Title: Effects of 10 week multicomponent exercise with different heart rate frequencies on body composition and physical fitness in overweight and obese young school-aged children.

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Abstract

Introduction: During childhood and adolescence, obesity is an important predictor of adulthood obesity. Therefore, there should be given an important care to young population to improve the future of our society. To compare the effects of ten-week multicomponent exercise training with different exercise frequencies on body composition (BC) and physical fitness (PF) in overweight and obese young children. **Material and Methods**: 40 children, aged 12-15 (14.77 ± 1.49), were randomly selected and assigned to two experimental groups to train 3 times per week (EG1) or twice a week (EG2) for 10 weeks: EG1 (n=10), EG2 (n= 10) groups and a CG group (n= 20; no training program). **Results**: It was shown that experimental groups (EG1 and EG2) increased aerobic capacity, muscular strength and flexibility from pre- to post-training. The highest gains on muscular strength were observed in experimental group that performed twice a week; but better improvements on flexibility, body mass index (BMI) and body fat percentage (BFP) were observed in experimental group that performed 3 times per week. **Conclusions:** This type of exercise suggests that performing physical activities 2 or 3 times per week appears to be effective for physical fitness improvement, independently of the exercise frequency. However, to improve BMI and decrease BFP (body fat percentage) exercise frequency will be important in overweight and obese children. This could be a reliable choice to optimize physical fitness and improve well-being in overweight and obese children.

Keywords: Obesity, Youth, Health, Strength, Aerobic

Introduction

Obesity has been considered by Antonogeorgos *et al*. (2011) as one of the epidemics of the twenty – first century, being a growing problem worldwide in western countries (Ogden et al., 2006) including Portugal (Padez et al., 2004; do Carmo et al., 2008; Fonseca et al.,2014), and affects a huge number of children and adolescents. Most of cases involving overweight and obesity are the result of excessive calorie/energy consumption and inadequate energy expenditure, as an example of low levels of physical activity and a more sedentary life style. Obesity causes negative effects on physical and psychological patterns for the long-term population (Must & Strauss, 1999; Strauss, 2000; Strauss & Pollack, 2003). According to Visness et al. (2010) obesity can lead to the risk of cardiovascular disease, type II diabetes mellitus and psychosocial concerns. However, this chronic disease has been considered a preventable illness worldwide by World Health Organization (WHO), and physical activity is a positive factor to prevent or decrease obesity in childhood (Hohepa et al., 2004; Miranda et al., 2006). Moreover, regular physical activity has many other benefits besides the body weight balance, body composition improvement, psychological well-being or social factors, although it should be associated to healthy eating habits (Miranda et al., 2006). However, despite of physical activity being essential the scientific community, it has been demonstrated little concerns related to the effects of physical activity program on body composition levels in overweight and obese people (Mota et al., 2009; Vanhelst et al., 2011). To the best of our knowledge, there is a paucity on the evaluation of body composition and physical fitness in childhood that must be clarified.

In a context of children health some of authors recommended that strength training should not be used on physical training program (Garganta et al., 2003) because of their low trainability. On the other hand, Barros (2003) and Raposo (2005) consider the applicability of strength training on physical education classes essential. Other studies (Ross & Gilbert, 1985), Bergmann et al., 2005), and Ughini (2011) even suggested that strength training in children is related to physical fitness improvements, concluded that children with better abdominal and arms strength have better results on physical fitness. Furthermore, strength training should be developed to prevent injuries, improve muscular strength (abdominal, dorsal, lumbar and cervical), and improve posture.

Hereupon, the literature presented an evolution regarding to the efficacy of concurrent training in children. Previous studies reported that concurrent training appears to be effective on both strength and aerobic fitness features of prepubescent children and also in adults (Marta et al., 2013, Shumann et al., 2014). Moreover, performing concurrent training allows the benefits from both aerobic and strength training to be acquired simultaneously (García-Pallarés et al., 2011, Izquierdo-Gabarren et al., 2010, Marta et al., 2013). Furthermore, introducing both aerobic and muscular fitness is fundamental to promote health and should be a suitable goal in a training program (Taanila et al., 2011). These studies' results allow to refute previous studies which have advised that concurrent training could have an interference effect on muscle strength development (García-Pallarés et al., 2011, Sale et al., 1990, Santos et al., 2012). Therefore, aerobic and strength training are frequently performed concurrently at school or in extracurricular activities (Santos et al., 2012) in an attempt to acquire gains in several physiologic systems to obtain total conditioning, to meet functional demands, or to improve several health-related components simultaneously (Marta, 2012).

Nowadays, school is a place where children and adolescents spend most of their time, therefore being a privileged place to meet the needs of youth physical activity, to enhance physical activity and physical fitness levels, (Bucher Della Torre et al., 2010; Marques et al., 2011), and to develop physical activity skills or habits that contribute to the acquirement of a healthy lifestyle in adulthood (Nettle & Sprogis, 2011). In order to minimize this problem, a specific training program should be implemented by physical education teachers to promote physical activity and physical fitness levels.

Such data would give knowledge about the influence of multicomponent exercise training with different exercise frequencies in overweight and obese children. Hereupon, the present study aimed to investigate the effects of multicomponent exercise training with different exercise frequencies on body composition and physical fitness in overweight and obese young school-aged children. Thus, we propose to: 1) assess the prevalence of overweight and obesity in children of Quinta das Palmeiras High School, and 2) compare training programs with different exercise frequencies using FITNESSGRAM® tests (aerobic resistance, muscular strength and flexibility). The established hypothesis submitted in this study is that overweight and obese children can increase their physical fitness performances independently from the different exercise frequencies approaches. We also hypothesize that body composition and body fat percentage can obtain better results performing multicomponent exercise training 3 times/week over a consecutive 10-week period.

Methods

Subjects

The sample consisted of 40 pubescent children (14.77 ± 1.49 years) from the school cluster in Quinta das Palmeiras (Covilhã, Portugal) that were randomly assigned into different training programs. The body mass and height was as follows: 26.26 ± 2.2 kg, and 1.62 ± 0.08 m, respectively.

The inclusion criteria were pubescent children aged between 12 and 14 years old with chronic pediatric disease (>85th percentile), and without a regular oriented extra-curricular activity (e.g., sports in sports clubs). No subject had regularly participated in any form of training program prior to this experiment. Efforts were made to collect a sample for making comparable groups. After local ethics board approval, ensuring compliance with the declaration of Helsinki, the participants (pubescent children) were informed about the study procedures, risks and benefits, and a written informed consent was signed by the parents of the subjects.

Physical fitness assessment

The Fitnessgram physical fitness assessment program was applied in all groups (experimental and control groups). This program used some health–related physical fitness tests designed to evaluate cardiovascular fitness, muscular strength, muscle endurance, and flexibility (Welk & Meredith, 2008). However, the following tests were applied at the beginning and at the end of the 10 – week exercise program: (a) aerobic capacity was estimated by the 20m shuttle run test; (b) the muscular strength, endurance and flexibility were evaluated by curl – up, trunk lift, push – up, and back saver sit and reach tests.

Testing Procedures

All anthropometric measurements were assessed according to international standards for anthropometric assessment (Marfell Jones, 2006) and were obtained prior to any physical performance test. To evaluate body height (cm), a Stadiometer (Seca, model 264, Germany) was used. Body mass (in kg) was measured to the nearest ± 150g using a digital floor scale (Soehnle Model L63747). Subjects were barefoot and wore only underwear. The BMI was calculated by a standard formula = weight (kg)/ [height (m) ^{2}], and associated to a percentile. Thus, for children with percentile equal or greater than 85 were classified as pre-obese children and for percentile equal or greater than 95 were characterized as obese children. To determine body fat percentage (BFP) it was used a standard formula: % Body fat = 1.2 (BMI) + 0.23 (age) - 10.8 (gender) - 5.4 (where gender = '1' for men and '0' for women). The National Health and Nutrition Examination Survey (NHANES, 2007) were used to assess the health and nutritional status of pubescent children.

Physical Fitness Training Program

The physical fitness training program was performed during ten weeks on the same day of the week and on the same morning hour for EG1 and EG2 groups, however, EG1 group have done one more session (Monday, Wednesday and Friday). Physical training program was constituted by activities of moderate intensity (ACSM, 2006) highlighting to aerobic activities, strength and flexibility exercises.

The training program was implemented additionally to physical education classes. Prior to the training, the subjects warmed up for approximately 10 min with low to moderate intensity exercises (e.g., running, sprints, stretching and joint specific warm-up). Joint-rotations included slow circular movements, both clockwise and counter-clockwise, until the entire joint moved smoothly. Stretching exercises included back and chest stretches, shoulder, wrist, waist, quadriceps, and hamstring stretches. At the end of the training sessions, all subjects performed 5 min of static stretching exercises such as kneeling lunges, ankle over knee, rotation and hamstrings. After the warm-up period, training groups were submitted to a combined aerobic and strength training that constituted 40 minutes of aerobic exercises (e.g., team sports, ski, hiking, cycling, aquatic exercises) and 10 minutes of strength exercises (e.g., elastic bands, dumbbells, hydraulic machines, etc.). Aerobic task was developed based on an individual training volume that was set to approximately 75% of the established maximum aerobic volume achieved on a previous test. After 4 weeks of training, EG1 and EG2 groups were reassessed using 20-m shuttle run test to readjust the volume. Each training session lasted approximately 60 minutes.

Before the start of the training, subjects completed two familiarization sessions to practice the drill and routines they would further perform during the training period (i.e., 20-m shuttle run test). During this time, the children were taught about the proper technique on each training exercise, and any of their questions were properly answered to clear out any doubts. During the training program there was a constant concern to ensure the necessary security and maintenance of safe hydration levels, as well as to encourage all children to do their best to achieve the best results. Clear instructions about the importance of adequate nutrition were also delivered. For the 20-m shuttle run, the instructions were given with the aid of a multi-stage fitness test audio CD of the FITNESSGRAM® test battery. Throughout the pre- and experimental periods, the subjects reported their non-involvement in additional regular exercise programs for developing or maintaining strength and endurance performance besides institutional regular physical education classes. The resources used in physical classes were a gymnasium, sports hall and snow equipment's. A more detailed analysis of the program can be founded in table 1.

This study is integrated in *Pró-Lúdico: Mais e Melhor Saúde* (*More and Better Health*), is a part of a program to promote healthy living habits, which aims to involve children in fun and dynamic activities, providing interactions on emotional, intellectual, physical, and social parameters to promote an healthy lifestyle starting in childhood / adolescence and maintaining active in future.

FREQUENCY									
Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**	**Week 8**	**Week 9**	**Week 10**
Day 1 45' Aerobics or Step Aerobics 15' Curl ups Flexibility	**Day 1** 45' Tennis 15' Strength training (upper limbs and trunk)	**Day 1** 50' Walk 5' Strength training (upper limbs) 5' Flexibility	**Day 1** 10' Bicycle ergometer 10' Treadmill 10' Rowing ergometer 10' Step 10' Elastics bands 10' Flexibility	**Day 1** 10' Bicycle 15' Step 10' Rowing ergometer 15' Elastics bands 10' Flexibility	**Day 1** 45' Collective sports games: Football 10' Lunges and squats. 5' Flexibility	**Day 1** 45' Collective sports games: korfbal 10' Curl ups and Lunges 5' Stretching	**Day 1** 45' Collective sports games: Tagruby 10' Strength training (upper limbs) 5' Stretching	**Day 1** 45' Aerobics or step aerobics 10' Stretching and flexibility	**Day 1** 30' Tennis 30' Aerobics or Step aerobics
Day 2 45' Collective sports games: handball 15' Strength training (upper limbs) 10' Flexibility	**Day 2** 10' Rowing ergometer 20' Treadmill 20' Bicycle ergometer 10' Flexibility	**Day 2** 10' Treadmill 20' Bicycle ergometer 20' Rowing ergometer 10' Stretching	**Day 2** 5' Warm up 40' Collective sports games: korfbal 10' Curl ups and Lunges 5' Stretching	**Day 2** 5' Warm up 50' Ski 5' Stretching	**Day 2** 35' Circuit training: curl ups, upper limbs, squats, trunk, squats and lunges 15' Treadmill 10' Stretching	**Day 2** 60' Hydrogymnastics	**Day 2** 15' Step 10' Walk 10' Rowing ergometer 15' Elastics bands 10' Flexibility	**Day 2** 10' Walk 20' Bicycle ergometer 20' Rowing ergometer 10' Stretching	**Day 2** 60' Peddy-Paper
Day 3 45' Aerobics or Steo aerobics 15' Curl ups; Flexibility	**Day 3** 45' Tennis 15' Strength training (upper limbs and trunk)	**Day 3** 45' Collective sports games: basketball 5'squats 10' Flexibility	**Day 3** 30' Hydrogymnastic 30' Hydrorider	**Day 3** 10' Walk 15' Step 10' Rowing ergometer 15' Elastics bands 10' Flexibility	**Day 3** 45' Traditional games 10' Lunges and squats. 5' Flexibility	**Day 3** 45' Collective sports games: korfbal 10' Curl ups and Lunges 5' Stretching	**Day 3** 45' Collective sports games: Tagruby 10' Strength training (upper limbs) 5' Stretching	**Day 3** 50' Aerobics or step aerobics 10' Stretching	**Day 3** 30' Traditional games 30' Collective sports games: Korfbal

Table 1 – The "*More and Better Health*" program design.

Physical fitness and body composition assessment

The experimental groups were assessed for aerobic capacity (20-m shuttle run test), muscular strength (curl-ups and push-ups tests) and flexibility (back saver sit and reach test) before and after the 10-weeks of training program. The same researcher performed data collection, anthropometric and physical fitness assessments, and training program.

I. Results

At baseline (table 2), there were no differences among the groups on sex, age, BMI, body fat percentage and physical fitness variables, except on curl-ups variable ($F(2,37) = 3.58$, $p < 0.05$). Body composition and physical fitness measures have significantly improved on EG1 group, except for percentile and curl-ups variables. Body composition and physical fitness measures have also improved significantly on EG2 group, except for push-ups variable.

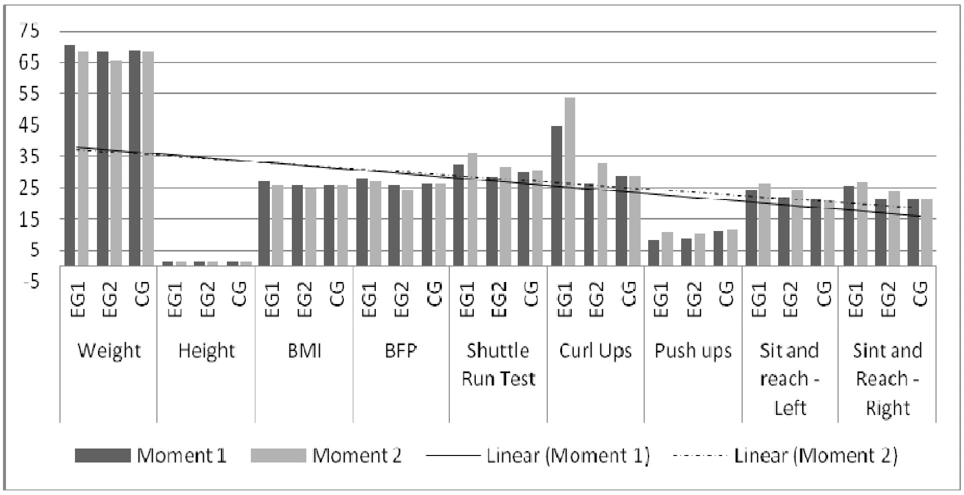

Figure 1: Data collected on the pre- and post-test of training in all groups on all tests.

CG group presented no statistical improvements on body composition, and physical fitness measures (table 3). These results corroborate the hypothesis that overweight and obese children can increase their physical fitness performances independently from the different exercise frequencies approaches, and the hypothesis that body composition and body fat percentage can obtain better results performing multicomponent exercise training 3 times/week over a consecutive 10-week period.

Bonferroni test presented on weight, BMI, BFP, and all physical fitness variables that changes were significantly higher in EG1 and EG2 groups than CG group (Figure 1); improvements on 20-m shuttle run and curl-ups tests were significantly higher on EG1 group than EG2 and CG groups; improvements on back saver sit and reach (left and right) variable were significantly higher in EG2 group than EG1 and CG groups. The results of MANCOVA showed small effect sizes were verified on the BMI (η_p^2 =0.191, F(2,37)=3.549, p<0.05), %MG (η_p^2 =0.044, F(2,37)=0.683, p=0.513), 20-m Shuttle run test (η_p^2 =0.019, F(2,37)=0.286, p=0.754), Curl-ups (η_p^2 =0.091, F(2,37)=1.497, p=0.240), Push-ups (η_p^2 =0.016, F(2,37)=0.248, p=0.782), Back Saver Sit and Reach right (η_p^2 =0.043, F(2,37)=0.676, p=0.516), and left (η_p^2=0.042, F(2,37)=0.662, p=0.523), tests. Although, only BMI variable showed small effect size and significant differences.

Discussion

The aim of the current study was to compare the effects of ten-week multicomponent exercise training with different exercise frequencies on body composition (BC) and physical fitness (PF) in overweight and obese young school-aged children. The main results confirmed that a physical activity training program provides improvements on BC and PF variables in all experimental groups.

The body composition and physical fitness improvements were observed in both experimental groups, although the experimental group that performed twice a week obtained better results on physical fitness variables while experimental group that performed 3 times /week obtained better results on body composition components in overweight and obese children. Moreover, no differences were found in post-training in the CG group in any variable related to body composition or physical fitness. The current data may have a significant importance to optimize exercise trainings in overweight and obese children. Our results are consistent with results of previous studies (Greening et al., 2011; Vanhelst et al.,2011), that were showed better results on physical fitness values and decreases on body composition values in experimental group constituted by obese students (8-week physical activity program, 2 sessions/week), and were observed significant differences on body mass index (BMI), with decreases in experimental group and increases in control group, after a physical activity program during 12 months, respectively. These results are also congruent with results of previous studies (Sun et al., 2011; Martins et al., 2011) in this area, although the researchers analysed effects on body composition and aerobic fitness, and observed effects only in girls, respectively. Dorgo et al. (2009) verified the effectiveness of different physical training programs on physical fitness levels, but did not verified differences on body composition values. The improved flexibility was observed in both training groups, however experimental group that performed 3times/week showed better results than experimental group that performed twice a week. These results are not consensual with Tokmakidis' study (2006) that reported association about inferior performances in physical fitness variables with higher BMI values except on flexibility, suggesting that high flexibility values are associated to obese children. According to our results, multicomponent exercise training is relevant to improve physical fitness levels and body composition parameters in overweight and obese children; and performing twice a week is more effective to improve physical fitness levels while performing 3 times/week is more effective and useful to improve body composition parameters when properly prescribed and supervised. The current study provides promising results for the application of multicomponent exercise training with different exercise frequencies to evaluate body composition and physical fitness components in overweight and obese children, supporting the future research in this area. There are some main limitations of present study: (i) the small size of the sample; (ii) there as discrepancy in the range of ages; (iii) nutrition parameters were not evaluated, which should be considered in future studies; (iv) the training-period of 10 weeks was quite short.

Conclusions

Short-term multicomponent exercise training improves BC and PF in overweight and obese young school-aged children. Performing 2 or 3 sessions/week seems to produce similar results over 10 weeks of training, although a multicomponent exercise training performing 3 times/week is suggested to be a more effective method to improve body composition, and a multicomponent exercise training performing twice a week is suggested to be more effective to improve physical fitness levels in overweight and obese children. Therefore, multicomponent exercise training should be applied in school permanently to promote physical activity since childhood until adulthood.

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