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Cardiometabolic Profile of a Functional Training Session

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ABSTRACT

Rabay AN, Silva AS, Pompeu MBD, Martins MO, Soares MY. Cardiometabolic Profile of a Funcional Training Session. **JEPonline** 2012;15(5):68-78. Functional training has been practiced by athletes and recreational practitioners to optimize sporting performance and physical fitness. Research has highlighted many benefits of the functional training, but its cardiometabolic profile is unknown yet. This study determined the cardiometabolic profile of 14 trained adults (26 ± 2.5 yrs old) during a functional training (FT) session and two control sessions (aerobic and resistance exercises). Blood pressure (BP), heart rate (HR), and lactate levels were measured before and during the sessions and venous blood collections were performed to determine the concentrations of creatine kinase (CK) and lactate dehydrogenase (LDH) in response to training sessions. The HR response in FT was significantly lower compared to aerobic and resistance exercises. The SBP increased in a similar way to resistance exercise, and was significantly lower than in aerobic exercise. Thus, double product (DP) was significantly lower in the FT session. Lactate production increased significantly compared to resting values, but did not differ between the three modalities examined. Similarly, exercise increased the serum activity of CK and LDH, but no differences between modalities were observed. These data suggest that FT imposes a metabolic overload similar to aerobic and resistance exercise training. Moreover, FT did not cause muscle damage and because of its lower cardiovascular demand is likely to be less stressful from the point of view of myocardial overload.

Key Words: Functional Exercise, Muscle Damage, Cardiovascular Behavior, Metabolic Behavior

INTRODUCTION

Functional training (FT) was developed by rehabilitation and physical therapy professionals to help injured people recover and resume their daily activities (16). In particular, this type of training improves the functional levels of patients with muscle-skeletal injuries (15), helps to prevent injuries induced by daily efforts (13), and promotes a meaningful improvement in lumbago cases (24). The benefits of FT can be explained by the fact that it combines strength, flexibility, coordination, and balance exercises to strengthen muscles (16) and improve the muscle-skeletal integration with the nervous system (7).

Personal trainers have used FT as a method to improve specific physical skills and, therefore, to improve physical and athletic performance as well. The activation of functional equilibrium that is related to body stability in athletes is an effective training strategy to decrease injury cases, to enhance the effectiveness of sports programs, and to develop functional postural activation (17). Moreover, the role of instability is important because of the instances in daily life and sport in which force must be exerted while an unstable condition is imposed (5). Tasks that combine resistance, strength, and instability must be performed to improve skills of the human body, which is one of the basic principles of the FT.

Given the interest in FT, it is used a lot in fitness centers where people practice physical exercises for health and/or recreational purposes. Increasingly, FT is substituted for conventional modalities with the primary purpose to develop strength and endurance. Despite its popularity, it is unclear as to the cardiometabolic demand that is required in a FT session. Thus, it is not possible to explain with great detail how FT adds to or even takes from the benefits attributed to traditional strength and endurance exercises performed at gyms.

In order to clarify the physiological demand of a session of FT, this study was designed to determine heart rate (HR), blood pressure (BP), double product (DP), lactate production, and damage indicators in response to a FT session performed by people practicing physical activities at recreational levels.

METHODS

Subjects

This research was completed using a sample of 7 males and 7 females (25.8 ± 2.5 yrs of age, body weight 68.4 ± 11 kg, size 1.70 ± 0.1 cm, IMC 23.4 ± 2.3 kg·m⁻²). Subjects were healthy young adults with no injuries; all practiced resistance training at the recreational level. This study was submitted to research ethics committee of Lauro Wanderley University Hospital in Universidade Federal da Paraíba. It was approved under the protocol CEP/HULW n^o 774/10. All subjects were previously informed about the purpose and procedures of the study and, then, signed the agreement term (as determined in Resolution 196/96 of National Health Counsel of Brazil).

Procedures

The subjects participated in a session of FT exercises and two control sessions: (a) resistance exercises (RE); and (b) aerobic exercises (AE). The order of the sessions was randomly determined with a 48-hr rest period between each session. Before and during the exercise sessions, heart rate (HR), blood pressure (BP), and arterialized blood were collected to determine plasmatic concentration of lactate. Other vein blood collections were made before and 1 hr after the exercise sessions to determine serum activity of creatine kinase (CK) and lactate dehydrogenase (LDH).

Preparation for the Study

One week before the beginning of the study, the subjects underwent three adaptation sessions for the exercises that would be used. Each session took 60 min, with a resting period of 48 hrs between them. Taking into consideration that previous experience with FT was an inclusion factor, the 3 sessions proved to be sufficient to qualify all subjects in the proper execution of the 9 FT exercises. Also, during these sessions, the number of rubbers to be used in extension exercises was determined as well as the thickness of the therabands for individuals that would perform 10-12 repetitions in exercises.

During the following week, in accordance with the protocol of Adams et al. (1), the subjects were submitted to anchor test in order to determine weight to execute 10-12 repetitions in resistance exercise. The subjects were asked about the usual weight applied in their respective training, and the exercises were performed at 30-40% of these loads for a first attempt. When the subjects executed less than 8 or more than 12 consecutive repetitions, the weight was adjusted and a new attempt was performed after a resting period of 3-5 min. The correct weight was found up to 3 attempts. Forty-eight hrs after the anchor test, the experimental protocols began. The modality order was randomly determined.

Functional Training Protocol

The FT protocol consisted of 9 exercises: (a) dumbbell chest fly on swiss ball; (b) barbell squats on balance pad; (c) frontal pull down with rubbers; (d) Lunge (front foot at balance disk) with dumbbells; (e) upright rows in balance disk; (f) knee flexion on swiss ball; (g) barbell curls on balance disk; (h) side step (abduction) with mini bands; and (i) lying dumbbell triceps on the swiss ball. Three sets of 10 repetitions for each exercise were executed, and 90 sec was fixed for the resting periods between series and exercises (60 min the whole session). The FT protocol and the resistance training protocol were similar with regard to the pace (i.e., the speed at which subjects performed was 1 sec for the concentric phase and 2 sec for the eccentric phase with no pause in between).

Dumbbell chest fly on swiss ball, squat on balance pad, lunge with dumbbells at balance disk and lying dumbbell triceps on swiss ball were executed with a load (dumbbells and weight discs) that corresponded to 15% of the weight used for similar muscle groups during the resistance exercises. With such criteria, these exercises were executed: dumbbell chest fly on swiss ball *versus* chest fly, squat on balance pad *versus* free squat, lunge at balance disc *versus* lunge, lying dumbbell triceps on swiss ball *versus* barbell triceps extension. The other exercises were performed using resistance tubings or therabands (amount of rubbers or thickness of the therabands) previously determined in adapting sessions, enabling the subjects to perform 8 to 12 repetitions.

Resistance Exercise Protocol

The resistance exercise protocol consisted of exercises and procedures to increase the size of the muscles (i.e., a muscular hypertrophy training protocol). It was designed with 3 sets of 10 repetitions with weight defined in the anchor test, pace of 2 sec in the eccentric phase and 1 sec in the concentric phase without any pause in between, 90 sec for resting periods between series and between exercises. Exercises were chosen so that the same muscular groups required on FT protocol would be required again. According to Fleck and Kraemer (8) terminology, the following exercises were chosen: (a) pec deck, (b) knee extensor with specific machine; (c) frontal bent-over with high pulley; (d) barbell squats; (e) smith machine upright rows; (f) lunge front immersion; (g) barbell curls; (h) knee flexion lying; (i) triceps down with straight bar; and (j) abductors with low pulley.

Aerobic Exercise Protocol

The aerobic exercise protocol consisted of a 60-min session on the bicycle ergometer at 60 to 70% maximal HR reserve. To estimate the maximal HR, the Inbar protocol (12) was adopted.

Biochemical and Cardiovascular Measures

Measures of HR, BP, and serum lactate were determined at rest and between each pair of exercises of the FT protocol and the resistance exercise protocol, and every 10 min during the aerobic exercise protocol. Vein blood collections were made at rest and 1 hr after each exercise session, thus making possible a later dosage of CK and LDH serum concentrations. Heart rate was determined by a HF monitor Timex SD456 (Middlebury, United States). Measures of arterial blood pressure were taken using an aneroid sphygmomanometer Missouri (Embu, Brazil), strictly following the protocol recommended by the Brazilian Guidelines of Arterial Hypertension.

As to serum lactate, arterialized blood collection consisted of taking 25 micro liters from the earlobe in heparinised capillars previously calibrated for such a volume. Afterwards, the samples were placed in ependorff tubes containing 400 milliliters of trichloroacetic acid at 4% and frozen until analysis. Samples were centrifuged at 3,000 rotations per minute for 10 min. Subsequently, 100 µl from the supernatant were taken and transferred to test tubes in which was placed 500 µl of reactive based on the stock in glicine/EDTA (50 mL), adding hydrazine hydrate (1,24mL). NAD (Beta-Nicotinamide Dinucleotide SIGMA) (100mg) or LDH (150µL) (L-Lactic Dehydrogenase bovine heart – 1000 units/mL SIGMA) were use to establish the solution's pH at 8.85. Afterwards, samples were mixed by inversion and incubated for 20 min at 37° C in a water-bath. Reading was done with a spectrophotometer with 340 nm of wave-length.

For evaluating serum activity of CK and LDH, 5 ml of vein blood was drawn from antecubital vein. The samples were placed in test tubes without anticoagulant and centrifuged at 3,000 rotations per minute for 15 min. Subsequently, supernatant was placed in ependorff tubes and frozen until analysis, which occurred in up to 4 days. For CK analysis, a commercial kit was used (Labtest, Minas Gerais, Brazil). A volume of 20 µl of plasma was added to 1 ml of the working reagent, according to the instructions provided by the kit and reading was done in a SP 22 spectrophotometer with 340 nm of wave-length. For measuring serum activity of LDH, commercial kit Labtest (Minas Gerais, Brazil) was used. Samples were in up to 4 days after the collection procedure. A volume of 20 µl of plasma was added to 1 ml of the working reagent, according to the instructions provided by the producer. Enzymatic activity's reading was done using a spectrophotometer with 340 nm of wave-length.

Statistic Analysis

Prior to system analysis, the data were processed to check normality of the sample. Two-way ANOVA test or its non-parametric equivalent was used according to each case. The level of statistical significance was set at $P=0.05$. The InStat 3.06 (GraphPAD software, inc. San Diego, USA) statistic software was used for statistical analyses. Data are presented as means \pm standard deviations.

RESULTS

Prior to the exercise protocols, the subjects were eutrophic, normotensive, and had normal levels of creatine kinase and lactate dehydrogenase (Table 1). The baseline HR, BP, serum lactate, and enzyme activities of CK and LDH were non-significantly different prior to performing the 3 exercise protocols.

Table 1: Cardiovascular Characteristics at Rest Prior to the Three Exercise Protocols

	Functional	Resistance	Aerobic	P Value
HR (beats·min ⁻¹)	80.2±12.5	77.6±12.1	76.8±11.6	0.739
Systolic BP (mm Hg)	113.1±12.7	112.6±8.8	113.7±12.6	0.966
Diastolic BP (mm Hg)	82.8±6.8	82±7.1	79.2±9.8	0.494
Lactate (mmol·l ⁻¹)	0.97±0.4	0.93±0.4	1.13±0.5	0.554
CK (U/L)	238±161	170.6±87.2	186.7±81	0.773
LDH (U/L)	389.1±246	342.9±237	379.5±221	0.912

Data are presented as average ± standard deviation. HR = heart rate component of autonomic variability; Systolic BP = systolic blood pressure; Diastolic BP = diastolic blood pressure; CK = creatine kinase; LDH = lactate dehydrogenase.

Heart rate responses to the 3 exercise modalities are shown in Figure 1, Panel A. the subjects' HR during aerobic exercise was stable at 155 beats·min⁻¹ during the exercise time. Heart rate during the FT oscillated from 120 beats·min⁻¹ to values very close to the aerobic effort, depending on the exercises performed. As a consequence, HR was found to be relatively lower in FT at the 5 measured moments compared to the aerobic exercise periods.

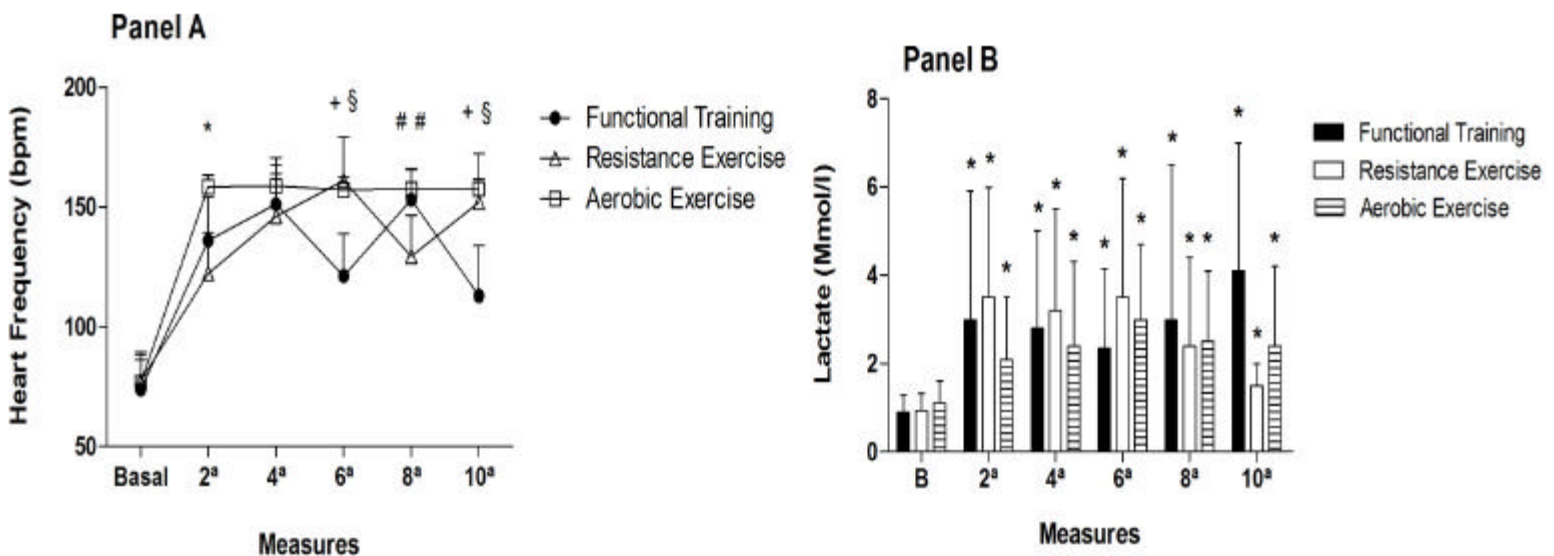


Figure 1. Panel A: Heart rate behavior in resistance exercise, aerobic exercise, and functional training. At Y axis are represented basal moments and measures at the end of the 2nd, 4th, 6th, 8th, and 10th exercises of functional training (FT) and resistance training. These moments correspond to each 10 min of aerobic exercises protocol. *Significant difference between FT and aerobic exercise at the same moment (P<0.05). +Significant difference between FT and aerobic exercise at the same moment (P<0.001). ##Significant difference between FT and resistance exercise at the same moment (P<0.01). §Significant difference between FT and resistance exercise at the same moment (P<0.001).

Figure 1. Panel B: The blood lactate responses in FT, resistance exercise, and aerobic exercise. In axis Y, basal moments are represented, as well as measures taken at the end of the 2nd, 4th, 6th, 8th, and 10th exercises of FT or resistance exercise. These moments correspond to each 10 min of the aerobic exercise protocol. Data are presented as means ± standard deviation. *Significant difference between FT and aerobic exercise at the same moment (P<0.03).

As observed in Figure 1, the HR responses during the resistance exercise were similar to the HR responses during FT (oscillating between 122 beats·min⁻¹ and 152 beats·min⁻¹ according to the exercises performed). In Figure 1, Panel B presents the lactacidemic responses during each of the three exercise sessions. A significant increase of resting lactate production was observed in the three protocols, but there are no significant differences among the exercise protocols. Lactate levels oscillated between 2 to 4 mmol·l⁻¹ in aerobic exercise and varied more significantly in FT and resistance exercise, although maintaining statistical similarity.

Blood pressure responses are presented in Figure 2. Pressure response in FT was similar to the responses during the resistance exercise. Nevertheless, FT resulted in lower systolic values in comparison to the aerobic exercise, noting that these values were significantly lower in two of three last measures made at the final half of the exercise sessions. Concerning diastolic BP, FT, resistance exercise and aerobic exercise presented the same variability in responses.

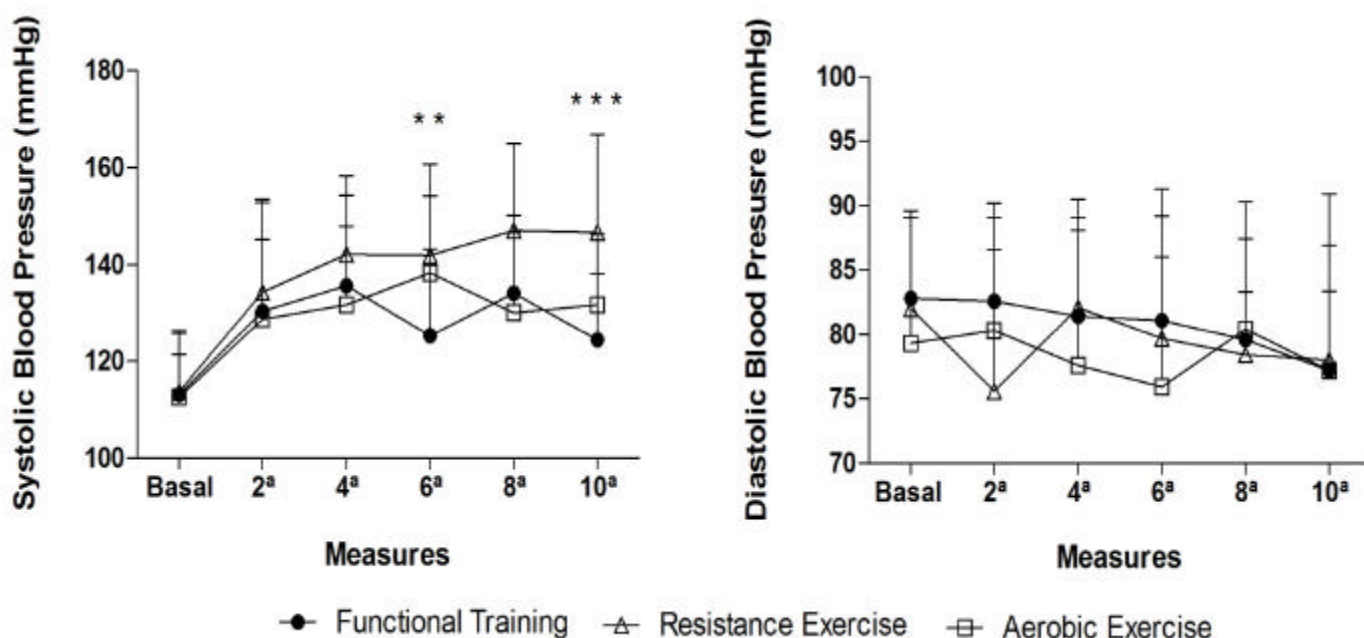


Figure 2. Blood pressure response to an acute session of FT, resistance exercise, and aerobic exercise. In axis Y, basal moments are represented as well as measures taken at the end of the 2nd, 4th, 6th, 8th, and 10th exercises of FT or resistance exercise. These moments correspond to each 10 min of the aerobic exercise protocol. **Significant difference between FT and aerobic exercise at the same moment ($P < 0.01$). ***Significant difference between FT and aerobic exercise at the same moment ($P < 0.001$).

As a result of the lower HR and the lower systolic BP responses in various moments during FT, DP in this modality was consistently lower than those obtained in the resistance exercises or the aerobic exercises (refer to Figure 3).

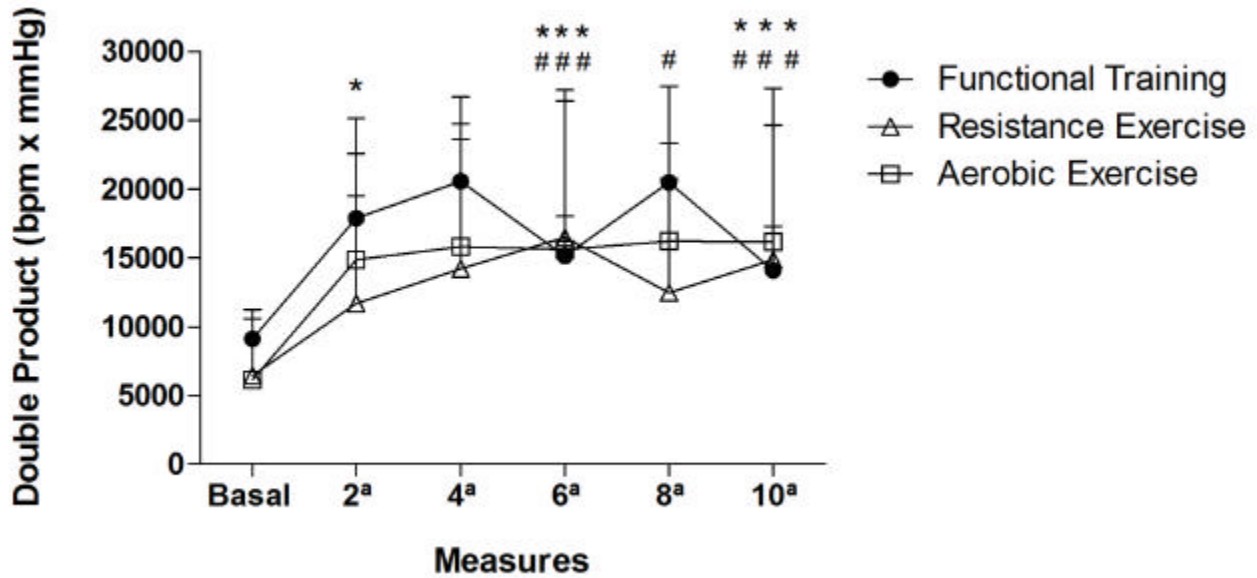


Figure 3. Double product (HR x SBP) responses during FT, resistance exercise, and aerobic exercise. In axis Y, basal moments are represented as well as measures taken at the end of the 2nd, 4th, 6th, 8th, and 10th exercises of FT or resistance exercise. These moments correspond to each 10 min of the aerobic exercise protocol. *Significant difference between FT and aerobic exercise at the same moment (P<0.05). ***Significant difference between FT and aerobic exercise at the same moment (P<0.001) #Significant difference between FT and resistance exercise at the same moment (P<0.05). ###Significant difference between FT and resistance exercise at the same moment (P<0.001).

The results indicate that the FT and resistance exercise protocols did not induce sufficient stress to promote muscle damage. When CK and LDH concentrations were compared (pre-training vs. post-training), no statistical differences were found. However, the data indicate that a significant increase in the activity of serum CK and LDH occurred with aerobic exercise (Figure 4).



Figure 4. Serum activity of creatine kinase and lactate dehydrogenase before and after a 1-hr session of FT, resistance exercise, and aerobic exercise. *Statistical difference between the post-exercise values between FT and aerobic exercise.

DISCUSSION

Cardiometabolic analysis of an exercise modality is essential if the modality is to be recommended for its therapeutic and/or health and fitness benefits (25). While aerobic exercise training uses the large muscles of the body in a continuous, rhythmical fashion to maintain and improve the cardiovascular capacity, resistance training is the best way to increase muscle mass, neural coordination, and strength. Both the American Heart Association (4) and the American College of Sports Medicine (19) recognize the potential health benefits of regular exercise, particularly when performed more frequently and for a longer duration.

Exercise prescription is based upon the frequency, intensity, duration of training, the mode of activity. Within this framework, however, there are questions regarding FT *versus* resistance training and aerobic training exercises. That is what makes necessary the cardiometabolic analysis of the FT modality if physical therapists and exercise physiologists are to know the right recommendations, goals, and even contraindications and cautions in practicing this modality.

Cardiovascular Behavior in Functional Training

Heart rate behavior indicates that FT exercises imposed a lower cardiovascular demand when compared to the aerobic exercise. This finding suggests that the cardiovascular aspect of intensity, duration, and the total volume of training are not sufficient in this modality to build a strong aerobic base. However, it is reasonable to conclude that the low DP observed in FT indicates a greater cardiovascular safety in this modality when compared to aerobic training (10,14). It is well-known that aerobic training imposes a larger myocardial demand in comparison to strength-building exercises, and the (9) DP values in were either similar or less in FT *versus* the resistance exercise protocol. Theoretically, then, in order to improve the health and well-being of people with coronary artery insufficiency, the FT protocol is the preferred modality from a myocardial point of view.

Metabolic Behavior

Lack of serum activity of CK and LDH appears to either indicate that the FT protocol lacked the intensity to promote muscular stress with respect to muscle damage or it indicates a limitation at inducing muscular adaptations. Interestingly, the resistance exercise protocol did not alter serum enzymes either, in spite of being executed with the weight, the number of repetitions, and the intervals believed to induce muscular adaptations (3). In contrast, however, the aerobic exercise protocol increased CK and LDH. This finding may be explained by the fact that the subjects were not accustomed to performing the bicycle ergometer exercises. In fact, Serrano and colleagues (21) and Pellegrinotti et al. (18) showed that CK and LDH do not change significantly in response to physical exercise if the subjects were previously adapted to the exercise.

It has been proposed that hypertrophy can be stimulated not only by weights that induce tensional stress with resulting muscular damage, but also by stimuli capable of imposing hypoxia or metabolite accumulation within the muscle. The hypoxia and/or metabolite within the muscle may activate other mechanisms (11) linked to hypertrophy. Also, given the similarities in the lactate response in FT and resistance exercise, it may be likely that the FT exercises have some hypertrophic property. Thus, the present study supports the idea that future investigations should be carried out to evaluate the role of the FT exercises in promoting muscular hypertrophy. Despite the fact that the weight used in FT is lighter than the weight used in RE, even loads reduced to 30-50% of 1RM may induce hypertrophy if metabolic stress is provided by a decrease in intervals or an increase in repetitions (6,23).

CONCLUSIONS

The findings in this study indicate that FT is a safe modality from a cardiovascular point of view, but it does not seem capable of promoting cardiovascular adaptations that are typical of aerobic exercises in young subjects. Also, given the similarity in metabolic stress with resistance exercise argues for the possibility that FT may be capable of producing muscular hypertrophy.

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