Effect of physical activity associated with nutritional orientation for obese adolescents: comparison between aerobic and anaerobic exercise

Renata Viccari Sabia[1], José Ernesto dos Santos[2] and Rosane Pilot Pessa Ribeiro[3]

ABSTRACT

Being a public health problem in modern society, obesity during adolescence is an increasingly universal disease that is turning into an epidemic one. This study aimed to compare the effect of continuous aerobic and intermittent anaerobic physical exercise associated with nutritional orientation on weight reduction, body composition, biochemical measures and physical capacity of obese adolescents. 28 adolescents between 12 and 14 years old were studied, whose body mass index (BMI) is above percentile 95 for age and gender. The volunteers were randomly distributed into 2 groups: continuous walking exercise (GEC; n = 13) and running intermittent exercise (GEI; n = 15) and underwent a physical training program 3 times a week during 16 weeks, with duration from 20 to 40 minutes. Nutritional orientation occurred once a week, in 60-minute group sessions, throughout the entire experiment. In the initial and final periods, weight and height were measured so as to calculate the BMI, as well as subcutaneous fold, arm (AC) and arm muscle circumferences (AMC), body composition by means of electric bioimpedance, biochemical serum analyses (glycemia and lipids), and direct determination of maximum oxygen intake ($\dot{V}O_2max$) and anaerobic threshold (LAn). In both groups (GEC and GEI), anthropometric findings, BMI and subcutaneous folds, were significant decreased. In biochemical evaluation, a significant decrease occurred in GEC with respect to HDL, LDL and total cholesterol serum levels, although still within normal values. Values of HDL and triglycerides presented significant decrease in GEI. $\dot{V}O_2max$ values increased significantly in both groups. We concluded that the physical activity proposed for both GEC and GEI was sufficient and satisfactory, promoting weight loss, better body composition and lipid levels, as well as an increase in the adolescents' aerobic capacity.

Key words: Obesity. Adolescence. Aerobic and anaerobic exercise.

INTRODUCTION

Being a public health problem in modern society, obesity during adolescence is an increasingly universal disease that is turning into an epidemy[1]. The individual is considered obese when the amount of fat relative to the body mass is equal or exceeds 30% in women and 25% in men, and the severe obesity is characterized by a body fat content above 40% in women and 35% in men[2].

Due to the fact that the body mass index (BMI) shows the proportion between height and body mass disregarding the body fat, the World Health Organization[3] no longer uses the term obesity but else the overweight I (BMI between 25 and 29.9 kg/m^2), overweight II (BMI between 30 and 39.9 kg/m^2) and overweight III (BMI equal or greater than 40 kg/m^2).

Obesity in childhood and adolescence has become a more and more frequent problem, being related to several diseases such as the increase on the risk of morbidity and mortality. In developed countries such as the United States, the obesity is considered a important public heath problem[4].

We know that there are different causes for the development of obesity, among them, the biochemical and genetic factors, psychological factors, physiological factors and the environmental factors are the most important[5].

The stable maintenance of weight and body composition during the years is a result of a precise balance between ingestion and energetic expenditure[6]; an unbalance in this relation unchains the obesity process[7-9]. Thus, undoubtedly the absence of physical activity and the alimentary disturbances are currently the main factors for the development of obesity[6,10,11].

The familiar transmission of obesity is well known. However, members of the same family are exposed to cultural and dietary habits that end by influencing the body mass gain. This evidences that, besides the genetic inheritance, the environmental influence plays important role in the development of the obesity[12].

The reduction of ingestion of homemade foods replaced by industrialized foods (fast-foods, snacks and candies) and the increase on the consumption of soft drinks and the ingestion of large amounts of calories derived from fat in addition to the reduction on the physical activity are etiological factors responsible for the increase on obesity prevalence among the western urban populations[12,13].

According to Fisberg[8], obesity in childhood is an important factor influencing the possibility of its maintenance during adult life. If morbidity is not frequent among individuals at early ages, in adult life the situation is risky and frequently leads to mortality by association with arteriosclerosis disease, hypertension and metabolic alterations. In adolescence, in addition to factors mentioned above, all alterations characteristic of the transition period into the adult life, low self-esteem, physical inactivity, excessive ingestion of unbalanced sandwiches and great susceptibility to consumption advertisement are also risk factors.

In this context, as obesity is a disease of difficult treatment in the adult life, one concludes that its prevention, avoiding its appearance at early life and adolescence, and its treatment, avoiding its development in cases already diagnosed, are very important, thus improving the prognosis of these patients in the adult life.

Thus, to promote the increase on physical activity and to encourage healthy alimentary habits, creating objective conditions in this purpose, would probably be the main components of healthy life policies among adolescents.

1. Physical Educator. Master of Science Degree in Public Health – Ribeirão Preto Nursery School-USP.
2. Physician. Assistant Professor of the Medical Clinics Department – Ribeirão Preto Medical School-USP.
3. Nutritionist. PhD Professor of the Mother-Child and Public Health Nursery Department – Ribeirão Preto Nursery School-USP.

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Correspondence to: Renata Viccari Sabia, Rua Jurumirim, 1.060 – 86870-000 – Ivaiporã, PR. Tel.: (43) 472-3913. E-mail: rvsabia@ig.com.br

Obesity in childhood and adolescence requires a multidisciplinary staff including pediatricians and endocrinologists, psychologists, nutritionists and exercise physiologists for its treatment[8,14].

According to Pollock & Wilmore[1], the motivation and responsibility of the subject with himself are important factors for the obesity treatment.

When the nutrition of a child is planned, one should keep in mind that it deals about a growing organism with an energetic requirement of vitamins, minerals, proteins and fibers, and the elaboration of a balanced and individualized diet should be valorized.

Used as one of the strategies for childhood and adolescence obesity prevention, the physical exercise plays important role in obesity treatment, once the energetic expenditure from physical activity seems to be associated to loss of body mass, also contributing for the increase on the physical fitness levels[1]. Physical exercise, especially in localized muscular strength, increase on the aerobic capacity, decrease on the body mass and body fat percentile without, however, limiting the linear growth speed or reducing the body mass free of fat[15].

Before these considerations and from the bibliographic reviewing performed, we have observed the existence of many studies in literature that corroborate the positive effect of physical activity on fat tissue reduction. However, these studies only consider the duration of the work performed and only a few demonstrate the influence of the type of exercise with regard to the predominance of aerobic or anaerobic energetic metabolism employed during movement.

Thus, we believe that investigating aspects of aerobic and anaerobic physical exercise will contribute for a better understanding on these mechanisms, producing specific knowledge to further better results on the obesity treatment.

The objective of this work was to compare the effect of the continuous aerobic and intermittent anaerobic physical exercise associated to alimentary orientation in obese adolescents on the reduction of body mass and body composition, blood lipids and physical work capacity.

METHODS

The volunteers were recruited by means of advertisements spread through the communication media (USP newspaper and Ribeirão Preto Network – SP).

The inclusion criteria considered were: age from 12 to 14 years, BMI above percentile 95[16] considered as obese for age and gender and full availability to participate in physical education activities (3 times a week from 2:00 pm to 3:15 pm) and nutritional orientation (1 time a week for 1.5 hour). The subjects who did not present these characteristics were considered as excluded.

Using data of weight and height, the body mass index (BMI), also known as Quetelet[17] index, was calculated, corresponding to the relation between weight in kg and the square of the height in meters. For the analysis of this parameter, the classification proposed by Must *et al.*[16] was used considering as obesity when the percentile was equal or greater than 95.

The schedule of activities was composed of: initial evaluation before physical education and nutritional orientation activities composed of: 1) body composition measures (weight, height, folds and circumference, electric bioimpedance); biochemical evaluation (serum cholesterol and fractions dosages, triglycerides and glucose); determination of the maximal oxygen intake and anaerobic threshold; 2) final evaluation after 16 weeks of physical activity and nutritional orientation including the same tests and measures as initial procedure. The evaluations were performed as blind-tests; in other words, the appraiser was not informed of which group the volunteer belonged to.

The adolescents' parents or responsible signed a consent form before the beginning of the experimental protocol and this project was previously approved by the Ethic Committee in Research of the Ribeirão Preto Nursery School – USP (num. 0157/2001).

In order to assure that individuals presented no contraindication to physical exercise, a medical certificate was requested before the beginning of the research.

For the weight measurement a platform balance label *Filizola* was used with maximal load of 150 kg and subdivisions of 100 g. The balance was calibrated before each measure and the volunteers were weighted standing, barefoot and wearing light clothes (trunks, t-shirts with or without sleeve).

The height measurement was verified in the same balance as the previous measure using the inflexible metal staff calibrated in cm/cm up to the height of 2 m, where the subject was positioned barefoot, leaning heels, hips, scapula and cranium occipital part against the device surface.

The skin folds (triceps and subscapular) were measured with a Lange Plicometer skin test (scale of 0.60 millimeter with accuracy of approximately 1 millimeter) at the non-dominant side of the body and for the brachial circumference a non-extensible measure tape was used.

For the evaluation of the electric bioimpedance, the body resistance and reactance were measured using a body composition analyzer (model BIA 101A, *RJL Systems*). The participants were oriented to remain in fast since the midnight of the preceding day, not to perform physical activity shortly after test and not to ingest alcoholic beverage at the preceding day.

Blood collection (4 ml) for biochemical analysis for lipoproteins (HDL and LDL), triglycerides and cholesterol was performed at the General Hospital Nutrition Laboratory – Ribeirão Preto Medical School/USP. All adolescents were found in 12 hours fasting. The method employed was the *Dimensionxpand*, equipment Dade Behring.

For the analysis of glycemia (5 ml) performed at the General Hospital Biochemistry Laboratory – Ribeirão Preto Medical School/USP, the hexokinase, equipment Dade Behring, model *Dimension RXL* was used as methodology.

In order to identify the exercise intensity (W) corresponding to the Anaerobic Threshold and to determine the Oxygen Maximal Intake, the subjects were submitted to treadmill exercise protocols performed at the LAFINE laboratory of the Ribeirão Preto University – UNAERP.

✓ To obtain the intensity corresponding to the Anaerobic Threshold (LAn), a continuous and progressive running was planned and performed in treadmill (IMBRAMED – ATL 10200) with initial load of 6 km/h and increment of 1 km/h each minute until exhaustion. At the end of each load, the cardiac frequency (FC) was measured by means of cardiac frequency monitor (*Polar-Vantage XL*) and samples of 25 micro liters of arterialized blood were collected from the earlobe by means of heparinized capillary tubes and stored in ependorf tubes containing 50 micro liters of NaF 1%. Later, these samples were enzymatically analyzed (*Yelowspring* 2700 stat) in order to observe the lactate concentration [lac] in each intensity. Thus, for each load, the FC and the lactate concentration were observed and by means of liner interpolation, the intensity (watts), the FC corresponding to 3.5 mM of lactate and the anaerobic threshold were found (Heck *et al.*, 1985). The measurement of the FC at the end of each stage of the progressive tests was determined through the equipment (*Polar Vantage XL*).

✓ The exhaled gas was measured during the entire evaluation protocol through the system *Vista CPX*, Vacumed, 1996 for the determination of the oxygen maximal intake ($\dot{V}O_2max$). This system allows the dosage of O_2 and CO_2 from the air exhaled each 30 seconds using the mixture chamber and analyzers *Oxygen Analyzer OM-11* and *Carbon Dioxide analyzer LB-2*, respectively. The determination of the exhaled air volume was obtained by means of the fluxometer *Flow Transducer K – 520*. The signals from the equipments were properly analyzed by means of the software from the system *Vista CPX* in order to provide values of oxygen intake ($\dot{V}O_2$), CO_2 production, respiratory exchanges ratio (R) and pulmonary ventilation (VE btps) each 30 seconds. To consider that individuals have reached $\dot{V}O_2$max during tests, the criteria proposed by Shephard *et al.* (1968) were adopted.

After the initial evaluation performance, the volunteers were subdivided into two random groups, in other words: the first experimental group was determined according to allotment of the type of exercise the group would perform. Thus, the first group performed activities of aerobic predominance (GEC = 13) and the second group performed activities of anaerobic predominance (GEI = 15), being both submitted to a physical training program three times a week during 16 weeks including continuous walking (GEC) and intermittent running (GEI).

In order to provide a progressive adaptation to the physical activity stress in the first and second weeks, the work duration was of 20 and 30 minutes, respectively. From the third week on, this period was of 40 minutes until the end of the experiment.

The aerobic training (GEC) was composed of a period of 10 warm-up minutes (calisthenics and stretching), one main part of 20 to 40 minutes of low-intensity continuous walking (aerobic predominance) performed in the racetrack with work load specific for each volunteer, according to results from the cardiorespiratory evaluation ($\dot{V}O_2$max) with intensity of 80-85% ($\dot{V}O_2$max), which was monitored through the cardiac frequency. Finally, they performed 15 minutes of sports with ball (volleyball, basketball and soccer) as means of motivation.

The anaerobic training (GEI) was performed using the "Training with Intervals" method[18-20] characterized by 20 to 40 minutes-duration physical activity, finishing with 60 minutes. The exercise proposed was high-intensity intermittent running (anaerobic predominance) and circuit with weights. The circuits were interspersed with runnings by weekday, working the large muscular groups only, also with 1-minute interval by exercise. The intensity determined was of 95-105% of the ($\dot{V}O_2$max), which was monitored by the cardiac frequency.

The training of the running with intervals was performed at the racetrack, where the volunteers accomplished 6 series of 30 seconds in the first month with interval of one minute per series, performing a distance of 100 meters per series. The volunteers finished the training performing 10 series of 35 seconds with 1 minute of interval between them, performing a distance of 210 meters.

The nutritional orientation activities were developed by nutritionist at the CEFER – USP Ribeirão Preto with all adolescents during the research before physical activities once a week with duration of 60 minutes. An alimentary reeducation program based on habits and behaviors modifications was developed considering the identification of alimentary mistakes and encouraging the practice of a balanced and healthy alimentation.

The data collected were organized in a data bank using the SPSS (*Statistical Package for Social Sciences*) program. We decided to show the results as median and semi-quartile amplitude (Q1 and Q3), using the non-parametric statistical analysis (test of Mann-Whitney and Wilcoxon, $p < 0.05$), due to the small size of the sample.

RESULTS

Comparing the initial values of the variables measured between groups, it was observed that the body weight, BMI and BC (brachial circumference) were not statistically different (Mann-Whitney test). In this context, the results to be presented are compared within each group separately, in other words, the evolution of the final values in relation to the initial value. For this, the non-parametric statistical analysis was performed (Wilcoxon test, $p < 0.05$) considering the small size of the sample.

Table 1 shows data related to total body weight, height and BMI in pre- and post-training stages. For the total body weight measure, a decrease on both groups was observed as well as an increase for height measures according to table below.

TABLE 1
Total body weight, height and body mass index (BMI) of pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	Total weight (kg)		Height (m)		BMI (kg/m²)	
	Pre	Post	Pre	Post	Pre	Post
GEC (n = 13)						
Me	80.6	80.3	1.64	1.66	30	28.6*
Q1	71.5	74.4	1.57	1.63	29	28
Q3	95	94	1.68	1.7	32.05	30.5
GEI (n = 16)						
Me	87	81	1.65	1.68	31.3	29.4*
Q1	82.1	77	1.61	1.64	29.6	27.1
Q3	90.35	87	1.69	1.72	32.4	29.85

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

The training effect on BMI reduction was very positive, presenting decreases with statistical difference in both groups (p = 0.001 for GEC and GEI) between initial and final values of each group.

For variable AC (arm circumference), a significant decrease of final values in relation to initial values was verified within both groups as shown in table 2 (p = 0.005 for GEC and p = 0.006 for GEI, Wilcoxon test). For AMC (arm muscular circumference), the same effect was not observed.

TABLE 2
Anthropometric measures: arm circumference (AC); arm muscular circumference (AMC) for pre- and post-treatment continuous aerobic (GEC), and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	AC (cm)		AMC (cm)	
	Pre	Post	Pre	Post
GEC (n = 13)				
Me	35	34*	25.8	25.7
Q1	34	33	24.5	24.5
Q3	37.75	36	27.8	27.6
GEI (n = 16)				
Me	35	34*	23.9	23.6
Q1	34.25	33	23.05	22.25
Q3	36.75	36	25.4	24.8

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

With regard to skin folds measures represented in table 3, a decrease statistically significant was observed in measures of TCF (triceps cutaneous fold), SECF (subscapular cutaneous fold) and SICF (suprailiac cutaneous fold) in post-training in relation to pre-training in GEC (p = 0.003, p = 0.008, p = 0.04, respectively) and in GEI (p = 0.017, p = 0.001, p = 0.03, respectively).

With regard to the body composition analyzed through electric bioimpedance, difference statistically significant was observed for both groups in the variables measured after physical training. Regarding fat mass, decreases in GEC (p = 0.001) and in GEI (p = 0.015) and increases on free-fat mass (GEC, p = 0.001; GEI, p = 0.015) and total body water (GEC and GEI, p = 0.001) were observed. These values are represented in table 4.

With regard to biochemical evaluation of the HDL and LDL lipoprotein plasmatic concentration and total cholesterol in groups GEC and GEI, the results are presented in table 5.

TABLE 3
Skin folds of pre and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	PCT (mm)		PCB (mm)		PCSE (mm)		PCSI (mm)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
GEC (n = 13)								
Me	28.5	27*	23	21	27	25*	38	36*
Q1	25.75	25	20	18	26	25	37	32
Q3	30	28	25	25	32	31	43	41
GEI (n = 16)								
Me	36	35*	30	30	34	35*	50	48*
Q1	35	33.5	25	25	31	27	43.5	41
Q3	39	37	35	35	40	39	55.5	52.5

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test
PCT: triceps cutaneous fold; PCB: biceps cutaneous fold; PCSE: subscapular cutaneous fold; PCSI: suprailiac cutaneous fold

TABLE 4
Body composition (fat mass, mass free of fat and water) for pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	Fat mass (%)		Mass free of fat (%)		H_2O (%)	
	Pre	Post	Pre	Post	Pre	Post
GEC (n = 13)						
Me	34	32*	66	68*	48	50*
Q1	31	27	58	62	42	45
Q3	42	38	69	73	50	53
GEI (n = 16)						
Me	28	25*	72	74*	53	55*
Q1	25	22.5	69	70.5	50.5	52
Q3	31	29.5	75	77.5	55	57

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

TABLE 5
Biochemical measures (HDL, LDL) and total cholesterol for pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	HDL (mg/dl)		LDL (mg/dl)		Total cholesterol (mg/dl)	
	Pre	Post	Pre	Post	Pre	Post
GEC (n = 13)						
Me	42	35*	101	78*	169	145*
Q1	37	33	85	67	136	123
Q3	46	40	121	96	182	153
GEI (n = 16)						
Me	41	38*	83	81.2	139	156
Q1	37.5	32.5	69.4	64.6	133.5	127
Q3	49	41.5	101.9	110.4	184.5	179

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

The initial values of the measures analyzed between both groups were statistically different (Mann-Whitney test) in relation to the triglycerides level (p = 0.009) and glycemia (p = 0.027). Comparing the final values in relation to the initial values within each group, we observed no significant decrease on HDL and LDL concentrations in group GEC (p = 0.002, Wilcoxon test). However, for group GEI, the HDL decreased statistically (p = 0.002) while the LDL value increased with no statistical difference. It is worthy mentioning that the initial average both for HDL and LDL was considered as within normal values (LDL < 110; 110-129) HDL ($\geq$ 35).

Regarding total cholesterol level, significant improvement occurred only in GEC (p = 0.006, Wilcoxon test) with decrease on the final value in relation to the initial value.

With regard to the glycemia and triglycerides levels, as previously mentioned, the initial values were statistically different between groups. As we observe the evolution of the glycemia concentration in GEC, a significant increase (p = 0.021, Wilcoxon test) curiously occurred; this effect was not observed in GEI. A significant increase in GEC (p = 0.05) and decrease in GEI (p = 0.03) on the triglycerides response also occurred, as represented in table 6.

TABLE 6
Biochemical measures: triglycerides (TG) and glycemia for pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	TG (mg/dl)		Glycemia (mg/dl)	
	Pre	Post	Pre	Post
GEC (n = 13)				
Me	79	99*	93.3	99*
Q1	54	83	93.15	95
Q3	100	108	100.15	101
GEI (n = 16)				
Me	134	88*	84	85
Q1	83.5	68.5	81.5	83
Q3	169	130.5	89	95

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

In addition to the anthropometric measures, the physiological effects of the physical work before and after continuous aerobic training (GEC) and intermittent anaerobic training (GEI) were also evaluated.

The LAn (anaerobic threshold) average values of GEC and GEI are represented in table 7. No significant difference was found in initial values between groups (Mann-Whitney test). After physical training, a significant increase on LAn velocity for both groups (GEC, p = 0.001; GEI, p = 0.002) was verified. The cardiac frequency response (CF) decreased for both groups with statistical value only in group GEI (p = 0.004).

TABLE 7
Anaerobic threshold (LAn) and cardiac frequency related to the anaerobic threshold (FC_{lan}) of pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	LAn (km/h)		FC_{lan} (bpm)	
	Pre	Post	Pre	Post
GEC (n = 13)				
Me	8	9.3*	179.1	174.6
Q1	7.6	8.1	175	168.6
Q3	8.3	9.7	181	177.5
GEI (n = 16)				
Me	7.35	7.65*	180.3	177*
Q1	6.59	7.56	176.95	167.5
Q3	7.8	8.68	193.1	180.5

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

The maximal oxygen intake values measured in liters per minute (absolute) and divided by kilogram of body weight (relative) are presented in table 8. No statistical difference on the initial values between groups was verified. As we analyze the evolution of this parameter within groups, both GEC and GEI presented increase with statistical difference in the absolute and relative maximal oxygen intake when initial and final periods are compared (GEC, p = 0.017 and 0.028; GEI, p = 0.001 and 0.001, respectively).

TABLE 8
Oxygen maximal intake: absolute (absolute $\dot{V}O_2$) and relative (relative $\dot{V}O_2$) values of pre- and post-treatment continuous aerobic (GEC) and intermittent anaerobic (GEI) groups. Values expressed as median (Me) and semi-quartile range (Q1 and Q3)

Group	Absolute $\dot{V}O_2$ (l/min)		Relative $\dot{V}O_2$ (ml/min/kg)	
	Pre	Post	Pre	Post
GEC (n = 13)				
Me	2.84	3.47*	35.25	46.75*
Q1	2.42	3.08	33	39.8
Q3	3.33	4.46	36.97	47.24
GEI (n = 16)				
Me	3.03	3.56*	35.93	45.15*
Q1	1.78	3.4	32.95	39.19
Q3	3.27	3.92	40.88	50.23

* $p < 0.05$ in relation to pre-treatment, Wilcoxon test

DISCUSSION

Many studies have demonstrated concurrent effect of diet and physical activity to prevent and to treat obesity. However, the diet and exercises optimization and action mechanisms need further enlightenments. Some disagreements found in results reported with regard to the diet and physical exercise effects on body mass, body composition and basal metabolism rate in obese individuals might be attributed to many factors such as the exercise intensity, magnitude of the caloric restriction, amount and distribution of the initial body fat, several combinations of diet and exercises using different protocols[21,22].

Sothern *et al.*[23] used a progressive and moderate-intensity physical training program defined as 45 to 55% of the $\dot{V}O_2$max along with diet and changes in alimentary habits with anthropometric evaluations performed with 10 to 30 weeks in obese children. The children presented decreases on BMI and fat percentile, but no changes on the body mass free of fat were observed. From the 11 subjects evaluated, eight of them presented positive responses to the body mass control, in other words, approximately 72% decreased their total body mass and 90% decreased their BMI.

Through our study, we can corroborate these modifications that occurred in these same parameters. In aerobic exercises, the total body mass was decreased 1.5% and in anaerobic exercises, 3.7%. This established the decrease in BMI of 4.5% in GEC and of 7.6% in GEI.

A statistically significant increase in fat-free mass was observed in post-exercises results both in GEC and in GEI. These results are in agreement with Krotkiewiski[24] and with other authors previously mentioned, showing that physical activity acts on the maintenance of fat-free mass and on loss of fat.

When exercise is compared directly to diet or when exercise associated to diet and compared to caloric restriction, the physical activity results in maintenance of fat-free mass and fat reducing and during a body mass reduction program with diet alone, the result is the loss of less fat and more musculature[25]. Both studies performed with animals by Oscai (1971) *apud* Powers & Howley[26] and studies performed with humans[27], using caloric restriction alone, the loss of fat-free body mass may be equal to 30-40% of the total weight loss. Exercise associated to diet leads to lower loss of fat-free body mass and proportionally, higher loss of fat[26,28]. Furthermore, the preferential mobilization of fat from the visceral fat tissue results in improvement of its body distribution and improvement of the risk factor profile[29].

Fernandez[30] evaluated 28 obese adolescents divided into aerobic, anaerobic and control groups and concluded that the anaerobic exercises are also effective in fat reduction.

We are able to corroborate these data with results of the present study, verifying the effectiveness of the anaerobic exercise for the loss of body mass as well as for the cardiorespiratory improvement, biochemical measurements and body composition.

Santarém[31] and Ceddia[32] also affirm that anaerobic exercises may promote high mobilization of free fatty acids with consequent control of the fat tissue levels, once the maintenance and/or increase of the mass free of fat through resistance exercises (strength) trends to maintain the basal metabolism elevated by many hours after anaerobic exercises due to the muscular tissue to maintain itself more active even in rest situation.

In the biochemical measures evaluated in this study, the HDL and LDL levels presented decrease in GEC with statistical difference. In group GEI, the HDL level also decreased statistically but the increase on the LDL level occurred without statistical difference, although within parameters expected for the age as well as the decrease in HDL for both groups. The triglycerides response (TG) increased statistically in GEC and decreased in GEI. The glycemia increase increased statistically in GEC and no significant alteration was observed in GEI. The cholesterol levels showed decrease in both groups with significant difference only in GEC.

The exercise presents small effect on the LDL-cholesterol level when factors such as body composition and lipids and cholesterol diet ingestion are taken into account[29].

Silva *et al.*[34] in their study with rats verified the effect of aerobic and anaerobic exercises on the serum and tissue fat of rats fed on hyperlipidic diet. They concluded that the anaerobic training may represent a stimulus as effective or even more effective when compared to the aerobic exercise on the reduction of the negative effects from the excess of fat in diet, both regarding the alterations on the serum fat and the tissue fat.

Curiously, Reaven *et al. apud* MaCauley *et al.*[35], verified that the HDL increased in active aged men and women (50 to 89 years old), where a dose-response relation was verified in male individuals, while the HDL levels remained slightly lower in women who performed intense activity.

In the present study, a decrease on the HDL serum levels also occurred in both groups (GEC and GEI), although these values were found within normal values.

With regard to the evaluation of the physical capacity of obese adolescents of our study, the results of the oxygen maximal intake responses ($\dot{V}O_2$max) and LAn (anaerobic threshold) increased statistically in GEC and GEI, sufficiently to improve their work capacity.

The $\dot{V}O_2$max responses presented statistical difference in both groups with regard to the training performed; one may conclude that both aerobic and anaerobic exercises were effective to improve physical capacity in obese adolescents, once positive alteration was observed in these results both in GEC (from 35.4 to 42.7 $ml.kg^{-1}.min^{-1}$) and in GEI (from 37 to 45 $ml.kg^{-1}.min^{-1}$).

The values with regard to $\dot{V}O_2$max for both groups obtained in the present study were similar to results found by Fernandez[30], who evaluated 28 adolescents and verified relative $\dot{V}O_2$max of 36.50 ± 6.33 $ml.kg^{-1}.min^{-1}$; 32.08 ± 2.61; 29.91 ± 6.49 $ml.kg^{-1}.min^{-1}$ for aerobic, anaerobic and control groups, respectively. These results reveal that both types of training used increased the oxygen maximal intake when compared to group that performed no physical activity.

Study similar to ours was performed by Woitge *et al.*[36], who trained two groups of young individuals from 20 to 29 years of age during 8 weeks using aerobic (40 to 60 minutes of duration with intensity of 60 to 85% of the $\dot{V}O_2$max) and anaerobic trainings (running "shots" with 90 to 100% of the maximal velocity of each volunteer). They concluded that both types of trainings increased the aerobic capacity (determined through the anaerobic threshold) in 10% after 8 weeks of intervention. These results were similar to results found in our protocol with increases of GEC = 6.5% and GEI = 8.1% of the LAn.

Considering the results obtained in each group, we conclude that the aerobic physicals exercise promoted reduction of the total body mass followed by improvement in the body composition, changes in the lipidic profile and improvement in the physical capacity. The anaerobic exercise behaved similarly considering the measures analyzed and the physical capacity response was better than the cardiac frequency response.

The nutritional orientation was important and useful to produce changes in the alimentary habits and standard of adolescents and their families. Despite the adhesion to the nutritional orientation was not rigorously monitored, the data found evidences that they actually changed their habits, once physical exercises alone would not induce such results.

This orientation, based on alimentary reeducation, had weekly meetings for adolescents and monthly meetings for their parents. With educative and informative purposes, they were encouraged to change their habits and behaviors, searching for a healthier and more balanced alimentation. In meetings with parents and sons altogether, we could hear comments with regard to these changes such as:

..."I am succeeding in changing my alimentary habits; I did not use to eat fruits, and today I always do".

..."I have been feeling more encouraged to change the bad habits, once I have noticed positive results in my life. I am no longer ashamed to practice sports with the others".

..."I could hardly walk and felt already tired before; today I can run and practice sports in my school and I am glad with it".

Considering all results presented, we can suggest that both aerobic and anaerobic exercises associated to nutritional orientation were satisfactory in promoting important body and behavioral changes, and they should be adopted in physical activity programs aiding on the fight against obesity in adolescence and preventing future complications in the adult life.

Despite these considerations, we are aware of the limitations of this study in relation to the size of the sample and the lack of a control group with no intervention at all. This did not occurred due to technical difficulties and availability of subjects for this research that involved a troublesome and dense protocol. However, we are sure that if these aspects were fulfilled, much more consistent results would have been obtained, enriching discussions and strengthening conclusions. We leave here proposals for further studies with this protocol, with control group and group with associated exercises (anaerobic and aerobic).

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