Original research

A single functional training session induces positive emotions and post-exercise hypotension

Une seule séance de formation fonctionnelle induit des émotions positives et hypotension post-exercice

Summary

Objectives: Post-exercise hypotension (PEH) is a clinically relevant phenomenon, which occurs after aerobic and resistance exercises. However, its existence following functional training (FT) remains unknown with negative feelings induced by the high intensity component of FT a potentially limiting factor to adherence of FT. Thus, the aim of this study was to examine the effects of a single bout of FT on psychophysiological (blood pressure and affective emotional) responses. **Equipment and methods:** Twenty-three female (n = 9) and male (n = 14) young (21.4 ± 3.8 years) with normal blood pressure (systolic and diastolic blood pressure 109 ± 10 and 65 ± 7 mmHg, respectively) and body mass index (24.7 ± 4.6 kg/m^2) completed two experimental sessions in a random order: no exercise/control or FT session. The FT bout consisted of four phases including warm-up, two phases neuromuscular and last one phase with high-intensity interval training. During each phase, ratings of perceived exertion and affective responses (Feeling and Felt Arousal Scales) were obtained. Blood pressure was obtained before and up to 60-minutes after the experimental sessions. Data were analyzed by analysis of variance with significance achieved at $p<0.05$. **Results:** During the FT session, participants reported positive and pleasant affective scores (Feeling Scale = +1 to +5; Felt Arousal Scale = 2 to 5) with moderate levels of perceived exertion. The FT session promoted a post-exercise blood pressure [~8 (Δ = -7.5%), 5 (Δ = -6.3%) and 6 (Δ = -7.5%) mmHg change for systolic, diastolic, and mean blood pressure, respectively; $P<0.01$] decreased and remaining lower as compared with the control session ($P<0.01$). A FT session resulted in a moderate level of perceived exertion, and positive emotional responses followed by PEH for up to 60 minutes. These positive affective and cardiovascular effects highlight FT as a potentially beneficial exercise modality to address exercise adherence and cardiovascular risk.

Résumé

Objectifs: L'hypotension post-exercice (HPE) est un phénomène couramment observé qui survient après des exercices d'aérobie et de résistance. Cependant, son existence suite à une formation fonctionnelle (FF) reste inconnue avec des émotions negatives induites par la composante de haute intensité de la FF, un facteur potentiellement limitant à l'adhérence de l'entraînement fonctionnel. Ainsi, le but de cette étude était d'examiner les effets d'un seul épisode de FF sur les réponses psychophysiologiques (tension artérielle et la réponse affective à l'exercice). **Méthodologie**: Vingt-trois jeunes femmes (n = 9) et hommes (n = 14) (21,4 ± 3,8 ans) avec une tension artérielle normale (pression artérielle systolique et diastolique 109 ± 10 et 65 ± 7 mmHg, respectivement) et un indice de masse corporelle (24,7 ± 4,6 kg / m2) ont effectué deux séances expérimentales dans un ordre aléatoire: pas d'exercice/contrôle ou séance FF. La session de FF combinnait quatre phases comprenant un échauffement, deux phases d'entraînement neuromusculaire et la dernière phase avec un entraînement par intervalles à haute intensité. Chaque phase était suivie d'évaluation subjective de l'effort perçu et des réponses affective. La pression artérielle a été obtenue avant et jusqu'à 60 minutes après les séances expérimentales. Les données ont été analysées avec une analyse de la variance et un niveau de significativité de p < 0,05. **Résultats:** Au cours de la séance de FF, les participants ont rapporté des scores affectifs positifs et agréables (Échelle de sentiment = +1 à +5; Échelle d'excitation ressentie = 2 à 5) avec des niveaux modérés d'efforts perçus. La séance de FT a diminuée la pression artérielle post-exercice [~8 (Δ = -7.5%), 5 (Δ = -6.3%) et 6 (Δ = -7.5%) mmHg de changement pour la pression artérielle systolique, diastolique et moyenne, P <0,01] tout en restant inférieure par rapport à la séance témoin (P <0,01). Une séance de FF a entraîné un niveau d'effort perçu modéré et des réponses émotionnelles positives suivies de PEH pendant 60 minutes. Ces effets affectifs et cardiovasculaires positifs soulignent le FF comme une modalité d'exercice potentiellement bénéfique pour améliorer l'observance à l'exercice et

réduire le risque cardiovasculaire.

Keywords: Blood pressure; Cardiovascular response; Feeling Scale; Felt Arousal Scale; Multicomponent Training.

Mots clés: Tension artérielle; Réponse cardiovasculaire; Échelle des sensation; Échelle d'excitation.

Introduction

Functional training (FT), an exercise modality that incorporates functional and multimodal movements designed to improve physical fitness and performance, has become popular over the last decade [1, 2]. Several studies have shown positive effects of FT on stability, motor coordination and muscular endurance in different populations [1, 3, 4] with low injury rate [5], and with FT bouts reported to result in energy expenditures that meet exercise recommendations for health [6]. Although FT is widely used in clinical practice to improve patient's health and functional capacity [3, 6, 7], the acute cardiovascular responses to a single session of FT remain poorly known. A greater understanding of these responses would confirm potential risks of engaging in FT and/or support the widespread use of FT to enhance health.

Post-exercise hypotension (PEH) is a typical cardiovascular response following exercise and characterized by a post-exercise reduction in blood pressure (BP) below values observed prior to exercise [8, 9]. The degree of PEH has been considered a clinically relevant, acute cardiovascular response to exercise [10] and a predictor of future adaptations to training [11-13]. The PEH response has been well described after aerobic [14-17] and resistance exercise sessions [12, 18, 19] but very little has been reported following other exercise types, including FT. As FT incorporates strength exercises and short bouts of high intensity aerobic exercise [1, 7, 20, 21], it is feasible that PEH also occurs after this exercise type and may provide a possible alternative strategy to manage BP, reducing cardiovascular risk even after vigorous exercise. Indeed, just recently, Tibana et al [22] and Lima et al [23] showed positive cardiovascular responses after a FT session using strength, gymnastic and metabolic conditioning exercises. However, these previous studies presented some important limitations as absence of control group [22], low sample size [22, 23] and only males included [22, 23], which could impact results.

The physiological benefits of exercise over time including chronic adaptations have been well documented [24, 25], however, this adaptation relies upon adherence to training [26].

Affective feelings following exercise have been reported as an important predictor of adherence to regular exercise regimes [27]. In contrast, exercise modalities that induce negative emotional responses tend to be not well tolerated with participants not complying with long-term exercise training regimes [28, 29]. For instance, high intensity exercises have been associated with unpleasant feelings [29, 30], which may increase dropout rates during chronic exercise programs [30]. Given the inclusion of high intensity activities within FT, it is possible that FT may also induce negative emotional feelings that may deter its use in exercise regimes, affecting long-term benefits such as reduced BP response. Identification of the acute emotional responses during FT may highlight potential limitations of FT in terms of exercise adherence during chronic exercise regimes and ultimately the impact of FT to reduce cardiovascular risk.

Thus, the aims of the present study were: (i) to identify the effects of a single bout of FT on BP responses in heathy individuals; and (ii) to evaluate the affective emotional responses (positive/negative and pleasure/displeasure) during a FT session. The hypothesis was that a single bout of FT would acutely reduce BP in healthy individuals despite the experience of affective response of pleasure during the exercise session.

Materials and methods

Participants

The sample size power was determined based on the systolic BP (SBP) and diastolic BP (DBP) post-exercise responses. Considering the sample size and an alpha error of 0.05, the power (1 – β) achieved for SBP and DBP were 0.97 and 0.96, respectively, for the experimental sessions (GPower software 3.1.9).

The sample included 23 individuals aged 18 to 33 years who were recruited from the university and local communities. Inclusion criteria were: (i) aged 18 – 35 years; (ii) no self-reported ankle instability; (iii) no chronic diseases (diabetes, hypertension, dyslipidemia); (iv) no osteoarticular and musculoskeletal diseases; (v) no surgical procedures in the last year and; (vi) no reported limitation in upper or lower limb function; (vii) no previous participation in any FT program. This study, which was in accordance with the Ethical Guidelines of the Helsinki Declaration, was approved by the Joint Committee on Ethics of Human Research of the University. Each participant was informed of the risks and benefits involved in the study and signed a written informed consent form before participation.

Study design

The present study included five visits. At the first visit, participants undertook an evaluation of medical history and physical activity levels via questionnaire, followed by assessment of anthropometric measurements (height and weight) and resting BP. At the 2nd and 3rd visits, participants completed familiarization sessions including the FT exercises and anchoring instructions for the rating of perceived exertion (RPE) scale [31], Felling Scale and Felt Arousal Scale [32]. During the 4th and 5th visits, participants completed two experimental sessions with each separated by 48 hours (Figure 1).

INSERT FIGURE 1

Pre-experimental procedures

Individuals data (gender and age), medical history (proportion of risk factors), drug use and physical activity levels were self-reported using a questionnaire. Body weight and height were measured using an analogue weighing scale with 0.1 kg precision (Filizola, MIC 2B/A Mecânica Antrop. 300 kg, Brazil) and a wooden stadiometer with accuracy of 0.001 m, respectively. Body mass index was calculated as weight/height^2. Resting BP (SBP, DBP, Mean

BP – MBP) was measured in both arms by a calibrated oscillometric monitor (Microlife BP3BT0-A, Microlife Corporation, Taipei, Taiwan) with the participant at rest and sitting [33]. Three consecutive recordings (1-minute interval between recordings) were obtained in each arm after five minutes of rest during two separate visits (Visit 2 and 3). The arm with the highest recorded BP was chosen for all BP evaluations during the experimental sessions (Visit 4 and 5). Within-individual BP variation was evaluated by the test and retest values measured in visit 4 (pre-intervention), expressed in relative terms to the variable mean values. Therefore, the coefficients of variation were 1.3, 4.7 and 2.6% for SBP, DBP and MBP, respectively, being coefficient of variation <20% considered desirable and >30% undesirable [34]. Finally, peak heart rate (HR – beats per minute [bpm]) that was used to monitor exercise intensity was calculated as 220 – age [35, 36].

During the familiarization sessions, participants were instructed on how to classify the perceptions felt during FT and how to perform the FT exercises during the experimental sessions, considering that individuals were not used to this type of training. For the Feeling Scale, participants received the following instructions: "When exercising, it is very common to experience fluctuations on mood. Some people feel exercise enjoyable, while others feel it unpleasant, and these feelings can fluctuate over time, feel good and bad a number of times during exercise. This scale was developed to measure such responses". The Feeling Scale was a bipolar scale that ranged from –5 (very bad) to +5 (very good). Participants then received instructions on the use of the Felt Arousal Scale during exercise with verbal anchors provided to describe the ways in which arousal may be experienced. Participants were told that "high arousal might be characterized by feelings of excitement, anxiety, or anger, and low arousal by feelings of relaxation, boredom or calmness". The Felt Arousal Scale ranged from 1 ("low arousal") to 6 ("high arousal"). Finally, participants received instructions on the use of the RPE scale with the following instructions provided: "You are about to perform exercise. The scale you are viewing contains the range of numbers 0-10 and will be used to evaluate your perception of exertion during exercise. Perceived effort is defined as the subjective intensity of exertion, tension, discomfort, and/or tiredness you feel during exercise. This scale is used to translate your feelings of effort into numbers. The number on this scale represents a range of feelings from effortless to extremely intense".

After these anchoring procedures, each participant completed the individual FT session while being supervised by an experienced coach, aiming to maintain established protocols and standardized stimuli. During each familiarization session, participants performed the four phases of the FT regime: (i) Warm-up (joint mobility – ankle, hip and glenohumeral, and coordination exercises); (ii) Neuromuscular 1 (four stations for strength exercises and two stations for agility and coordination); (iii) Neuromuscular 2 (four stations representing activities of daily life and two stations for transport activities) and; (iv) Cardiometabolic phase (short bouts of high-intensity interval training – HIIT; 10 secs running with 10 secs of passive recovery between). All exercises included in the study were performed with free weights or body weight with an overview of the FT session shown in Table 1.

INSERT TABLE 1

Experimental protocol

Participants underwent two experimental sessions (FT and control – C) in a randomized order (via computer random number generator). Participants were instructed to have a light meal two hours before arriving at the laboratory and not to ingest coffee, tea or other stimulants for 12 hours before the sessions. They were also instructed to refrain vigorous physical activity for the previous 48 hours and from alcohol ingestion for the previous 24 hours. Laboratory temperature was kept between 20–22°C and all sessions were performed between 13:00 and 16:00 and each lasted approximately two hours as shown in Figure 2.

INSERT FIGURE 2

Patients arrived at 13:00 p.m. and received a standardized bottle of water (~ 200 ml) to drink during both experimental sessions. After that, the pre-intervention period started with individuals resting in the seated position for 10 minutes, followed by BP assessments in triplicate. Resting BP was measured using a previously calibrated oscillometric monitor (Microlife BP3BT0-A, Microlife Corporation, Taipei, Taiwan) in accordance with standardized, national recommendations for BP monitoring [33].

The FT experimental session included four phases as described previously with participants performing the Neuromuscular 1 and Neuromuscular 2 phases twice with one minute per station. During all phases, exercise intensity was monitored every minute by RPE and HR (> 80% of peak HR) obtained by a telemetric cardiac monitor (Polar RS800CX; Polar Electro, Kempele, Finland). Affective responses (negative/unpleasant and positive/pleasant) were measured by the Feeling Scale and Felt Arousal Scale at end of each phase. During the C session, participants remained standing for ~35 minutes, the same approximate duration of the FT session.

After the FT and C interventions, participants returned to a seated position for 60 minutes (post-intervention period) where BP was measured in triplicate, every 15 minutes from 30 minutes onwards (Figure 2). The mean values of the triplicate measurements at each time-point were used for later analyses (pre- vs. post-intervention).

Statistical analysis

Normal and homogeneous distribution of the data were confirmed by the Shapiro Wilk and Levene's test. BP responses were analyzed using two-way analysis of variance (ANOVA) for repeated measures and post-hoc Newman-Keuls tests with the main factors being session (FT and C) and time (pre- vs, 30-, 45-, 60-mins post-intervention). Additionally, psychophysiological responses (HR, RPE, and Feeling and Felt Arousal Scales) during the exercise phases were compared via one-way ANOVA and least significant difference, post-hoc tests for multiple comparisons. For all analyses, the value of $P < 0.05$ was considered significant. Statistical analyses and figure production were performed using Statistica 10.0 (Statasoft Inc., Tulsa, OK, USA) and GraphPad Prim (GraphPad Software Inc., La Jolla, California, USA), respectively. All data analyses were conducted by the same investigator who was blinded to the interventions and experimental sessions.

Results

Thirty-five individuals were initially recruited with 12 declining to participate and undertake all procedures. Thus, 23 healthy adults participated in this study with their characteristics shown in Table 2. Participants were young, physically active and mostly males (n=14) with normal BP and body mass index. The C session was the first experimental intervention for 10 participants while the FT session was the first experimental intervention for the remaining 13 participants.

INSERT TABLE 2

BP responses after both experimental sessions are shown in Figure 3. Compared with pre-intervention, SBP, DBP and MBP were significantly decreased and remained lower following the FT intervention with values significantly lower than corresponding post-intervention timepoints during the C session (Figure 3).

INSERT FIGURE 3

Psychophysiological responses during exercise within the FT session are shown in Figure 4. During exercise, HR remained within the prescribed limits between 165±11 and 178±8 bpm (> 80% of peak HR, Figure 4A) with participants experiencing moderate RPE levels (Figure 4B) that increased after warm-up (Warm-up: 4±2; Neuro 1: 7±2; Neuro 2: 6±2; HIIT: 8±2, $p<0.05$). During exercise within the FT session, participants experienced positive feelings (Warm-up: 2±1; Neuro 1: 1±2; Neuro 2: 2±2; HIIT: 1±3, $p>0.05$) (Figure 4C) and moderate arousal (Warm-up: 4±1; Neuro 1: 3±1; Neuro 2: 4±2; HIIT: 3±2, $p>0.05$) (Figure 4D).

INSERT FIGURE 4

Discussion

Our results demonstrated that a single FT session resulted in acute positive feelings, moderate arousal and RPE, and a significant, post-exercise reduction in BP (i.e. PEH) that lasted for at least 60 minutes. These positive affective and cardiovascular effects confirm FT as a potentially beneficial exercise modality to address exercise adherence and cardiovascular risk.

The magnitude of the SBP and DBP responses observed in the current study (greatest drop: -8 and -5 mmHg, respectively) were similar to previous studies for healthy individuals undertaking aerobic, resistance and FT sessions [22, 23, 37-40]. It is important to highlight that FT protocols (volume, exercises and recovery intervals) performed in aforementioned studies were different as compared to current study. Indeed, Tibana's study [22] used strength (snatch from blocks, jerk blocks), gymnastic (weighted plank hold, strict handstand push up), and metabolic conditioning (power snatches, power snatches, target burpees) exercises, with recovery intervals varying between 90 seconds and five minutes, while Lima's study [23] used 10 exercises (between them – squat jump over the bar, skipping rope, squat with calf raise) in circuit training with 60 minutes of duration. Taken together, these results showed an important cardiovascular effect from FT session, despite these differences abovementioned.

Therefore, the acute cardiovascular effects of the current FT session were relevant. This is further important because the magnitude presented has been recommended as being clinically significant [10, 41]. For example, previous study from Moreira et al [13] demonstrated that subjects with acutely decreased SBP or DBP presented higher chronic decreases in BP compared with subjects without acute decreases, suggesting that acute response may mirror the chronic adaptation to exercise training. The mechanisms underlying the FT-induced PEH response were not investigated in the current study. However, it is possible that the PEH response was a result of decreased peripheral vascular resistance [42, 43] as reductions in both SBP and DBP were noted. Potentially, the HIIT performed at the end of FT session may have enhanced this vasodilatory response and amplified the PEH response [44]. Future studies should clarify the mechanisms responsible for hypotension after FT exercise and their contribution to future cardiovascular risk.

Given the favorable cardiovascular response induced by FT, it was crucial to also examine the affective or emotional responses to the bout and confirm any potential adherence issues associated with FT for future chronic exercise regimes. Positive scores on the Feeling Scale and Felt Arousal Scale were observed during the entire FT session including the HIIT component. This affect was unexpected, once a previous study employing HIIT (4-6 × 30 s of all-out cycling efforts at 180% of peak workload with 4-min recovery) with twenty-six healthy middle-age sedentary men reported unpleasant sensations during the exercise bout [45]. Differences between studies might explain these contrasting responses. Firstly, participants in the current study were physically active with affective responses reported to be more unpleasant for insufficiently active subjects [46]. It is important to highlight that participants self-reported that they did not engage of any FT program before to start our study, which could influence affective responses. Second, our protocol involved low-volume HIIT with feelings of pleasure reported during lower volume exercises compared to high-volume [46]. Finally, FT usually is performed with variety of exercise, using functional and multimodal movements [1, 2], which could avoid annoying stimulus and stimulates positive emotional response. Importantly, the current results indicated that a FT session was well tolerated by healthy individuals with FT potentially a valuable exercise modality for future chronic exercise regimes. Future studies are encouraged to examine whether a FT focused exercise program could sustain positive emotions in the long-term, contributing to greater adherence and physical activity engagement.

In this study, exercise intensity was prescribed using peak HR obtained by index 220 – age. This option aimed to increase the clinical applicability, as a maximal treadmill test is not feasible for several practitioners. The results indicated that during exercise session, individuals were able to maintain the target (80 – 90% of peak HR). Interestingly, although high HR levels were experienced, participants reported only a moderate perceived exertion, despite perceived exertion to be an useful indicator of the cardiovascular response during FT session [47]. These findings are in accordance to previous study [48] that support the notion that the relative contribution of motor drive and physiological afferent feedback (i.e. heart rate) may differ in the development of these variables. Indeed, it appears likely that perceptions of effort are strongly influenced by information being sent directly from motor to sensory regions of the brain (i.e. efference copies of central drive) or from higher brain centres [49, 50] rather than actual peripheral physiological disturbances and associated afferent sensory feedback.

Our results suggest to the coach or practitioner that a FT session prescribed at 80 and 90% of peak HR is a pleasurable mode of exercise and can acutely reduce BP in healthy subjects. Furthermore, it is important to highlight some aspects that favor the ecological validity of this study: i) FT can be successfully implemented and maintained in a real-life setting; ii) use of simple tools to assess cardiovascular and psychometric responses to exercise (i.e., Borg scale, Feeling Scale and Felt Arousal Scale), which may be easily integrated into practice by exercise professionals. Thus, this mode of exercise could be included as an alternative strategy to improve adherence and to manage BP in different populations. Future studies are still necessary to analyze adherence to FT protocols, the chronic adaptations of this exercise mode on cardiovascular parameters, and to compare their effects with other forms of exercise (e.g., resistance and aerobic exercise).

This study has provided important findings about FT but some limitations should be mentioned. First, all individuals were healthy and physically active. Therefore, caution should be made in generalizing these findings to other populations including clinical (e.g. hypertensive patients) with future studies encouraged to examine FT in clinical populations. Second, BP responses were analyzed for only 60 minutes after FT exercise with further investigation warranted to examine the lasting extent of these effects including when the individual is ambulant. Third, exercise prescription was based on predicted maximal HR with the prescription of FT based on actual maximal HR potentially impacting both affective and BP responses that remains to be confirmed. Furthermore, the mental and/or emotional status of participants (e.g., mood, stress, depression, etc.) was not assessed during the pre-experimental procedures and prior to the FT session. Potentially, FT-induced response may differ with individuals of varying mental and/or emotional status that remain to be identified. Finally, the participants did not receive any standardized meal before experimental sessions. However, diet was controlled, in part at least, once we instructed the participants to have a light meal two hours before arriving at the laboratory and not to ingest coffee, tea or other stimulants for 12 hours before the sessions. Futures studies should control better this aspect.

Conclusion

Healthy adults completed a feasible and well-tolerated FT session that resulted in moderate levels of perceived exertion, and positive emotional responses followed by a substantial post-exercise reduction in BP for up to 60 minutes. These favorable responses indicate that incorporating FT bouts within chronic exercise regimes may be beneficial for future health outcomes and cardiovascular risk.

Conflict of interest: none declared

Authors' contribution:

SILVA DR, RITTI-DIAS RM, and ANDRADE-LIMA A: conception and design, analysis and interpretation of data, drafting the article, and revised it critically for important intellectual content.

LEICHT AS, SILVA-GRIGOLETTO ME, and ROGÉRIO BW: analysis and interpretation of data, drafting the article, and revised it critically for important intellectual content;

PANTALEÃO AEM, SOUZA AA, HORA JEJ, and SILVA GIC: acquisition of data, analysis and interpretation of data

All authors approved the final manuscript and agreed to be accountable for all aspects of the work.

References

1. Distefano LJ, Distefano MJ, Frank BS, Clark MA, Padua DA. Comparison of integrated and isolated training on performance measures and neuromuscular control. J Strength Cond Res 2013; 27: 1083-90.

2. Granacher U, Lacroix A, Muehlbauer T, Roettger K, Gollhofer A. Effects of core instability strength training on trunk muscle strength, spinal mobility, dynamic balance and functional mobility in older adults. Gerontology 2013; 59: 105-13.

3. Tomljanović M, Spasić M, Gabrilo G, Uljević O, Foretić N. Effects of five weeks of functional vs. traditional resistance training on anthropometric and motor performance variables. Kinesiology: International journal of fundamental and applied kinesiology 2011; 43: 145-54.

4. Tait JL, Duckham RL, Milte CM, Main LC, Daly RM. Influence of Sequential vs. Simultaneous Dual-Task Exercise Training on Cognitive Function in Older Adults. Front Aging Neurosci 2017; 9: 368.

5. Tibana RA, Sousa NMF. Are extreme conditioning programmes effective and safe? A narrative review of high-intensity functional training methods research paradigms and findings. BMJ Open Sport & Exercise Medicine 2018; 4.

6. Lagally KM, Cordero J, Good J, Brown DD, McCaw ST. Physiologic and metabolic responses to a continuous functional resistance exercise workout. J Strength Cond Res 2009; 23: 373-9.

7. Kibele A, Behm DG. Seven weeks of instability and traditional resistance training effects on strength, balance and functional performance. J Strength Cond Res 2009; 23: 2443-50.

8. Kenney MJ, Seals DR. Postexercise hypotension. Key features, mechanisms, and clinical significance. Hypertension 1993; 22: 653-64.

9. de Brito LC, Fecchio RY, Pecanha T, Lima A, Halliwill J, Forjaz CLM. Recommendations in Post-exercise Hypotension: Concerns, Best Practices and Interpretation. Int J Sports Med 2019; 40: 487-97.

10. Brito LC, Fecchio RY, Pecanha T, Andrade-Lima A, Halliwill JR, Forjaz CLM. Postexercise hypotension as a clinical tool: a "single brick" in the wall. J Am Soc Hypertens 2018; 12: e59-e64.

11. Luttrell MJ, Halliwill JR. Recovery from exercise: vulnerable state, window of opportunity, or crystal ball? Frontiers in physiology 2015; 6: 204.

12. Romero SA, Minson CT, Halliwill JR. The cardiovascular system after exercise. J Appl Physiol (1985) 2017; 122: 925-32.

13. Moreira SR, Cucato GG, Terra DF, Ritti-Dias RM. Acute blood pressure changes are related to chronic effects of resistance exercise in medicated hypertensives elderly women. Clin Physiol Funct Imaging 2016; 36: 242-8.

14. Cucato GG, Chehuen Mda R, Ritti-Dias RM, Carvalho CR, Wolosker N, Saxton JM, et al. Post-walking exercise hypotension in patients with intermittent claudication. Med Sci Sports Exerc 2015; 47: 460-7.

15. Cavalcante BR, Ritti-Dias RM, Soares AH, Lima AH, Correia MA, De Matos LD, et al. A Single Bout of Arm-crank Exercise Promotes Positive Emotions and Post-Exercise Hypotension in Patients with Symptomatic Peripheral Artery Disease. Eur J Vasc Endovasc Surg 2017; 53: 223-8.

16. Forjaz CL, Ortega KC, Santaella DF, Mion Jr D, Negrão CE. Factors affecting post-exercise hypotension in normotensive and hypertensive humans. Blood Press Monit 2000; 5: 255-62.

17. Carpio-Rivera E, Moncada-Jimenez J, Salazar-Rojas W, Solera-Herrera A. Acute Effects of Exercise on Blood Pressure: A Meta-Analytic Investigation. Arq Bras Cardiol 2016; 106: 422-33.

18. Cucato GG, Ritti-Dias RM, Wolosker N, Santarem JM, Jacob Filho W, Forjaz CL. Post-resistance exercise hypotension in patients with intermittent claudication. Clinics (Sao Paulo) 2011; 66: 221-6.

19. Rodrigues LB, Forjaz CL, Lima AH, Miranda AS, Rodrigues SL, Cardoso CG, Jr., et al. A single bout of resistance exercise does not modify cardiovascular responses during daily activities in patients with peripheral artery disease. Blood Press Monit 2014; 19: 64-71.

20. Behm DG, Drinkwater EJ, Willardson JM, Cowley PM. Canadian Society for Exercise Physiology position stand: The use of instability to train the core in athletic and nonathletic conditioning. Appl Physiol Nutr Metab 2010; 35: 109-12.

21. Mok NW, Yeung EW, Cho JC, Hui SC, Liu KC, Pang CH. Core muscle activity during suspension exercises. Journal of science and medicine in sport 2015; 18: 189-94.

22. Tibana RA, Almeida LM, Sousa Neto IV, Sousa NM, Almeida JA, Salles BF, et al. Extreme Conditioning Program Induced Acute Hypotensive Effects are Independent of the Exercise Session Intensity. Int J Exerc Sci 2017; 10: 1165-73.

23. Lima RC, Oliveira CV, Gomes JB, Silva CP, Souza AM, Rabay AN, et al. Blood pressure responses after a session of functional training in young and elderly: a pilot study. Human Movement 2017; 18: 67–73.

24. Hellsten Y, Nyberg M. Cardiovascular Adaptations to Exercise Training. Compr Physiol 2015; 6: 1-32.

25. MacInnis MJ, Gibala MJ. Physiological adaptations to interval training and the role of exercise intensity. J Physiol 2017; 595: 2915-30.

26. Batrakoulis A, Loules G, Georgakouli K, Tsimeas P, Draganidis D, Chatzinikolaou A, et al. High-Intensity Interval Neuromuscular Training Promotes Exercise Behavioral Regulation, Adherence and Weight Loss in Inactive Obese Women. Eur J Sport Sci 2019: 1-25.

27. Ekkekakis P, Parfitt G, Petruzzello SJ. The pleasure and displeasure people feel when they exercise at different intensities: decennial update and progress towards a tripartite rationale for exercise intensity prescription. Sports Med 2011; 41: 641-71.

28. Burgess E, Hassmen P, Welvaert M, Pumpa KL. Behavioural treatment strategies improve adherence to lifestyle intervention programmes in adults with obesity: a systematic review and meta-analysis. Clin Obes 2017; 7: 105-14.

29. Ekkekakis P, Vazou S, Bixby W, Georgiadis E. The mysterious case of the public health guideline that is (almost) entirely ignored: call for a research agenda on the causes of the extreme avoidance of physical activity in obesity. Obesity reviews 2016; 17: 313-29.

30. Rose EA, Parfitt G. A quantitative analysis and qualitative explanation of the individual differences in affective responses to prescribed and self-selected exercise intensities. J Sport Exerc Psychol 2007; 29: 281-309.

31. Heath EM. Borg's perceived exertion and pain scales. Med Sci Sports Exerc 1998; 30: 1461.

32. Hardy CJ, Rejeski WJ. Not what, but how one feels: the measurement of affect during exercise. J Sport Exerc Psychol 1989; 11: 304-17.

33. Sociedade Brasileira de Cardiologia, Sociedade Brasileira de Hipertensão, Sociedade Brasileira de Nefrologia. [VI Brazilian Guidelines on Hypertension]. Arq Bras Cardiol 2010; 95: 1-51.

34. Rosner B. Fundamentals of Biostatistics. Boston: Brooks/Cole: Cengage Learning; 2011. 888 p.

35. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol 2001; 37: 153-6.

36. Nes BM, Janszky I, Wisloff U, Stoylen A, Karlsen T. Age-predicted maximal heart rate in healthy subjects: The HUNT fitness study. Scand J Med Sci Sports 2013; 23: 697-704.

37. Rezk C, Marrache R, Tinucci T, Mion D, Forjaz C. Post-resistance exercise hypotension, hemodynamics, and heart rate variability: influence of exercise intensity. Eur J Appl Physiol 2006; 98: 105-12.

38. Cardoso CG, Jr., Gomides RS, Queiroz AC, Pinto LG, da Silveira Lobo F, Tinucci T, et al. Acute and chronic effects of aerobic and resistance exercise on ambulatory blood pressure. Clinics (Sao Paulo) 2010; 65: 317-25.

39. Queiroz AC, Gagliardi JF, Forjaz CL, Rezk CC. Clinic and ambulatory blood pressure responses after resistance exercise. J Strength Cond Res 2009; 23: 571-8.

40. Queiroz AC, Sousa JC, Cavalli AA, Silva ND, Jr., Costa LA, Tobaldini E, et al. Post-resistance exercise hemodynamic and autonomic responses: Comparison between normotensive and hypertensive men. Scand J Med Sci Sports 2015; 25: 486-94.

41. Touyz RM, Campbell N, Logan A, Gledhill N, Petrella R, Padwal R, et al. The 2004 Canadian recommendations for the management of hypertension: Part III--Lifestyle modifications to prevent and control hypertension. Can J Cardiol 2004; 20: 55-9.

42. Queiroz AC, Sousa JC, Jr., Silva ND, Jr., Tobaldini E, Ortega KC, de Oliveira EM, et al. Captopril does not Potentiate Post-Exercise Hypotension: A Randomized Crossover Study. Int J Sports Med 2017; 38: 270-7.

43. Aprile DC, Oneda B, Gusmao JL, Costa LA, Forjaz CL, Mion D, Jr., et al. Post-Exercise Hypotension Is Mediated by a Decrease in Sympathetic Nerve Activity in Stages 2-3 CKD. Am J Nephrol 2016; 43: 206-12.

44. Ciolac EG. High-intensity interval training and hypertension: maximizing the benefits of exercise? Am J Cardiovasc Dis 2012; 2: 102-10.

45. Saanijoki T, Nummenmaa L, Eskelinen JJ, Savolainen AM, Vahlberg T, Kalliokoski KK, et al. Affective Responses to Repeated Sessions of High-Intensity Interval Training. Med Sci Sports Exerc 2015; 47: 2604-11.

46. Frazão DT dFJL, Dantas TCB, Krinski K, Elsangedy HM, Prestes J, et al. Feeling of pleasure to high-intensity interval exercise is dependent of the number of work bouts and physical activity status. PloS one 2016; 11(3): e0152752.

47. Tibana RA, Manuel Frade de Sousa N, Prestes J, da Cunha Nascimento D, Ernesto C, Falk Neto JH, et al. Is Perceived Exertion a Useful Indicator of the Metabolic and Cardiovascular Responses to a Metabolic Conditioning Session of Functional Fitness? Sports (Basel) 2019; 7.

48. Penailillo L, Mackay K, Abbiss CR. Rating of Perceived Exertion During Concentric and Eccentric Cycling: Are We Measuring Effort or Exertion? Int J Sports Physiol Perform 2018; 13: 517-23.

49. Carson RG, Riek S, Shahbazpour N. Central and peripheral mediation of human force sensation following eccentric or concentric contractions. J Physiol 2002; 539: 913-25.

50. de Morree HM, Klein C, Marcora SM. Perception of effort reflects central motor command during movement execution. Psychophysiology 2012; 49: 1242-53.

Figure legends

Figure 1. Overview of study design

Figure 2. Design of the experimental sessions

Figure 3. Mean responses in systolic (SBP, panel A), diastolic (DBP, panel B), mean (MBP, panel C) blood pressures observed after control (white circles) and functional training sessions (black circles) in 23 individuals. * Significantly ($p<0.05$) different from pre-intervention. # Significantly ($p<0.05$) different from control session.

Figure 4. Responses in heart rate peak (HR, panel A), rating of perceived exertion (RPE, panel B), Feeling scale (panel C) and Felt arousal scale (panel D) observed during functional training session in 23 individuals. * Significantly ($p<0.05$) different from warm-up. † Significantly ($p<0.05$) different from Neuro 2.

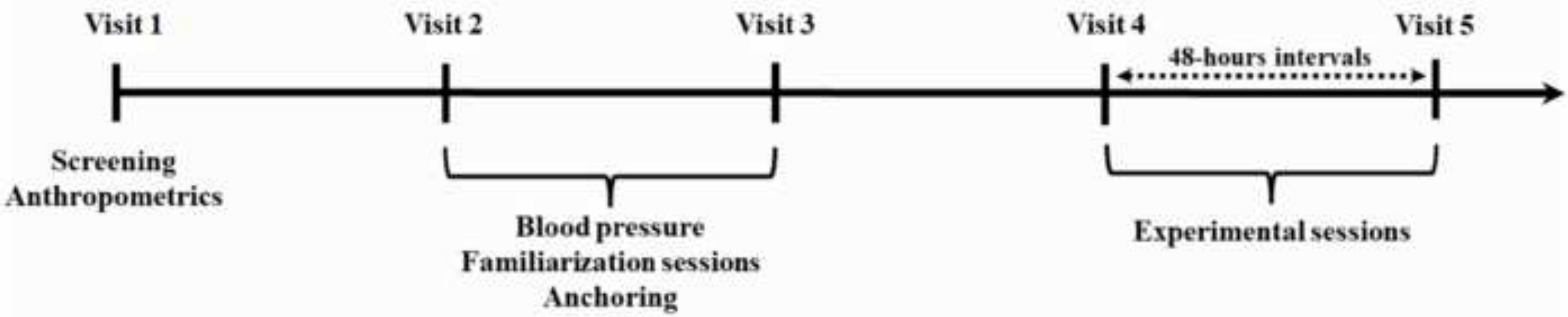
Table 1. Overview of functional training session exercises

Phases	Exercises
Warm-up	Joint mobility (Neck, shoulder, hip and ankle) Coordination exercises (Gait, One, two and stop, Skipping, Lateral displacement)
Neuromuscular 1	Agility Ladder (Cross-over in front), Vertical Jump, Medicine ball throws (Downward Slam Throw), Sprint, rope alternating wave, Horizontal jump
Neuromuscular 2	Deadlift, Pull up, Loaded carries with kettlebell (Farmers walk), Push up, Goblet Squat, Unilateral kettlebell row
Cardiometabolic	Short bouts of high-intensity interval training

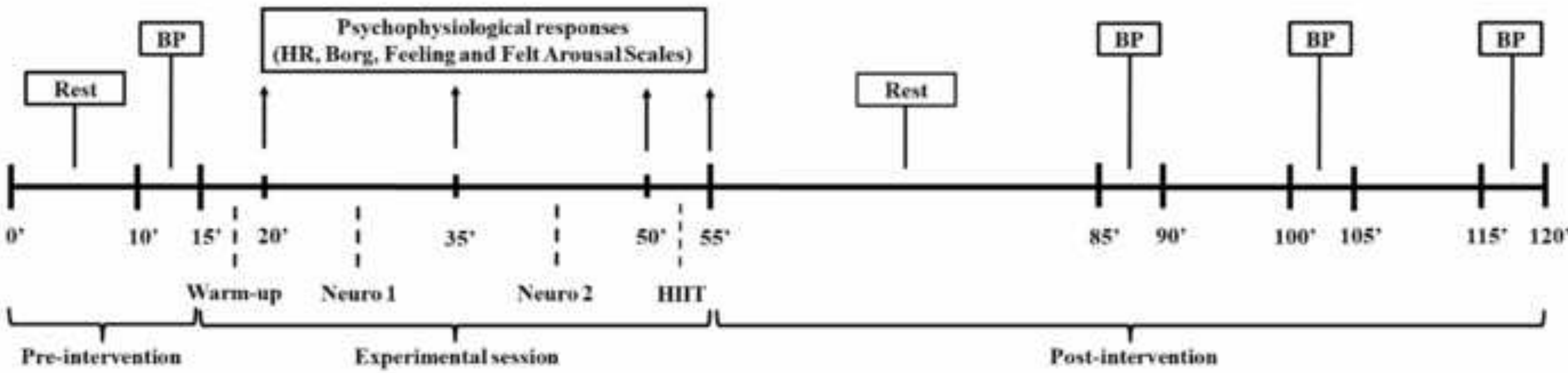
Table 2. Physical activity, resting blood pressure and characteristics of participants (n= 23).

Variables	Mean ± SD
Male / female (n)	14 / 9
Age (years)	21.4 ± 3.8
Height (m)	1.67 ± 0.07
Weight (kg)	69.2 ± 14.7
Body mass index (kg/m^2)	24.7 ± 4.6
Physical activity levels (min/week)	202 ± 22
Peak heart rate (bpm)	198 ± 12
Systolic blood pressure (mmHg)	109 ± 10
Diastolic blood pressure (mmHg)	65 ± 7
Mean blood pressure (mmHg)	80 ± 7

Data are mean ± Standard deviation

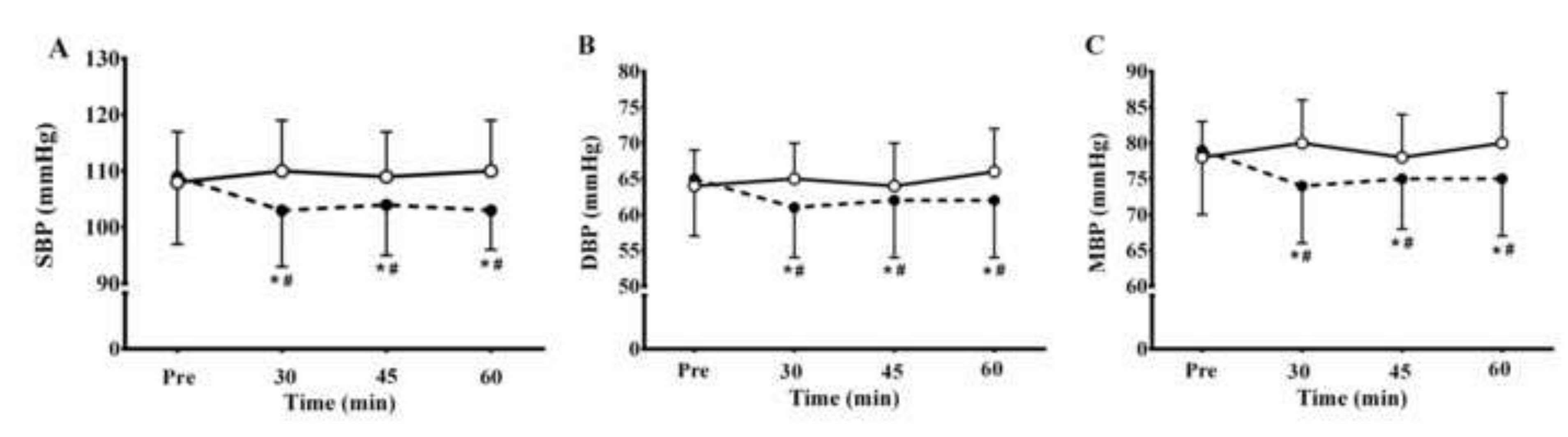

Visit 1
Visit 2
Visit 3
Visit 4
Visit 5
48-hours intervals
Screening
Anthropometrics
Blood pressure
Familiarization sessions
Anchoring
Experimental sessions

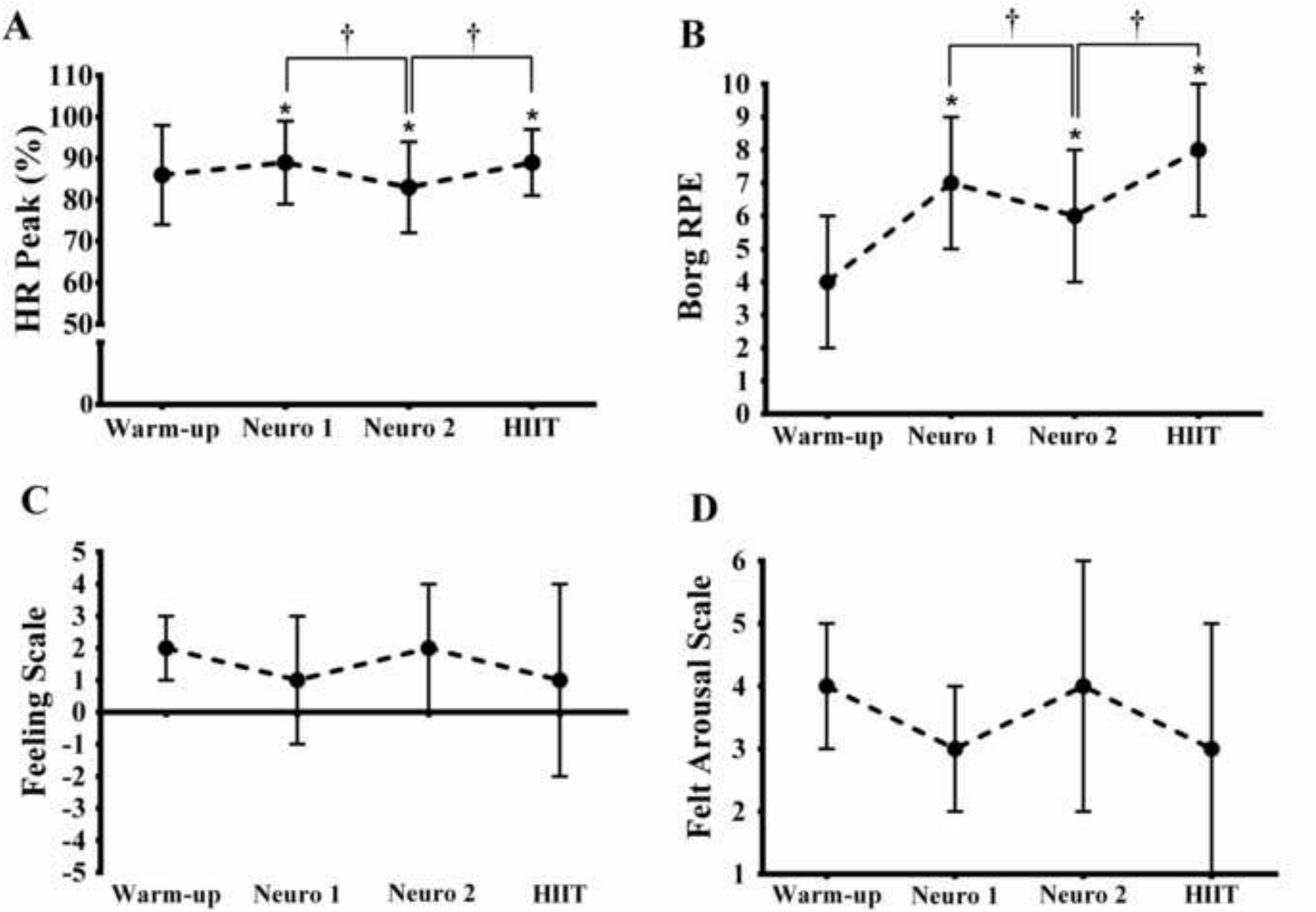
Figure


Psychophysiological responses
(HR, Borg, Feeling and Felt Arousal Scales)
Rest
BP
Rest
BP
BP
BP
0'
10'
15'
20'
35'
50'
55'
85'
90'
100'
105'
115'
120'
Warm-up
Neuro 1
Neuro 2
HIIT
Pre-intervention
Experimental session
Post-intervention

Figure

Click here to access/download;Figure;Figure 3.tif




A
HR Peak (%)
110
100
90
80
70
60
50
0
Warm-up
Neuro 1
Neuro 2
HIIT
†
*
B
Borg RPE
10
9
8
7
6
5
4
3
2
1
0
C
Feeling Scale
5
4
3
2
1
0
-1
-2
-3
-4
-5
D
Felt Arousal Scale
6
5
4
3
2
1