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Effects of combined exercises performed in different periods of the day on post-exercise blood pressure brazilian jiu jitsu athletes

Efeitos de exercícios combinados realizados em diferentes períodos do dia na pressão arterial pós-exercício em atletas do jiu jitsu brasileiro

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ABSTRACT: Post-exercise hypotension has been extensively investigated with combined exercise (aerobic + resistance). However, its response in different periods of the day is still unknown. Objective: To determine the effects of a combined exercise session performed at different times of the day on blood pressure response after exercise. Anaerobic threshold (AT) and 12 repetition maximum (12RM) tests were evaluated in nine male Brazilian jiu-jitsu athletes (22±3.7 y; 176±5.0 cm; 73.4±9.7 kg; 6.8±2.1 % body fat). Four experimental sessions were performed: resistance exercise followed by aerobic exercise [Morning (*RAM)* and Afternoon (*RAA)*] and Control (C) [Morning and Afternoon]. The morning sessions were conducted at 09:00 a.m. and the afternoon sessions were conducted at 3:00 p.m. Resistance exercise consisted of three sets at 90% of 12RM in six exercises, while aerobic exercise consisted of 15min at 90% of the AT. Blood pressure (BP) was measured before, during and 1h after the performance of exercises in laboratory. When comparing the AE and RE intensity marker variables (heart rate, RPE, running speed and number of repetitions) significant differences (p>0.05) were not evidenced between the experimental protocols (RAM and RAA). The morning session presented a hypotensive effect in SBP (mean recovery 1h) (109.5±6.9mmHg) when compared to control morning session (117.4±5.6mmHg) (p=0.001). Both sessions of combined exercise promoted HPE, without differences between them.

Key Words: Physical Exercise; Blood Pressure; Diurnal Variation.

RESUMO: A hipotensão pós-exercício tem siso amplamente investigada com exercícios combinado (resistido+aeróbio). Contudo, ainda é desconhecida sua resposta em diferentes períodos do dia. Objetivo: verificar o efeito de uma sessão de exercício combinado realizado em diferentes períodos do dia sobre a resposta da PA pós-exercício. Limiar anaeróbio (LA) e teste de 12 repetições máximas (12RM) foram avaliados em nove atletas (masculinos) de jiu-jitsu (22,0±3,7 anos; 176,0±5,0 cm; 73,4±9,7 kg; 6,8±2,1 %gordura). Quatro sessões experimentais foram realizadas: exercício resistido + exercício aeróbio [manhã (ManhaE) e tarde (TardeE)] e sessão controle (C) [manhã e tarde]. A sessão da manhã foi realizada 09:00h e a sessão da tarde foi realizada ás 15:00h. O exercício resistido consistiu em três séries a 90% de 12RM em seis exercícios. O exercício aeróbio consistiu em 15min a 90% do LA. PA foi mensurada antes, durante e 1h após a realização dos exercícios em laboratório. Quando comparado o AE e re variáveis marcador de intensidade como: freqüência cardíaca, RPE, velocidade e número de repetições em execução, as diferenças significativas (p> 0,05) não foram evidenciados entre os protocolos experimentais (RAM e RAA). A sessão de exercício de manhã apresentou um efeito hipotensor na PAS (média de 1h de recuperação) (109,5±6,9mmHg) quando comparado a sessão controle da manhã (117,4±5,6mmHg) (p=0,001). Ambas as sessões de exercício combinado foram interessantes para promover HPE, sem diferença entre elas.

Palavras-chave: Exercício Físico; Pressão Arterial; Variação Diurna.

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Introduction

The total estimated number of adults with arterial systemic hypertension (ASH) in the year 2000 was about 972 million people[1]. It is estimated that in the year 2025 there will be an increase of 60% of individuals with ASH, reaching 1.56 billion adults[2]. In Brazil, it is estimated that 27.4% of the total deaths are due to cardiovascular disease[3]. Moreover, only in 2011, the country's public cost with the treatment of ASH exceeded 17 million dollars[4]. It is noteworthy that among the factors that cause ASH, most of them derive from modifiable behavior, such as smoking, eating habits, and especially physical inactivity[5]. Clinical and epidemiological studies have already proven the benefits of exercise to general health and to the cardiovascular system[6-9].

A single exercise session (aerobic or resistance) may reduce blood pressure to values lower than that measured on pre-exercise, as demonstrated in several populations, such as elderly[10], individuals with type-2 diabetes[11-13], hypertensives[14] and normotensives[15], being this phenomenon known as post-exercise hypotension (PEH).

Many studies have demonstrated that the magnitude and duration of PEH seems to vary according to the type of exercise (aerobic or resistance)[12], as well as intensity[10,16] and duration[17]. On the other hand, there are no studies regarding the influence of the combination of these two models, performed in different periods of the day, on blood pressure (BP) responses.

There are few data regarding the comparisons between different periods of day for aerobic exercise (cycle ergometer) performed in the morning and in the afternoon[18]. These data demonstrated that aerobic exercise performed in the afternoon resulted in a higher decrease on post-exercise systolic blood pressure (SBP), diastolic blood pressure (DBP) e mean arterial pressure (MAP), when compared to the exercise session performed in the morning.

The importance of investigating PEH in normotensive individuals is that independently of the population studied (elderly, adult, diabetics, normotensive and hypertensive), a decrease in BP of 2 mmHg or more may be related to a reduction of 6% on the risk of stroke and of 4% on the risk of chronic heart disease[19]. In addition, recent studies[20,21] have shown that PEH is related to the chronic decrease of BP on normotensive and pre-hypertensive individuals. Therefore, exercise can be a protective factor against the development of ASH.

Given the above, the purpose of the present study was to verify the effects of a combined exercise session (aerobic and resistance exercise), performed in different periods of the day, on post-exercise BP responses.

Methods

Sample

This cross-sectional study was conducted after the approval of the Research Ethics Committee of the Catholic University of Brasília (n°126/10). After giving a written consent, according to Resolution nº 196/96 about humans research, nine young male individuals (22 ± 3.7 year old; 176 ± 5.0 cm stature; 6.8 ± 2.1 % body fat), Brazilian jiu-jitsu athletes, with competitive results ranging from regional to Pan-American levels, with a training frequency at least three times a week, were conveniently selected, since all athletes are part of the jiu-jitsu team of the Catholic University of Brasília. As inclusion criteria, each participant should have between 18 and 30 years of age, be physically active, present a body mass index $<25 kg\cdot m^{-2}$), and not have any bone, muscle or joint injury that could compromise the tests and experimental protocols.

General procedures

Previous to the experimental sessions, all volunteers were submitted to an electrocardiogram at rest in order to verify any condition that could compromise their participation in the study. The exams were conducted and analyzed by a cardiologist at the Physical Evaluation and Training Laboratory (LAFIT) at the Catholic University of Brasília.

After medical clearance, each volunteer carried out seven visits separated by at least 48 hours. Body mass index (BMI) was calculated considering the quotient between body mass (Toledo 2096 PP, Brazil) in kilograms, and stature (SECA® 214, USA) in squared meters ($kg\cdot m^{-2}$). . Body fat was estimated through skinfold thickness measurements and, after calculating body density, values were converted to body fat percentage using the equation proposed by Siri[23].

The 1600m running test was performed to estimate the maximum oxygen uptake[24] and to predict lactate minimum velocity[25]. This allowed the prescription of aerobic exercise intensity during the experimental sessions.

In the second visit, the volunteers were submitted to a familiarization of the 12 maximal repetition (12RM) test. Finally, in the third visit, the 12 RM test was properly performed being this result used in the prescription of the intensity of the resistance exercise session. Lastly, all experimental sessions were carried out in a randomized order. All volunteers were instructed not to perform any hard physical exercise in the 24 hours that preceded the experimental sessions and to maintain their daily food habits.

Maximum oxygen uptake and lactate minimum velocity prediction tests

The volunteers were oriented to run a distance of 1600 m in a 400 m athletics track in the lowest time possible. Afterwards, the mean velocity of the 1600 m test was calculated (mV1600). The mV1600 ($m \cdot min^{-1}$) obtained in test, was applied on the predictive equation of VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$) = [0.177 x mV1600 ($m \cdot min^{-1}$)] + 8.101)[24]. The lactate minimum velocity was estimated by the equation proposed by Sotero et al.[25], as follows: [(0.7507 x mV 1600) + 21.575].

The test results of the lactate minimum velocity estimation allowed determining the intensity of the aerobic exercise experimental session.

12 RM test familiarization

In order to promote an adaptation to 12RM test, the participants were submitted to three sets of each exercise (leg press, seated bench press, leg extension , lat pull down, leg curl and seated row) in which, in the first set, the participants performed twenty repetitions with a light load, and in the subsequent sets (2nd and 3rd) more intense loads were used to the 12RM specific familiarization.

12 RM test

A ten repetition set with 50% of the possible 12RM load was performed as warm-up. After two minutes, the participants were instructed to perform the highest number of repetitions possible in a load given subjectly by the evaluator.

If more than 12 repetitions were performed, two kilos were added to each two repetitions that exceeded. On the other hand, if the number of repetitions executed was below 12, the load was reduced, by trial and error, until they could execute the load correspondent to 12RM.

The 12RM load determination considered the performance speed, range of motion, and physical signs shown by the volunteer. During the tests, the maximum of three attempts at each exercise was performed, with five minutes of recovery between each attempt.

Experimental protocols

All sessions were performed in a laboratory with controlled temperature (18 to 22 °C) and relative air humidity (between 50 and 70%)[26]. All individuals were submitted to four sessions, being two control sessions (CO) and two combined exercise sessions (CE): CO and CE were performed equally, being one in the morning, beginning at 9 am and finishing at 10:45 am and one in the afternoon, beginning and finishing at 3 pm and 4:45 pm, respectively. Afterwards, the participants waited in the lab for measurements of other variables of interest.

The CE experimental sessions were performed in the same order and had the same duration. The resistance exercise (RE) was performed before the aerobic exercise (AE). This also occurred in the different periods of the day, since resistance and aerobic exercise were performed in the morning (RAM) and in the afternoon (RAA).

The same occurred to the CO sessions, being one session in the morning (COM) and another in the afternoon (COA). Both control sessions were performed in the same period of the day, in which the participants remained in a seated position for 30 minutes. The same data collection procedures of the experimental sessions were perfomed, however, without exercise.

Resistance exercise (RE)

A circuit training method was applied to perform RE, composed of 6 exercises with 12 repetitions each, alternating body segments (legs and arms) with an intensity of 90% of the 12 RM load, in the following exercises: leg extension, seated bench press, leg press, lat pull-down, leg curl and seated row. The participants performed three laps on the circuit, totalizing three sets at each exercise. There was no rest interval between the exercise bouts and also between the laps on the circuit. The volunteers were oriented to perform the exercises with a speed of one second to the concentric phase and one second to the eccentric phase, totalizing approximately 48 seconds to each exercise, completing a total duration of around 15 minutes.

Aerobic Exercise (AE)

The AE was performed in a treadmill (Movement®, São Paulo, Brazil), during 15 minutes with constant workload corresponding to 90% of lactate minimum velocity obtained from the 1600m running test, as suggested by Sotero et al.[25].

Blood Pressure measurements

BP was measured before, during and over 1-h after the experimental sessions. Initially, the participant remained seated at rest and BP was measured in three moments: at 5, 10 and 15 minutes, and the average of these three measurements was considered the resting BP. The BP values during exercise were measured at the end of each exercise model (RE and AE). After all sessions the BP values were obtained every 15 minutes in a seated position during the 60 minutes of post-exercise recovery. All BP measurements were performed using a digital instrument (Microlife BP3A1C). All sessions followed the same BP measurement protocol.

Rate of perceived exertion (RPE)

Two distinct scales were used to measure this variable. For AE the Borg Scale with values ranging from 6 to 20 was used [27], while the OMNI-RES scale with a 0 to 10 range of values was used in RE[28,29].

Statistical analysis

The data normality and homogeneity were tested using the Shapiro-Wilk and Levene's test (p>0.05). With all variables showing normal distribution, the descriptive statistics were performed (mean and standard deviation). The values of RPE, number of repetitions (resistance exercise), running velocity (aerobic exercise) and heart rate between the different experimental protocols (RAM and RAA) was compared through the paired Student's t-test.

The area under the curve (AUC) was estimated using the trapezoidal method analysis for blood pressure over 1-h of post-exercise recovery. One way ANOVA was used to compare AUC between sessions (RAM, RAA, COA e COM) [(4 (session x 1 measure).

Split-plot ANOVA (4 sessions x 5 recovery moments) was used to compare the absolute values of BP between (RAM, RAA, COM and COA) and within (Rest, R15, R30, R45 and R60) sessions. When any of the dependent variables did not show sphericity in the Mauchly's test, the epsilon of Greenhouse-Geisser was used to analyze the F statistic.

To compare the values regarding the 1 hour average BP and the values of AUC, a One-Way ANOVA was performed..The level of significance was chosen as 5% ($p \leq 0.05$) and all analyses were carried out using the Statistical Package for the Social Sciences (SPSS) 20.0.

Results

The physical characteristics of the individuals are represented in table 1.

When comparing the AE and RE intensity variables (heart rate, RPE, running speed and number of repetitions) no significant differences (p>0.05) were evidenced between the experimental protocols (RAM and RAA) (Table 2).

Likewise, no significant difference was found when comparing SBP between the experimental sessions (RAM and RAA) in the moments immediately after resistance exercise (RE) and after aerobic exercise (AE). On the other hand, both the resistance exercise session (RAA and RAM) showed significant differences when compared to their respective control session values (COA and COM), being SBP - (4.76) t = 7, 08, p = 0.001], DBP (3.35) t = 3.85, p = 0.001 and MAP (4.3) t = 4.04, p = 0.001 to COA session and SBP - (4.26) t = 6.53, p = 0.008, DBP (3.65) t = 3.29, p = 0.005 and MAP (3.6) t = 4.56, p = 0.001 to COM session.

However, after performing aerobic exercise (RAA and RAM), only SBP [RAA- (8.31) t = 3.92, p = 0.001; RAM - (6.06) t = 3.92, p = 0.008)] and MAP [RAA - (6.75) t = 2.36, p = 0.031; RAM – (2.97) t = 3.12, p = 0.006] showed statistical difference to their respective control session values (COA and COM).

Table 1. Sample's characterization

Variables	Mean ± SD
Age	22.0 ± 3.7
Body mass (kg)	73.4 ± 10.0
Stature (cm)	178.0 ± 0.1
Body mass index (kg·m^{-2})	23.0 ± 1.5
Body fat (%)	6.8 ± 2.1
VO_2max (mL·kg^{-1}·min^{-1})	50.4 ± 4.0
Indirect lactate minimum (km·h^{-1})	12.4 ± 1.3

VO_2max = indirect maximum oxygen uptake

Table 2. Values regarding intensities during exercise. Data are expressed in mean ± standard deviation (n=9).

	Aerobic Exercise			Resistance exercise	
Protocols	RPE	HR (bpm)	Speed (km.h^{-1})	RPE	Repetition
RAA	14.0 ± 2.4	179.3 ± 9.0	11.0 ± 1.6	6.4 ± 1.4	11.9 ± 0.2
RAM	12.9 ± 2.8	180 ± 16.3	11.0 ± 1.2	5.5 ± 1.9	12.0 ± 0.0

RPE - rate of perceived exertion; HR – heart rate; RAA – resistance-aerobic exercise session in the afternoon; RAM – resistance-aerobic exercise session in the morning.

Table 3. Blood Pressure values during the sessions. Data are expressed in mean and (±) standard deviation (n=9).

Protocols/variables		RAA	RAM	COA	COM
SBP (mmHg)	Post RE	153 ± 12*	142.9 ± 12.4#	119 ± 8	115 ± 3
	Post AE	149 ± 23†	142.1 ± 17.5£	116 ± 9	118 ± 5
DBP (mmHg)	Post RE	80.9 ± 7.9*	80.9 ± 9.3#	67.9 ± 6.2	68.8 ± 5.7
	Post AE	76.2 ± 19.6	77.4 ± 6.8	68.9 ± 7.5	72.2 ± 8.2
MAP (mmHg)	Post RE	104.8 ± 8.6*	100.6 ± 9.8#	87.3 ± 9.6	84.3 ± 4.4
	Post AE	100.5 ± 18.9†	96.9 ± 5.9£	84.5 ± 7.2	87.6 ± 6.6

Post RE: after the resistance exercise; Post AE: after the aerobic exercise; SBP - systolic blood pressure; DBP – diastolic blood pressure; MAP – mean arterial pressure; RAA – resistance-aerobic exercise session in the afternoon; RAM – resistance-aerobic exercise session in the morning; COA – control session in the afternoon; COM – control session in the morning; *: when compared to the COA session (Post RE) (p=0,001); #: when compared to to the COM session (Post RE) (p=0,008-0,001); †: when compared to to the COA session (Post AE) (p=0,031-0,001); £: when compared to the COA session (Post AE) (p=0,006-0,008)

Regarding the BP response during the post-exercise recovery period, the combined exercise session performed in the afternoon presented significantly lower values of SBP at 45' (Wilks' Lambda=0,16; $F_{4,5}$= 6,441; p= 0.003) and 60' (Wilks' Lambda=0,16; $F_{4,5}$= 6,441; p= 0.016) minutes of the recovery period and 60' minutes of recovery (Wilks' Lambda= 0,19; $F_{4,5}$= 5,515; p= 0.025) for the exercise session performed in the morning. No significant differences were found for DBP and MAP (Table 4).

Regarding the 1 hour average values and area under the curve after the exercise sessions, only the exercise session carried out in the morning (RAM), resulted in significant differences when compared to its control session (COM) for SBP, being Wilks' Lambda= 0,15; $F_{3,6}$=11,095; p= 0.001 for the 1 hour average values and Wilks' Lambda= 0,21; $F_{3,6}$=7,351; p= 0.004 for the AUC (Table 4).

Table 4. Blood Pressure values Pre and Post experimental exercises. Data are expressed in mean and (±) standard deviation (n=9).

BP	Protocols	REST	R15	R30	R45	R60	1h average	TAUC
SBP	RAA	118.9 ± 7.3	112.4 ± 11.6	111.9 ± 10.0	104.8 ± 9.7**	108.2 ± 9.5*	109.3 ± 10.1	6777.9 ± 505.2
	RAM	117.2 ± 7.6	111.5 ± 5.4	112.4 ± 6.6	108.8 ± 8.2	105.2 ± 7.7*	109.5 ± 6.9#	6737.0 ± 370.0#
	COA	115.4 ± 8.8	113.6 ± 8.4	111.9 ± 7.7	114.7 ± 9.7	113.2 ± 5.4	113.3 ± 7.8	6962.5 ± 443.6
	COM	117.4 ± 3.1	116.3 ± 8.0	117.0 ± 5.5	118.9 ± 3.8	117.4 ± 5.2	117.4 ± 5.6	7184.9 ± 204.9
DBP	RAA	68.6 ± 5.3	68.1 ± 9.9	64.9 ± 10.1	69.3 ± 9.4	67.4 ± 7.5	67.4 ± 9.2	4189.6 ± 501.9
	RAM	69.1 ± 6.3	71 ± 6.3	65.4 ± 5.4	65 ± 7.9	70.8 ± 7.2	68 ± 5.2	4255.0 ± 349.7
	COA	68.9 ± 7.9	71.1 ± 11.1	68.8 ± 8.1	66,2 ± 6.8	70.7 ± 8.7	69.2 ± 8.7	4325.7 ± 472.2
	COM	69.5 ± 4.4	69.4 ± 6.7	71 ± 6.2	68.9 ± 5.8	71.9 ± 5.4	70.3 ± 6	4329.4 ± 334.8
MAP	RAA	85.7 ± 4.4	82.9 ± 9.9	80.6 ± 9.1	81.1 ± 8.4	81 ± 7.1	81.4 ± 8.1	5007.7 ± 462.5
	RAM	83.8 ± 6.8	84 ± 6.9	80.2 ± 5.9	78.7 ± 8	81.9 ± 7.6	81.2 ± 7.1	4995.8 ± 407.5
	COA	84.5 ± 8.1	85.3 ± 9.2	83.1 ± 7.4	82.4 ± 7.6	84.9 ± 6.8	83.9 ± 6.9	5161.5 ± 407.5
	COM	85.4 ± 3.4	85 ± 5.6	86.3 ± 4.7	85.6 ± 3.8	87 ± 5.0	86 ± 4.8	5247.9 ± 264.9

BP – blood pressure; SBP - systolic blood pressure; DBP – diastolic blood pressure; MAP – mean arterial pressure; RAA – resistance-aerobic exercise session at afternoon; RAM – resistance-aerobic exercise session at morning; COA – control session at afternoon; COM – control session at morning; TAUC - total area under the curve. *: when compared to to rest in the same session (p=0,025–0,016); **: when compared to rest in the same session (p=0,004–0,001); #: when compared to the COM session (p=0,004-0,001)

Discussion

The main finding of the present study was that the modification of the period of the day in which combined exercise is acutely performed (morning or afternoon) seems to modify the BP responses of young adults. Even though both exercise sessions (morning or afternoon) promoted post-exercise hypotension, only RAM significantly decreased the 1h average SBP values (p=0.001) when compared with COM.

Regarding the AUC for SBP, RAM also presented a statistically significant (p<0.004) reduction when compared to COM, showing a protective effect of exercise, especially when it is performed in the morning. However, no differences were identified between the exercise sessions (RAM and RAA).

Similarly, Park et al.[30], when analyzing the effects of 3 sets of 10 minutes of walking at 50% of VO_2max, with 3 minutes of recovery between the sets, on the 24 hour BP responses of 14 individuals (9 n*on-dippers* e 5 *dippers)* with mean age of 54 years, observed that, for the *dippers* (like the present study's volunteers), exercise performed in the morning (6am to 8am) was more efficient to decrease BP in the 24h mean (-5.56±2.27 mmHg) when compared to the exercise session performed in the afternoon/evening (5pm to 7pm), in which no decrease in BP was evidenced (0.11±2.29 mmHg). Moreover, when analyzing the BP response only after performing the exercise session, *dippers* showed a significant decrease in BP (-5.67±2.59 mmHg), while no reduction was evidenced when exercise was performed at night (-0.30±1.17mmHg).

Jones et al.[31] also reported significant reductions (p<0.05) in SBP when submitting 10 young male adults (28 years old) to an aerobic exercise session on cycle ergometer (70% of VO_2max) performed in different periods of the day (8am and 4 pm). In other words, PEH seems to occur independently of the period of the day that exercise is performed. However, the same researchers demonstrated that the magnitude of PEH was lower when exercise was performed in the morning (8am). This can be partly explained by the pre-exercise resting SBP values, since resting SBP values of participants before the exercise session performed in the afternoon (4pm) were approximately 5 mmHg higher (p=0.01) than when compared to resting SBP values of the exercise session performed in the morning. Therefore favoring a higher PEH magnitude in the afternoon[32,33].

Many studies[34,18,35,33] with similar models and populations have shown that exercise performed in the afternoon seems to be more efficient in reducing BP than when compared to exercise performed in the morning, which agrees with the present study's findings. This difference can be partly explained by the sample composition, since this is the only study that investigated the effects of combined exercise in different periods of the day on post-exercise BP responses of athletes (jiu-jitsu) who can benefit from the hypotensive response independently of the period of the day that exercise is performed. It is noteworthy that no significant differences ($p<0.05$) between the exercise sessions (RAM and RAA) were found.

Moreover, both combined exercise sessions may be of great clinical relevance, since Stergiou et al.[36] observed a perceptual increase on the risk of stroke in the morning (6am to 12 am) of 12.7% and in the afternoon to evening (4pm to 8pm) of 8%, factors that are evidenced by the abrupt increase of SBP and DBP. This increase in the values of BP in the periods reported above can generate a rupture of atheromatous plaques, which can result in the formation of occlusive thrombi[35,36]. In addition, BP reductions greater than or equal to 2 mmHg, as shown by combined exercise, configure a 6% reduction on the risk of stroke and a decrease of 4% on the risk of developing chronic heart disease[19]. Finally, Liu et al.[20] demonstrated that acute BP reductions derived from exercise are related to chronic BP reductions in normotensive subjects.

A possible limitation of the present study is the reduced number of volunteers. However, it is worth highlighting that for our knowledge this is the first study that investigated the effects of a combined exercise session (aerobic + resistance) performed in different periods of the day (morning *vs.* afternoon) on BP response. In addition, the fact that we have not investigated the mechanisms that may be involved in post-exercise hypotension can also be considered a limitation of this research.

Finally, we conclude that both sessions of combined exercise promoted HPE, without differences between them.

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