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Original Research

Neuromuscular Responses to Failure vs Non-Failure During Blood Flow Restriction Training in Untrained Females

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ABSTRACT

International Journal of Exercise Science 16(1): 293-303, 2023. Applying blood flow restriction (BFR) during resistance exercise is a potent stimulus of muscular adaption, but there is little direct comparison of its effect on neuromuscular function. The purpose of this investigation was to compare surface electromyography amplitude and frequency responses during a 75 (1 × 30, 3 × 15) repetition bout (BFR-75) of BFR to 4 sets to failure (BFR-F). Twelve women (mean ± SD age = 22 ± 4 years; body mass = 72 ± 14.4 kg; height = 162.1 ± 4.0 cm) volunteered for the investigation. One leg was randomly assigned to complete BFR-75 and the other to BFR-F. Each leg performed isokinetic, unilateral, concentric-eccentric, leg extension at 30% of maximal strength while surface electromyographic (sEMG) data was recorded. More repetitions (p = 0.006) were completed during set 2 for BFR-F (21.2 ± 7.4) than BFR-75 (14.7 ± 1.2), but there were no other between condition differences for set 1 (29.8 ± 0.9 vs 28.9 ± 10.1), set 3 (14.4 ± 1.4 vs 17.1 ± 6.9), or set 4 (14.8 ± 0.9 vs 16.3 ± 7.0). Collapsed across condition, normalized sEMG amplitude increased (p = 0.014, 132.66 ± 14.03% to 208.21 ± 24.82%) across the first three sets of exercise then plateaued, while normalized sEMG frequency decreased (p = 0.342, 103.07 ± 3.89% to 83.73 ± 4.47%) across the first two sets then plateaued. The present findings indicated that BFR-75 and BFR-F elicited similar acute neuromuscular fatigue responses. The plateau in amplitude and frequency suggested that maximal motor unit excitation and metabolic buildup may be maximized after two to three sets of BFR-75 and BFR-F.

KEY WORDS: Electromyography, fatigue, resistance training, BFR

INTRODUCTION

Traditional high-load resistance training (≥ 70% of one-repetition maximum [1-RM]) and low-load resistance training (~30% of 1RM) are commonly used to induce positive skeletal muscle adaptations such as muscle hypertrophy and/or strength (33, 34). Previous investigations (30) have demonstrated that low-loads combined with a pneumatic cuff on the proximal aspect of the limb, which partially occludes muscle blood flow (blood flow restriction, [BFR]), can also induce positive muscular adaptions. Low-load resistance training with blood flow restriction

(LL+BFR) has been shown to induce greater hypertrophy and strength increases compared to low-load non-BFR training and similar hypertrophic adaptations as non-BFR high-load training (5, 7, 29).

A variety of exercise protocols, loads, and arterial occlusion pressures (AOP) have been used in previous LL+BFR studies (29). While there is a growing body of literature that suggests loads of 30-40% of 1RM and occlusion pressures between 50-80% are beneficial, less is known regarding the difference between exercise protocols (7). Typically, a 75-repetition (1 × 30, 3 × 15) protocol (BFR-75) or sets to failure (3-5 sets to volitional failure) protocol (BFR-F) has been utilized (29). Both approaches have been shown to elicit positive muscular adaptions independently, but there is little direct comparison between these protocols (22). Sieljacks et al. (35), however, examined the chronic effect of BFR-F and a variation of BFR-F which performed 25% fewer repetitions per set. Across 8-weeks of isotonic, unilateral, concentric-eccentric leg extension muscle actions at 25% of 1RM, muscle cross-sectional area and maximal isometric strength increased similarly between BFR-F (25.5% and 9.9%, respectively) and a variation of BFR-F (16.0% and 11.5%, respectively) (35). Thus, various LL+BFR protocols have been shown to induce similar muscular adaptations, but less is known regarding the neuromuscular responses between protocols.

Examining changes in neuromuscular function may elucidate the underlying effects of LL+BFR as changes in motor unit recruitment patterns are one of the theoretical mechanisms facilitating muscular adaptation associated with LL+BFR (20, 30). Muscle excitation can be assessed using surface electromyography (sEMG) which can provide insight into motor control strategies. Specifically, sEMG amplitude is a function of motor unit recruitment and firing rate (8, 38). During fatiguing resistance exercise, active motor units are stimulated at a higher rate and/or higher-order motor units are recruited to maintain force output which increases sEMG amplitude (1, 28). sEMG frequency is a measure of muscle action potential conduction velocity and is sensitive to peripheral factors of muscle fatigue (e.g., accumulation of metabolites) (12, 23, 25, 32, 37). Together, sEMG amplitude and sEMG frequency can be used to compare the acute neuromuscular responses between BFR-75 and BFR-F.

Assessing changes in muscle excitation (sEMG amplitude) and action potential conduction velocity (sEMG frequency), which indirectly quantify motor unit activation and fatigue-induced metabolite build-up, respectively, may provide an assessment of BFR-75 and BFR-F muscular adaption processes (1, 12, 23, 25, 28, 32, 37). Furthermore, analyzing patterns of neuromuscular responses at multiple time points during a single exercise session can provide a deeper understanding of the acute time course of changes in muscle function associated with BFR-75 and BFR-F. Therefore, the purpose of this investigation was to compare the sEMG amplitude and sEMG frequency responses during an acute bout of BFR-75 and BFR-F. Based on the chronic findings of Sieljacks et al. (35), we hypothesized that there will be similar acute neuromuscular responses between BFR-75 and BFR-F conditions.

METHODS

Participants

Twelve women volunteered to participate in this investigation (n = 12; mean ± SD age = 22 ± 4 years; body mass = 72 ± 14.4 kg; height = 162.1 ± 4.0 cm). All participants were recreationally active (tier one) but had not completed lower-body resistance training within the past six months (24). Sample size calculation was performed with G*Power (10). The sample size was computed based on previous investigations that examined various aspects of LL+BFR (14, 27, 39) with power set at 0.8 and an alpha of 0.05 and indicated a sample size of 6 to 26 was sufficient. Participants with muscular, metabolic, pulmonary, or cardiovascular disease were excluded from this study. Participants were required to maintain their current sleep, diet, and exercise habits for the duration of the study. This investigation was approved by the University Institutional Review Board for Human Subjects and was in accordance with the ethical standards of the Helsinki Declaration. Furthermore, this research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (26). All participants provided written informed consent before participating in the study.

Protocol

This investigation used a randomized, within-subjects, parallel design. Each participant completed a single bout of BFR-75 and BFR-F during the same visit, separated between legs and by approximately 15 minutes. Previous investigations have shown that this is a sufficient amount of time to allow for the clearance of metabolic byproducts and recovery (6, 11). The order of completion and leg was randomly assigned. During both protocols, isokinetic, concentric-eccentric leg extension muscle actions were completed at 120°s^{-1} on an isokinetic dynamometer (Biodex Medical Systems, Inc., Shirly, New York, US) at 30% of maximal voluntary isometric contraction (MVIC) torque. Each repetition was performed through a 90° range of motion (90° to 180° of knee extension) while force was tracked in real-time on a computer display. The BFR-75 protocol consisted of (1 × 30, 3 × 15) repetitions and the BFR-F protocol consisted of 4 sets to volitional failure. For both protocols, 30 seconds of rest were allotted between sets. An 11-centimeter-wide cuff connected to a Hokanson rapid cuff inflator device (Hokanson Inc., Belleview, Washington, US) was applied to the most proximal aspect of the exercising leg at 60% of total arterial occlusion pressure (29). sEMG of the vastus medialis was recorded across both the BFR-75 and BFR-F protocols.

Prior to exercise, the BFR cuff was applied and the participants laid supine on a padded table. The cuff was slowly inflated and deflated while blood flow through the posterior tibial artery was visually monitored with a Doppler ultrasound. Total occlusion pressure was defined as the lowest pressure required to fully obstruct blood flow through the posterior tibial artery. The same procedure was repeated on the opposite leg. During exercise, BFR was applied at 60% of total arterial occlusion pressure for each limb.

Participants then completed a 5-minute warm-up on a stationary bicycle (Corival, Lode B.V., Groningen, Netherlands) at a self-selected cadence and resistance. Following the warm-up,

participants were seated and secured to the isokinetic dynamometer. The dynamometer was adjusted so the axis of motion of the lever arm was aligned with the axis of rotation of the knee. Participants then performed three maximal isometric leg extension muscle actions at a knee angle of 90° (where 180° corresponds to full extension) at the knee to determine MVIC torque. The BFR cuff was then inflated immediately prior to the first repetition and remained inflated until the fourth set was completed. Participants performed either the BFR-75 or BFR-F protocols at 30% of MVIC torque which was displayed in real-time on a computer monitor. Feedback and strong verbal encouragement were provided throughout both protocols.

EMG: 4 silver bar wireless sEMG sensors (Delsys Trigno Avanti, Delsys, Inc., Natick, MA, USA) were applied to the vastus medialis muscle at 80% of the distance from the anterior superior iliac spine to the medial aspect of the patella while the hip was internally rotated (13). Sensors were oriented in line with the estimated angle of pennation of the muscle fibers (approximately 50°). The area was shaved, and the skin was cleaned with alcohol wipes before sensor placement. Sensors were attached using manufacture provided double-sided tape. Analog sEMG signals were digitized at 2,148 Hz and stored on a personal computer for analysis. Signals were digitally bandpass filtered (zero-phase shift, fourth-order Butterworth) at 10-500 Hz. The concentric portion of each repetition was selected and used for further analysis. sEMG amplitude (μV root-mean-square) and mean power frequency (Hz) values were determined offline for each sample using offline using custom-written software (LabVIEW 2021, National Instruments, Austin, TX, USA). sEMG values were normalized to the first repetition of the exercise bout and expressed as a percent change from the initial repetition of each protocol. The beginning of the set is denoted as "$B_{\#}$" and the end of the set is denoted as "$E_{\#}$", where "#" indicates the set number.

Statistical Analysis

A two-way repeated-measures ANOVA 2 [condition (BFR-75 and BFR-F)] x 4 [set (1-4)] was used to compare repetitions completed between the two conditions. Separate two-way repeated-measures ANOVAs 2 [condition (BFR-75 and BFR-F)] x 8 [time (B_1, E_1, B_2, E_2, B_3, E_3, B_4, E_4)] were used to compare the effects of the protocols on sEMG amplitude and frequency at the beginning and end of each set of exercise. Mauchly's test was used to assess the assumption of sphericity. Where the assumption of sphericity was not met, the Greenhouse-Geisser correction was used. Significant interactions were decomposed using one-way, repeated measures ANOVAs and paired sample *t*-tests. In addition, polynomial regression analyses (first, second, and third-order) were performed to determine the best-fit model for the changes in sEMG amplitude across the first set of repetitions for both BFR-75 and BFR-F. The statistical significance ($p < 0.05$) for the increment in the proportion of the variance that would be accounted for by a higher-degree polynomial was determined using an *F*-test. All statistical analyses were performed using the IBM SPSS v. 27 statistical software platform (Armonk, NY) at an alpha $p \leq 0.05$ being considered significant for all analyses.

RESULTS

Repetitions Completed: There was a significant (p = 0.010; η_p^2 = 0.289) condition × set interaction for repetitions completed as well as significant (p < 0.001; η_p^2 = 0.881) simple main effects for BFR-75 and BFR-F (p < 0.001; η_p^2 = 0.427). Specifically, for BFR-75, repetitions competed were greater (p < 0.001, $CI_{95\%}$ = 13.663 – 16.183) during set 1 (29.8 ± 0.9) compared to sets 2 (14.7 ± 1.2), 3 (14.4 ± 1.4), and 4 (14.8 ± 0.9). Similarly, for BFR-F, repetitions completed were greater (p = 0.006 – 0.031, $CI_{95\%}$ = 0.778 – 19.683) during set 1 (28.9 ± 10.1) compared to sets 3 (17.1 ± 6.9) and 4 (16.3 ± 7.0), but set 1 was not significantly different than set 2 (21.2 ± 7.4). Furthermore, between conditions, during set 2 more repetitions (p = 0.006, Cohen's d = -0.920, $CI_{95\%}$ = -13.130 – -2.716) were completed for BFR-F (21.2 ± 7.4) than BFR-75 (14.7 ± 1.2), but there were no other between condition differences (p = 0.91 – 0.736, Cohen's d = -0.509 – 0.92, $CI_{95\%}$ = -10.203 – 2.665) for set 1 (29.8 ± 0.9 vs 28.9 ± 10.1), set 3 (14.4 ± 1.4 vs 17.1 ± 6.9), or set 4 (14.8 ± 0.9 vs 16.3 ± 7.0) (Table 1).

Table 1. Repetitions completed per set by conditions

	Set 1	Set 2	Set 3	Set 4	Total Repetitions
BFR-75	29.8 ± 0.9	14.7 ± 1.2	14.4 ± 1.4	14.8 ± 0.9	73.7 ± 3.2
BFR-F	28.9 ± 10.1	21.2 ± 7.4	17.1 ± 6.9	16.3 ± 7.0	83.5 ± 26.8

Note. Mean ± SD; BFR-75 = 75-repetition (1 × 30, 3 × 15) protocol; BFR-F = 4 sets to failure protocol

sEMG Amplitude: There was no significant (p = 0.422; η_p^2 = 0.092) condition × set interaction for sEMG amplitude and there was no significant (p = 0.925; η_p^2 = 0.001) main effect for condition. There was, however, a significant main effect for time (p = 0.014; η_p^2 = 0.358). Specifically, collapsed across condition, sEMG amplitude increased across time (B_1 < E_1, E_2, B_3, E_3, B_4, E_4 $p \leq$ 0.001– .049, $CI_{95\%}$ = -72.106 – -28.295, -63.359 – -0.142; B_2 < E_2, E_3, B_4, E_4 p = 0.002–0.030, $CI_{95\%}$ = -85.662 – -28.649, -64.021 – -4.377; B_3 < E_3, E_4, p = 0.008–0.049, $CI_{95\%}$ = -69.298 – -14.679, 0.142 – 63.359). Additionally, sEMG amplitude partially recovered between set 1 and set 2 (E_1 > B_2, B_3, p = 0.002–0.027, $CI_{95\%}$ = 28.649 – 85.662, 6.140 – 76.673) (Figure 1A).

sEMG Frequency: There was no significant (p = 0.342; η_p^2 = 0.176) condition × set interaction for sEMG frequency and there was no significant main effect for condition (p = 0.815; η_p^2 = 0.007). There was, however, a significant main effect for time (p = 0.024; η_p^2 = 0.241). Specifically, collapsed across condition, sEMG frequency decreased across time (B_1 > E_1, B_2, E_2, B_3, E_3, B_4, E_4, p = 0.002–0.035, $CI_{95\%}$ = 10.066 – 28.588, 1.450 – 29.074; B_2 > E_2, p = 0.004, $CI_{95\%}$ = 4.159 – 15.027). Additionally, sEMG frequency partially recovered between sets 2 and 3 (E_2 < B_3, p = 0.004, $CI_{95\%}$ = -15.027 – -4.159) (Figure 1B).

Patterns of Responses BFR-75: For the individual sEMG amplitude versus repetitions across the first set of the BFR-75 protocol, there were significant linear increases for one participant, significant cubic increases for eight participants, and no significant relationships for three of the 12 participants (Table 2). For the composite sEMG amplitude versus repetitions, there was a significant cubic (r^2 = 0.797) increase (Table 2).

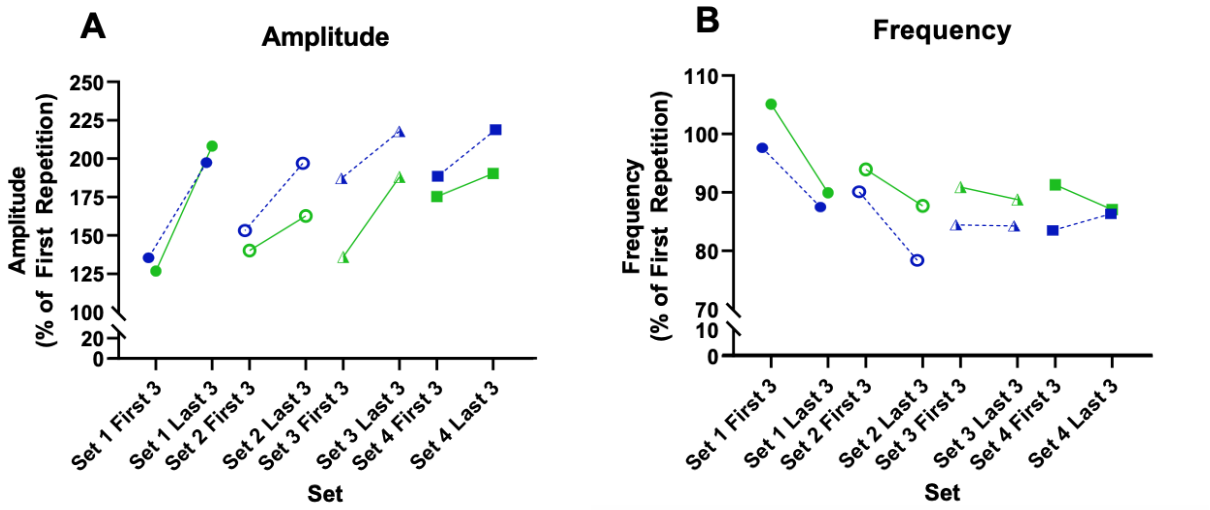

Figure 1. Surface electromyography (sEMG) Amplitude (A) and sEMG Frequency (B) of the first three and last three repetitions for each set of blood flow restriction (BFR) exercise. All signals were normalized to the first repetition of the first set. Solid green lines represent 75-repetition (1 × 30, 3 × 15; BFR-75) protocol, blue dotted lines represent 4 sets to failure protocol (BFR-F).

Patterns of Responses BFR-F: For the individual sEMG amplitude versus repetitions across the first set of the BFR-F protocol, there were significant cubic increases for five participants, and no significant relationships for seven of the 12 participants (Table 2). For the composite sEMG amplitude versus repetitions, there was a significant cubic ($r^2 = 0.692$) increase for the BFR-F protocol (Table 2).

Table 2. Individual and composite polynomial regression analyses (first, second, and third order) for normalized (to the first repetition of the first set) surface electromyography amplitude versus repetition relationships across the first set of BFR-75 and BFR-F

	BFR-75			BFR-F		
Participant	Relationship	r^2	*p*-value	Relationship	r^2	*p*-value
1	Linear	0.202	0.019	NS	0.063	0.431
2	Cubic	0.343	0.020	NS	0.013	0.646
3	Cubic	0.506	0.001	Cubic	0.454	0.025
4	NS	0.001	0.897	Cubic	0.605	< 0.001
5	Cubic	0.463	< 0.001	NS	0.075	0.474
6	Cubic	0.444	0.002	NS	0.115	0.168
7	Cubic	0.285	0.036	NS	0.031	0.296
8	Cubic	0.635	0.001	Cubic	0.361	0.022
9	Cubic	0.270	0.046	NS	0.010	0.601
10	Cubic	0.666	< 0.001	Cubic	0.355	0.006
11	NS	0.035	0.332	NS	0.038	0.270
12	NS	0.072	0.168	Cubic	0.303	< 0.001
Composite	Cubic	0.797	< 0.001	Cubic	0.692	< 0.001

NS = Non-significant

DISCUSSION

The results of the present study indicated that, in general, the BFR-75 and BFR-F protocols elicited similar changes in sEMG amplitude and sEMG frequency across repetitions and sets. Specifically, sEMG amplitude increased across sets of BFR-75 and BFR-F, while sEMG frequency decreased across sets (Figure 1). Additionally, there were similar composite patterns of responses for sEMG amplitude across repetitions that increased cubically for both BFR-75 and BFR-F (Table 2). There was, however, large variability among the individual sEMG amplitude versus repetition relationships. Furthermore, there were no differences in the total number of repetitions completed between BFR-75 (73.7 ± 3.2 repetitions) and BFR-F (83.5 ± 26.8 repetitions), although more repetitions were completed during the second set of BFR-F (21.7 ± 7.4 repetitions) than the second set of BFR-75 (14.7 ± 1.2 repetitions) (Table 1). Collectively, the results of the present study indicated that both BFR-75 and BFR-F elicited similar neuromuscular and fatigue responses.

The results of the present study were consistent with previous investigations (15–17, 21) that have examined sEMG amplitude responses during BFR-75 and BFR-F. For example, in trained males, sEMG amplitude of the vastus lateralis and vastus medialis increased within set (first 3 repetitions to last 3 repetitions) and across sets (relative to the first 3 repetitions of set 1) during 75 repetitions of unilateral, isotonic leg extensions at 30% of 1RM with BFR (60% AOP) (15). Furthermore, in trained males, sEMG amplitude of the vastus lateralis increased within each of 4 sets and across time for both the first 3 repetitions (35 ± 14% to 60 ± 17% MVC) and the last 3 repetitions (53 ± 16% to 77 ± 28% MVC) during 75 repetitions of unilateral isotonic leg extensions at 30% of 1RM with BFR (60% AOP) (21). Similarly, in trained males, sEMG amplitude of the triceps brachii increased within each set during four sets of isotonic bench press to failure at 30% of 1RM with BFR (40% AOP). However, sEMG amplitude increased incrementally between the first 3 repetitions (54 ± 26 to 89 ± 44 %MVC) of each set but was similar during the last 3 repetitions (106 ± 68 to 128 ± 60 %MVIC) of each set (17). Additionally, in trained males and females, sEMG amplitude of the rectus femoris increased within each set and across time for the first 3 repetitions (30.8 ± 13.3 to 55.5 ± 24.2 % MVC), but there was no significant difference during the last 3 repetitions (69.8 ± 32.4 to 79.3 ± 45.6 %MVC) during 4 sets of unilateral isotonic leg extensions to failure at 15% of 1RM with BFR (40% AOP) (16). Thus, our findings, in conjunction with previous investigations (15–17, 21), indicated that LL+BFR increased sEMG amplitude regardless of condition.

In the present study, sEMG frequency decreased similarly during the first two sets of BFR-75 and BFR-F that remained depressed during sets 3 and 4 which was partially consistent with previous investigations (18, 40). For example, in untrained males, sEMG mean power frequency decreased similarly within sets and between sets (except between sets 1 and 2 and sets 4 and 5) during 5 sets of 20 repetitions of unilateral, isotonic leg extensions at 20% of 1RM with BFR and without BFR (AOP of 1.44 times systolic blood pressure) (18). Furthermore, in untrained males, sEMG mean power frequency decreased during sets 2 through 4 during 75 repetitions of unilateral, isotonic forearm flexion muscle actions at 20% of 1RM with BFR (AOP of 160 mmHg)

(40). Thus, our findings, in conjunction with previous investigations (18, 40), indicated that BFR-75 and BFR-F may induce reductions in sEMG mean power frequency across sets. The variability among the sEMG mean power frequency responses between the findings of the present study and previous investigations (18, 40) may reflect methodological differences in exercise load (30% vs 20% of maximal strength), occlusion pressure (60% total arterial occlusion pressure vs 1.44 times systolic blood pressure), and/or muscle group (leg extensors vs arm flexors).

In the present study, sEMG amplitude increased progressively across the first three sets of exercise and then plateaued between sets three and four (Figure 1). Similarly, sEMG frequency decreased across sets one and two and plateaued and remained depressed during sets three and four. Thus, it is possible that maximal motor unit excitation and/or metabolic buildup were maximized after two to three sets of BFR-75 and BFR-F (2, 19, 23, 32). Our acute findings were consistent with the chronic findings of Sieljacks et al. (35) that reported similar changes in muscle strength and size across eight weeks of a non-failure BFR protocol (where participants completed 73–81 total repetitions) versus a failure BFR protocol (97–108 total repetitions) for leg extension muscle actions (25% 1-RM, 40% AOP) (35). Therefore, the application of BFR may result in similar acute and chronic physiological responses when implementing a standard 75-repetition or to failure design. Furthermore, 75 repetitions may exceed the minimal effective dose required to elicit muscle maximal motor unit excitation and/or metabolic buildup.

There were similar cubic increases for composite sEMG amplitude versus repetitions during the first set of exercise for both the BFR-75 and BFR-F protocols (Table 2). While no previous studies have examined sEMG amplitude patterns of responses in the vastus medialis muscle during BFR-75 or BFR-F leg extension protocols, these findings were consistent with previous investigations (9, 31, 36) that reported cubic increases for rectus femoris sEMG amplitude during fatiguing leg extension muscle actions without BFR (9, 31, 36). Thus, both BFR-75 and BFR-F were associated with similar muscle excitation responses across the first set of exercise when using a low load corresponding to 30% of maximal strength.

There was no significant difference in the total number of repetitions completed across all four sets of the BFR-75 (74 ± 3 repetitions) or BFR-F protocols (84 ± 32 repetitions) (Table 1). The lack of difference in total repetitions completed was an unexpected finding, but also confirmed the efficacy of BFR to accelerate muscle fatigue. Most participants (10 of 12) were able to complete the BFR-75 protocol, while there was large individual variability in the number of repetitions completed per set during BFR-F (Table 1). Specifically, a similar number of repetitions were completed during the first, third, and fourth sets during BFR-75 (29.8 ± 0.9; 14.7 ± 1.2; 14.8 ± 1.4 repetitions, respectively) and BFR-F (28.9 ± 10.1; 17.1 ± 6.9; 16.3 ± 7.0 repetitions, respectively). During the second set, however, more repetitions were completed during BFR-F (22 ± 10 repetitions) compared to BFR-75 (15 ± 1 repetitions). Together, these findings indicated that differences between BFR-75 and BFR-F may become less apparent after three or more sets of exercise.

Limitations: In the present study, the participants were untrained females which may limit the generalizability to other populations including men, symptomatic, and older adult populations which exhibit unique motor unit activation strategies. Furthermore, a within-subjects, parallel, repeated measures design was used in the present study to control for individual variability. This design, however, creates the potential that the crossover effect may have influenced the results. However, the order completed was randomized and there was no evidence the suggested order altered the observed responses. Finally, the neuromuscular assessments in the present study were from the vastus medialis exclusively. The vastus medialis muscle is a single joint muscle that is different from the other superficial muscles of the quadriceps (rectus femoris) and may not reflect the totality of muscle excitation for the quadriceps muscle group.

Conclusion: The results of the present study indicated that BFR-75 and BFR-F protocols elicited similar acute neuromuscular changes in the leg extensors of previously untrained women. Specifically, sEMG amplitude increased progressively across the first three sets of exercise and then plateaued, while sEMG frequency decreased across the first two sets and then plateaued. These results suggested that maximal motor unit excitation and metabolic buildup may be maximized after two to three sets of BFR-75 and BFR-F. There were also no differences in the total number of repetitions completed between BFR-75 and BFR-F. Thus, both BFR-75 and BFR-F appear to elicit comparable acute neuromuscular and muscular fatigue responses. Future investigations should seek to expand on the present findings with a between-subjects design and include non-BFR, low-load without BFR, and high-load conditions.

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