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Original Article

What is the most effective exercise protocol to improve cardiovascular fitness in overweight and obese subjects? [1]

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Abstract

Background: Increased peak oxygen consumption (VO_{2peak}) can reduce cardiovascular risks associated with obesity. Our aim was to analyze the effect of a weight loss program on cardiovascular fitness in overweight (W) and obese (O) subjects.

Methods: One hundred sixty-seven subjects (77 males and 90 females), aged 18–50 years, performed a modified Bruce protocol before (pre) and after (post) a weight loss program of 24 weeks. This program combined physical training (strength, S; endurance, E; combined strength + endurance, SE; or physical activity recommendation, PA) 3 times per week, with a 25%-30 % caloric restriction diet.

Results: In overweight and obese males, VO_{2peak} improved (pre and post values in L/min, respectively; W = 3.2 ± 0.6 *vs.* 3.7 ± 0.5, $p < 0.001$; O = 3.6 ± 0.6 *vs.* 3.8 ± 0.6, $p = 0.013$), as well as in overweight females (2.0 ± 0.3 *vs.* 2.3 ± 0.4, $p < 0.001$). VO_2 in the first ventilatory threshold (VT_1) increased for all 4 interventions in men ($p < 0.05$), except for S in the obese group (1.6 ± 0.2 *vs.* 1.7 ± 0.3, $p = 0.141$). In females, it increased in E (0.9 ± 0.2 *vs.* 1.4 ± 0.3, $p < 0.001$), SE (0.9 ± 0.2 *vs.* 1.2 ± 0.4, $p = 0.003$), and PA (0.9 ± 0.1 *vs.* 1.2 ± 0.2, $p = 0.006$) overweight groups. Time-to-exhaustion improved in all subjects except for women in PA group (15.7 ± 0.3 *vs.* 15.9 ± 0.3, $p = 0.495$).

Conclusion: Our results suggest that all methods, including the recommendation of physical activity, can improve cardiovascular fitness in overweight subjects and obese males.

Keywords: Oxygen consumption; Strength training; Combined training; Endurance training; Ventilatory threshold; Obesity; Physical activity

1. Introduction

From a clinical point of view, obesity is associated with many comorbidities and represents an important health problem.[1] Studies have suggested that lower aerobic fitness is also associated with a less favorable coronary or cardiovascular risk factor profile and an increase in peak oxygen consumption (VO_{2peak}) in the amount of one metabolic equivalent, correlated with a 13% reduction of all-cause mortality as well as with a 15% decrease in cardiovascular risk.[2,3] In general, obese individuals have lower cardiovascular fitness than lean counterparts.[4] Results suggest that increased fitness could reduce the risks associated with obesity.[5]

Data regarding the effect of different training methods for improving cardiovascular fitness in obese subjects are still inconsistent. Some found improvements in VO_{2peak} only with aerobic and/or combined (aerobic/resistance) training,[6–10] whereas others also found improvements applying resistance training.[11–17] Aerobic training promotes changes in aerobic capacity, increasing mitochondrial oxidative capacities and capillary density in skeletal muscle,[18] whereas resistance training increases muscle mass, which should increase maximal aerobic capacity.[19] Therefore, it is reasonable to suggest that both types of training together can contribute to the improvement in cardiorespiratory fitness. In fact, many authors have found combined training to have a greater influence on cardiorespiratory response.[20,21] However, the comparison among

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studies is difficult owing to the different training methodologies used. It is therefore still unknown which method is the one achieving greatest enhancements.[20] Along this line, and to the best of our knowledge, no study has compared the effects of different training methods applying the same volume and intensity, and therefore assuring that the distinct results were due only to the change in the type of training. In addition, there is little literature about circuit training, which has been used in many fitness centers for some years. There are also few studies reporting data regarding aerobic and anaerobic threshold changes after a weight loss program.[8,22,23] These data could uncover interesting information about the cardiovascular fitness response of overweight and obese people following this kind of program. The improvement in these parameters is also related to a longer duration of exercise in the same intensity and consequently a longer period of fatty acid oxidation or increased intensity of exercise, which can ensure excess post-exercise oxygen consumption and contribute to weight loss.[24,25] Finally, some authors have suggested that if dietary intervention is associated with the training program, VO_{2peak} will improve even more.[26]

Therefore, the main objective of this study was to analyze the effect of a weight loss program on cardiovascular fitness in overweight and obese subjects, comparing the effectiveness of isolated and combined aerobic and resistance training on VO_{2peak}.

2. Methods

2.1. Participants

This study was performed as part of the *Nutrition and Physical Activity for Obesity Study* (the PRONAF study according to its Spanish initials) , the aim of which was to assess the usefulness of different types of physical activity (PA) and nutrition programs for the treatment of obesity. The inclusion criteria specified adult subjects, aged 18 to 50 years, who were overweight or obese (25 kg/m^2 ≤ body mass index (BMI) ≤ 34.9 kg/m^2), sedentary (<30 min PA/day), normoglycemic, and non-smoking. Only females with regular menstrual cycles were included. A total of 167 participants (77 males and 90 females) completed all the tests. Adherence to diet (80%) and exercise (90%) were included in the analysis. All participants were informed about the risks and benefits of the study and signed a document of informed consent. The PRONAF study was approved by the Human Research Review Committee of the University Hospital La Paz (HULP) (No.NCT01116856).

2.2. Study protocol

The complete methodology and the flow diagram can be found in Zapico et al.[27] Briefly, subjects who fulfilled the inclusion criteria were randomly assigned to one of the 4 interventions detailed here, assuring a homogeneous distribution of age and gender among groups. The intervention programs lasted 22 weeks, and the assessment tests took place 1 week before (baseline) and after (post) the intervention.

2.2.1. Exercise protocols

Four different interventions were performed: strength training (S), endurance training (E), combined strength + endurance training (SE) groups followed the corresponding supervised exercise program plus the dietary intervention, and the PA group followed dietary intervention and was instructed about the general recommendations about PA from the American College of Sports Medicine (ACSM).[5] The exercise of the PA group was not supervised, only registered with an accelerometer.

Subjects in the S, E, and SE groups trained 3 times per week for 22 weeks. All training sessions were carefully supervised by certified personal trainers. The exercise programs were designed according to the subject's muscle strength and heart rate reserve. Muscle strength was measured using the 15-repetition maximum testing method in the S and SE groups. Resting heart rate was calculated as the average heart rate during 10 min in a lying position, and maximal heart rate (HR_{max}) was obtained by means of the cardiovascular maximal effort test.

In the S group the session routine consisted of the execution of 8 scheduled exercises (i.e., shoulder press, squat, barbell row, lateral split, bench press, front split, biceps curl, and french press for triceps). For group E, running, cycling, or elliptical (self-selected) exercises were the main components of the session routine, whereas the routine for the SE group consisted of a combination program using cycle ergometry, treadmill or elliptical machine intercalated with squatting, rowing machine, bench press, and front split.

Both volume and intensity of the 3 training programs increased progressively (Fig. 1). The S and SE participants performed 15 repetitions of each strength exercise or 45 of aerobic exercise (only SE participants) with a rest period of 15 between them. Feedbacks of training loads were evaluated with the Rate of Perceived Exertion scale once a month, following a similar methodology used elsewhere.[28]

2.2.2. Hypocaloric diet

All groups underwent an individualized and hypocaloric diet (between 1200 and 3000 kcal) prescribed by expert dieticians in the Nutrition Department of HULP. The diet aimed for a 25% reduction of the total daily energy expenditure measured using the SenseWear Pro Armband (BodyMedia, Inc, Pittsburgh, PA) accelerometer.

2.3. Measurements

2.3.1. Cardiovascular fitness

The test evaluating cardiovascular fitness was maximal ergospirometry following the modified Bruce protocol with a computerized treadmill (H/P/COSMOS 3PW 4.0; H/P/Cosmos Sports & Medical, Nussdorf-Traunstein, Germany). VO_{2peak} was measured with the gas analyzer Jaeger Oxycon Pro (Erich Jaeger; Viasys Healthcare; Hoechberg, Germany). Heart response was continuously monitored with a 12-lead electrocardiogram. The effort test was maintained until exhaustion. The mean of the 3 highest measurements was used as VO_{2peak} and HR_{max}.

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