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Physiological responses of three strength training methods in trained individuals

Respostas fisiológicas de três métodos de treinamento de força em indivíduos treinados

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Abstract – Strength training is an integral part of training programs for aesthetics and sports performance. Although experiments compare the responses of some methods, there is a lack of studies that analyze the time of execution, the recovery and perceptions of pain and exertion. The aim of the present study was to evaluate and compare the metabolic and physiological responses of traditional, drop set and blood flow restriction training. The sample consisted of 16 trained men aged 32 ± 10,5 and minimum of 3 years of continuous and regular practice of ST. Data were collected in 4 days, being the first one assigned to maximum load testing and the following 3 days we analyzed randomly the drop set, blood flow restriction and traditional training methods. Blood lactate was analyzed after the training session. Pre and post intervention arm circumference, heart rate and total time, perceived pain and exertion rating scales, repetition and total volumes. Results showed no significant difference on repetitions number between blood flow restriction and drop set methods but total volume and time were significantly higher on drop set. The highest blood lactate value was found on drop set despite the other methods also show high values. Blood flow restriction and drop set showed significant difference regarding to traditional method on post exercise subjective exertion rating scale, a fact that relates with the highest total volume, mostly on drop set.

Key words: Strength training; Hypertrophy; Performance.

Resumo – *O treinamento de força é parte integrante dos programas de treinamento para estética, e desempenho esportivo. Embora experimentos comparem as respostas de alguns métodos, faltam estudos que analisem o tempo de execução, a recuperação e as percepções de dor e esforço. O objetivo do presente estudo foi avaliar e comparar as respostas metabólicas e fisiológicas do treinamento tradicional, drop set e restrição de fluxo sanguíneo em indivíduos treinados. A amostra foi composta por 16 homens treinados com idade entre 32 ± 10,5 e mínimo de 3 anos de prática contínua e regular de TF. Os dados foram coletados em 4 dias, sendo o primeiro atribuído ao teste de carga máxima e nos 3 dias seguintes analisamos aleatoriamente o drop set, restrição de fluxo sanguíneo e métodos tradicionais de treinamento. O lactato sanguíneo foi analisado após a sessão de treinamento. Circunferência do braço pré e pós-intervenção, frequência cardíaca e tempo total, escalas de percepção de dor e esforço, repetições e volumes totais. Os resultados não mostraram diferença significativa no número de repetições entre os métodos de restrição de fluxo sanguíneo e drop set, mas o volume total e o tempo foram significativamente maiores no drop set. O maior valor de lactato sanguíneo foi encontrado no drop set apesar dos outros métodos também apresentarem valores elevado. A restrição do fluxo sanguíneo e o drop set apresentaram diferença significativa em relação ao método tradicional na escala subjetiva de esforço pós-exercício, fato que se relaciona com o maior volume total, principalmente no drop set.*

Palavras-chave: *Treinamento de força; Hipertrofia; Desempenho.*

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INTRODUCTION

Strength training (ST) is an integral part of physical training programs for aesthetics, health and sports performance. Strength and muscle hypertrophy are directly related to the variable load manipulation model of training, that includes: sets, rests, repetitions, exercises, speed, amplitude and weekly frequency of sessions.[1,2]

Besides these total load components, there were developed some manipulation strategies of training variables that were named ST methods, used mainly by trained individuals who aim to potentialize results.[3] Some of these methods increase training density, which means to train with great volume and intensity in a relatively short time.[4]

Investigate and compare metabolic and physiological responses and adjustments of these methods on muscular strength and hypertrophy become extremely relevant with the aim of using and distributing them on the planning and periodization of training season of athletes or recreational practitioners.

Studies[5,6] compared respectively the responses (acute effect) and the adjustments (chronic effect) from HIRT and rest-pause to traditional method, showing significantly result to rest-pause method on energy expenditure at rest and hypertrophy and muscular endurance of lower limb.

Fink et al.[7] compared the acute effect in muscle thickness through ultrasound and muscle fatigue by exercise subjective perceived exertion scale, heart rate HR and lactate from drop set and traditional methods. The sample was set by two groups of 8 men each. Both groups had significant increase on muscle strength and cross-sectional area, the muscle thickness. Angleri et al.[8] comparing growing pyramid, drop set and traditional methods with equalized volume showed significant increase on cross-sectional area, pennation angle and fascicle length after the intervention of training in all groups but there was no significant difference among groups.

Although the experiments compare the responses of some strength training methods there is a lack of studies that analyze the metabolic and physiological responses to traditional, drop set, and blood flow restriction methods on trained individuals. In this way the aim of study were evaluated the runtime of each one, recovery, accumulation of metabolic substrates, and pain and exertion perception in trained individuals performed traditional, drop set, and blood flow strength training methods.

METHOD

The present study has a cross-sectional descriptive characteristic. After volunteers signed the consent form, the sample consisted of 16 trained men aged 32±10,5 and minimum of 3 years of continuous and regular practice of ST.

Subjects attended the laboratory in 4 days, with a minimum interval of 72 hours and always at the same schedule to accomplish protocols and data collection. On the first day it was collected body mass and height through scale branded Filizola® and performed dynamic maximum load test (1MR) on barbell elbow flexion. Along three following sessions, participants performed proposed methods. The exercise session order was randomized and volunteers were informed about the method to be performed just before accomplishment.

Subjects were advised not to work out at least 24 hours before protocol execution. The following training protocol were performed:

- Traditional method (TM) was performed with 70% workload of 1 MR until concentric failure for 3 sets and 1'30" pause between sets;
- Drop set (DS), the initial workload was 80% of 1 MR, and repetitions were always executed until concentric failure, at that moment load was reduced to 60% and 40% of 1 MR respectively. There were 3 sets performed with 1'30" pause between sets. The weight decrease was done by two evaluators positioned next to the bar so that there was the minimum possible pause;
- Blood flow restriction (BFR) was performed using 80% of the total occlusion measured using the palpatory method in the radial artery and the weight for performing the exercise was 30% of 1RM.[9,10] The volunteer was instructed to perform repetitions until concentric failure, numbered by one of the evaluators. There were 3 sets with a rest of 30" among them. Occlusion was kept from the beginning of the first until the end of the last set.

Volunteers were encouraged through verbal motivational stimuli from evaluators throughout the protocol. All collections were performed by the same evaluator. In addition, the repetitions by every volunteer were counted by an evaluator and recorded so would be calculated the volume of repetitions for each method posteriorly. Total volume was calculated through the formula: the number of repetitions x weight x number of sets for each method.

Blood lactate

The blood lactate analysis was evaluated right after the conclusion of the last set of each method. Thereunto, it was used a branded Accutrend Plus Roche® device, collecting a sample from the right index finger of the volunteer who remained seated.

Heart rate

In order to monitor heart rate (HR) and total time of session, it was used Polar branded heart monitor - model FT4. Volunteer remained resting, seated for 5 minutes to measure Resting HR (RHR) and immediately after the end of the last set, HR was checked again. Total time was calculated from the beginning of the first set until the end of the last repetition on the last set.

Subjective scales

Rating scales as Omni for exertion[11] and Borg for pain[12] were used in a standard mode and shown to volunteers before the beginning and at the end of sessions. Pain scale was repeated after 24 hours from the end of each session.

Circumferences

To measure circumferences, it was used a tape from Sanny® brand, accurately in millimeters. Right arm circumference was checked before and after each session on the bent elbow at 90 degrees, measuring tape placed at biceps brachii muscle belly in two situations: relaxed and contracted muscles.

Statistical analyses

All analyses were performed using the SPSS version 15.0 statistical package. The differences were analyzed by repeated ANOVA with post hoc Bonferroni test was used. The effect size was calculated using Cohen's d. The data are presented as mean ± standard deviation with significance of p≤ 0.05.

RESULTS

The results presented on Table 1 show number of repetitions statistically higher to BFR and DS methods compared to TM of 39.9 (p≤.001) e 53,4 (p≤.001) respectively. The total volume was higher for DS method related to TM in 54% (p≤ 0.001) and BFR with 33% (p≤0.001). The length of duration to DS method showed differences (05.39) compared to TM and BFR (01.56 e 02.06).

About Borg's post exercise rating scale, BFR and S methods showed greater results from 24 and 23% respectively to the value found for TM (p≤ 0.001). Blood lactate has showed to be statistically superior on DS (9.1±1.9) related to BFR (23%) and TM (21%) (p≤ 0.001). For the other variables, it was not found significant difference.

Table 1. Responses to the strength training, pain and exertion perception and physiological variables of three different methods.

Parameters	TM	BFR	DS
Repetitions	28.7 ± 7.1	82.1 ± 18.1*	68.6 ± 14.8*
Volume (kg)	1287.8 ± 337.9	1594.4 ± 417.4	2364.4 ± 549.5*#
Time (min)	3.43 ±.42	3.33 ± 37	5.39 ± 34#
Omni	8.5 ± 1.7	8.8 ± 1.1	9.2 ± 0.8
Borg_Post	6.5 ± 1.8	8.6 ± 1.5*	8.4 ± 1.3*
Borg_24h	3.2 ± 2.5	3.3 ± 2	4.6 ± 2.2
HR_Pre (bpm)	73.5 ± 11.9	73.5 ± 10.9	74.1 ± 11.9
HR_Post (bpm)	149.2 ± 19.4	143 ± 25.3	156.8 ± 18.3
Lactate (mmol/l)	7.2 ± 2.4	7 ± 2.5	9.1 ± 1.9#
Circ_Pre-Relaxed (cm)	38.3 ± 3.7	38.3 ± 4	38.5 ± 3.7
Circ_Post-Relaxed (cm)	40 ± 3.7	39.8 ± 4.1	40 ± 3.7
Circ_Pre-Contracted (cm)	40 ± 3.9	39.9 ± 3.9	40.1 ± 3.9
Circ_Post-Contracted (cm)	41.2 ± 3.6	41.2 ± 3.9	41. 5 ± 3.6

Note. Values presented in mean ± standard deviation of traditional (TM), blood flow restriction (BFR) and drop set (DS) methods. Cir (circumference). *Indicates statistical difference to TM. #Indicates statistical difference to BFR.

On Table 2 it is observed a percentage that DS method shows a descriptively higher physiological load than the other methods, due to 56% of the sample did not get adequate recover in less than 2 days and 1/4 of the sample did not get to recover totally after 48 hours of rest.

Table 2. Maximum strength recovery among the evaluated methods after 24 and 48 hours.

Parameters	TM		BFR		DS	
	ABS	Δ%	ABS	Δ%	ABS	Δ%
24h	9	56	10	63	7	44
48h	5	31	5	31	5	31
N_48h	2	13	1	6	4	25

Note. Data presented in absolute (ABS) and relative (Δ) descriptive form of maximum load recovery after 24h (24h); maximum load recovery after 48h (48h); failed to recover the maximum load after 48h (N_48h) to traditional (TM), blood flow restriction (BFR) and drop set (DS) methods.

The results in table 3 registered that the effect size (ES) was high in volume between BFR and TM methods and greater when compared DS to TM and DS to BFR. The time in minutes was classified as very big between DS and TM, as well as in DS related to BFR. Also, on the Borg rating scale after 24 hours, ES was very big in individuals when they compared BFR to TM and big on DS related to TM. Finally, blood lactate was high on DS related to the other two methods.

Table 3. Effect size among traditional, blood flow restriction and drop set methods.

Parameters	OVP - MT	DS - MT	DS - OVP
Volume	0.83	2.43	1.63
Time_min	0.26	3.13	3.66
Omni	0.21	0.54	0.43
Borg_Post	1.30	1.25	0.14
Borg_24h	0.04	0.61	0.63
HR_Pre	0.00	0.05	0.05
HR_Post	0.28	0.41	0.64
Lactate_mmol/l	0.08	0.90	0.97
Circum_Pre_Relaxed	0.00	0.56	0.54
Circum_Post_Relaxed	0.05	0.00	0.05
Circum_Pre_Contracted	0.02	0.02	0.05
Circum_Post_Contracted	0.00	0.08	0.08

Note. Traditional method (TM); Blood Flow Restriction (BFR) method; Drop Set Method (DS); Time in minutes (Time_min); Blood Lactate concentration in millimols per liter (Lactate_mmol / l); Circumference (Circum).

DISCUSSION

Muscle hypertrophy is directly associated to the way training variable loads are manipulated, being responsible for the control of volume and intensity. Some ST methods are used by athletes as a form to increase training density.[13] The application of methods as DS, rest-pause, BFR, increasing and decreasing pyramid, allows to train with great volume and intensities in a relatively short time gap (length), increasing training density[6,14]

Despite BFR method shows a bigger number of repetitions, the total volume o DS was greater due to the bigger load lifted in each set[8] did not find significant difference on cross-sectional area and muscle length from the fascicle in vastus lateralis muscle during a 12 weeks protocol in 22 trained men. In this study, training volume was equalized for all methods. In the present study, the load of training considered the execution recommended characteristics for each method and the repetitions extended until concentric failure for each set. This protocol method was chosen due to its application in trained individuals, which is the way to use the methods during the training sessions. Thus, the number of repetitions, duration and total volume were different among the methods. A study carried out by Fink et al.[7] demonstrated that the DS method presented higher muscle hypertrophy of the triceps brachii in relation to TM in trained individuals. The acute responses to the exertion perception (DS: 7.7±1.5; TM: 5.3±1.4, $P<0.01$), the muscle thickness of triceps brachii were significantly higher on DS when compared to TM. The blood lactate showed no significant difference between the two methods, a fact that opposes to the results found in the present study. In the study mentioned, the DS method was performed in a single set, while in the same study the number of sets was the same for the three methods. In addition, the weights used were also different.

In the experiment by Alves et al.[15] compared the energy expenditure of three different strength training methods, the TM, the bi-set method and the DS method in 10 recreational trained men. All methods were performed with 80% of 1 MR, and in the DS method the weight was decreased by 20% after the concentric failure. The exercises performed were the squat, leg curl bench, seated leg extension and the plantar flexion. The bi-set and traditional methods were performed with 3 sets and 1-minute intervals among sets, while the DS was performed with only 1 set and 1-minute interval. The DS showed a significant difference in the number of repetitions (DS = 216, bi-set = 120, TM = 230) and in the total volume (DS = 17,231, bi-set 8,769, TM = 8,769) when compared to the other two methods, meeting the data of the present study. Still, there was a significant difference in the physiological variables of HR (DS = 128 ± 27.1, bi-set = 118 ± 27.6 TM = 113 ± 22.4). The results suggest that the DS method is more efficient in promoting greater energy expenditure during a training session.

A study conducted by Gentil et al.[14] compared the metabolic and mechanical responses in seven training methods: 10 MR, 6 MR, DS, forced repetitions, functional isometry, BFR and super slow. The sample consisted of seven recreational trained men, with at least one year of experience in ST. The methods were performed for lower limb, in the seated leg extension, performing a set, and for each session an interval from 24 and 48 hours was respected. All methods showed a significant increase in blood lactate in relation to resting levels ($p \leq 0.01$), but there was no significant difference among the methods, a fact that is opposed to the findings in the present study. Blood lactate was collected three minutes after the end of the method, while in the present study, the collection was immediately after the end of the last set. Another difference among the study protocols was the number of sets. Confirming our results, the DS presented a higher total volume when compared to the other methods ($p \leq 0.05$). DS was able to induce high metabolic stress in addition to greater mechanical stress when compared to the other methods analyzed.

In BFR training with,[16] the literature has proven the effectiveness of this method when compared to traditional ones with high load.[17] In the experiment by Matheus et al.,[18] they analyzed 37 volunteers who were randomly assigned to three groups: Group 1, low intensity exercise (40% of 1MR) with BFR. The protocol consisted of 4 sets, with the first one taking 30 repetitions and the subsequent 15 repetitions, with 60-second intervals; Group 2, high intensity exercise (75% of 1 MR) with TM, with 3 sets of 10 repetitions; Group 3, low intensity exercise (40% of 1MR) without BFR. Blood lactate was collected at 3 different times: before, during and immediately after exercise. This last group under the same conditions described in group 1, but without BFR. There were no significant differences in blood lactate between groups 1 and 2 (6.86 ± 1.30 and 7.64 ± 2.49 respectively. These findings corroborate with the data found in the current sample, however it is noteworthy that the study mentioned above consisted of individuals from both genders and who were not engaged in any type of strength training and the exercises performed were: bench press, lat pulldown, squat, leg press, barbell curls and triceps pulley.

The experiment carried out by Mota et al.[19] verified the hemodynamic physiological factors of blood flow restriction on squat exercise in 30 healthy men who were recreational bodybuilders. After performing the maximum load protocol in the squat, the volunteers used the 30% load of 1MR with BFR and performed six sets of 10 to 15 repetitions, respecting a 90 seconds interval. The acute responses in blood lactate were 7.66 ± 3.04, in line with the results of

the present study, however, it is worth mentioning that in the current findings there were three series, in a single-joint exercise and a smaller muscle group.

Lastly, concerning muscle recovery, it became evident that the ST when performed at a high intensity (according to the blood lactate responses and the subjective exertion rating scales of the present study), requires for some individuals an interval greater than that suggested by the literature. The research by Muniz et al.[20] evaluated 14 men, ST practitioners divided into two groups A and B. Participants performed five sets of maximum repetitions, with two minutes of an interval between sets at 85% of 1MR, in the biceps curl exercise on the unilateral Scott bench with the non-dominant arm. The second training session was performed 24 hours later, for group A, and 48 hours later for group B. When the first two exercise sessions were performed with shorter rest intervals (24 hours), there was an increase in the sensation of pain and maintenance of reduced joint amplitude for longer.

CONCLUSION

The results showed no significant difference in the number of repetitions between the BFR and DS methods, however the total volume and time were significantly greater on DS. The highest blood lactate value was found on DS although the other methods also showed high values. The BFR and DS showed a significant difference in relation to TM in the post-exercise ERS (Borg scale), a fact that is related to the higher total volume, mainly on DS. Thus the DS method shows to be efficient to provide an increase in training density for muscle hypertrophy in addition to be a strategy for a time efficient training model.

Compliance with ethical standards

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Ethical approval

Ethical approval was obtained from the local Human Research Ethics Committee –Metropolitan University of Santos (no. 1.598.072) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conceived and designed the experiments: RPS; Performed the experiments: KMG, GPLA, LEML; Analyzed the data: AFJ; Contributed reagents/materials/analysis tools: DSB; Wrote the paper: RLR; Conceived and designed the experiments: DPGJ. All authors read and approved the final version of the manuscript.

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