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Does the exercise order affect body composition in ten weeks of concurrent training?

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ORIGINAL ARTICLE

ABSTRACT

This study aimed to observe if the order of the predominantly aerobic exercise, concerning the predominantly anaerobic exercises, in the concurrent training affects the body composition. Nine young males and nine young females were equitably dived into three groups that performed for ten weeks a concurrent training, differing between them in the order of the predominantly aerobic exercise in relation to the predominantly anaerobic exercises, with the objective to change the body composition: i) before; ii) after; and iii) interleaved. The measurements of the body composition were performed before (T0) and after ten weeks (T1) of concurrent training, a protocol using the dual-energy x-ray absorptiometry (DXA). It was observed a significant ($p<0.05$) reduction in the percentage of total body fat in all groups (25.75±9.34 to 25.08±9.38, 26.08±8.17 to 25.51±7.54, 28.20±4.29 to 26.45±5.56, T0 and T1, before, after and, interleaved, respectively). The total fat-free mass it was significantly increased in the after order group (50.74±11.82 kg to 51.01±11.85 kg, T0, and T1, respectively) and the upper limbs fat-free mass also significantly increased only in the before order group (6.66±2.64kg to 7.15±2.95kg, T0, and T1, respectively). No statistical differences were observed in any study variables between groups. Based on the data of the present study, the order of the predominantly aerobic exercise concerning the predominantly anaerobic exercises in the concurrent training did not influence the alterations in the body composition.

Keywords: Exercise Order, Concurrent Training, Body Composition

INTRODUCTION

The physical exercise has an essential effect on the promotion of alterations in body composition, promoting the reduction of body mass, visceral, and subcutaneous fat (Okamoto et al., 2007). These alterations in the body composition promote a reduction in the effects and prevalence of some chronic diseases associated with metabolic syndrome (Sartorelli & Franco, 2003).

The American College of Sports Medicine (Ferguson, 2014) suggests that predominantly aerobic (PAE), and anaerobic exercises (PANE) should be part of the physical activity program to promote human health. The conjugation of PAE with PANE, in the same session, is commonly called concurrent training (CT) and is very commonly used in individuals who have limited time to exercise. The CT is usually used when the objective is to promote changes in the body composition, mainly in the reduction of total body fat and maintenance or increase the fat-free mass (Vilaça-Alves et al., 2011; Wilson et al., 2012).

The benefits of combining PAE with PANE in the same session have demonstrated for

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alterations in the body composition, and the sequence in which exercise is performed may also be an essential consideration to maximize benefits.

The effect of the order on the conjugation of PAE with PANE in the body composition has studied (Cadore et al., 2013; Davis et al., 2008; Davitt et al., 2014; Küüsmaa et al., 2016; Schumann et al., 2014), and only in the study of Davis et al. (2008), present significant differences between orders in the fat and free fat mass.

It is important to note that there are several significant differences between studies that study the effect of the CT in the body composition (frequency of weekly training sessions, number of exercise session, duration of the session, participants training level, device used for PAE, intensity of PAE, load used in PANE, muscle involved in PANE exercises). These differences may influence the energy expenditure during and after exercise sessions that help to increase a diary caloric deficit between the energy consumed and spends. This deficit is significant when the objective is promoting changes in body composition. So, to promote a higher energy expenditure during and post exercises session the structure of the PANE should: i) involve large muscles masses (Mazzetti et al., 2007); ii) use loads between the 60% and 80% of the maximal repetitions (Thornton & Potteiger, 2002); iii) switch the order of the exercises between the lower and upper limbs (Farinatti et al., 2009); iv) using multiple sets and repetitions (Haddock & Wilkin, 2006; Okamoto et al., 2007); and iv) using rest pauses between the 30s to 60s (Okamoto et al., 2007).

The relation of the acute effect of the exercise order (PAE with the PANE) on the energy expenditure during and after exercise sessions have been studied by Vilaça-Alves et al. (2012) and Vilaça-Alves et al. (2018). They observed no significant differences between orders in session energy expenditure, and differing between them only in the 15 minutes post-exercise energy expenditure in favor when the PAE is performed before or interleaved the PANE.

However, in the equation of the exercise-induced alterations in the body composition, the energy expenditure, during and post-exercise session, it is only a piece. The capacity of the stress-induced in the body muscles by the exercise session to maintain or promote muscle hypertrophy is another essential piece.

The acute hormonal responses to the CT is an important factor to promote an anabolic environment (1hour post-exercise sessions) and may promote an increase or maintenance of muscle mass (Baar, 2014; Schoenfeld, 2013).

Concerning the hormonal responses in the same structure of CT, it was observed a significant increase of the IGF-1 binding protein 3 when the PAE was performed before the PANE (Rosa et al., 2015). The IGF-1 is a protein produced by the liver in response to the action of the growth hormone and, when inside the muscle fibers, promotes enzymatic activity and protein synthesis (Kraemer & Ratamess, 2005). The increase of protein synthesis can promote the maintenance or increase of the muscle mass (Schoenfeld, 2013).

So, if the exercise order in the CT, with the structure of the exercises that can promote higher energy expenditure during and after an exercise session, it seems to influence the acute hormonal response of the IGF-1 possibly can also influence the chronic changes in the body composition. The confirmation, or not, of this hypothesis should be verified.

METHOD

Participants

Eighteen participants of both sexes (9 males and 9 females) volunteered for the experiment (24.90±6.28 years old, 171.63±4.53 cm of height, and 71.34±17.98 kg of body mass). The participants were divided into three groups that performed a CT for ten weeks: a) PAE before PANE (BPANE); PAE after PANE (APANE); and c) PAE interleaved PANE (IPANE). Participants were experienced in strength and aerobic training for at least six months and trained at least three times a week. Before data collection, participants responded to the Par-Q questionnaire and signed an informed consent form. The following exclusion criteria were adopted: a) use of drugs that could affect the metabolic responses to the training; b) bone, joint or muscle diagnosed problems that could limit the execution of the concurrent training; and c) any metabolic disease. The characteristics of the participants can be seen in table 1.

Table 1
Mean ± Standard Deviation of the age, stature, body mass of the participants

Variables	BPANE	APANE	IPANE
Age (years)	24.83±6.77	24.33±5.24	25.67±6.98
Stature (cm)	170.97±4.53	169.97±4.53	173.97±4.53
Body Mass (Kg)	71.33±22.46	73.02±16.39	69.67±14.81

BPANE– The predominantly aerobic exercise was performed before the predominantly anaerobic exercise; APANE – The predominantly anaerobic exercise was performed after the predominantly anaerobic exercise; IPANE - The predominantly aerobic exercise was performed interleaved the predominantly anaerobic exercise

Procedures

Concurrent training protocols

The CT consists in one PAE (treadmill) and four PANE (Squat in smith machine (SSM), barbell free chest press (BFCP), 45° Leg press (45°LP) and back row (BR)). The characterizes of the PAE were run in a treadmill, at 70% of the reserve heart rate, for 30 minutes and the PANE 3 sets, of 10 repetitions, with a load correspondent to 70% of 1RM and an execution cadence of 60 beats/min controlled with a metronome.

The intensity of PAE execution was increasing 2% each week at 80% of the reserve heart rate and in the PANE, 5% of 1RM every two weeks.

The CT was identical in all three groups differing only in the order of the PAE in relation to the PANE: in the BPANE the 30 minutes of PAE was performed before the PANE; in the APANE the 30 minutes of PAE was performed after the PANE, and; in the IPANE the 30 minutes PAE was divided into three blocks of 10 minutes and were performed interleaved into the two blocks of 2 PANE.

Ten repetitions maximum testing

Before pre-testing, all participants underwent a familiarization period for three days during one week, in which the participants performed the same PANE as used in the 10-RM tests and retests, intending to standardize the technique of each exercise. The sessions included three sets of 10 repetitions using a light load. After the familiarization period, all participants performed the 10-RM tests and retests, on two non-consecutive days, in order to determine test-retest reliability. The 10-RM tests were performed on the same day, with a 10-minute rest interval between PANE, using the same order that used in the CT. The 10-RM loads were determined in fewer than five attempts with a rest interval of five minutes between attempts. The heaviest load achieved on either of the test days was considered the 10-RM value for each exercise. No other exercises besides the other tests performed were allowed in the period between 10-RM test sessions, in order not to interfere with the test-retest reliability results. The following strategies were adopted To minimize error during the 10-RM tests: a) standardized instructions concerning the testing procedure were given to the participants before the test; b) participants received standardized instructions on specific exercise technique, and; c) verbal encouragement was provided during the testing procedure (Simão et al., 2005).

Calculation of reserve heart rate

To estimate the reserve heart rate has used the difference between theory maximal heart rate and the rest heart rate (Karvonen et al., 1957). The maximal heart rate was calculated using the Tanaka equation (208-(0.7xage)) (Tanaka et al., 2001) and the rest heart rate was measured continuously with the participant lying in supine position, for 5 minutes, using an HR monitor (Polar Wireless Double Electrode FT80, Kempele, Finland), in an isolated room, with the door closed and the lights dimmed. The rest heart rate used was the lowest values measured in the 5 minutes.

Body Composition analysis

Participants were heightened with a standard stadiometer and weighed on an electronic scale with the body mass recorded to the nearest 0.1 kg. Fat mass and fat-free mass (in Kg and %) were estimated using dual-energy x-ray absorptiometry of the General Electric Company brand, model Lunar Prodigy Advance, manufactured in New York - United States. During the scanning, the participants lay barefoot in the supine position with arms and legs at their sides. A single licensed and experienced technician performed the DXA.

Statistical analysis

Data are presented as mean±standard deviation (SD) and confidence interval 95% (CI95%). Normality and homogeneity were checked respectively with Shapiro-Wilk and the Levene tests. A 2 moments (pre and post 10 intervention weeks) x 3 groups (BPANE, APANE, and IPANE) ANOVA was independently conducted for each exercise. When a significant main effect was found, posthoc tests (Bonferroni test with adjustment for multiple comparisons) were used to identify pairwise differences. The effect sizes (ES)were calculated using partial eta squared (μ_p^2) and Cohen´s d (d=difference between means /pooled SD) for pairwise comparisons. The small, medium, and large ES would be reflected in values higher than 0.0099, 0.0588, and 0.1379, respectively, and for Cohen´s *d* in values greater than 0.2, 0.5, and 0.8 (Cohen, 1988). The level of significance in this study was set at $p<0.05$.

Table 2

Mean ± Standard Deviation and confidence interval 95% (CI95%) of body composition variables before (T0) and after (T1) 10 weeks of intervention

	BPANE		APANE		IPANE	
Variables	T0	T1	T0	T1	T0	T1
BM (kg)	71.33±22.46 (55.50-87.16)	71.66±23.06 (55.06-88.28)	73.02±16.39 (57.19-88.85)	73.83±17.37 (57.22-90.44)	69.67±14.81 (53.84-85.50)	68.67±16.10 (53.84-85.28)
TFM(kg)	18.80±10.21 (11.88-25.73)	18.65±10.64 (11.42-25.89)	19.26±7.97 (12.34-26.19)	18.89±8.05 (11.66-26.13)	19.71±4.70 (12.79-26.64)	18.24±5.39 (11.01-25.48)
TFMp(%)	25.75±9.34 (19.15-32.35)	25.08±9.38 (18.42-31.75)	26.08±8.17 (19.48-32.69)	25.51±7.54 (18.85-32.18)	28.20±4.29 (21.60-34.80)	26.45±5.56 (19.79-33.11)
ULFM(%)	21.23±10.44 (13.04-29.42)	21.56±10.79 (13.50-29.64)	23.78±9.32 (15.59-31.97)	22.73±8.20 (14.66-30.80)	23.55±8.35 (15.36-31.74)	22.41±8.60 (14.35-30.49)
LLFM(%)	24.55±8.68 (18.36-30.74)	24.11±8.05 (17.94-30.29)	25.98±8.06 (19.80-32.17)	26.00±8.32 (19.82-32.18)	27.55±3.33 (21.36-33.74)	25.86±4.10 (19.69-32.04)
TRFM(%)	29.60±10.74 (21.99-37.21)	28.46±11.25 (20.59-36.35)*	28.65±9.27 (21.04-36.26)	27.80±8.14 (19.92-35.68)	32.21±5.30 (24.61-39.83)	30.06±7.29 (22.19-37.95)
TFFM(kg)	49.22±13.63 (38.81-59.64)	50.39±14.82 (39.50-61.28)	50.74±11.82 (40.33-61.17)	51.01±11.85 (40.11-61.90)*	47.10±10.20 (36.69-57.52)	47.01±10.48 (36.12-57.90)
ULFFM(kg)	6.66±2.64 (4.61-8.73)	7.15±2.95 (4.87-9.44)*	6.15±2.05 (4.09-8.22)	6.42±2.41 (4.14-8.72)	5.87±2.38 (3.82-7.94)	5.84±2.49 (3.56-8.13)
LLFFM(kg)	16.57±4.01 (13.15-19.99)	17.21±5.07 (13.42-21.01)	18.25±4.07 (14.84-21.68)	18.28±4.14 (14.49-22.08)	16.56±3.69 (13.14-19.98)	16.30±3.75 (12.51-20.10)
TRFFM(kg)	22.12±6.49 (17.52-26.73)	22.21±6.27 (17.82-26.60)	22.45±5.19 (17.86-27.06)	21.90±4.63 (17.52-26.29)	21.13±3.83 (16.53-25.74)	21.27±3.93 (16.88-25.66)
AFFM(Kg)	23.23±6.59 (17.81-26.67)	24.36±7.96 (18.33-30.40)	24.41±6.12 (18.98-29.85)	24.71±6.52 (18.68-30.75)	22.45±6.01 (17.02-27.89)	22.16±6.19 (16.13-28.21)

BPANE– The predominantly aerobic exercise was performed before the predominantly anaerobic exercise; APANE – The predominantly anaerobic exercise was performed after the predominantly anaerobic exercise; IPANE - The predominantly aerobic exercise was performed interleaved the predominantly anaerobic exercise; BM – body mass; TFM – total fat mass; TFMp – Total fat mass in percentage; ULFM – Upper limbs fat mass; LLFM – lower limbs fat mass; TRFM – Trunk fat mass; TFFM – Total fat-free mass; ULFFM – Upper limbs fat-free mass; LLFFM – Lower limbs fat-free mass; TFFM – Trunk fat-free mass; AFFM – Appendicular fat-free mass; T0 – Before intervention; T1 – post 10 weeks of intervention; *$p<0,005$ between T0 and T1

RESULTS

It was observed high reliability (intra-class correlation coefficients (ICCs)) between the 10RM test and retest in the PANE: squat in the smith machine (r=0.97); 45° leg press (r=0.98), back row (r=0.99), and; free barbell chest press (r=0.98). It was observed a time effect in the percentage of the total fat mass ($F_{(1,15)}=8.900$; $p=0.019$; $\mu_p^2=0.316$; CI95% = -0.189 - -1.800), in the percentage of the trunk fat mass ($F_{(1,5)}$= 8.145; p=0.012; μ_p^2=0.352; CI95% = - 0.349 - -2.407) and in the fat free mass of the upper limbs ($F_{(1,5)}$= 9.993; p=0.006; μ_p^2=0.400; CI95% = 0.405 — 0.079). It was observed an interaction group x time ($F_{(2,15)}$= 3.856; p=0.045; μ_p^2=0.340), and no significant group effect in any variable of body composition analysed. When each group was analysed separately, in the BPANE a decrease in the trunk fat mass (29.60±10.74 to 28.46±11.25, p=0.030, CI95%= -2.10 - -0.16, d=1.23) and an increase in the upper limb fat-free mass (6.66±2.64 to 7.15±2.95, p=0.017, CI95%=0.13 – 0.84, d=1,44), in the APANE it was observed an increase in the total fat-free mass (50.74±11.82 to 51.01±11.85, p=0.024, CI95%=0.05 – 0.46, d=1.32), and concerning the IPANE it was not observed any significant differences between T0 and T1.

Table 3

Mean ± Standard Deviation and confidence interval 95% (CI95%) of 10RM values in all predominantly anaerobic exercises before (T0) and after (T1) ten weeks of concurrent training.

	BPANE		APANE		IPANE	
Variables	T0	T1	T0	T1	T0	T1
BFCP (kg)	46.67±21.34 (31.44-54.12)	51.33±21.97 (35.46-59.43)*	40.00±19.14 (57.19-88.85)	44.67±20.73 (57.22-90.44)*	41.67±21.40 (53.84-85.50)	46.33±28.21 (53.84-85.28)*
SSM (kg)	51.33±21.97 (11.88-25.73)	73.33±27.41 (11.42-25.89)*	61.50±15.67 (12.34-26.19)	80.00±23.66 (11.66-26.13)*	42.33±21.18 (12.79-26.64)	61.00±25.04 (11.01-25.48)*
BR (kg)	45.33±17.69 (19.15-32.35)	52.33±18.48 (18.42-31.75)*	45.33±20.66 (19.48-32.69)	51.00±22.62 (27.26-74.74)	38.67±20.81 (21.60-34.80)	43.33±20.26 (19.79-33.11)*
45º LP (kg)	198.33±129.99 (13.04-29.42)	240.33±112.47 (13.50-29.64)*	211.67±33.12 (15.59-31.97)	261.67±40.21 (14.66-30.80)*	191.33±72.96 (15.36-31.74)	191.33±72.96 (14.35-30.49)*

BPANE– The predominantly aerobic exercise was performed before the predominantly anaerobic exercise; APANE – The predominantly anaerobic exercise was performed after the predominantly anaerobic exercise; IPANE - The predominantly aerobic exercise was performed interleaved the predominantly anaerobic exercise; BFCP – Barbell free chest press; SSM –Squat in the smith machine; 45º LP – 45º Leg press; BR – Back row

The 10RM values in the PANE increased significantly between T0 a T1 in all groups without significantly differences between them. When each group was analysed, it was observed in all groups, and in all PANE a significant difference between times: BPANE ($F_{(1,5)}$= 7.000; p=0.046; μp2=0.583; CI95% = 0.13 - 9.20; F(1,5)= 51.524; p=0.001; μp2=0.912; CI95% = 10.48 - 22.18; $F_{(1,5)}$= 12.458; p=0.017; μ_p^2=0.714; CI95% = 1.90 – 12.10; $F_{(1,5)}$= 14.074; p=0.013; μ_p^2=07.38; CI95% = 13.22 – 70.78, BFCP, SSM, BR e 45º LP, respectively); APANE ($F_{(1,5)}$= 25.34; p<0.001; μp2=0.628; CI95% = 2.69 – 6.64; $F_{(1,5)}$= 92.566; p<0.0001; μ_p^2=0.861; CI95% = 35.46 – 55.64; $F_{(1,5)}$= 86.896; p<0.001; μ_p^2=0.853; CI95% = 13.75 - 21,91; $F_{(1,5)}$= 29.780; p<0.0001; μ_p^2=0.665; CI95% = 3.52 - 8,03, BFCP, SSM, BR e 45º LP, respectively), and; IPANE ($F_{(1,5)}$= 8.448; p=0.034; μ_p^2=0.628; CI95% = = 0.53 - 8,79; $F_{(1,5)}$= 83.404; p<0.0001; μ_p^2=0.943; CI95% = 13.41 – 23.92; $F_{(1,5)}$=10.652; p=0.022; μ_p^2=0.681; CI95% = 0.89 - 8,34; $F_{(1,5)}$= 54.744; p=0.001; μ_p^2=0.916; CI95% = -29.14 - 60,18, BFCP, SSM, BR e 45º LP, respectively).

DISCUSSION

The main objective of the present study was to observe if the order of PAE in the CT affects the body composition of university students. Based on their results, the order of PAE on CT did not influence the body composition and strength gains.

These results corroborate previous studies that observed a significant increase in fat-free mass in youngsters (Arazi et al., 2011; Schumann et al., 2014) and the elderly (Cadore et al., 2013; Faramarzi et al., 2018) and decreased body fat percentage regardless of the order of PAE concerning PANE (Davitt et al., 2014; Eklund et al., 2016; Schoenfeld, 2013; Schumann et al., 2014; Shiotsu & Yanagita, 2018). Only in the study by Davis et al. (2008), it was observed that in women, youth and athletes, there were significant differences in the fat-free mass as well as in the fat mass among the group that performed the intermittent PAE concerning the group that performed the PANE before the PAE. Methodological differences between the study by Davis et al. (2008) and the other studies mentioned may have influenced the divergence between the results. In the study by Davis et al. (2008), the fat mass was estimated by skinfold measurement at seven sites and in other studies by ultrasonography and tomography.

The same studies showed a better significant reduction of body fat using the PAE, performed in the interval mode concerning the continuous mode with moderate intensity (De Feo, 2013; Heydari et al., 2012; Tremblay et al., 1994). The use of PAE in the continuous mode, in the present study, maybe the reason for the lower results observed concerning the increase of free fat mass and decrease of fat mass. Supporting the latter statement, Schumann et al. (2014) and Eklund et al. (2016) observed significant differences in fat-free mass and fat mass in the group that performed PAE in the interval mode, and there were no significant differences in the group that performed PAE continuously.

In another context, and still analysing the body composition, some studies showed positive interference concerning the performance of PAE and PANE on alternate days or in the same training session. Ihalainen et al. (2018), stated that abdominal fat was altered more significantly in the group that performed the exercises on alternate days. These results were also found in the studies of Eklund et al. (2016) and Arazi et al. (2011). However, in Vilaça-Alves et al. (2012), the results were opposite to those cited above. These divergences may have been because the subjects analysed were heterogeneous, young people with a mean age of 10.35 years, and some PAE and PANE training procedures, differed completely between the studies.

Based on the results of the present study, the dynamic force was also not altered by the order of PAE and PANE exercises. However, an improvement in strength was observed in both experimental groups in the pre- and post-intervention moments. These results are also confirmed in some researches that addressed the order of PAE and PANE exercise in the same training session, with young and elderly subjects (Okamoto et al., 2007; Shiotsu & Yanagita, 2018).

In the study by Arazi et al. (2011), it was pointed out in his scientific research results that corroborate with those mentioned above, even when the exercises were performed on alternate days or in the same training session. Again, in contrast to previous findings, the study by Davis (2008) differs concerning the order of PAE and PANE in the force variable. In this research, the group that trained by intercalating the exercises had more significant results. This difference can be explained by the heterogeneity among the study population, since it was analysed with athletes, making the comparison of the data unattainable.

Other aspects such as the effect of maximal oxygen consumption (VO_2max), functional capacity and hormonal responses when the order of PAE and PANE exercises are performed on CT, are also very important variables for comparison between studies (Cadore et al., 2013; Rosa et al., 2015). However, the present research did not compare these variables mentioned above, leaving these answers as a proposal for future scientific research.

In general, we can suggest that the combination forms of PAE and PANE exercise in the same training session seem to be equally effective for body composition and dynamic strength. Future studies should address these effects in different populations so that these results may become more established in the literature.

CONCLUSION

The present data expresses the prior knowledge about the sequence of the predominantly aerobic with predominantly anaerobic exercises performed in the same training session. The data found in this study demonstrated that the order used in a CT session, performed over ten weeks, did not seem to interfere in the variables of body composition and dynamic strength.

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