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HIGH INTENSITY STRENGTH TRAINING IN OVERWEIGHT ADULTS IN THE WORKPLACE: A PILOT STUDY

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Abstract

The aim of this pilot study was to determine (a) the effects of high intensity strength training in the workplace on blood pressure, fat percentage and physical fitness in overweight adults, and (b) the influence of this intervention on the blood pressure in a subsample of hypertensive subjects. Overweight adults (n=15) aged 42.8 years underwent anthropometric assessment (weight, fat percentage, waist circumference, and triceps skinfold), physical fitness assessment (leg extensor power, upper body endurance, hand grip strength and Vo2max) and blood pressure assessment before and after 8 weeks of high intensity resistance training in the workplace. Each training session consisted of 16 sets of 45 repetitions performed at 1 repetition per second, decreasing load at the point of muscular failure starting at 60% of repetition maximum (RM). The effects of the intervention were analyzed by paired sample t-tests. For exploratory purposes, a non-parametric test was also performed (Wilcoxon matched-pair signed-rank) to examine if this decision could affect the results. Weight, body fat percentage, and triceps skinfold decreased significantly with the high intensity resistance training protocol in the workplace (all P<0.05). Performance in physical fitness tests increased significantly with training (all P<0.05), except for handgrip strength. Both systolic and diastolic blood pressure decreased significantly with R-HIRT in the workplace (all P <0.05) in hypertensive subjects (n=10). This protocol performed in the workplace in this pilot study produces health and fitness benefits in overweight and hypertensive people.

Key words: *endurance, health, hypertension, physical fitness.*

Introduction

The problems of weight increase and obesity are linked to raised risk of morbidity from hypertension, dyslipidemia, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea and respiratory problems, and endometrial, postmenopausal breast, prostate, and other cancers (1, 29). In addition, obesity is associated with increased overall mortality (10).

Benefits of increased muscle mass and muscle strength have been reported recently (36). Higher levels of muscular strength, independent of aerobic fitness level, are associated with a general lower level of mortality rates in men and women (28, 31). Muscular strength has been shown to be inversely related to excessive body fat and abdominal fat (18), both of which are associated with increased risk for chronic diseases and adverse events that include heart disease (37), type 2 diabetes (7), cancer (30), and stroke (34). Muscle strength becomes especially important for preventing falls (12).

High intensity progressive resistance training (HI PRT) is associated with substantial gains in appendicular lean mass and losses of total and special trunk fat mass (22). Heavy resistance strength training can cause decreases in metabolic risk factors related to body composition, blood pressure and glucose and insulin metabolism (32, 33). However, the optimal type and intensity of resistance training that should be used to maximize health weight loss and other health benefits in overweight people is unclear (20).

Exercise intensity is important for increasing metabolic rate; high intensity exercise increases metabolic rate higher than low intensity exercise, and vigorous intensity and high duration programs have shown greater benefits in overweight sections of the population (19). This type of intensity helps spare lean mass, maintain nitrogen balance and compensates blood glucose concentration with fatty acids and ketones at rest (5).

Obesity and weight increase affects the lives of many adults of working age. Action is therefore imperative to provide preventive strategies to reduce the trend. Activity habits of overweight people must change at home and in the work place (13, 16). Feasible ways of introducing exercise in the workplace are through strength training, which can be implemented in a small place, over a short period of time (2), and with a diverse group of people working at a time, with great benefits for health and fitness and even reducing work absenteeism (38).

The primary purpose of this study was to examine the effects of a high intensity resistance training program in the workplace, on body fat percentage, blood pressure, and physical fitness in overweight adults. By combining previously established evidence in Regressive High Intensity Resistance Training (R-HIRT) effects, we tested the following primary hypothesis: R-HIRT reduces BMI, Blood pressure, Fat percentage and increases performance in tests of physical fitness. Furthermore we hypothesize that R-HIRT is a determinate dose of high intensity exercise that can affect blood pressure in our hypertensive subjects.

MATERIALS AND METHODS

Experimental Approach to the Problem

The present study was developed as a pilot study to test the possible effectiveness of R-HIRT program in overweight and obese adults. It was performed at the University of Balearic Islands (Majorca, Spain) from March to June of 2010. The target group was overweight university employees.

The study outcomes were body measurements (anthropometry) and physical fitness. Data on anthropometric characteristics included: weight, BMI, body fat, waist circumference, hip circumference, mid-upper arm circumference and triceps skinfold thickness.

Anthropometry was assessed using an Omrom body composition monitor BF500 and a measuring tape for body circumferences.

Physical fitness was assessed by Alpha-Fit an battery test for adults (35) and Queen College Step Test (24). Data on physical fitness included: lower extremity strength, upper body endurance and hand grip strength.

The R-HIRT program consisted in 16 sessions (two per week), in which participants were evaluated twice: before the intervention (baseline, Week 0) and after the intervention (post-test, Week 8). The sessions were provided early in the morning at the university sport facilities before the start of the working day and supervised by a specialist. An informative session was held with the participants in order to explain in detail the procedures, aims and characteristics of the intervention program. Written information was also delivered to the participants.

The R-HIRT program was based on current scientific literature (8, 11, 14, 17, 19, 20, 23, 27, 32) and the amount of exercise carried out was strength training involving 18 sets of 45 repetitions, starting at 60% (1 RM) and decreasing the intensity at the point of muscular failure or inability to follow the 1 second repetition rhythm. This dose (>9 MET) allows the patient to expend calories on average at about 400 kcal. per session. The R-HIRT intends to consume as many High-energy phosphates as possible in every set.

Subjects

Fifteen obese adult university employees participated in the study. A total of 19 participants completed the baseline assessment and 15 participants (10 men and 5 women) completed the assessment at post-test (dropout rate=21.05%).

Participants were 42.83 years old (SD 5.81) and had 81.64 kg (SD 13.73), 163.93 cm (SD 7.09), 30.27 kg/m2 (SD 4.12) and 34.51 % of weight, height, body mass index (BMI) and percentage of body fat respectively.

Procedure

This study was a non-randomized controlled trial. The University of the Balearic Islands has a medical service available to employees. The study used accidental sampling methods to draw a voluntary population, from which the medical service selected participants according toy the following inclusion criteria: (i) age between 18 and 65 years; (ii) BMI equal to or greater than 25 kg/m2; (iii) do not have any medical contraindications to performing high-intensity exercise; (iiii) not participating in any weight reduction program. Study flow is depicted in Figure 1.

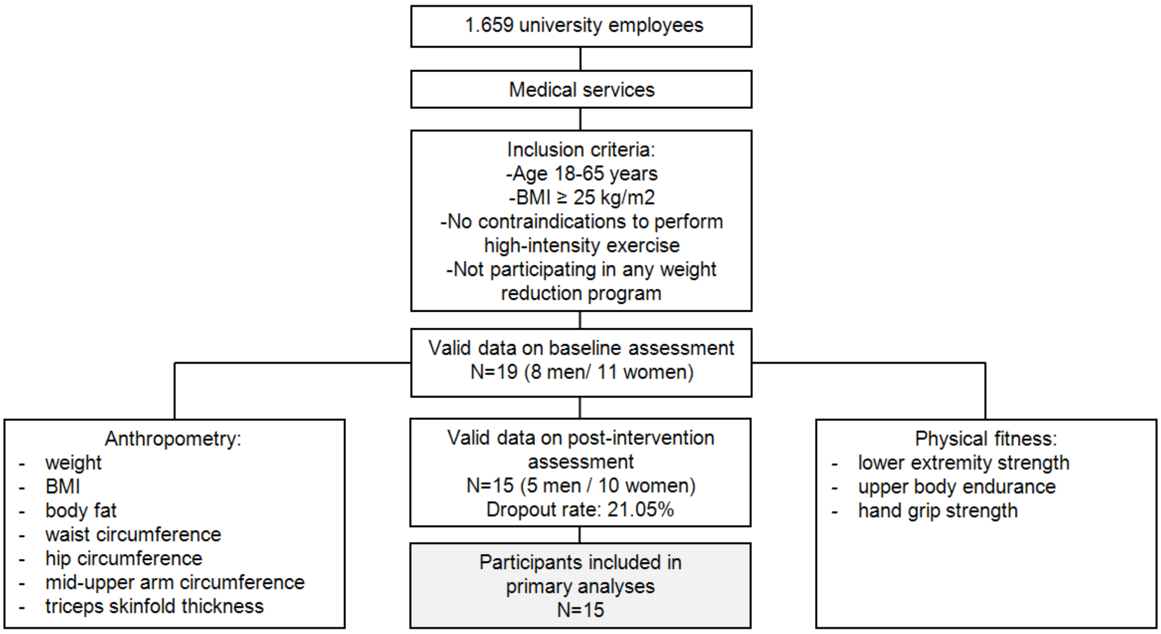

Figure 1. Study flow.

Anthropometric assessment. Participants removed shoes, heavy clothing and contents of pockets. Body weight (recorded in kilograms) and body fat (percentage) were measured with a composition monitor (Omrom BF500). Height was measured with a tape measure affixed to the wall. Subjects stood barefoot with heels together and back as straight as possible. The participants' height was judged to be the location at which the top of his or her head intersected the tape and was recorded in inches. Height and weight were used to calculate BMI. Waist circumference, hip circumference and mid-upper arm circumference were assessed using anatomic marks on the participant's skin and recorded in centimeters using a tape measure. Result was the mean of the 3 measurements rounded off to the nearest 0.5 cm. If these 3 measurements differed more than 1 cm from each other, 2 additional measurements were performed. Skinfold measurement of the nondominant arm triceps was taken with a Holtain skinfold caliper (Holtain Ltd., Dyfed, UK). The triceps skinfold was taken on the back of the upper arm midway between the shoulder and elbow. Two measurements were not performed consecutively and the mean was used in analyses.

Physical fitness assessment. Lower extremity strength (leg extensor power) was measured with the jump-and-reach test, the aim of which is to jump as high as possible. The participant stands beside the jump-board facing forward. Dominant upper extremity is raised up straight against the jumping board, and marked with a magnesium powdered middle finger. The vertical difference between the "standing height" and the "jumping height" was measured in centimeters with a tape measure.

Upper body endurance was tested with modified push-ups to measure short-term endurance capacity of the upper extremity extensor muscles and the ability to stabilize the trunk. The participant lies prone on the mat, and begins the push-up cycle by clapping hands behind the back once; this is followed by a normal straight-leg push-up with elbows completely straight in the up-position, so that the participant can touch one hand with the other hand. The participant ends the cycle in prone position. The number of correctly performed push-ups completed in 40 seconds was counted.

Hand grip strength was measured with a hand dynamometer (TKK-5001). The participant stands in an upright position with the dynamometer in the preferred hand. The arm is straight and slightly away from the body, the scale facing the tester. The better result of two attempts was the score recorded in kilograms.

Queen's College Step Test was conducted for indirectly estimating maximum oxygen intake (24) (Vo2max). The participant steps up and down on a platform (16.25 inches) at a rate of 22 steps per minute for females and at 24 steps per minute for males. Participants are to step using a four-step cadence, "up-up-down-down" for 3 minutes. Heart beats are counted from 5-20 second of recovery.

Blood pressure assessment. Blood pressure was measured with a blood pressure computer (Omron MIT Elite Plus).

Statistical Analyses

The analyses were performed of those participants that had complete data at the two measurement points (baseline and post-test) using PASW (Predictive Analytics SoftWare, formerly SPSS), version 19.0 SPSS Inc., Chicago, IL, USA. The level of significance was set at <0.05 for all the analyses.

The effects of the intervention were analyzed by paired sample t-tests. For exploratory purposes, a non-parametric test was also performed (Wilcoxon matched-pair signed-rank) to examine if this decision could affect the results.

Ethics

Written permission of participants was required for participation in the study. All participants had been previously informed about the protocol and purposes of the research. The study protocol was approved by the local Ethical Committee of the University of Balearic Islands and performed in accordance with the ethical standards of the Helsinki Declaration.

RESULTS

Anthropometric parameters

Weight (-1.46 ±2.14), BMI (-0.54 ±0.83), body fat (-1.68 ±0.93) and triceps skinfold thickness (-7.71 ±2.59) decreased after intervention ($p<0.05$). Waist circumference (-1.77 ±7.16) and hip circumference (-1.41 ±6.55) decreased slightly ($p>0.05$), and mid-upper arm circumference (+0.93 ±0.92) increased ($p>0.05$) (Table 1).

Physical fitness parameters

Lower extremity strength (+2.85 ±2.61), upper body endurance (+4.86 ±3.21) and Vo2max (+2.81 ±4.06) increased after intervention ($p<0.05$), and hand grip strength (+0.25 ±3.97) increased slightly ($p> 0.05$) (Table 1).

Table 1. Characteristics of the study sample at pretest and posttest

	Pretest	Posttest	Relative	Absolute	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean	P=
Weight (kg)	81.64 ± 13.73	80.18 ± 13.83	-1.46 ± 2.14	-0.02 ± 0.02	0.019
Body mass index (kg/m2)	30.27 ± 4.12	29.73 ± 1.02	-0.54 ± 0.83	-0.02 ± 0.02	0.026
Body fat (%)	34.51 ± 6.02	32.83 ± 1.59	-1.68 ± 0.93	-0.05 ± 0.03	0.000
Waist circumference	93.47 ± 12.21	91.69 ± 11.12	-1.77 ± 7.16	-0.01 ± 0.08	0.354
Hip circumference	108.4 ± 10.29	107.0 ± 10.73	-1.41 ± 6.55	-0.01 ± 0.07	0.419
0.01 ± 0.03	32.67 ± 3.17	32.76 ± 2.68	0.09 ± 0.92		0.701
-0.28 ± 0.09	28.55 ± 7.91	20.83 ± 7.18	-7.71 ± 2.59		0.000
Vertical jump	21.85 ± 6.85	24.69 ± 8.15	2.85 ± 2.61	0.13 ± 0.14	0.002
Modified push-ups	10.93 ± 6.07	15.79 ± 4.85	4.86 ± 3.21	0.49 ± 0.39	0.000
Hand grip strength	34.82 ± 9.23	35.07 ± 10.50	0.25 ± 3.97	0.01 ± 0.12	0.818
VO2 max	22.15 ± 4.73	24.96 ± 6.49	0.12 ± 0.19	2.81 ± 4.06	0.036
Systolic blood pressure	131.93 ± 16.45	124.07 ± 11.87	-0.04 ± 0.07	-5.79 ± 9.72	0.044
Diastolic blood pressure	89.67 ± 10.35	81.93 ± 9.74	-0.09 ± 0.08	-8.21 ± 8.20	0.002

Blood pressure parameters

Systolic pressure (-5.79 ±9.72) and diastolic pressure (-8.21 ±8.20) decreased after intervention (p< 0.05) (Table 1).

A subsample of subjects with high blood pressure was extracted from total sample to determine the effects of the intervention in this sample concretely. Systolic pressure (-8.50 ±10.84) decreased slightly (p=0.062), and diastolic pressure (-11.62 ±9.27) decreased after intervention (p=0.009) (Figure 2).

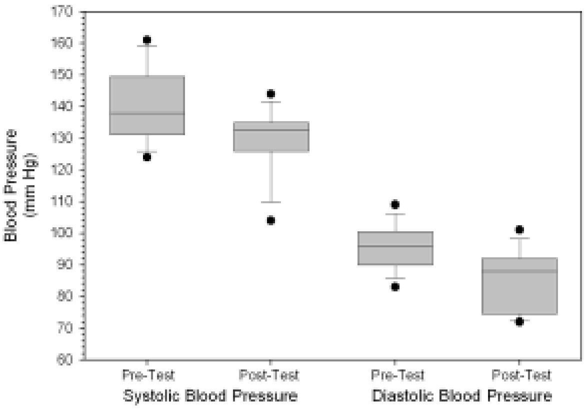

Figure 2. Intervention effects on sub-sample of subjects with high blood pressure.

DISCUSSION AND CONCLUSION

The findings of this study support the hypothesis that high intensity resistance training with a regressive intensity modulation, (R-HIRT) reduces BMI, Blood pressure, fat percentage and increases performance in tests of physical fitness, and this dose of exercise reduces Blood pressure in the sub-sample of hypertension subjects.

These results suggest that the efficacy of high intensity resistance training in the workplace to reduce weight, fat percentage, blood pressure and increase fitness performance as shown in this pilot study can lead to a larger scale study.

Our Regressive High Intensity Resistance Training protocol produced findings that are supported by some investigations, meaning that high energy expenditure dose of exercise leads to a decrease in body weight (23), body fat, triceps skinfold, waist circumference and hip circumference (22,25). None of the investigations we know of to date have tested the effects of this kind of exercise dosage. The innovation of this high intensity resistance training rests in the administration of the work load (9); starting the set at 60%RM, the subject is able to complete about 15 repetitions at one repetition per second; to complete the rest of the set, the subject must decrease the intensity until he or she is able to complete a 45 set. This regressive protocol creates a pre-exhaustion effect and the intensity of the set is very high (>9 MET). This can explain the results, but we cannot generalize our findings due to the limitation of the sample size.

The improvements in physical fitness through strength training are well documented, the increase in upper body endurance and handgrip strength in our subjects with this pre-exhaustion training are not new (3). We can explain these results by the effect of the first 15 repetitions in every set at 60% (RM), when the balance of nitrogen is bigger and the enlargement of muscle fibers is greater (5, 26).

Few studies have addressed the importance of vo2max adaptations that occur with strength training, which may make an important contribution towards improving physical fitness. Our findings suggest that this dosage of exercise increases endurance performance, supporting the findings of other studies (15, 21).

The effects of our protocol with regard to blood pressure in people with hypertension are similar to the findings of Sillanpää et al. (32) with the main difference that their study was conducted on healthy people, and the protocol included endurance training. The effect on high blood pressure of high intensity training amongst people with hypertension may lead to confusion, due to the different utilization of the concept intensity; the maximum load we have used in the study is 60% RM, but the intensity in MET's is >9, considered a high intensity work load. This intensity may cause a large increase in mitochondria, oxidative enzymes, and the number of capillaries per muscle fiber.

The prescription of the training required to achieve a specific goal (weight loss, reduction of blood pressure or increase Vo2max) has been largely instinctive, resulting from years of personal experience. The 45 set training load in our protocol of regressive high intensity strength training corresponds to the direct observation on speed performance during the complete abduction and adduction phases (4). One repetition per second aims at the consumption of maximum ATP molecules in every set.

The workplace has been considered a valuable intervention site for a number of reasons, including the amount of time people spend at work, access to populations that may be difficult to engage in different settings, and the opportunity to utilize peer networks and employer incentives (16). For workers, an unhealthy lifestyle and being overweight not only affect risk of cardiovascular disease, but may also have major disadvantages related to work (6,13). Thus, changing body weight and physical fitness, and reducing blood pressure amongst hypertensive workers has many benefits, including work absenteeism rates (38). Our findings suggest that the high intensity intervention amongst these workers improved different aspects of health and fitness in overweight men and women, thereby potentially providing other work-related benefits. These findings are supported by other investigations in the workplace using resistance training. Zavanela et al. (38), for example, used progressive resistance training; however, the main difference is that in our study we developed a protocol based on high energy expenditure, due to the overweight nature of the subjects. Our protocol suggests that was effective when performed in the workplace; at least in our study group. The strengths of the present study include the originality of the protocol (45 repetition sets decreasing at the point of muscular failure from 60%RM at a 1 second repetition), and the supervised training period in the workplace, that allows a difficult to engage population to achieve health and fitness goals.

The limitations of the study are those characteristic of design or methodology that set parameters on the application or interpretation of results; that is, the constraints on generalizability and utility of findings that are the result of the devices of design or method that establish internal and external validity. There are two limitations related to the ability to draw descriptive or inferential conclusions from sample data. One of those is the study design a without control group, and consequently the data results should be interpreted with caution. The other limitation is the relatively small sample participating in this study.

On the other hand, this is a pilot study and the aim was to test a new research hypothesis initially among a small number of subjects. This avoids spending too many resources on finding an association between a factor and a disorder when there really is no effect. However, clear associations were found in the pilot study and it encourages the implementation of a larger confirmatory study.

Our results suggest that exercise prescription has health benefits in overweight adults. The training protocol used in this study is of high intensity and allows the participant to consume as many phosphates as possible in every set; that means sets of around 45 seconds of a very high intensity.

Workplace is a great opportunity to engage this traditionally hard to reach population. This intervention can be performed in a short period of time (approx. 20 minutes), the time invested is not a barrier and the motivation of the participants increases with the training supervised. Workplace regressive high intensity resistance training intervention is a facilitator for the fulfilment of health and fitness goals for an overweight population. Clearly, additional investigation is warranted to confirm or contradict our findings.

CONFLICT OF INTEREST DECLARATION

All the authors have substantially contributed to this work. They are all fully aware that the manuscript is to be submitted to the Journal and none of them has any conflict of interest. The experiment reported has been undertaken in compliance with the current laws of Spain, where the experiment was performed.

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