Does the level of effort during resistance training influence arterial stiffness and blood pressure in young healthy adults?

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Abstract.

BACKGROUND: The cardiovascular response to resistance training is influenced by different variables such as intensity and volume.

OBJECTIVE: To compare the effects of resistance training sessions differing in level of effort on blood pressure and arterial stiffness.

METHODS: Thirty-two men performed 3 sets at 75% of 1-RM during the bench press and squat exercises to failure (\textit{n} = 16; high-effort group), or performing half of the maximum possible number of repetitions per set (\textit{n} = 16; low-effort group). Blood pressure (systolic blood pressure [SBP], diastolic blood pressure [DBP], and mean arterial pressure [MAP]) and arterial stiffness (pulse wave velocity [PWV]) were measured before training (Pre), immediately after training (Post 1), 5 minutes after training (Post 2), and 24 hours after training (Post 3).

RESULTS: A main effect of time (\textit{p} \leq 0.012) was observed for all variables due to higher values at Post 1 compared to Post 2 (effect size [ES] range: 0.34–1.37) and Post 3 (ES range: 0.37–0.92). When compared to Pre, increases higher than a ES of 0.20 were observed for the high-effort group compared to the low-effort group at all time points.

CONCLUSIONS: Training to failure should be discouraged to avoid acute increases in blood pressure and arterial stiffness.

Keywords: Cardiovascular disease, exercise prescription, pulse wave velocity, velocity based training.

1. Introduction

Cardiovascular diseases are one of the leading causes of mortality and disability worldwide \cite{1}. High blood pressure has been considered as one the main risk factors to develop cardiovascular diseases \cite{2}. More recently, a marker of arterial ageing known as arterial stiffness has also been proposed as a relevant risk factor...
for cardiovascular diseases [3]. Given the huge economic burden derived from cardiovascular diseases [4], identifying modifiable behavioural patterns and non-pharmacological interventions that may contribute both to controlling blood pressure and to delaying the arterial stiffening process inherent to aging has received considerable research attention [5].

Aerobic-based exercise has proven to be beneficial for reducing both blood pressure and arterial stiffness [6]. Several meta-analyses have also shown that blood pressure may be decreased as a result of both [7,8] chronic and acute (i.e., within 24 hours after a single session) [9] exposure to resistance training. However, the effect of resistance training on arterial stiffness is not conclusive. Indeed, both increases and decreases in arterial stiffness have been reported for healthy young adults as a result of either chronic [8,10] or acute [11,12] exposure to resistance training. There is compelling evidence that resistance training is the most effective method to increase muscular strength [13], which is negatively associated with the emergence of cardiovascular diseases [14] and positively with life expectancy [15]. Therefore, it is very important to elucidate how the different resistance training variables (e.g., choice of exercises, intensity, volume, movement velocity, etc.) can be manipulated to enhance both muscular strength levels and arterial stiffness.

The time elapsed between the end of a resistance training session and the measurement of arterial stiffness may be one of the factors that explain the variance in previous findings regarding the acute effect of resistance training on arterial stiffness. An increase in arterial stiffness has been reported within the 20 minutes after completing a resistance training session [12,16,17], while a decrease in arterial stiffness has been found after 30–60 minutes [11]. These results suggest that arterial stiffness may require more time than blood pressure until returning to (or going below) baseline levels following a resistance training session [9]. In this regard, it would be interesting to determine the immediate (e.g., after 5–10 minutes) and delayed (e.g., after 24 hours) effects of resistance training on both blood pressure and arterial stiffness.

Another factor that may contribute to explain the variance between the findings of previous studies examining the acute effect of resistance training on arterial stiffness is the level of effort incurred during resistance training (i.e., number of repetitions performed with respect to the maximum possible number of repetitions). Traditionally, resistance training sets have been performed to muscular failure (i.e., maximizing the level of effort) to develop muscle mass and strength [18]. However, there is currently evidence that training to failure does not provide the optimal stimulus to maximize muscular strength levels [18,19]. Indeed, performing only half of the maximum possible number of repetitions has been recommended as a possible strategy to obtain comparable, if not higher, improvements in muscular strength while reducing the fatigue induced by training [18,20]. Therefore, it would be important to elucidate whether the acute changes in arterial stiffness may also be modulated by the level of effort incurred during resistance training.

The aim of the present study was to investigate the immediate and delayed effects of a resistance training session differing in the level of effort on blood pressure and arterial stiffness [5,21–24]. It was hypothesized that both blood pressure and arterial stiffness would increase immediately after training compared to baseline values, but will decrease 5-min and 24-h after training. The scarce number of similar studies did not allow us to formulate any hypothesis regarding the possible influence of the level of effort on blood pressure and arterial stiffness.

2. Methods

2.1. Participants

An a priori power analysis was used to compute the required sample size for the interactions of the ANOVAs using the G Power software (version 3.1.9.4, Heinrich Heine University, Düsseldorf, Germany) considering a medium effect size of 0.25, an alpha of 0.05, a power of 0.95, 2 groups, 4 measurements, and the correlations between repeated measures of 0.60. A total sample size of 30 participants was deemed suitable. Therefore, we recruited 32 young physically active men who volunteered to participate in this study by providing verbal consent. They were randomised into two groups of 16 participants: low level of effort (age = 21.7 ± 2.2 years, body mass = 77.9 ± 7.3 kg, height = 1.77 ± 0.07 m) and high level of effort (age = 21.8 ± 1.1 years, body mass = 74.9 ± 10.1 kg, height = 1.74 ± 0.05 m). To be included in the study sample participants had to be physically active, normotensive, and experienced with resistance training (at least 1 year). Participants were excluded if they had cardiovascular or metabolic diseases, and if they were taking any medication that could affect blood pressure or heart rate. Participants were instructed to avoid the consumption of alcohol and caf-