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# The Immediate Effects of Lower Body Resistance Exercise on Brachial Flow-Mediated Dilation and Brachial-Ankle Pulse Wave Velocity

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## ABSTRACT

**Choeipho R, Mitranun W, Napatpittayatorn P**, The Immediate Effects of Lower Body Resistance Exercise on Brachial Flow-Mediated Dilation and Brachial-Ankle Pulse Wave Velocity. **JEPonline** 2024;27(3):43-51. The purpose of this study was to investigate the acute effects of lower body resistance exercise on brachial flow-mediated dilation (FMD) and brachial-ankle pulse wave velocity (PWV). This study included 22 untrained male subjects 18 and 25 years of age. The participants engaged in a single bout of resistance exercise with leg extensions at 70% of the one-repetition maximum, 10 repetitions per set for 5 sets with a 1-minute rest per set. FMD and PWV were measured immediately at intervals of 10, 15, 30, and 60 minutes. The results demonstrated no significant change in FMD, PWV, diatolic blood pressure, or mean arterial pressure ($P>0.05$). Only an increment in systolic blood pressure was observed immediately after exercise ($P<0.05$). In conclusion, the results of this study showed that a single bout of lower body resistance exercise had no influence on the acute brachial FMD and PWV.

**Key Words:** Arterial Stiffness, Endothelial Function, Leg Extension, Vascular Function

## INTRODUCTION

A dysfunctional endothelium is caused by an imbalance between the vasodilator and vasoconstrictor factors (3,22). The endothelium regulates blood flow, vessel wall inflammation, and the permeability of plasma components. Additionally, nitric oxide (NO) plays a crucial anti-atherogenic role by maintaining endothelial integrity and promoting vasodilation. Vascular tone and diameter are controlled by NO through the regulation of the balance between tissue, oxygen supply, and metabolic requirements. Endothelial NO synthase (eNOS) is activated to produce NO from L-arginine in response to various endogenous, exogenous, and mechanical stimuli. Among these stimuli, shear stress is particularly distinctive (3,22).

Flow-mediated dilation (FMD) is a crucial indicator used to evaluate the function of the vascular endothelium (3,22). Several exercise studies on FMD suggest that acute effects on vascular function may be observed. In a previous study on resistance exercise, a decrease in brachial FMD was noted following a single session of elbow flexion exercise (12). Another study included exercises such as crunch training, side crunch training, and leg raise training, targeting the upper and lower abdominal muscles, respectively. Measurements of FMD in the brachial artery revealed that only crunch training led to a significant decrease (13). Although some exercise postures involving the lower body may affect vascular function and arterial stiffness (15,17,18), further investigation into the impact of lower body exercise on brachial FMD is warranted.

Pulse wave velocity (PWV) is a measure utilized to evaluate arterial stiffness, where higher PWV values correlate with heightened arterial stiffness, while lower values signify improved arterial stiffness (25). While some long-term studies on the impact of resistance training on arterial stiffness have reported no notable alterations, contrasting research suggests that resistance training, particularly involving free weights, may elevate arterial stiffness. Furthermore, immediate effects following resistance exercise sessions have been observed to temporarily raise arterial stiffness in healthy young men (8,27,28). These results emphasize the nuanced interaction between resistance training and arterial stiffness that suggest the need for additional research to verify the effects of a single bout of lower body resistance exercise. Further studies are essential to fully understand this relationship and to confirm the initial findings. Due to a lack of extensive investigation into how lower body resistance exercise affects brachial flow-mediated dilation (FMD) and pulse wave velocity (PWV), this study focuses specifically on understanding the immediate impact of resistance training on these variables.

## METHODS

### Subjects

The study enrolled 22 untrained males 18 to 25 years of age, from Srinakharinwirot University in Ongkharak. The inclusion criteria were no history of resistance or aerobic training for a minimum of 6 months before initiation of the study. During this investigation, the participants completed a health assessment using the PAR-Q form in Thailand. Fulfilling the standards for inclusion required answering "Yes" to every question. Additionally, the participants were instructed to stop smoking and submit a request for their study involving human subjects to be reviewed by the Ethics Committee of Srinakharinwirot University The project code is (SWUEC-G-358/2021).

## Procedures: Experimental Method

In the first session, the one-repetition maximum (1RM) was determined by having participants lift the maximum weight they could handle in a single repetition. After establishing the 1RM, 70% of this value was calculated. The participants were then instructed to rest for 2 days before the test and to avoid heavy activities, vitamin C, caffeine, smoking, alcohol, or any supplements that might affect vascular function. In the second session, the participants warmed up with leg extensions for 10 repetitions at an intensity of 20% 1RM, followed by 5 sets of 10 repetitions per set at 70%. The participants rested for 60 seconds after each set, and FMD and PWV values were measured at 0, 10, 15, 30, and 60 minutes (Figure 1).

To evaluate the FMD of the brachial artery, an ultrasound device (Vivid i-GE Healthcare Cardiovascular Ultrasound System, Tirat Carmel, Israel) was used. The artery was imaged above the antecubital fossa along its longitudinal axis. Following resistance exercise, a blood pressure cuff was placed around the participants' right forearms. The cuff was quickly inflated for 5 minutes to a pressure 50 mmHg above their systolic blood pressure and then deflated for another 5 minutes. Baseline measurements were taken for 1 minute before starting the procedure. For analyzing vascular data offline, ultrasound images were transferred to a software program called Brachial Analyzer (Medical Imaging Application, USA). The FMD was calculated using the formula: (Maximum diameter – Baseline diameter) / Baseline diameter (12,13,22). Arterial stiffness was assessed using a non-invasive vascular screening device (OMRON; Colin VP-1000 Plus, Kyoto, Japan) designed to measure pulse wave velocity (PWV). This method employs 4 cuffs positioned on both arms and ankles.

## Statistical Analyses

SPSS software was used to determine the mean ($\overline{x}$) and standard deviation (SD) for heart rate, vascular function, and blood pressure. A one-way ANOVA with repeated measurements was used to analyze the data. The significance threshold was set at an alpha level of P<0.05.

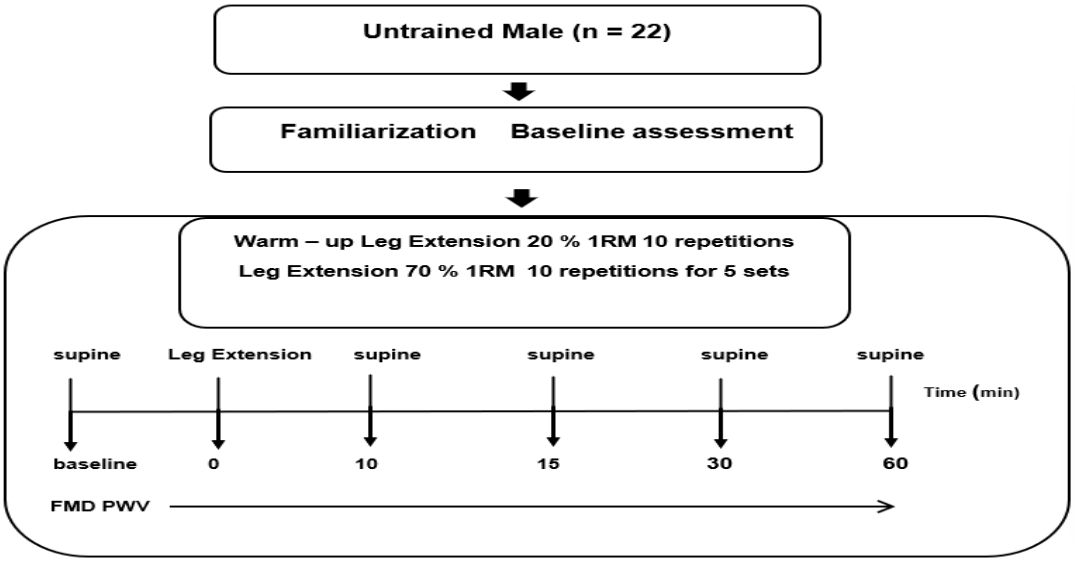

**Figure 1. Experimental Design. Intensity of Resistance Exercise.**

## RESULTS

The average age, weight, height, fat percentage (%), muscle mass (%), body mass index (BMI) (kg·m$^{-2}$), maximal heart rate recorded (beats·min$^{-1}$), sting heart rate (beats·min$^{-1}$), systolic blood pressure (SBP) (mmHg), diastolic blood pressure (DBP) (mmHg), FMD, PWV, and mean arterial pressure (MAP) of the participants are presented in Table 1.

**Table 1. Participant Characteristics.**

| **Participant Characteristics** (N = 22) | **Mean** $(\bar{x})$ | **Standard deviation** )SD) |
|---|---|---|
| **Age** )year( | **22** | **1.07** |
| **Weight** )kg) | **71.90** | **16.91** |
| **Height** (cm) | **173.13** | **6.29** |
| **Fat Percentage** )%( | **23.61** | **4.43** |
| **Muscle Mass** )%( | **22.45** | **5.33** |
| **Body Mass Index** (BMI) (kg·m$^{-2}$) | **30.11** | **4.28** |
| **Maximal Heart Rate Recorded** )beats·min$^{-1}$( | **192.47** | **0.75** |
| **Sting Heart Rate** )beats·min$^{-1}$) | **74.5** | **10.42** |
| **Systolic Blood Pressure** )SBP) )mmHg) | **121.59** | **13.48** |
| **Diastolic Blood Pressure )**DBP) )mmHg) | **69.13** | **7.61** |
| **Flow-Mediated Dilatation** )FMD( | **4.05** | **0.45** |
| **Pulse Wave Velocity** )PWV( | **1184.65** | **134.52** |
| **Mean Arterial Pressure** )MAP( | **89.78** | **10.58** |

As shown in Table 2, the brachial characteristics and blood pressure data showed no significant change in FMD, PWV, DBP, or MAP when compared to baseline. ($P>0.05$). Only an increment in SBP was observed after immediate exercise ($P<0.05$).

**Table 2. The Variations in FMD, PWV, SBP, DBP, and MAP Due to the Resistance Exercise (RE).**

| **Outcome** RE | **Baseline** | **0 min** | **10 min** | **15 min** | **30 min** | **60 min** |
|---|---|---|---|---|---|---|
| **Flow-Mediated Dilation (FMD)** )**%**( )Mean ± SD**(** | 4.05<br>± .46 | 4.12<br>± .47 | 4.11<br>± .50 | 4.10<br>± .46 | 4.10<br>± .47 | 4.07<br>± .44 |
| **Pulse Wave Velocity** (PWV, mmHg) | 1170.16<br>±122.69 | 1164.66<br>±131.41 | 1093.90<br>± 96.34 | 1097.64<br>±114.05 | 1113.97<br>±126.12 | 1133.11<br>±131.18 |
| **Systolic Blood Pressure** (SBP, mmHg) | 121.59<br>±13.80 | 131.50<br>±14.37* | 123.54<br>±12.14 | 120.36<br>±10.81 | 121.04<br>±11.66 | 119.00<br>±12.43 |
| **Diastolic Blood Pressure** (DBP, mmHg) | 69.13<br>±7.79 | 71.81<br>±7.48 | 68.90<br>±6.38 | 69.00<br>±7.20 | 68.77<br>±9.40 | 68.04<br>±7.45 |
| **Mean Arterial Pressure** )MAP, mmHg) | 89.77<br>±10.83 | 94.27<br>±9.51 | 90.77<br>±8.08 | 89.77<br>±7.40 | 90.18<br>±9.10 | 87.50<br>±8.34 |

Values are presented as mean ± standard deviation (SD) , * vs. baseline, P<0.05

## DISCUSSION

The primary findings of this research indicated that a single session of lower body resistance training is unlikely to have an immediate impact on brachial FMD and PWV.

### Systolic Blood Pressure )SBP)

Systolic blood pressure increased immediately after resistance exercise. This finding is consistent with other studies on the type and intensity of exercise that result in high systolic blood pressure, such as sprint interval exercise in inactive men (9) and resistance exercise, where the increase in systolic blood pressure was more significant in males than in females (16). Moderate-intensity resistance exercise at 60% 1RM also causes high blood pressure (10).

According to the data, exercise stimulates the sympathetic nervous system (SNS) (22). The sympathetic receptor types include alpha and beta receptors. When the alpha receptor is stimulated by epinephrine or norepinephrine, the arteries are constricted, along with increased stiffness. Additionally, heart rate, cardiac output, and blood pressure increase when the beta receptor is stimulated (23). Systolic blood pressure usually increases with respiration. During inspiration, negative intrathoracic pressure causes blood pooling in the expanding pulmonary vessels and delays flow to the left ventricle. Thus, systolic pressure decreases momentarily as the cardiac output decreases (26(. However, this study focused only on a single bout of lower body resistance exercise.

### *Pulse-Wave Velocity (PWV)*

Resistance exercise can cause a temporary increase in arterial stiffness immediately following the workout. This is due to the increase in sympathetic nervous system activity, which causes vasoconstriction and elevates arterial pressure that leads to increased PWV (11). However, this study showed that resistance exercise did not significantly affect pulse wave velocity, and it had no impact on arterial stiffness. These findings are consistent with those of a meta-analysis that found that most studies claim that resistance exercise has no significant effect on arterial stiffness (24) in overweight, obese adults (2,5,7), and obese postmenopausal women (6). This contradicts the previous finding that resistance exercise, which includes exercises such as lateral pulldowns, biceps curls, triceps extensions, seated dumbbell presses, and lateral dumbbell raises increases arterial stiffness in pre-hypertensive and hypertensive individuals (11). Light-to-moderate intensity exercise significantly decreased pulse wave velocity, while high intensity exercise was not significant. Only light-to-moderate intensity significantly reduced arterial stiffness in the under-40 and over-40 age groups (18). Also, combined aerobic and resistance exercise reduced arterial stiffness in postmenopausal women )17). However, the different results may depend on the factors and impact of exercise )types, intensity, and frequency) and target group, including the location of the PWV measurement, which may also be related to the exercise posture, such as measuring PWV on the upper body for exercise in the lower body. This might have caused the values to differ.

### *Flow-Mediated Dilatation (%FMD)*

This study found no significant results in the percentage of FMD completed in 5 sets of 10 repetitions of 70% intensity. Similar studies have shown that a single resistance exercise session performed at high intensity (maximal repetition) reduced the flow-mediated dilatation (FMD) response (4,15). Interestingly, this study presented results different from those of previous research. This contradicts the findings of the studies indicating that higher blood pressure leads to a decrease in FMD )20(.

In contrast, other studies have shown increased FMD during cycling after resistance exercise (21,25). We found that brachial artery FMD remained unchanged after the resistance exercise trial in untrained (active) males. This finding is consistent with other studies that showed changes in vascular function following resistance training. In active persons, the association between high levels of exercise training and increased FMD is age-dependent (14). In other studies, FMD remained unchanged in the elastic tubing alone condition (20), and no changes in FMD were observed when performing 8 to 10 repetitions of resistance training (19) or higher repetitions (1). In our study, the lower body resistance exercise might not affect the change in brachial FMD. Additional studies may be necessary in the future, and appropriate adjustments can be made accordingly.

### Limitations in this Study

This study has some limitations. First, the sample size was relatively small. Second, the immediate effects of resistance exercise on function and accurate noninvasive estimation are challenging and clinically necessary. Long-term confirmation of developmental or mechanistic changes at the molecular level, such as the measurement of nitrite/nitrate levels, endothelin-1, or other biochemical markers, may necessitate further research. Third, leg extension was the only lower body training exercise selected. The appropriate training posture for each muscle group needs to be determined. Fourth, this study relied solely on self-reported physical activity using questionnaires. Future studies should consider using devices such as pedometers or wearable activity trackers for a more accurate measurement of physical activity levels.

## CONCLUSION

A single bout of lower body resistance exercise may not affect the acute brachial FMD and PWV.

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