



BLOOD PRESSURE RESPONSES AFTER A SESSION OF FUNCTIONAL TRAINING IN YOUNG ADULTS AND THE ELDERLY: A PILOT STUDY

original paper

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ABSTRACT

Purpose. The potential of functional training (FT) to improve health is evident. However, regarding post-exercise hypotension (PEH) in older adults, there are few data. The study aimed to determine the cardiometabolic demand imposed by an FT session and evaluate PEH, comparing it with exercise sessions with aerobic and resistance exercises in physically active practitioners.

Methods. Fourteen young (23.3 ± 2 years) and 15 older (68 ± 4 years) adults underwent a control session and FT session randomly determined. Blood pressure, heart rate, and double product were recorded at rest, during exercise, and in every 10 minutes over 60 minutes of recovery. Additionally, we measured the rate of perceived exertion (RPE).

Results. The FT protocol promoted systolic PEH in both groups in the last half of recovery, reaching a reduction of 10.4 ± 4.9 mm Hg in young and 13.4 ± 3.8 mm Hg in older adults ($p < 0.05$). No differences were observed between the groups ($p > 0.05$). There were no differences between the groups with reference to RPE at any time ($p > 0.05$).

Conclusions. A single FT session is able to promote PEH in normotensive young and borderline hypertensive older adults but without changing the RPE in comparison over the time, owing to a great similarity of FT practices in the groups.

Key words: functional training, post-exercise hypotension, blood pressure, elderly, young

Introduction

Functional training (FT) is a type of exercise training characterized by exercises focused on strength [1] that differ from resistance exercises in being performed with a significant demand for isometric strength, besides coordination, balance, and flexibility. A training session is composed of free unstable exercises and owing to this peculiarity they are performed with light loads which can progress to heavier ones (but still low in relation to resistance exercises) [2]. Isometric contractions generate high request of the trunk musculature (abdominal, paraspinal, gluteus, and pelvis), the region where the foundations of the body are located, which consequently favours adequate postural control [3, 4].

The method was created by physiotherapy as a means to restore autonomy to individuals with musculoskeletal injuries [5] and has become well used by trainers to improve specific sports skills and prevent injuries [6]. It is also applied to promote gains in muscle strength [7], as well as to reduce injury in the skeletal muscle [6] and lumbar pain [8]. It has been observed that recreational athletes also have started to practice FT as a complementary modality or as a single modality of choice in gyms.

It has already been demonstrated that mechanical stress caused by flexibility training can affect hemodynamic responses [9]. Muscle fibres recruited activate mechanoreceptors, which elicit cardiovascular adjustments through parasympathetic withdrawal and sympathetic activation [10–12]. Furthermore, small muscle

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fibre receptors also react to stretching in humans [13, 14] with a significant impact on the initial heart rate (HR) acceleration. Furthermore, sustained contractions of muscle groups increase the peripheral vascular resistance and therefore influence the cardiac output and blood pressure (BP) [15].

Despite the significant growth of FT, little is known about its demands and cardiometabolic effects. Studies of cardiovascular post-exercise responses have focused mainly on aerobic and resistance training bouts. There is substantial evidence showing that BP decreases following these dynamic exercises, a phenomenon called post-exercise hypotension (PEH) [16]. It is well accepted that cardiovascular responses are influenced by training variables, such as exercise execution time (or number of repetitions), load, muscle mass recruited and type of contraction [15, 17, 18]. To our knowledge, there is no previous research that would observe the influence of these variables on BP following FT sessions.

Although there are many studies indicating the influence of the isometric component in reducing BP, all they were performed with isolated exercises like hand-grip [19, 20]. To date, only one study has been conducted regarding exercises that involves flexibility and PEH [21]. However, exercises were performed there with four sets of passive static stretching for 30 seconds in relation to two muscles (*gastrocnemius* and *ischio-tibialis*), which does not respond whether FT in real settings (involving several muscle groups and performed in longer sessions) is able to promote PEH. Therefore, if this cardiovascular benefit can also be attributed to FT is not known.

Assuming that high levels of static contraction may occur during a session of this kind of exercise, it is possible that cardiovascular responses are great enough to be a concern in exercise programs designed for special populations, such as hypertensive patients. Thus, we evaluated normotensive young and borderline hypertensive older adults. The study aimed to determine the cardiometabolic demand imposed by an FT session and evaluate PEH, comparing it with exercise sessions with aerobic and resistance exercises in physically active practitioners.

Material and methods

Participants

The study was performed among 14 young adults (23.3 ± 2 years) and 15 older adults (68.0 ± 4 years). To be included in the study, the individuals had to be apparently healthy and previously practicing resistance, aerobic, and FT exercises. All the elderly participants were users of hypertensive medications, but these included only angiotensin-converting enzyme inhibitors and diuretics. The research project was approved by the Ethics Committee of the Lauro Wanderley Hospital from the Federal University of Paraíba, under the CAAE-

01958112.2.0000.5188 protocol, according to Resolution 196/96 of the National Health Council. The sample size was determined as proposed by Eng [22], with the use of Gpower 3.1.0 software (Franz Faul, Universitat Kiel, Germany). The statistical power of 0.80 was adopted, as well as the alpha error of 0.05. A reduction in systolic BP of 2 mm Hg was estimated for residual standard deviation of 2 mm Hg after resistance exercise [23]. As a result, the number of subjects to form the group was determined as the minimum of 12. All participants were previously informed about the purposes and procedures of the study and asked to sign the instrument of consent (IC), according to Resolution 196/96 of the National Health Council.

Design

The groups underwent a control session and FT session, with a 48-hour interval between them, randomly determined (www.randomizer.org). HR and BP were measured at rest, during and after the sessions (every 10 minutes). We used the Borg scale to measure the subjective perceived exertion [24].

Study preparation

One week before starting the protocol, the participants underwent an adaptation session specifically for functional exercises that were applied in the study. The sessions proved sufficient to all subjects to demonstrate autonomy in the movements performed. On these occasions, the number of elastic garters was determined that would be used in the exercises with extensor apparatus and the thickness of therabands necessary for the individuals to perform 10–12 repetitions in the exercises.

Functional training session protocol

The functional exercises session lasted approximately 60 minutes; it was composed of 10 exercise sequences in circuit training. The adopted exercises were to be performed in the following sequence: (1) advancing front and back squat with a 5-second pause in the eccentric phase; (2) jumping squats over the bar (hopping); (3) skipping rope; (4) jumping squat; (5) calf raises from squat; (6) knee flexors on the ball; (7) pelvis elevation with the cervix on the ball and supine; (8) extension of the hips with trunk flexion; (9) triceps kickback with hips isometry; (10) transverse abdominal.

The squats on the jump, squats with development and calf, pelvis elevation with the cervix on the ball, and supine and triceps kickback with hips isometry were performed with an overload (dumbbells) of 2–5 kilograms, as previously determined in the adaptation session in a way that allowed the volunteers to perform at least 10 repetitions.

All the volunteers performed 3–5 transitions on the circuit (according to their fitness condition), did not have any interval between each station, at the end of each circuit they had an interval of 40 seconds. For the older adults, the same circuit was applied but they practised for 1,5 minute in each station, performing the maximal repetition number they could.

Cardiovascular measures

BP, HR, and double product (DP) (systolic BP \times HR) were evaluated in rest, during exercise and in every 10 minutes within the 60 minutes of recovery after the control and FT sessions. The BP measurement followed the recommendations of the American Heart Association [25], which state that the subject should remain seated during the rest period, leaving the right arm extended and relaxed at the heart level. The cuff was placed 3 cm above the antecubital fold, rapidly inflated from 10 mm Hg by 10 mm Hg until exceeding 20–30 mm Hg of the baseline levels, and the deflation rate was 2–4 mm Hg per second. The systolic BP was determined at the period of onset of the first sound (Korotkoff phase I), and diastolic BP was established in the dissipation of sound (Korotkoff phase V). For these measurements, an aneroid sphygmomanometer Missouri brand was used (Embu, Brazil), previously calibrated against mercury column one. The HR was verified by a HR monitor, Timex brand SD456 (Middlebury, United States).

Statistical analysis

The normality of the data and differences between the standard deviation were verified by Shapiro-Wilk test and Levine test, respectively. Data are presented as means and standard deviations. A two-way ANOVA was performed to measure the subjective perceived exertion; *post hoc* Newman-Keuls test was used to identify the differences within the analyses. For all tests, the value of $p < 0.05$ in the interaction was adopted. The procedures were performed in the InStat 3.06 statistical software (GraphPad Software, Inc., San Diego, USA).

Results

All the subjects completed the study without any adverse events. The young adults were normotensive and

the elderly were borderline hypertensive. On the days of the experimental procedure, the subjects presented similar baseline values for BP and HR, thus there was not any statistical difference between the sessions ($p > 0.05$). The data are summarized in Tables 1 and 2.

Table 2 shows the hemodynamic characteristics of the participants.

Figure 1 presents the rate of perceived exertion (RPE) (panel A) and HR (panel B). There were no differences in the perception of effort between the groups in any of the time points ($p > 0.05$). However, at the end of the FT (50 minutes), the young FT group reported higher physical stress as compared with their baseline ($p < 0.05$). Conversely, the HR increased in both groups as compared with their baseline at 10, 30 and 50 minutes ($p < 0.05$), but no significant differences were observed between the groups ($p > 0.05$).

The pressure responses during the experimental sessions are presented in Figure 2. The chronotropic response to exercising was similar between the two groups. Increases in systolic BP were observed in relation to their baseline at 10, 30 and 50 minutes ($p < 0.05$), however without differences in diastolic BP. In addition, no differences were reported between the experimental sessions ($p > 0.05$).

As in the case of systolic and diastolic BP, it was shown that the FT session resulted in increased myocardium effort as compared with baseline, as the DP was raised at 10, 30 and 50 minutes of measurement (reaching 20,000 and 23,000 mm Hg \times bpm for young adults and the elderly, respectively) ($p < 0.05$) (Figure 3). However, there was no difference between the groups ($p > 0.05$).

The FT protocol was able to promote PEH (Figure 4). In young adults FT, systolic BP decreased at 40, 50 and 60 minutes, with a higher reduction of 10.4 ± 4.9 mm Hg. In the elderly FT, there was a decrease at 30, 40, 50 and

Table 1. Baseline anthropometric characteristics

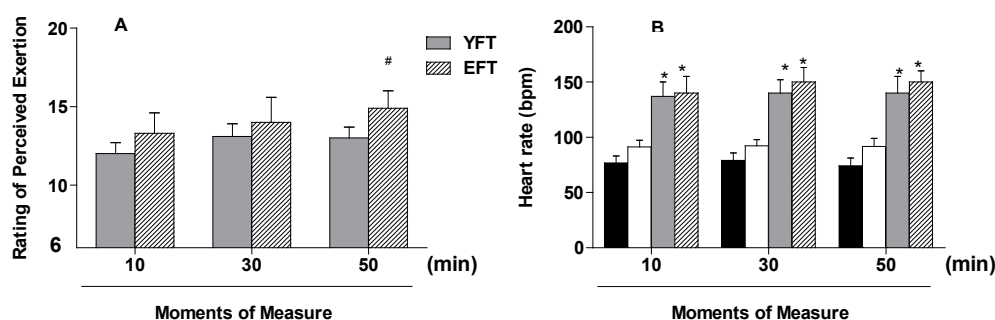
Young/elderly (n)	14	15
Age (years)	23.3 \pm 2.0	68.0 \pm 4.0
Height (m)	1.70 \pm 1.0	1.65 \pm 0.3
Weight (kg)	69.7 \pm 6.0	74.7 \pm 6.0
BMI (kg \cdot m ⁻²)	24.2 \pm 1.6	27.6 \pm 1.2

Data are presented as means \pm standard deviations.
BMI – body mass index

Table 2. Baseline hemodynamic characteristics of the subjects

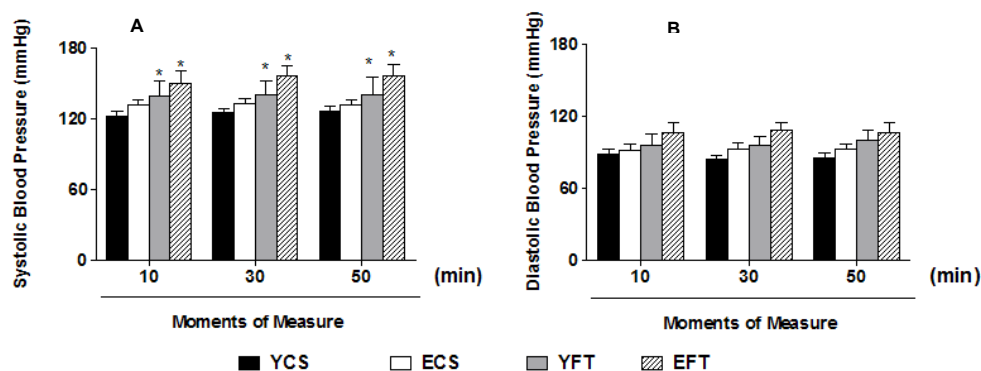
	Young adults, control session	Elderly, control session	Young adults, functional training	Elderly, functional training
SBP (mm Hg)	125.0 \pm 11	130.5 \pm 12	124.4 \pm 4	132.0 \pm 6
DBP (mm Hg)	82.2 \pm 5	86.7 \pm 7	82.0 \pm 8	90.2 \pm 9
HR (bpm)	74.3 \pm 8	80.0 \pm 10	76.5 \pm 7	80.2 \pm 11

Data are presented as means \pm standard deviations. SBP – systolic blood pressure, DBP – diastolic blood pressure, HR – heart rate



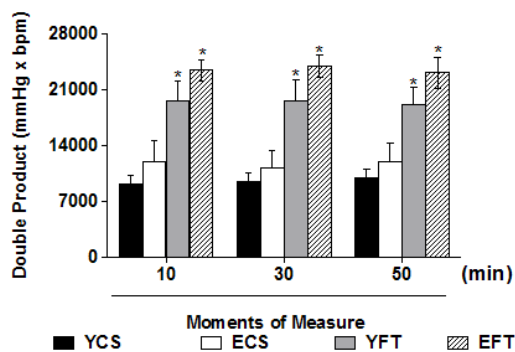
* Significant differences ($p < 0.05$) compared with baseline, # Significant differences ($p < 0.05$) compared with the YFT group.
YFT – young adults, functional training, EFT – elderly, functional training

Figure 1. A. Perceived exertion mentioned by the subjects during the exercises. B. Heart rate during the exercises. ANOVA (group vs. time)



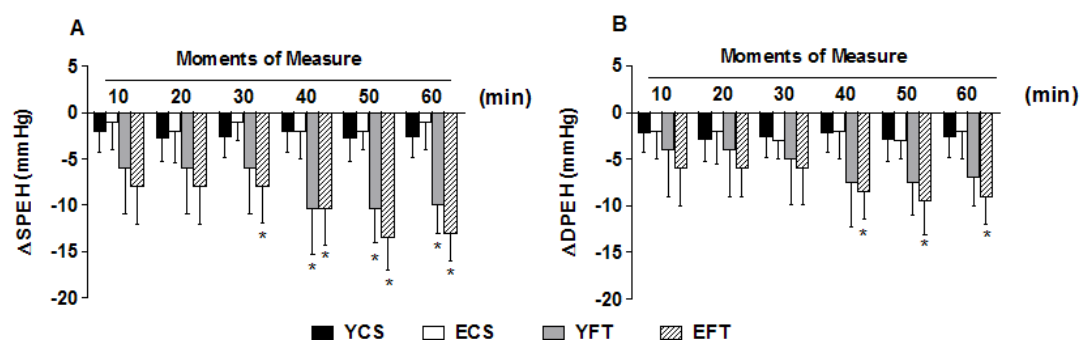
* Significant differences ($p < 0.05$) compared with baseline.
YCS – young adults, control session, ECS – elderly, control session, YFT – young adults, functional training, EFT – elderly, functional training

Figure 2. A. Systolic blood pressure during the exercises. B. Diastolic blood pressure during the exercises. ANOVA (group vs. time)



* Significant differences ($p < 0.05$) compared with baseline.
YCS – young adults, control session, ECS – elderly, control session, YFT – young adults, functional training, EFT – elderly, functional training

Figure 3. Double product values. ANOVA (group vs. time)



* Significant differences ($p < 0.05$) compared with baseline.
YCS – young adults, control session, ECS – elderly, control session, YFT – young adults, functional training, EFT – elderly, functional training

Figure 4. A. Systolic post-exercise hypotension (SPEH). B. Diastolic PEH (DPEH). ANOVA (group vs. time)

60 minutes, with a higher reduction of 13.4 ± 3.8 mm Hg. Regarding diastolic BP, although there was a reduction in the final measurement of recovery in both groups, reaching a higher reduction of 7.4 ± 4.9 mm Hg (young) and 9.4 ± 3.6 mm Hg (older adults), no significant changes were observed in young adults FT. In turn, there was a significant decrease in the elderly FT at 40, 50 and 60 minutes ($p < 0.05$).

Discussion

The results of the study show that a single session of FT is able to promote PEH in normotensive young adults and borderline hypertensive elderly people, as well as impose an effort on the cardiovascular system (as observed by the increased BP and DP), but without changing the RPE. This is the first study to illustrate that FT can be used as an adjuvant tool for the control of hypertension.

Previous data already indicate that the practice of FT promotes improvement in the kinetic chain and muscle balance, helps avoid injury in athletes [26], stimulates gains in muscle strength [7], reduces injury in the skeletal muscle [9] and lumbar pain [8]. However, investigations of possible benefits from the cardiovascular standpoint have not been disclosed to date.

Several non-pharmacological methods have been studied to reduce hypertension. Among these, one can mention alternative techniques – such as meditation, relaxation therapies, and psychological education ('biofeedback techniques') – and techniques involving exercises – aerobic, anaerobic, yoga [16], and circuit-type [27, 28]. The former ones, although they do not confer adverse risks to participants, are bound with several methodological weaknesses (small sample size, heterogeneous results and protocols, and lack of appropriate control groups) that prevent practical recommendations to be formulated for hypertensive populations [16, 29]. On the other hand, the exercise techniques, which comprise a wide variety of methods/types, have acquired consolidated body of evidence referring to the prevention/minimization of higher BP [17].

The magnitude of PEH is very important, since high BP levels are associated with increased morbidity from all causes [29]. It is known that the higher BP, the higher PEH [20, 30]. In the present study, young adults and elderly people presented similar mean systolic PEH (-8.1 vs. -10.1 mm Hg, respectively) and mean diastolic PEH (-5.8 vs. -7.5 mm Hg, respectively), which can be explained by the similarity of their BP values at baseline. It has been suggested that the reduction of merely 5 mm Hg in arterial BP leads to a 40% reduction in the risk of cerebrovascular accidents, and a 15% reduction the risk of acute myocardial infarctions [31]. In the present study, benefits could have been even greater since reductions observed at rest were greater than 5 mm Hg for systolic BP, suggesting a benefit from practicing FT in the two different populations.

Besides the BP levels at baseline, the type of exercise performed also influences the magnitude of PEH [17]. The majority of studies show that aerobic exercises are more effective in promoting PEH in comparison with resistance exercises. These values range from 2 to 17 and from 2 to 7 mm Hg for systolic and diastolic BP, respectively, in aerobic exercises [4, 32]. For resistance exercises, most studies prove a reduction of 2–13 mm Hg for systolic BP and 2–7.9 mm Hg for diastolic BP [23, 32–36]. On the basis of the PEH values found in this study, the effectiveness and possibility are evident of applying FT in order to promote PEH in borderline hypertensive patients. Nevertheless, if such a reduction is also observed in individuals with higher BP, the present study and the current literature are not able to respond properly.

The fact that our study was carried out in a university fitness centre, offering FT programs, enabled us to provide data from relevant populations. The results of the research demonstrate that our work has external validity, since it shows that even normotensive trained people, a population more difficult in achieving hypotensive responses owing to physiological adaptations [37], can benefit of regular training (as it is logical to be engaged in an training program). Additionally, the older adults, with borderline higher BP and receiving anti-hypertensive drugs, can also benefit from FT.

RPE provides a global quantification of an individual's effort or fatigue, taking into account physiological, psychological, and performance factors [38]. The perceived effort may be an important modifier of what a person does versus what the person can do during certain protocol of exercise. The impact of interventions on participation may be influenced by a patient's perception of the ability to exercise. Thus, if FT is perceived to be effortful, an elderly person may limit their physical activity for recreation and promotion of good health. In the present study, there was no alteration of RPE with FT, which demonstrates its possibility to be included as an exercise routine in the long term.

Unfortunately, although the cardiovascular repercussions prove beneficial, it is necessary to investigate whether hypertensive patients can maintain an FT protocol, with several muscle groups being exercised for several sessions, without symptoms of chronic fatigue. These issues constitute a line of future research to provide effective and safe methodologies on the prescription of FT for older adults.

DP is a variable hardly ever used by health professionals. Nevertheless, the parameter is directly related with HR and BP, being an estimate of myocardial effort and therefore expressing the exercise intensity on the myocardium [39]. According to Pollock et al. [40], the rate of work imposed on the myocardium presents differences between aerobic and anaerobic exercises. In resistance exercises, it would be lower than in aerobic exercise (owing to a lower DP achieved in the former because of lower peak HR). Unfortunately, the study did not compare FT with other exercise modalities. It is there-

fore suggested to conduct research that would compare alternative training methods (such as FT, yoga) with 'classical' protocols (aerobic and anaerobic) with regard to the impact of these modalities on the myocardium effort and the consequent risk of adverse effects during exercise.

The present study has some limitations. First, only the clinical BP status was measured. Although BP measurement in a clinical laboratory is the classical form of BP assessment, ambulatory BP (characterized by measurements throughout the day) has been shown to be a better predictor of target organ damage [41]. Moreover, this method allows to compare BP in the laboratory environment and during the awake period, contributing to the detection of 'white coat hypertension' [42]. Second, the results of the study cannot be extrapolated to people with higher degree hypertension, since the participants were normotensive (young adults) and borderline hypertensive (the elderly).

Conclusions

A single session of FT is able to promote PEH in normotensive young adults and borderline hypertensive older patients, but without changing the RPE in comparison over time. In this way, FT can be an effective adjunct therapy for high BP, worth including in clinical guidelines, yet in the present state of the art, with the great heterogeneity of FT practices and the variable quality of the research, it is difficult to recommend any specific FT protocol for high BP. Future research needs to focus on high quality clinical trials along with studies on the mechanisms of action of different FT practices.

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