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Improvement of Cardio-Ankle Vascular Index by Arm-Swing Exercise in Older Adults

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Abstract:

Objective: The purpose of this study was to determine the effect of the arm-swing exercise on cardio-ankle vascular index (CAVI), ankle-brachial index (ABI), heart rate and blood pressure (BP) in older adults with abnormal CAVI values.

Material and Method: Seventeen participants aged 50 or over were asked to do the arm-swing exercise at least 30 minutes a day, at least 3 times per week for 8 weeks. The vascular function parameters, CAVI and ABI, resting heart rate and blood pressure were measured before and after exercising. The comparison of these parameters was performed using statistical analysis.

Results: It was shown that the arm-swing exercise could lower both left and right CAVI significantly (left CAVI, pre: 10.0±0.2 vs. post: 9.7±0.2, p-value=0.017 and right CAVI, pre: 10.0±0.2 vs. post: 9.7±0.2, p-value=0.034). Furthermore, the arm-swing exercise also reduced arterial blood pressure and pulse pressure significantly (systolic BP, pre: 141.9±4.3 mmHg vs. post: 130.5±4.8 mmHg, p-value=0.004, diastolic BP, pre: 82.1±1.6 mmHg vs. post: 76.5±1.7 mmHg, p-value=0.003, and pulse pressure, pre: 59.7±3.7 vs. post: 54.0±4.0 mmHg, p-value=0.031). However, the study demonstrated that ABI, resting heart rate and body mass index were not affected by the exercise.

Conclusion: This study demonstrated that 8 weeks of the arm-swing exercise could lower systolic and diastolic blood pressure. This simple physical activity could also reduce CAVI values in older adults.

Keywords: ankle-brachial index, arm-swing exercise, cardio-ankle vascular index, peripheral arterial disease, physical activity

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Introduction

Atherosclerosis is a disease in which fat gradually builds up inside arteries overtime, called atherosclerotic plaque, resulting in hardening and narrowing of arteries.[1,2] It leads to the limitation of oxygen-rich blood flow to many organs in parts of the body, which can bring about serious health problems, including peripheral arterial disease (PAD), heart attack, stroke, or even death.[3] Evaluation of vascular function by both invasive and non-invasive testing has been useful for the prevention and treatment of such diseases. Among these, ankle brachial index (ABI) and the cardio-ankle vascular index (CAVI) have been widely used due to their accessibility, reliability and low cost. ABI is an indicator for peripheral artery occlusive disease, whereas CAVI, which is not influenced by blood pressure, is an indicator for the diagnosis of arterial wall stiffness.[4] ABI values of 0.9 or less indicate arterial occlusion, whereas CAVI values of 9.0 or higher reflect arterial stiffness.[5]

PAD is a common disease in older adults. Exercise is one of strategies recommended for PAD patients.[6] It is known that exercise can improve vascular hemodynamics and promote arteriogenesis in PAD patients.[6,7] However, there are some limitations for older adults who attempt to do some types of exercise, i.e., walking or running. This especially applies to patients with intermittent claudication or joint problems.[8] The arm-swing exercise is light in intensity, which is appropriate for older adults who have such limitations. Moreover, it can be performed regardless of time and place. There is evidence supporting the effects of the arm-swing exercise on the cardiovascular system. Churproong et al. showed the acute effect of the arm-swing exercise on heart rate and energy expenditure in healthy volunteers aged 18-55 years old.[9] They found that during the arm-swing exercise, heart rate increased by 35.0%. Previous studies reported that walking while doing the arm-swing exercise could lower blood pressure in older adults.[10] In addition, the study of Leelayuwat et al. showed that the arm-swing exercise could reduce blood glucose, free radicals, and increase antioxidants in type 2 diabetic patients.[11] The arm-swing exercise could also improve lung function in diabetic patients.[9] However, there are limited data regarding the benefits of the arm-swing exercise on arterial stiffness in older adults with vascular stiffness. In the present study, the researchers are interested in assessing the impact of the arm-swing exercise on peripheral arterial stiffness in participants with abnormal cardio ankle vascular index. We hypothesized that the arm-swing exercise can improve vascular compliance as well as lowering blood pressure and heart rate.

Material and Method

Participants

Seventeen participants were recruited from the community around Naresuan University. The study was approved by the Ethics Review Board (325/56), Naresuan University, Phitsanulok, Thailand. All participants were informed of the purposes and procedures of the study. Written informed consent was obtained from participants before they took part in the experiment. The data were collected between October and December 2012. The inclusion criteria of the participants were aged 50 or over with CAVI of both sides >9 (high index). Participants who did not exercise regularly were recruited. Participants with contraindications for exercise, such as a disconnected joint or bone fracture, were excluded.

Sample size calculation

The sample size was calculated using the following formula:

$$n = \frac{\left(Z_{\alpha/2} + Z_{\beta}\right)^2 \times 2\sigma^2}{d^2}$$

The sample size (n) was 20, where the level of significance (α) was 0.05, the type II error (β) was 0.2, the population variance (σ^2) was 0.64, the difference between population mean (d^2) was 0.5. The variance for sample size calculation was obtained from a previous study.[12] However, 3 participants dropped out of the study for unknown reasons. Therefore, the sample size (n) used in this study was 17.

Experimental design

The participants were interviewed about their demography and history of illness using a questionnaire. Anthropometric data were collected by a qualified cardio-thoracic technologist who measured weight, height, waist circumference, and body mass index (BMI). After which, the participants were investigated for resting heart rate and blood pressure, ABI, and CAVI. They were then asked to do the arm-swing exercise at home at least 30 minutes a day and at least 3 times a week for 8 weeks. Time, duration, and exercise frequency were recorded by the participants. An investigator called them twice a week for encouragement, and to confirm that they were following the exercise protocol. After 8 weeks, they were reassessed for anthropometry, resting heart rate and blood pressure, ABI, and CAVI. The data were then analyzed to evaluate the effect of the arm-swing exercise on such parameters using the paired t-test.

The arm-swing exercise

The arm-swing exercise was introduced and demonstrated to all participants. The participants were told to relax and stand in balance keeping their feet at hip width, to take a deep breath and then throw both arms up backwards about 60 degree and hold for 2 seconds. Next, they were to release their arms, allowing them to swing forward naturally about 30 degree.[13] The speed of swinging was at least 25 times/min. The duration of the exercise was to be at least 30 minutes per day. Participants could do two 15-minute sessions or a 30-minute session. They were asked to do the arm-swing exercise at least 3 times a week. Participants who discontinued the exercise were excluded from this study.

Blood pressure and heart rate measurement

The participants were measured for resting blood pressure and heart rate while lying down, after resting for 5 minutes in a quiet environment. The measurement was performed 3 times and then the average value was obtained. After which, waist circumference was measured using a waist measuring tape. All procedures in this step were performed by a qualified cardiothoracic technologist. The data were recorded and analyzed.

Ankle-brachial index and cardio-ankle vascular index measurement

The participants were asked to lie down and rest for 5 minutes. Next, CAVI measurement was applied using a vascular screening device (Fukuda Denshi VS1500N, Japan). The components of CAVI consist of electrocardiography (ECG), arms and legs blood pressure, and phonograph. The CAVI was done by the qualified cardiothoracic technologist throughout the project. The procedure for CAVI measurement was performed following the instructions of the manufacturer. The participants were measured for leg and arm blood pressure simultaneously while using ECG and phonocardiography for calculating pulse wave velocity (PWV), which was then used as a factor to calculate ABI and CAVI.[14]

Statistical analysis

The data are presented as mean±standard error of the mean. All statistical analyses were performed using

Statistical Package for the Social Sciences (SPSS) for Windows version 17.0 (SPSS Inc., Chicago, IL, United States). The distribution of sample mean was analyzed using Shapiro-Wilk test. The data with a normal distribution were analyzed with the paired t-test in order to compare the differences of parameters before and after exercise. P-value<0.05 indicates statistical significance.

Results

This study mainly determined the effects of the arm-swing exercise on CAVI in 17 older adults with a mean age of 69.4±1.5 years old. Some participants had underlying diseases, i.e, hypertension and diabetes. Demographic data are summarized in Table 1. Interestingly, the arm-swing exercise could reduce waist circumference significantly whereas weight and BMI were not affected by the exercise (Table 2).

Effects of the arm-swing exercise on CAVI and ABI

Before the exercise, the mean CAVI values for both the right and left sides showed atherosclerotic suspected values (10.0±0.2 for the right and 10.0±0.2 for the left). The mean ABI values of both the right and left sides were in the normal range (1.1±0.0 for the right and 1.1±0.0 for the left sides). After doing the exercise, both side CAVI values significantly decreased (9.7±0.2 for the right and 9.7±0.2 for the left sides). However, the ABI values did not change significantly (Table 3).

Table 1 Demographic data

Parameters (n=17)	Parametric values
Sex (male/female)	6/11
Age (years)	69.4±1.5
Age (min-max)	54-79
Present illness (number)	
Hypertension	9
Diabetes	5
Dyslipidemia	9
Ischemic heart disease	2
Prior stroke	1
Asthma	1
Osteoporosis	1
Thyroid	1
Smoking	2
Arm-swing exercise	
Frequency (times/week)	4.9±1.7
Frequency (min-max, times/week)	3-7
Duration (min/day)	36.7±11.8
Duration (min-max, min/day)	30-70

Table 2 Anthropometric data

Parameters (n=17)	Before exercise	After exercise	P-value
Weight (kg)	58.2±2.1	57.7±2.0	0.072
BMI (kg/m^2)	22.7±0.7	22.5±0.7	0.077
Waist circumference (cm)	34.8±7.0	33.5±3.4	0.04*

*represents the significant difference between before and after the exercise

BMI=body mass index

Effects of the arm-swing exercise on blood pressure and heart rate

Before the exercise, the resting heart rate of the participants was 65.4±2.7 bpm while their systolic blood pressure was slightly high at 141.9±4.3 mmHg. It was found that the arm-swing exercise affected both systolic and diastolic blood pressure but not the resting heart rate. After the exercise, the systolic blood pressure fell significantly to 130.5±4.8 mmHg. Diastolic blood pressure also decreased significantly, from 82.1±1.6 mmHg to 76.5±1.7 mmHg. However, the resting heart rate did not differ after doing the exercise (Table 4).

Discussion

To the best of our knowledge, this is the first study to demonstrate the effects of the arm-swing exercise on vascular function in older adults with vascular dysfunction. It was found that the arm-swing exercise improved CAVI, as well as waist circumference and blood pressure, but not ABI or resting heart rate. The arm-swing exercise is a mild intensity exercise with a 25.0% increase in oxygen consumption and a 23.0% increase in maximal heart rate.[15] According to Loprinzi, elderly people performing light intensity physical activity had lower risks of all-cause mortality.[16] Similarly, another study indicated

Table 3 Effects of the arm-swing exercise on cardio-ankle vascular index and ankle-brachial index

Parameters (n=17)	Before exercise	After exercise	P-value
Right – CAVI	10.0±0.2	9.7±0.2	0.034*
Left – CAVI	10.0±0.2	9.7±0.2	0.017*
Right – ABI	1.1±0.0	1.1±0.0	0.259
Left – ABI	1.1±0.0	1.1±0.0	0.286

CAVI=cardio-ankle vascular index, ABI=ankle-brachial index

*represents the significant difference between before and after the exercise

Table 4 Effects of the arm-swing exercise on heart rate and blood pressure

Parameters (n=17)	Before exercise	After exercise	P-value
Resting Heart rate (bpm)	65.4±2.7	66.9±2.7	0.213
Systolic blood pressure (mmHg)	141.9±4.3	130.5±4.8	0.004*
Diastolic blood pressure (mmHg)	82.1±1.6	76.5±1.7	0.003*
Pulse pressure (mmHg)	59.7±3.7	54.0±4.0	0.031*
Mean arterial blood pressure (mmHg)	108.2±3.0	99.7±3.1	0.005*

*represents the significant difference between before and after the exercise

that light intensity exercise is as powerful as the higher intensity exercise in PAD patients.[17] In an animal model, Jordao et al. demonstrated that low-intensity training could reduce blood pressure, heart rate, and pulse pressure.[18] Interestingly, this experiment showed restoration of aorta elastic tissue in spontaneous hypertensive rats.[18] However, Gardner et al.[19] showed that PAD patients who engaged in physical activity that goes beyond light intensity at baseline regularly had a lower mortality rate than the sedentary group who performed either no physical activity or only light-intensity activities. Although the mechanisms of the beneficial effects of light intensity exercise are unclear, one possible mechanism concerns the anti-oxidation state. Leelayuwat et al. demonstrated that the arm-swing exercise can improve oxidative stress and influence the blood glucose level in type 2 diabatic patients.[20] However, the effect of the arm-swing exercise on anti-oxidant levels in PAD patients has not been studied. The other potential mechanisms by which the arm-swing exercise improves vascular function may be similar to the mechanisms of other types of exercise, i.e, via anti-inflammatory responses, angiogenesis, or improved endothelial function.[21] However, the effect of the arm-swing exercise on hemodynamics is still controversial. We found that the arm-swing exercise could reduce systolic blood pressure, diastolic blood pressure, mean arterial blood pressure, but not resting heart rate, whereas Leelayuwat et al.[20] did not find any changes of blood pressure and heart rate after 8 weeks of the arm-swing exercise in diabetics. This difference may be due to the underlying disease of the subjects. The decline of systolic and diastolic blood pressure could be a result of improved vascular compliance. Although the study indicated the influence of the arm-swing exercise on the CAVI, it showed no effect on the ABI. The unchanged ABI after exercise in this study is related to previous study results,[22,23] which explained that exercise is postulated to increase walking ability by promoting the development of collateral vessels. This effect would be under represented by changes in the ABI.[22]

A limitation of this study was the small number of participants. A control group was not recruited in this study due to ethical concerns, since a control group would not be permitted to exercise for 8 weeks, which could affect members' health status. Another limitation is that the duration of the exercise period was short, only eight weeks. A longer period may have improved vascular function and given a more definite result. However, the pre-post interventional study design could minimize confounding effects between the studied groups by itself. For further investigation, a larger sample size is required to ensure the power of a hypothesis test. In this study, we used a CAVI of >9 as the suspected arteriosclerosis condition. However, for Thai people a CAVI of >8 was recently reported as the cut-off value most significantly associated with the presence of coronary artery disease, with a sensitivity of 92.0%, specificity of 63.0%, and accuracy of 70.0%.[24] Therefore, this cut-off CAVI value should be considered when conducting future research in the Thai population. Moreover, biochemical parameters and other vascular functions, including vascular hemodynamics, should be obtained in order to explore the mechanisms involved in this effect.

Conclusion

This study demonstrated that an 8-week period of the arm-swing exercise could lower systolic and diastolic blood pressure, as well as CAVI values, in older adults. However, further investigation of long-term arm-swing exercise on improving arterial stiffness is needed.

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