Short Communication

The cardiovascular adaptations to repeated "Strength Snacks"

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A training program consisting of working up to a one-repetition maximum (1RM) results in similar strength adaptations as traditional resistance exercise, while also decreasing the volume of work necessary to achieve this outcome. However, little is known regarding the cardiovascular adaptations to this type of training.

Objective: To examine chronic changes in heart rate and blood pressure, as well as forearm and calf vascular conductance to either a traditional resistance exercise program or a bi-weekly 1RM-training program.

Design and Methods: Participants trained for 8 weeks (2x/week) on the knee extension and chest press exercises. The HYPER group completed 4 sets of 8-12 repetitions; the 1RM group (TEST) worked up to a single maximal rep.

Results: Age [HYPER: 21 (SD 3) vs. TEST: 22 (SD 4) years], height [HYPER: 169.3 (SD 8.4) vs. TEST: 173.5 (SD 8.5) cm], and body mass HYPER: 79.3 (SD 22.6) vs. TEST: 70.4 (SD 14.4) kg]. There were no between group differences for changes in systolic [1 (-3, 5) mmHg, $p = 0.586$] or diastolic blood pressure [1 (-3, 4) mmHg, $p = 0.775$]. For heart rate, there were between group differences [6 (1, 11) bpm, $p = 0.025$], with the TEST group having a greater reduction than the HYPER group. There were no differences in changes in forearm or calf conductance.

Conclusion: HYPER and TEST training elicited similar cardiovascular adaptations. Thus, 1RM training may provide a low volume, less time-demanding alternative to traditional resistance exercise.

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Key words: vascular conductance ■ blood flow ■ resistance training

INTRODUCTION

We recently provided experimental evidence suggesting muscle growth is not required nor additive to the strength changes following resistance exercise in trained [1] and untrained [2] participants. The protocol used to maximize strength without growth involves repeatedly practicing the one repetition maximum (1RM) strength skill. Given the minimal time required for this type of training, we hypothesize that this method may be a time efficient way for individuals to increase strength. In addition, this type of training appears to result in a more favorable affective response compared to more traditional resistance type training (i.e., 4 sets of 8-12 reps).[3] Thus, this method may be preferred for strength development. To date, however, little is known regarding the cardiovascular adaptations to just practicing a 1RM strength skill. Traditional resistance exercise has been shown to improve limb blood flow and vascular conductance.[4,5] This might be important as basal limb blood flow is an important measure of cardiovascular health, associated with metabolic syndrome [6] and advancing age.[7,8]

Interestingly, high load, low load, and low load resistance exercise with the application to blood flow restriction result in similar chronic adaptations in limb blood flow.[4,5] Although the mechanisms are not completely understood, there has been some suggestion that these changes may occur through reductions in myogenic modulation of vascular tone,[5] as well as increases in the number of arterioles and/or capillaries in parallel.[4] However, Dinenno et al.[8] found that age-related reductions in basal whole-leg blood flow and vascular conductance are mediated primarily by tonically augmented sympathetic α-adrenergic vasoconstriction. This suggests that changes in vascular function may be possible in the absence of structural changes (i.e., number of arterioles and/or capillaries in parallel), providing a potential mechanism through which a low volume exercise program (i.e. practicing the 1RM test) might influence these measures. Thus, the aims of the present paper were to examine chronic changes in heart rate, brachial blood pressure, as well as forearm and calf vascular conductance following 8 weeks of either traditional high load or bi-weekly 1RM training.

METHODS

A total of forty untrained individuals were recruited for the present study. Two individuals (1 male, 1 female) in the Hypertrophy training group (HYPER) were unable to complete the study due to personal reasons; thus, their data was excluded from further analyses, leaving a final sample of 18 individuals in the HYPER group and 20 individuals in the 1RM testing group (TEST). The study received approval from the University's institutional review board and each participant gave written informed consent before participation. The mus-

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cle size and strength data and the behavior change data from this study have been published elsewhere.[3,2]

Study Design

During the first visit, brachial blood pressure and resting forearm and calf blood flow were measured. Following the pre visit, participants were enrolled in a training program consisting of 16 training sessions dispersed over 8 weeks. Following the 8 weeks of training, participants completed the post-testing visit (48-72 hours following last exercise bout), which consisted of brachial blood pressure and resting calf and forearm blood flow. All participants were instructed to refrain from: (1) eating 2 h prior, (2) consuming caffeine 8 h prior, and (3) consuming alcohol 24 h prior to the pre and post-testing measurements.

Training Protocol

The HYPER group performed a high-volume resistance training program designed to produce muscle growth and increase strength (HYPER; n = 18; males = 7 females = 11) while the TEST group completed a program designed to minimize muscle growth and maximize strength by simply performing a 1RM strength test (TEST; n = 20; males = 10 females = 10).The training protocol for the HYPER group consisted of 4 sets with a goal of 8-12 repetitions on a knee extension and chest press machine with 90 seconds rest between sets. The training protocol for the TEST group consisted of up to 5 attempts to lift as much weight as possible one time for that training visit with 90 seconds of rest between attempts. The load was progressively increased each attempt to try to reach or exceed their previous 1RM. For the knee extension the participants in both groups performed one set of 10 unloaded repetitions in each leg as a warm-up. For the chest press warm up, due to differences in baseline strength the female participants performed one set of 5 unloaded repetitions while male participants performed one set of 10 repetitions. Additional details on the training protocol can be found elsewhere.[2]

Heart Rate and Brachial Blood Pressure

Heart Rate and brachial blood pressure were assessed following 10 min of quiet supine rest using an automated blood pressure machine (Omron #HEM-907XL) fitted with an appropriately sized cuff on the dominant arm.

Forearm and Calf Vascular Conductance

Forearm and calf blood flow were measured using venous occlusion strain-gauge plethysmography (EC5; Hokanson, Bellevue, WA, USA). Forearm and calf vascular conductance was measured on the non-dominant limb following the blood pressure measurement. While lying in the supine position, an appropriately sized (2 cm less than the greatest circumference of the limb) mercury-filled strain gauge was placed around the forearm/calf at the area with the greatest circumference and blood pressure cuffs were placed on the wrist/ankle (5 cm wide) and the upper arm/above the knee (10 cm wide) while the limb was slightly elevated above heart level to prevent venous pooling between measurements. The wrist/ankle cuff was inflated to a pressure of 250 mmHg one minute prior to blood flow measurements, remaining inflated for the duration of blood flow assessment in order to temporarily occlude blood flow to the hand / foot. The arm/leg cuff was inflated to a pressure of 50 mmHg during each blood flow measurement. The average of five 15s plethysmographic cycles was used for determining forearm / calf blood flow (ml per 100 ml tissue^{-1} min^{-1}). Blood flow was normalized to flow per unit of mean arterial pressure to calculate vascular conductance using the equation: Vascular Conductance = (Blood Flow / Mean Arterial Pressure) × 1000. Forearm flow was measured first, followed by calf measurements.

Statistical Analyses

Data are presented as mean (95% confidence interval) unless otherwise noted. A one way ANOVA with baseline values as a covariate assessed whether the changes in blood pressure, heart rate, and conductance over the 8 week period differed by group. Statistical significance was set at $p \leq 0.05$.

RESULTS

Demographics

Descriptive data is presented as mean (standard deviation). Age [HYPER: 21 (SD 3) vs. TEST: 22 (SD 4) years], height [HYPER: 169.3 (SD 8.4) vs. TEST: 173.5 (SD 8.5) cm], and body mass HYPER: 79.3 (SD 22.6) vs. TEST: 70.4 (SD 14.4) kg]. We were unable to obtain a calf vascular conductance measurement for one individual in the TEST group and 5 individuals in the HYPER group due to limb circumference exceeding the limit of our lower body cuff. The exercise volume difference between groups has been published previously.[2]

Blood Pressure and Heart Rate

There were no between group differences for changes in brachial systolic [1 (-3, 5) mmHg, $p = 0.586$, Table 1] or diastolic blood pressure [1 (-3, 4) mmHg, $p = 0.775$, Table 1]. For heart rate, there were between group differences [6 (1, 11) bpm, $p = 0.025$, Table 1], with the HYPER group having a greater change score than the TEST group.

Forearm and Calf Conductance

There were no between group differences for changes in conductance of the forearm [-1.8 (-7.7, 3.9) flow/mmHg, $p = 0.517$, Table 1] or for changes in conductance of the calf [-1.8 (-7.2, 3.5) flow/mmHg, $p = 0.494$, Table 1].

DISCUSSION

We did not identify any changes within the cardiovascular system in response to a group that was simply practicing the strength test or a group exercising at an 8-12 repetition maximum. Previous studies examining changes in vascular conductance and limb blood flow included more exercise, with participants performing full body resistance training programs.[4,5] Since we utilized only two exercises, this may have limited our ability to observe changes in vascular conductance.

Table 1 The adjusted pre, as well as the pre to post means and 95% CI for cardiovascular measures. An asterisk* indicates between group differences.

		Pre-Post Change	
	Adjusted Pre	HYPER	TEST
Systolic Blood Pressure (mmHg)	113	0 (-3, 3)	-1 (-4, 2)
Diastolic Blood Pressure (mmHg)	66	-1 (-4, 1)	-1 (-4, 1)
Mean Arterial Pressure (mmHg)	82	-1 (-3, 1)	-1 (-4, 1)
Heart Rate (bpm)	62	5 (-1, 12)*	-4 (-10, 1)
Forearm Conductance (flow/mmHg)	26.1	0.8 (-3.4, 5.0)	2.7 (-1.3, 6.7)
Calf Conductance (flow/mmHg)	25.4	-0.2 (-4.1, 4.1)	1.8 (-1.6, 5.2)

The blood pressure response we observed was similar to previous studies.[9,10] Notably, isometric resistance exercise has been shown to improve blood pressure for individuals with high blood pressure at baseline;[11] however, blood pressure does not typically change a great deal in response to resistance exercise in healthy normotensive individuals.[12] For resting heart rate, there was a between group difference, with a trend to see a change from pre to post in the HYPER group. We believe this difference is likely spurious, which would be in line with previous research noting no change in resting heart rate following resistance training interventions[4,13]. Nevertheless, it is possible that there was a small increase in heart rate, perhaps partially explained by the lower perceived recovery status observed in the HYPER group compared to the TEST group.[2] Our study was limited by the lack of a non-exercise control group. For example, knowing the variability of the change in these measurements within a time matched control group would have helped to better determine how much random error there was in our measurement over time.[14] Nonetheless, these same techniques have previously demonstrated stability across a training.[4]

CONCLUSION

In conclusion, this form of low volume training did not negatively impact the cardiovascular system. This approach may ultimately help improve participation for individuals with a lack of time for traditional resistance training methods.[15] Given the minimal amount of work needed for strength adaptation by the group practicing the strength test, this method may serve as a viable way of training as it is less exhausting compared with traditional training[3] and appears to increase strength without negatively impacting the cardiovascular system. Previous work has coined the term "exercise snack" in response to brief intense bouts of endurance exercise[16] In this spirit, bi-weekly 1RM training may improve participation for individuals with a lack of time (i.e. a strength snack).[15]

Conflicts of interest

The authors report no relationships that could be construed as a conflict of interest.

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