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The Acute Effects of Various Intensity and Repetition of Resistance Exercise on Vascular Function in Older Adults: A Randomized Cross-Over Design Study

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ABSTRACT

Sarikavanich K, Mitranun W, Paditsaeree K. The Acute Effects of Various Intensity and Repetition of Resistance Exercise on Vascular Function in Older Adults: A Randomized Crossover Design Study. **JEPonline** 2024;27(1):1-9. The purpose of the study was to investigate the acute effects of resistance exercises with different loads and repetitions on vascular function in adults who were 60 to 69 years of age. This acute effect study included 15 participants who performed three conditions of resistance exercise: (a) high intensity and low repetition (HL); (b) moderate intensity and moderate repetition (MM); and (c) low intensity and high repetition (LH). Brachial artery flow-mediated dilation (FMD) and blood pressure were measured at baseline and at 0, 10, 30, and 60 minutes after exercise. The results showed that LH immediately increased FMD at 0, 10, 30, and 60 minutes after exercise compared to the baseline. Additionally, a decrease in systolic blood pressure after the intervention was observed only in the LH condition, with no significant changes in HL and MM conditions. In summary, the acute effects of low-intensity and high-repetition resistance exercise improved vascular function and lowered blood pressure among older adults.

Key Words: Blood Pressure, Endothelial Function, Flow-Mediated Dilation, Older Adults, Repetition

INTRODUCTION

The vascular endothelium plays a crucial role in regulating vasoconstrictive tone through various mechanisms. Nitric oxide is one of the important vasodilation markers for good vascular health. Flow measurement-mediated dilation (FMD) is a key hallmark in the assessment of the vascular endothelium (2). With aging FMD is known to increase the risk of atherosclerosis and ischemic heart disease (10). According to a systematic review and meta-analysis of randomized controlled trials (19), aerobic activity, particularly moderate- and vigorous-intensity aerobic exercise, improves FMD.

As for the effects of resistance exercise, there are many variations. Some studies have found that regular resistance training causes an increase in arterial stiffness among middle-aged adults (1,13). It has been reported that in both normotensive and hypertensive adults, high-intensity resistance training has been linked to an increase in arterial stiffness indicators (11). Researchers have also observed a reduction in blood pressure with high-intensity resistance exercise (5). These findings support the idea that endothelial dysfunction caused by high-intensity resistance training might be dependent on hypertension.

In a scoping review of the effects of exercise on vascular function in middle-aged and older adults, six studies reported that resistance training has a beneficial effect on blood vessels, while seven studies concluded that resistance training does not affect FMD (3). Another study involving moderate- to high-intensity older adults found that resistance training did not impact FMD (15). Long-term studies may not provide a clear consensus, and further studies are needed to investigate differences in intensity and repetitions.

A recent study by Dawson et al. (6) found that acute changes in FMD after resistance exercise may predict long-term FMD. The chronic change of FMD may be from the acute phase. To consider acute vascular changes, a previous study examined differences in FMD among adolescents with varying intensity and repetitions, consisting of high intensity with low repetition, low intensity with high repetition, and moderate intensity with moderate repetition. High intensity with low repetition has a better protective effect against the impairment of FMD (14). However, this has not been studied in older adults. Therefore, the purpose of this study was to investigate the acute effects of different intensities and repetitions of resistance exercise in older adults.

METHODS

Subjects

Screening, Initial Instruction, and Randomization

A randomized crossover design was employed, consisting of three conditions: (a) high intensity and low repetition (HL); (b) moderate intensity and moderate repetition (MM); and (c) low intensity and high repetition (LH). To mitigate any potential carryover effects, there was a minimum 72-hour separation between each condition. The allocation of the subjects to these conditions was random and followed the 3x3 Latin square method.

A total of 15 individuals were recruited to participate in this study. They were provided with detailed instructions for three specific exercises using weight machines: (a) leg extensions; (b) chest presses; and (c) seated rows that ensured the participants executed them correctly. Before the main study, there was a 2-week familiarization period, during which subjects engaged in these exercises 2 times·wk^{-1}. This period allowed them to determine their one-repetition maximum (1RM) for each exercise posture, which is the maximum weight they could lift just once.

The subjects were provided with specific guidelines for preparation, including consuming a meal at least 2 hours before the test, refraining from caffeine and alcohol for at least 10 hours, and avoiding exercise for 24 hours prior to the test. The tests were conducted in a controlled environment, maintaining a temperature of 25º Celsius and a relative humidity level of 46 to 49%. Measurements were taken at consistent intervals for each subject.

On the first day of data collection, the sample group underwent testing in a controlled room at 25 degrees Celsius. Basic physiological parameters, such as body weight, height, BMI, and measurements of fat and lean body mass, were recorded. Vascular function was also assessed, including the measurement of blood pressure, flow-mediated dilation (FMD), and brachial-ankle pulse wave velocity (baPWV).

The 3 different exercise conditions (HL, MM, and LH) included 3 exercises: leg extensions, chest presses, and seated rows, each with their respective specifications:

1. HL featured high-intensity resistance exercises at 85% of 1RM with 180 seconds of rest between sets and a total of 3 sets each with 3 repetitions.

2. MM consisted of resistance exercises using moderate weights at 70% of 1RM with 60 seconds of rest between sets and a total of 3 exercises with 10 repetitions per exercise and 3 sets in total.

3. LH involved low-intensity exercises at 30% of 1RM with 60 seconds of rest between sets and a total of 3 sets with 40 repetitions per set.

Biology Measurement

An electrical body composition analyzer (Omron BF511, Omron Healthcare Europe B.V., Hoofddorp, Netherlands) was employed to assess various aspects of body composition, such as weight, BMI, percentage of body fat (%fat), and percentage of muscle (%muscle)

Data Collection and Measurement

The subjects were dressed informally and took off any metal accessories before the various measurements. Pre-exercise measurements for blood pressure (BP), pulse wave velocity (PWV), and flow-mediated dilation (FMD) were taken, and then the post-exercise measurements were recorded at 0, 10, 30, and 60 minutes. All the subjects participated in the data collection process.

Throughout the study period, which occurred between 9:00 a.m. and 12:00 p.m., the subjects were instructed to maintain their regular food intake without making any changes and they were told to obtain sufficient rest by avoiding any strenuous physical activity.

To assess FMD of the brachial artery, an ultrasound device (Vivid i-GE Healthcare Cardiovascular Ultrasound System, Tirat Carmel, Israel) was used. The brachial artery, located above the antecubital fossa along the longitudinal axis, was visualized. After resistance exercise, the subjects had a blood pressure cuff wrapped around their right forearms. The cuff was rapidly inflated for 5 minutes to 50 mmHg above their systolic blood pressure and then deflated for 5 minutes. Baseline data were monitored for 1 minute prior to this process (16). For the offline analysis of the vascular data, ultrasound images were transferred to a digital program called Brachial Analyzer (Medical Imaging Application, USA). FMD was calculated using the formula: (Maximum diameter – Baseline diameter) / Baseline diameter.

All brachial characteristic data were collected in real-time and subsequently exported for external analysis. Changes in brachial diameter were analyzed offline using a computer-based analysis tool, Brachial Analyzer (Medical Imaging Applications, Coralville, IA, USA). The intraclass correlation coefficient for FMD exceeded 0.85.

The baPWV measurement is a non-invasive vascular screening tool (OMRON; Colin VP-1000 Plus, Kyoto, Japan) that evaluates arterial stiffness. It involves using 4 cuffs on both arms and ankles. The subjects were assessed in a supine position, and baPWV calculated the time intervals between the brachial waveform and the maximum point of the ankle waveform. The pressure waveforms of the left and right thoracic arteries and the posterior tibial artery were examined. The distances between the measurement sites for baPWV were automatically determined based on the individuals' heights.

Statistical Analyses

A repeated-measures analysis of variance (ANOVA) was conducted with a two-way (time trial) design. The *post hoc* Tukey test was performed to compare dependent variables between the MM trial and HL trial, as well as between the LH trial and HL trial. These statistical tests were carried out using SPSS software (version 23, IBM). Statistical significance was considered at a level of $P < 0.05$. The data are presented as mean ± standard error (SE).

RESULTS

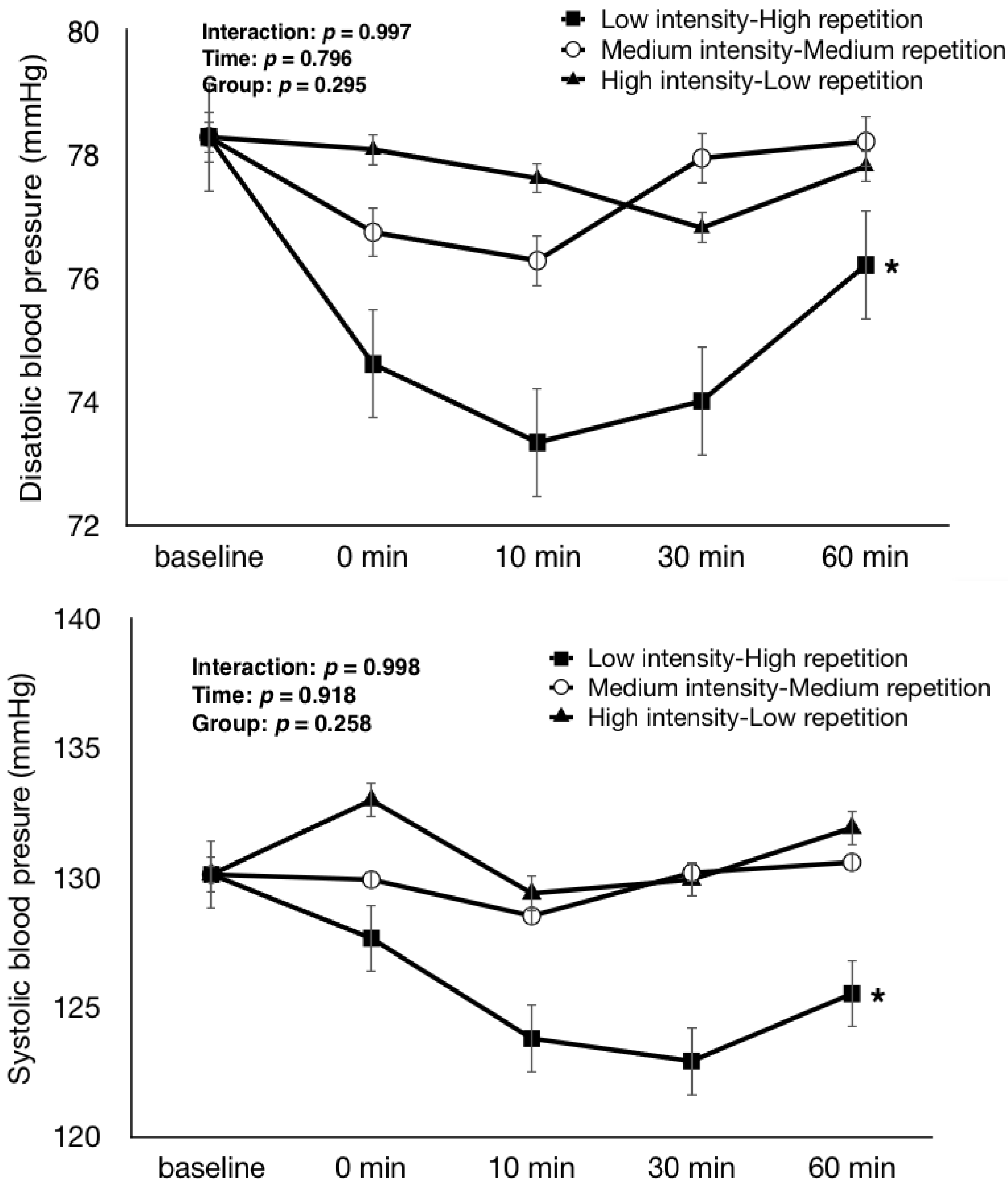

Figure 1. Diastolic and Systolic Blood Pressure.

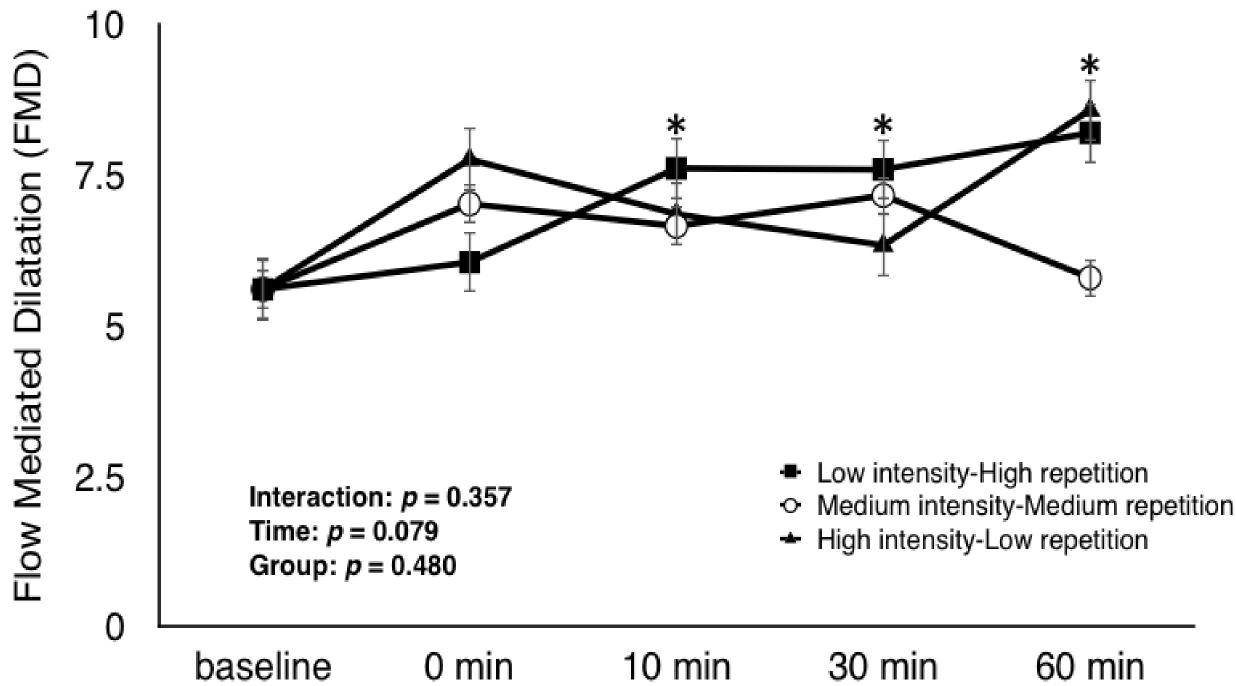

Figure 2. Flow-Mediated Dilation.

The results showed that LH immediately increased FMD at 0, 10, 30, and 60 minutes after exercise compared to the baseline. Additionally, a decrease in systolic blood pressure after the intervention was observed only in the LH condition, with no significant changes in HL and MM conditions (Figure 1, Figure 2).

DISCUSSION

The key findings of this study indicate that the type of resistance exercise does not result in acute impairment of vascular function in older adults. However, it is worth noting that the LH condition appears to have a positive impact on enhancing Flow-Mediated Dilation (FMD) at 10 minutes and 30 minutes post-exercise, coinciding with a reduction in systolic blood pressure (SBP). This suggests that the LH condition might be suitable for older adults to help regulate blood pressure.

No significant differences were observed among the various forms of resistance exercise, except for the LH condition that showed an immediate increase in FMD at 10 and 30 minutes after resistance exercise. It is important to mention that, while not common, there is typically a sudden increase in both systolic and diastolic blood pressure during resistance exercise. In young individuals performing double-leg press exercises, blood pressure can reach levels as high as 320/250 mmHg (12). Surprisingly, none of the exercise conditions in this study caused substantial changes in exercise blood pressure. This could be attributed to age-related alterations in the circulatory system, where middle-aged men exhibit higher muscle sympathetic nerve activity compared to younger men at the same exercise intensity (9). Furthermore, older adults tend to have higher sympathetic nerve activity at rest compared to their younger counterparts, resulting in reduced increases in cardiac output and peripheral vasoconstriction during exercise with advancing age (7).

The aging process contributes to reduced vascular elasticity and increased rigidity, which can limit the blood vessels' ability to adapt to increased blood flow and pressure during resistance exercise. This limited vascular compliance may explain why high-intensity resistance exercise in older adults does not lead to a more significant elevation in blood pressure. Additionally, post-exercise hypotension, characterized by a sudden drop in blood pressure and heart rate after exercise, is influenced by the release of nitric oxide from blood vessel lining cells that leads to blood vessel dilation. Resistance exercises with higher volume are more effective in inducing post-exercise hypotension, accompanied by an increase in forearm blood flow and a decrease in forearm vascular resistance (4).

The LH condition appears to be a promising option for managing blood pressure during exercise in the older adults, given that SBP decreases the most after exercise. There may be a potential connection between this phenomenon and post-exercise blood pressure regulation. The increase in blood flow induced by exercise is necessary to promote this process (8). Post-exercise sympathoinhibition, involving the consistent inhibition of sympathetic impulses through neurological and hormonal pathways, is in alignment with the findings of this study, given the rapid decline in blood pressure that was observed in low-intensity with high-repetition resistance exercise.

Regarding acute vascular changes, a study in adolescents examined variations in FMD following resistance exercises with varying intensity and repetition patterns, including high intensity with low repetition, low intensity with high repetition, and moderate intensity with moderate repetition. It was found that high intensity with low repetition had a more favorable impact on mitigating the abrupt decline in FMD following resistance exercise, particularly in younger subjects (14). This contrasts with the results of this study involving older subjects in the HL and MM conditions that found no increase in FMD following exercise.

In the LH condition, an increase in FMD was observed after 10 minutes of exercise, and this effect persisted up to 60 minutes. High blood pressure during resistance exercise may lead to a decline in FMD (17). The condition that resulted in higher blood pressure during exercise exhibited worsened FMD, while the resistance exercise condition that did not significantly raise blood pressure did not experience a decline in FMD (18). It appears that in older adults, the LH condition that involves exercises with lower intensity does not significantly increase blood pressure and, therefore, does not adversely affect acute FMD. Inactivity of FMD can be attributed to both low intensity and high volume, as seen in the younger subjects, where it did not lead to a deterioration of FMD.

CONCLUSION

The acute effects of low-intensity, high-repetition resistance exercise improved vascular function and lowered blood pressure among older adults.

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