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Brief communication

Are there perceptual differences to varying levels of blood flow restriction?☆,☆☆,★,★★,☆☆☆,★★★

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ABSTRACT

The application of blood flow restriction (BFR) with low load exercise has been shown to produce favorable muscle and vascular adaptations. Given the potential clinical utility of BFR, it is important to characterize the ratings of perceived exertion (RPE) and discomfort across a variety of relative pressures as the individual's perceptual response may ultimately dictate whether a participant continues with this modality of exercise. Fourteen participants completed 3 days of exercise. Conditions included unilateral elbow flexion with six pressures ranging from 40% to 90% arterial occlusion at 30% of their one repetition maximum (1RM). Differences in RPE (6: no exertion at all, 20: maximal exertion) were found across conditions for set 2 (range of 13–15), 3 (range of 15–16), and 4 (range of 15–17). Following Bonferroni adjustments, none were significant. Differences in discomfort (0: no discomfort at all; 10: maximum discomfort) were found across conditions for set 1 (range of 2–3), 2 (range of 3.2–5), 3 (range of 4–6.5), and 4 (range of 5–7). Post-hoc analyses only found differences within set 3. Although it is presently unknown if higher pressures are required for optimal adaption of tissues other than skeletal muscle, our results suggest that the perceptual rating during exercise is unlikely to be a limiting factor in the application of higher pressures.

1. Introduction

The application of blood flow restriction (BFR) has been shown to be attenuate atrophy [12] and increase muscle size and strength when combined with low load (20–30% 1RM) resistance exercise in a variety of populations [10]. In addition, there is also evidence that this stimulus produces favorable adaptations to the vascular system [7,8]. Despite the observed benefits of low load resistance exercise in combination with BFR, little is known about the perceptual response across differing relative pressures. This is meaningful, as a recent review of the literature in the upper body has found that a wide range of pressures are used with little consistency across studies [3]. Recent work suggests that lower relative pressures (40% of resting arterial occlusion) may be all that is required for skeletal muscle adaptation [2], however, it is presently unknown whether higher pressures (at or near resting arterial occlusion) are required for the vascular adaptations associated with this type of exercise [4,11]. Given the potential clinical utility of BFR, it is important to characterize the ratings of perceived exertion (RPE) and discomfort across a variety of relative pressures as the individual's perceptual response may ultimately dictate whether a participant continues with this modality of exercise. Thus, the current study sought to quantify the perceptual response to six different pressures, ranging from 40% to 90% arterial occlusion (measured not estimated) within the same participant.

2. Methods

2.1. Participants

Fourteen physically active participants (10 men, 4 women) completed all of the testing sessions. Physically active was defined as being active three or more days per week with an upper body resistance training component two or more days per week for at least the last three months. Physically active participants were used to better reflect the actual acute responses to different exercises and limit the possibility

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of a training effect due to repeated testing. The study received approval from the University's institutional review board, and each participant gave written informed consent before participation. The acute torque and muscle activation data from this study has been published elsewhere [2].

2.2. Study design

During the initial visit participants had their standing arterial occlusion pressure determined and were then tested on each arm for their unilateral dumbbell elbow flexion 1RM. Participants were then familiarized with the BFR stimulus. Next, participants were scheduled for their first of three testing visits with a minimum of five and a maximum of 10 days between visits. Participants completed all of the exercise conditions in random order (1 condition per arm) across 3 separate visits (2 conditions per visit). The exercise bouts within each day were separated by 10 min of rest. For each condition the participants were instructed to complete one set of 30 repetitions followed by 3 sets of 15 repetitions at 30% of their concentric 1RM at 40%, 50%, 60%, 70%, 80%, or 90% of their standing arterial occlusion pressure. All conditions were separated by 30 s rest periods between sets. A metronome was used to ensure that the participants held the cadence of one second for the concentric muscle action and one second for the eccentric muscle action during the unilateral elbow flexion exercise. If the participant could not maintain the cadence during a particular set, the set was stopped and the participant rested 30 s until the next set. All testing sessions were completed prior to the participant exercising for that day and each visit was completed at least 24 h after their last upper body workout. All participants were blinded to the applied pressure throughout the experiment. RPE and discomfort were measured prior to exercise and following each set of exercise.

2.3. One repetition maximum testing

The maximum load that could be lifted for the unilateral dumbbell curl through a full range of motion with proper form was assessed and recorded as the concentric 1RM. Each arm was tested in a random order. Participants completed all 1RM attempts with their feet shoulder width apart and their backs against a wall. This was done to ensure strict form for all 1RM tests. All 1RMs were determined within five attempts and approximately one min rest was allotted between attempts.

2.4. Determination of arterial occlusion pressure

With participants in a standing position, a nylon (5 cm) blood pressure cuff (same cuff used during the exercise) was randomly applied to the most proximal portion of one arm and the pressure at which blood flow at the radial artery was no longer present was determined using a Doppler probe. To start, the cuff was inflated to the participant's brachial systolic blood pressure for 30-seconds. The cuff was then deflated for 10-seconds and the pressure was increased by 20 mm Hg until the Doppler pulse was no longer present. The cuff pressure was then decreased incrementally until the minimum pressure needed for arterial occlusion was found (nearest 1 mm Hg). The cuff was then removed from that arm and the participants sat quietly for 5 min after which the entire process was completed again for the opposite arm.

2.5. Blood flow restriction

With the participants in a standing position the blood flow restriction cuffs (5 cm wide, Hokanson, Inc.) were applied to the most proximal portion of the upper arm. The cuff was inflated to 50 mm Hg for 30 s and then deflated for 10 s, unless the exercise pressure was at or below 50 mm Hg in which case the participants began exercise. The cuff pressure was then increased incrementally (~20–40 mm Hg increases) until the target inflation pressure was reached (to the nearest 1 mm Hg). The cuff was inflated to the target inflation pressure prior to the first set of exercise and then deflated and removed immediately following the final set of exercise. The final pressure was set to a percentage of arterial occlusion ranging from 40% to 90% arterial occlusion.

2.6. Ratings of perceived exertion (RPE)

RPE was taken prior to the start of exercise and following each set using the standard Borg 6–20 scale with methods similar to that of Hollander et al. [5]. Participants were instructed on how to rate RPE prior to each exercise visit. Participants were told, "We want you to rate your perception of exertion, that is, how heavy and strenuous the exercise feels to you. The perception of exertion depends mainly on the strain and fatigue in your muscles. We want you to use this scale from 6–20, where 6 means 'no exertion at all' and 20 means 'maximal exertion'; any questions?" Participants confirmed that they fully understood how to rate RPE prior to actual testing.

2.7. Ratings of discomfort

A rating of discomfort was taken prior to the start of exercise and following each set using the Borg Discomfort scale (CR-10+). Methods similar to that of Hollander et al. [5] were used. For example, participants were asked, "What are your worst experiences of discomfort? 'Maximum discomfort (rating of 10)' is your main point of reference; it is anchored by your previously experienced worst discomfort. The worst discomfort that you have ever experienced, the 'Maximum discomfort' may not be the highest possible level of discomfort. There may be a level of discomfort that is still stronger than your 10; if this is the case, you will say 11 or 12. If the discomfort is much stronger, for example, 1.5 times 'Maximum Discomfort' you will say 15; any questions?" Participants confirmed that they fully understood how to rate discomfort prior to actual testing.

2.8. Statistical analyses

All data were analyzed using the SPSS 18.0 statistical software package (SPSS Inc., Chicago, IL). To compare differences in the perceptual responses (RPE and Discomfort), the Friedman non-parametric test was used to determine if median differences existed between conditions at different time points (Pre, 1st set, 2nd set, 3rd set, 4th set). If significant differences existed, Wilcoxon related samples non-parametric tests were used to determine where the difference occurred. Statistical significance for this test was set at an alpha level of 0.05. All post-hoc comparisons maintained the error rate by Bonferroni correcting the p level. Analysis across time was not completed as the purpose of the study was to investigate the influence of applied pressure on the perceptual response within each set. Data for the perceptual responses are represented as 25th–50th–75th percentiles.

3. Results

3.1. Characteristics

Participant characteristics have been published elsewhere (Acute Experiment of [2]). The participants resting arterial occlusion pressure ranged from 111 to 161 mm Hg in the right arm and 108–172 mm Hg in the left arm.

3.2. Ratings of perceived exertion

A Friedman non-parametric test found no significant differences between conditions for baseline RPE (Table 1, $p = 0.999$), however, significant differences were found across conditions for set 2 ($p = 0.002$), 3 ($p = 0.046$), and 4 ($p = 0.01$). Post-hoc tests were not significant (Table 1). There were no relationships between the pressure applied