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Original article

Acute metabolic and inflammatory responses in active men undergoing postural corrective training

Respostas metabólicas e inflamatórias agudas em homens ativos submetidos ao treinamento corretivo postural

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ABSTRACT

Introduction: The practice of physical exercises has become recurrent throughout life in the search of health promotion. Among numerous methods offered by the fitness market, the Corrective Postural Training TCP aims, through a gymnastics model, to increase adherence to the practice, with a reduced risk of muscle-joint injuries. **Objective:** To analyze the effects of an initial session of TCP on lactacidemia, blood glucose, heart rate, interleukin-6, tumor necrosis factor-alpha and creatine kinase in healthy individuals without previous experience with the method. **Methods:** 16 active men, without preexisting diseases (28.5 ± 5.0 years; 72.16 ± 8.1 kg; 1.75 ± 0.06 m and body mass index 23.31 ± 2.1) underwent three visits to the laboratory. Two visits for data collection and one for the TCP session. **Results:** The session showed stable levels for the variables of blood glucose, creatine kinase, tumor necrosis factor-alpha and interleukin-6. Significant differences were found for lactic acid in the 20' (4.9 ± 1.5 mmol/L) and 30' (4.1 ± 1.6 mmol/L) minutes of the session. **Conclusion:** The evaluated session has no strenuous metabolic and inflammatory levels.

Keywords: exercise; metabolism; inflammation; creatine kinase.

RESUMO

Introdução: A prática de exercícios físicos tem se tornado recorrente ao longo da vida na busca pela promoção da saúde. Dentre inúmeros métodos oferecidos pelo mercado fitness, o Treinamento Corretivo Postural (TCP) tem por objetivo, por meio de um modelo ginástico, aumentar a aderência à prática, com reduzido risco de lesões musculoarticulares. **Objetivo:** Analisar os efeitos de uma sessão inicial do TCP sobre a lactacidemia, glicemia, frequência cardíaca, interleucina-6, fator de necrose tumoral- alfa e creatina quinase em indivíduos saudáveis sem experiência prévia ao método. **Métodos:** 16 homens ativos, sem doenças preexistentes (28,5 ± 5,0 anos ;72,16 ± 8,1 kg, 1,75 ± 0,06 m e índice de massa corporal 23,31 ± 2,1) três visitas ao laboratório. Duas para coleta de dados e uma para realização da sessão do TCP. **Resultados:** A sessão apresentou níveis estáveis para as variáveis de glicemia, creatina quinase, fator de necrose tumoral-alfa e interleucina-6 sanguíneas. Foram encontradas diferenças significativas para lactacidademia nos minutos 20' (4,9 ± 1,5 mmol/L) e 30' (4,1 ± 1,6 mmol/L) da sessão. **Conclusão:** A sessão avaliada não apresenta níveis metabólicos e inflamatórios extenuantes.

Palavras-chave: exercício físico; metabolismo; inflamação; creatina quinase.

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Introduction

The search for health promotion and quality of life has been a growing target for human beings. The change in daily habits, particularly the practice of physical exercise (PE), has become recurrent. Benefits include improved cardiorespiratory capacity, muscle hypertrophy, weight loss and others [1].

Among the most used models, we highlight the high intensity interval training (HIIT), functional training and resistance training [2]. The characteristics of performance and the high intensity of training, is increasingly distancing these methods from a sedentary public from regular practice of physical exercise. Corrective Postural Training (TCP) was created with the goal of increasing practice adherence, reducing the risks of joint muscle injuries and to offer a training method, which considers the relationship between the individual and their environment [3].

The TCP method aims at biomechanical balance to improve daily activities. Based on the principles of physical training, its demands occur through dynamic and postural muscle actions executed in angles and amplitudes which promote better biochemical and mechanical adaptations [3].

Biochemically, the instant increase in energy requisition provided by physical exercise results in physiological adjustments for new metabolic demands [4], which include the uptake of circulating glucose or glucose obtained via glycolysis of the muscles/liver in order to generate energy; lipid mobilization in the face of long-term activities and lactate production in an intensity-dependent manner [5].

Mechanical stress can be another response to PE's demands which results in damage and inflammation of the muscle tissue [6,7]. Muscle microlesions promote lysis of muscle tissue causing extravasation of the enzyme creatine kinase (CK) into the bloodstream, becoming an important muscle injury biomarker [8]. In inflammatory processes, cytokines such as Interleukin-6 (IL-6) and Tumor Necrosis Factor-Alpha (TNF-α) alter their levels, conferring an anti-inflammatory effect in view of the physical activity performed [9].

In view of the above, the objective of the present study was to analyze the effects of a TCP session on lactic acid (LAC), glycemia (GLY), heart rate (HR), IL-6, TNF-α and creatine kinase (CK) in active and healthy men without previous experience with the method.

Methods

Subjects

Sixteen active men, without preexisting diseases, took part in the study (28,5 ± 5,0 years old, 72,16 ± 8,1 kg, 1,75 ± 0,06 m) and body mass index (BMI) 23,31 ± 2,1 kg/m^2. Inclusion criteria: male adults (between 20 and 40 years old), recreationally active (150 weekly minutes) over the last six months. Exclusion criteria: anabolic steroids users; smokers; cardiovascular disease history, type 2 diabetes mellitus; systemic ar-

terial hypertension; history of metabolic disease that advocated the use of drugs capable of affecting the metabolism of carbohydrates or lipids and/or any change in the lipid profile and inflammatory markers. Fourteen volunteers were selected (n = 14).

The study was approved by the Human Research Ethics Committee (CEP) from the Federal University of São Carlos (opinion No. 65352917.9.0000.5504). All volunteers signed the Informed Consent Form (ICF).

Experimental design

The selected subjects took part in three visits to the laboratory at the Department of Physical Education and Human Motricity (DEFMH) located at the Federal University of São Carlos (UFSCar). Inside an interval of approximately 15 days, the visits were characterized by: method familiarization (F1), acute session of TCP (AS2) and blood collection 24 hours after the session (C3) (Figure 1).

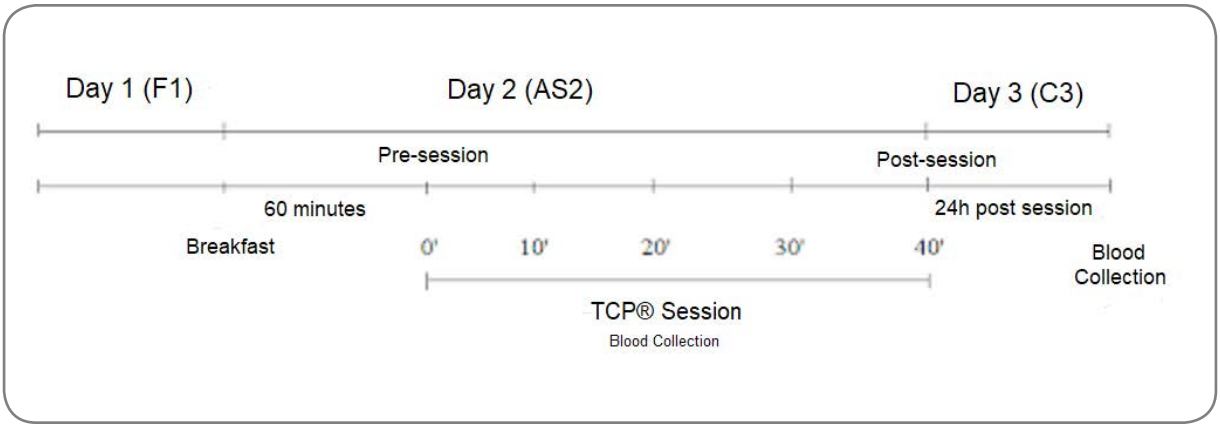


Figure 1 - Experimental design

Before the meeting in person, the volunteers answered the anamnesis through an online questionnaire. The meeting in person (F1) was characterized by signing the informed consent form (ICF), collecting anthropometric measurements and familiarizing the method. After seven days, the second meeting (AS2) (in fasting and individually), the acute TCP session was performed and blood collections (TNF-α and IL-6, LAC, GLY, CK) were collected by a qualified professional. The session took place 60' after breakfast. 24 hours after the session, in the third meeting (C3), the last blood collection of CK was carried out and the volunteers were subsequently dismissed.

Blood variables

Blood collections were performed on day 2 (SA2) (times: 0', 10', 20' 30' and 40' of the acute session) and 24 hours after the session, on day 3 (C3), as described in Figure 2.

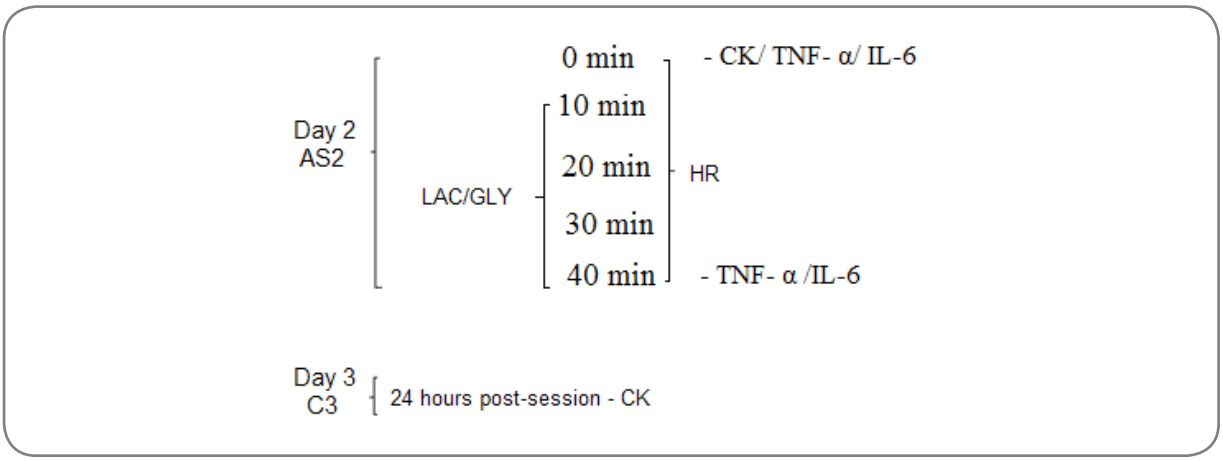


Figure 2 - TCP Acute Session (AS2), Collection (C3), Heart Rate (HR) / Tumor Necrosis Factor- α (TNF-α) and Interleukin 6 (IL-6), Creatine Kinase (CK), Lactacidemia (LAC) and Glycemia (GLY)

The collected blood was stored in dry tubes or with EDTA (depending on the analyzed variable) for approximately 2 hours. Then the tubes were centrifuged at 3000 rpm for 15 minutes at 4ºC, to obtain plasma and/or serum. The inflammatory profile analyses were carried out in partnership with the Pathology Laboratory of the Federal University of São Carlos (DMP-UFSCar). Quantifications were determined by the Immunoenzymatic Assay (ELISA) method, following the specifications corresponding to the DuoSet ELISA kit. The technique was based on the sandwich ELISA model: high-affinity microplates were sensitized with monoclonal anti-cytokine antibodies and remained overnight. Afterwards, they were washed 3 times with 300 µL/well of phosphate buffered saline (PBS) pH 7.2-Tween-20 0.05% (PBS-Tw), and incubated with the blocking solution containing albumin (PBS pH 7 , 2 + 4% bovine albumin) for 1h, at room temperature (RT). Then, after another wash cycle, samples were added and standard curves of recombinant cytokines were made. The plates were kept at RT for 2 hours and then washed again. Then biotinylated anti-cytokine antibodies or conjugated with peroxidase enzyme were added and maintained for 1 hour and 30 minutes at RT. After 5 washes with PBS, 100 µl of the developer solution containing tetramethylbenzidine (TMB) was added. The reaction was blocked with 50 µL of 1 molar sulfuric acid (M) and the reading was carried out in a spectrophotometer 450 nanomolar (nm). Sample concentrations were calculated from the titration curve of cytokine standards and final concentrations expressed in pg/ml.

GLY, LAC and CK analyses were performed at the Laboratory of Nutrition and Metabolism Applied to Exercise (LNMAE) at the DEFMH. For GLY and LAC determinations, Roche's Accu-Chek Active portable equipment and Roche's Accutrend Lactate 3012522 mmol/L, respectively, were handled, both calibrated with blood. For CK analysis, the Roche Reflotron Plus device was used. For these analyses, blood was collected through a finger puncture with the Accu-chek Safe-T Pro lancet, from the Roche brand (subsequently discarded) and applied to the reagent strips. After the period stipulated for each equipment, the results were extracted.

Heart Rate

HR was recorded by the Polar monitor between the minute 0' and 40' of the session between 5 min intervals.

TCP Session

The session consisted of a video class (40 minutes) elaborated with natural, functional, and coordinating movements simultaneously. Muscle activity was harmoniously standardized, with acyclic movements and low impact, performed predominantly in the frontal plane. Some of these movements were: lateral dislocations, flexion, and extension (knee, elbow, shoulder, and hip) and stationary gait. The musical frequencies remained between 124bpm to 132bpm.

Statistical analysis

Parametric tests were used for data exhibiting normal distribution (Kolmogorov-Smirnov) and equality of variance (Levene). The non-parametric test (Wilcoxon) was used when the data did not present normal distribution and/or equality of variance (for IL-6 and TNF-α). For pre and post-session comparisons of the CK variable, the paired t-test was required. The parametric test of variance analysis for one factor (one-way ANOVA) was used to identify possible changes induced by the TCP exercise factor in the LAC and GLY variables during the session. When statistical difference was detected by the one-way ANOVA test, Tukey's multiple comparison test (Post-hoc) was used.

The required statistical program was SPSS for Windows, version 17.0 (IBM SPSS, Chicago, IL). The results are presented as mean and standard deviation. The level of significance was set at $p < 0.05$. We chose the GraphPad Prism software (version 6) to make the graphs.

Results

General information regarding the characterization of the sample is shown in table I.

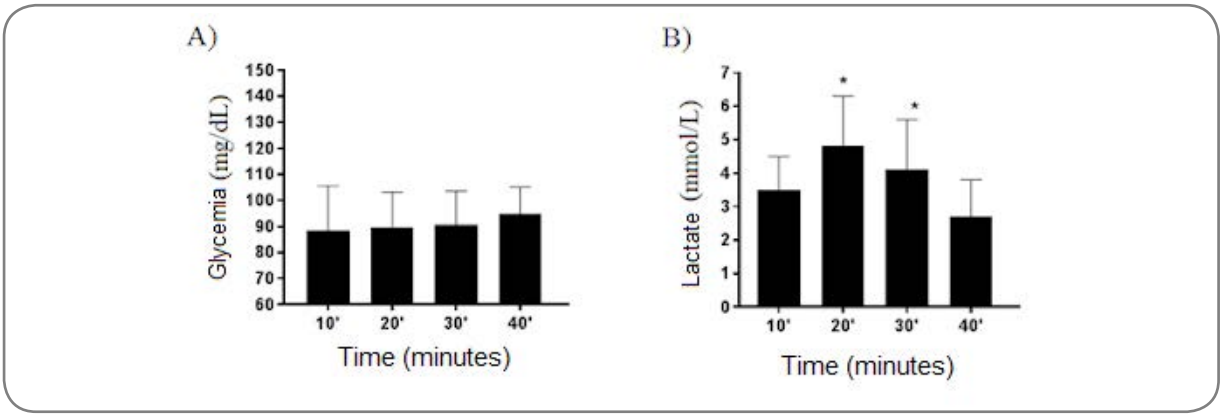
Table I - Anthropometric and hemodynamic parameters in physically active adult men

Variables (n = 14)	Mean ± SDM
Age (years old)	28.5 ± 5.0
Body mass (kg)	72.2 ± 8.1
Height (meters)	1.7 ± 0.1
BMI (kg/m²)	23.3 ± 2.1
SBP (mmHg)	120.2 ±14.0
DBP (mmHg)	79.3 ±12.7

SDM = Standard Deviation of the Mean; BMI = body mass index; SBP = systolic blood pressure; DBP = diastolic blood pressure

Regarding glycemia, the mean over the session was 92.96 ± 5.17 mg/dL (p = 0.57). No significant differences were found between the collected points (10': 88.5 ± 17.1 mg/dL; 20': 89.7 ± 13.6 mg/dL; 30': 90.6 ± 12.9 mg/dL; powders (40 '): 95.0 ± 10.0 mg/dL) (Figure 3).

The mean value of the LAC concentration was 3.8 mmol/L changes, compared to the mean values immediately after the session (2.8 ± 1.1 mmol/L). No significant differences were found between the 10 'values (3.6 ± 1.0 mmol/L) and immediately after the session (40') (2.8 ± 1.2 mmol/L) (Figure.3).



A) Mean blood glucose values during the TCP class and immediately after the session. One-way ANOVA (p = 0.57); B) Mean lactacidemia values during the TCP class and immediately after the session. *20'and 30' other than time 40' (immediately after the session). One-way ANOVA, Tukey, F (6.4) (p = 0.00)

Figure 3 - Mean values of glycemia and lactic acid during the TCP session in physically active adult men

The plasma levels pre (0') and post-session (40') of TCP for the cytokines IL-6 and TNF-α did not show significant statistical changes, as described in the table below.

Table II - Mean values ± standard deviation of serum levels of IL-6 and TNF-α, in active adults before and immediately after the TCP session

Variables (n = 14)	Pre-session Mean ± SDM	Immediately post session Mean ± SDM	p
IL-6 (pg/mL)	20.04 ± 5.07	25.96 ± 10.47	0.14
TNF-α (pg/mL)	21.00 ± 4.09	24.80 ± 3.90	0.57

Wilcoxon; SDM = Standard Deviation of the Mean; IL-6 = interleukin-6; TNF-α = tumor necrosis factor-alpha

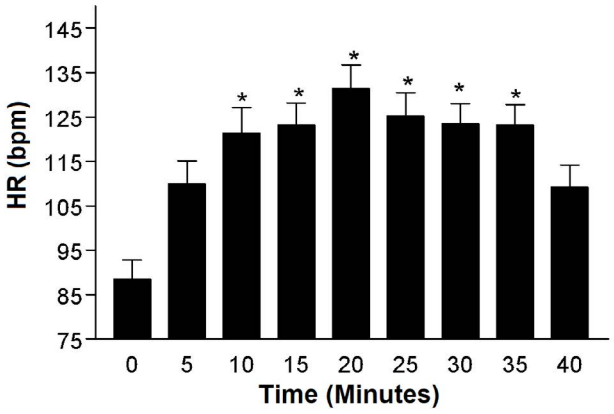
The blood CK concentration between the pre (0 ') and 24h periods after the TCP session did not show significant differences as described in the table below.

Table III - Mean values ± standard deviation of CK blood concentrations in active adults, pre and 24h after the TCP session

Variable (n = 14) CK (UL)	Pre-session Mean ± SDM	24h post-session Mean ± SDM	p
	132.6 ± 67.0	136.1 ± 54.0	0.67

Paired t-test; SDM = Standard deviation from mean; CK = creatine kinase

Finally, the mean HR values increased progressively, returning to baseline levels at the end of the session. Significant values stood out from 10', remaining until 35', when compared to the average values of the initial and final minutes (Figure 4).



HR = Heart rate; bpm = beats per minute; * 10', 15', 20', 25', 30', and 35' different from 0', 5', 40', single--factor ANOVA, Tukey, F (6.7) (p = 0.00)
Figure 4 - Mean heart rate values during the TCP session in physically active adult men

Discussion

The responses mediated by the acute session of the TCP training model with active and adult men, were characterized by maintaining stable blood glucose levels, blood CK concentrations (24h post-session), TNF-α and IL-6 (pre and post-session). Significant changes were seen in lactacidemia, with an increase in times 20 'and 30' and for HR between the period 10 'to 35', compared to the rest of the session.

During physical exercise, in an acute way, the maintenance of energy control for energy generation occurs mainly through the metabolism of carbohydrates and lipids, coming from intra and extramuscular substrates. They are: glycogen, blood glucose, fatty acids and triglyceride reserves of adipose tissue. The intensity and duration of the exercise are the determinants of the relative contribution of these substrates to oxidative metabolism. While oxidation of carbohydrates, particularly muscle glycogen, dominates at higher exercise intensities, fat oxidation stands out at lower intensities [10].

Blood glucose is derived from hepatic glycogenolysis, gluconeogenesis and from the intestine when carbohydrate is ingested. During physical exercise, with the increase in blood supply, the availability of glucose increases in order to regulate the use of energy in the worked muscles. Depending on the intensity performed, glucose is measured by the concentration available in the bloodstream and/or by glycogenolysis mainly from the muscle [10]. The entry of glucose into the cell, allowed primarily by diffusion, is facilitated through GLUT 4, either by the action of insulin or through adjacent mechanisms of physical exercise [5,11,12]. Our data showed that glycemic levels during the TCP session remained unchanged. These results corrobo-

rate data from the literature in which they recorded average blood glucose levels of 95.08 ± 11.55 mg/dL in 40' in moderate-intensity aerobic exercise [13]. This stability is possibly due to the intensity of the session, in which it promoted a balance between the consumption of muscle glycogen, fatty acids by the muscle in activity with hepatic glycogenolysis, maintaining the ideal glycemic levels for use as an energy source by peripheral tissues.

However, extremely active muscles have accelerated rates of glycolysis, generating lactate. Depending on the intensity of the exercise, the lactate concentration increases in the muscle and in the bloodstream in the face of more intense demands [10]. During the session, between 20' and 30 'times, lactacidemic rates showed a significant increase, compared to the other periods, reaching a plateau. These results point to a greater intensity of the session, resulting from the movements performed, involving larger muscle groups. However, the concentration was not sufficient to cause fatigue, regarding this condition a physiological response consistent with the effort made. The mean lactic acid level was 3.57 mmol/L, this result reinforces the idea that the TCP session is maintained via the oxidative process [14], due to the mean lactate values remaining within the considered Maximum Stable Lactate Phase (MSLP).

In support of the findings, data from our study group [14], when measuring energy expenditure, VO2max and HR in a similar session of TCP modality, demonstrated that these variables were greater for the same periods measured in the present study (20 'to 30' of the session), showing that the metabolic demand was similar in both conditions. The behavior of HR is associated with the direct response of muscle contraction in view of the need of the active muscle for oxygen and blood supply for nutrition and removal of metabolites generated by physical exercise, being proportional to the individual's current intensity and physical capacity [15]. Concomitantly with the data presented, the HR means increased progressively, remaining stable between 10 to 35 minutes. These moments represent the greatest work intensity, however at non-strenuous levels. As assessed in another study, the same session was of moderate intensity with mean values of 66% of HRmax [14].

Another way to assess the intensity of PE is to ascertain its ability to generate muscle microlesions and inflammation through CK. Biochemically, this enzyme is involved in the simplest and fastest of the energy systems for resynthesis of Adenosine Triphosphate (ATP) in generating energy [16-18]. Due to its low molecular weight, CK is the first substance to appear in the circulation depending on the amount of damage to sarcomeres induced by muscle damage, ischemia and inflammation [19]. Although the evaluated TCP session showed a brief increase in intensity over time, the values obtained for this variable, as expected, were not able to generate significant muscle damage 24 hours after the session. Such results can be explained due to the movements performed in the session being composed of greater recruitment of postural muscles and low demand for eccentric muscle contraction. According to some authors, static actions, and especially eccentric ones, as well as the speed of movement are factors that promote muscle damage [19,20].

Still, it is observed that the TCP session has a low inflammatory response, since it did not show changes in the plasma levels of TNF-α and IL-6 immediately after the session. During the acute session of physical exercise, cytokines are produced and released to induce an inflammatory response. The cytokine IL-6 when associated with the immune response is the first signaling molecule synthesized by macrophages and lymphocytes in conditions of tissue damage or infection. In the presence of tissue damage, the pro-inflammatory cytokine TNF-α is one of the main modulators of the acute phase inflammatory response [21,22]. The kinetics of these cytokines, from muscle contraction immediately after the session, is dependent on the intensity and duration of the session, muscle damage, muscle glycogen content and blood glucose [22-25]. Despite the findings for the TCP session showing slight increases in the plasma concentration of IL-6 and TNF-α, the session was not significantly influenced when compared to the resting values, which demonstrates that the session did not show strenuous inflammatory levels. These results are similar to previous studies that have shown small increases or no effect of low or moderate-intensity acute aerobic exercise on IL-6 and TNF-α [21,26-29].

Conclusion

Considering the physiological behavior, through the results obtained from the maintenance of glycemic levels and mild lactacidemic alteration, the evaluated TCP session is an aerobic session of moderate intensity, with low inflammatory condition and low muscle damage. Thus, this TCP session can be considered a possible training session for sedentary individuals, in physical rehabilitation processes, or even as an active recovery approach for athletes after strenuous physical exertion. Although there are limited studies in literature about methods and movements similar to TCP, further studies are needed on the physiological effects promoted by the method in other sessions, thus demonstrating its benefits in the prevention of metabolic diseases.

Potential conflict of interest
No conflicts of interest potentially relevant have been reported for this article.

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Academic affiliation
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Author contribution
Conception and design of the research: Rodrigues CNS, Fabrizzi F; Duarte ACG. **Data obtainment:** Rodrigues CNS; Furino VO; Marine DA; Lima MA. **Analysis and interpretation of data:** Rodrigues CNS; Alves JM, Fabrizzi F; Duarte ACGO. **Statistical analysis:** Rodrigues CNS, Marine DA. **Financing:** no. **Writing of the manuscript:** Rodrigues CNS, Alves JM. **Critical review of the manuscript for important intellectual content:** Rodrigues CNS; Furino VO; Marine DA; Lima MA, Alves JM, Fabrizzi F, Duarte ACGO.

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