with endothelial dysfunction which has a negative effect on BP[21]. Of the 23 subjects analyzed here, 33.3% and 22.2% of the obese boys had abnormal BPS and BPD respectively at the start of the intervention. For the girls these figures were 35.7% and 7.1%. After intervention the boys exhibited a significant increase in BPS, which did not occur among the girls. These results do not agree with the literature, which indicates that intervention with aerobic activities is effective for improving BP[22]. Two of the possible reasons for this are as follows: (i) the short intervention period and (ii) the discrete reduction in body fat, since this is strongly associated with hypertension[23]. Therefore, in order to achieve significant reductions in BP among hypertense people, it appears that it is necessary to practice physical activity for a longer period[24].

Many studies[15,16,25,26] have shown that better results can be achieved when a change in dietary habits is combined with physical exercise, whether over the short or the long term. This combination promotes significant improvement in body composition, reducing body mass index and waist circumference, eliminating risk factors for the metabolic syndrome, reducing the risk of diabetes and improving the inflammatory markers profile. The objective of the multidisciplinary intervention described here was not only to improve motor capacity through physical exercise, but also to provide guidance on how to improve nutritional quality and to intervene in aspects that may be contributing to anxiety, depression and social isolation, which may make it more likely that young people will tend towards inactivity and excessive eating[27]. According to Biro and Wien[28], this type of intervention is considered the most effective for treating obesity and the multiple co-morbidities related with it, specifically because it does not only impact on the physical aspects, but also on dietary and psychological features which, taken together, are the environmental factors that most contribute to increasing the prevalence of obesity, particularly among children and adolescents.

The data reported here are important for elucidation of the effects of intervention by a multidisciplinary team on the risk factors for metabolic syndrome. Notwithstanding, it is important to mention certain limitations of this research, including the short intervention period and the small number of children and adolescents in the sample, which mean that the conclusions should be generalized with caution. It should also be borne in mind that the biochemical variables analyzed do not amount to a diagnosis of metabolic syndrome, although other authors also use the same definitions employed here[15].

The results indicate an elevated prevalence of the risk factors for metabolic syndrome among these children and adolescents, indicating a need for more rigorous surveillance of this population and for treatment through physical activity and nutritional reeducation for long periods, stimulating profound and long-lasting lifestyle changes, since prospective studies have indicated a tendency for young people with metabolic syndrome to become adults with metabolic syndrome[29].

It is therefore concluded that a 12-week intervention with a multidisciplinary team, was effective for improving glycemia and triglycerides in obese children and adolescents. However, there were no statistically significant changes to systolic arterial blood pressure, diastolic arterial blood pressure, total cholesterol or body composition, suggesting that longer interventions are needed in order to achieve more substantial changes.

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