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Effects of A Single Bout of Cycling Exercise on Pulse Wave Velocity (PWV) in Healthy Middle-Aged Individuals

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Abstract. [Purpose] In this study, the brachial-ankle PWV (baPWV) was measured continuously from before to after a single bout of cycling exercise in healthy middle-aged individuals to evaluate the immediate changes associated with short-time exercise. [Subjects] We examined the effects of a bout of low-intensity leg cycling exercise (60 watt, 5 min) on pulse wave velocity from the brachial to the ankle arteries (baPWV) in 7 healthy middle-aged individuals. [Methods] The baPWV and heart rate (HR) were measured using a Form PWV/ABI (Nihon Colin) twice at 5-minute intervals during the rest before exercising, every 3 minutes for 15 minutes from immediately after the end of exercise, and 20 minutes after the end of exercise. The reproducibility of the resting baPWV before exercise was examined using Pearson's correlation coefficient, and changes in baPWV between before and after exercise were examined by Wilcoxon's rank sum test. [Results] After the exercise, baPWV remained significantly decreased 7% for 20 min, despite the recoveries of the heart rate and blood pressure to pre-exercise levels. [Conclusion] These results suggest that a single bout of low-intensity cycling exercise decreases arterial stiffness following of normal subjects dynamic exercise.
Key words: Pulse wave velocity, Exercise, Arterial stiffness

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INTRODUCTION

The importance of compliant arterial circulation for minimizing cardiac work and providing adequate coronary perfusion has been shown experimentally[1, 2)]. Furthermore, clinical studies indicate that the physiological consequences of arterial stiffening, as a result of aging or the development of cardiovascular disease, have associations with serious outcomes such as myocardial infarction and death[3)]. Changes in environmental factors of living such as lack of exercise and excessive nutritional intake have increased the importance of prevention of lifestyle-related diseases such as hypertension, hyperlipidemia, and diabetes mellitus.

Recently, the examination of pulse wave velocity (PWV) based on simultaneous sphygmomanometry in the four limbs has been developed, and PWV has been widely accepted as a clinical index of hardening of the arterial wall[4–6)]. Effects of long-term training on arterial stiffness based on measurements of PWV have been reported[7, 8)]. Recent findings indicate that regular aerobic exercise attenuates age-associated reductions in central arterial compliance and partially restores compliance in sedentary middle-aged and older adults[9)]. However, acute changes in PWV due to short-time exercise have scarcely been investigated and remain largely unknown.

In this study, the brachial-ankle PWV (baPWV) was measured continuously from before to after a single bout of cycling exercise in healthy middle-aged individuals to evaluate the immediate changes associated with short-time exercise.

SUBJECTSAND AND METHODS

The subjects were 7 normotensive middle-aged (51 ± 4 years) males with no habit of regular exercise. After sufficient rest, the subjects performed 5 minutes of exercise on a bicycle ergometer (Lode Corival WLP-400, Netherlands) at a fixed load (60 W). The baPWV and heart rate (HR) were measured using a Form PWV/ABI (Nihon Colin) twice at 5-minute intervals during the rest before exercising, every 3 minutes for 15 minutes from immediately after the end of exercise, and 20 minutes after the end of exercise. The value of baPWV was expressed as the mean of the left limb baPWV and right limb baPWV.

The subjects were given an explanation about the purpose and contents of this study and were enrolled after providing their informed consent.

The values obtained were expressed as the mean ± standard deviation. The reproducibility of resting baPWV before exercise was examined using Pearson's correlation

Table 1. The changes in brachial-ankle PWV and heart rate induced by a single bout of cycling exercise

	baPWV (cm/sec)	HR (beats/min)
Before exercise(min)		
-5	1477 ± 47	78 ± 10
After exercise		
3	1468 ± 89	88 ± 15 **
6	1430 ± 64	84 ± 15 **
9	1421 ± 66 *	81 ± 13
12	1406 ± 68 **	79 ± 11
15	1396 ± 41 **	78 ± 12
20	1399 ± 68 **	78 ± 13

Mean ± SD, Wilcoxon analysis, *p<0.05, ** p<0.005, Before exercise vs. After exercise

coefficient, and changes in baPWV between before and after exercise were examined by Wilcoxon's rank sum test. P<0.05 was considered significant.

RESULTS

The baPWV was 1,485 ± 54 and 1,477 ± 47 cm/sec at the first and second measurements, respectively, and a positive correlation was observed between the two values (r=0.72, p<0.05).

Table 1 shows the temporal changes in baPWV from before to after fixed-load exercise. The baPWV increased in 2, but was reduced in 5, of the 7 subjects 3 minutes after the end of fixed-load exercise. It was 1,430 ± 64 and 1,421 ± 66 cm/sec at 6 and 9 minutes, respectively, after the end of exercise, and was significantly reduced compared with the values before exercise (p<0.05). It continued to show significant decreases (p<0.005) to 1,396 ± 41 and 1,399 ± 68 cm/sec 15 and 20 minutes, respectively, after exercise.

Next, Table 1 shows the temporal changes in HR from before to after fixed-load exercise. The resting HR before exercise was 78 ± 10 beats/min, and increased significantly (p<0.005) to 88 ± 15 beats/min 3 minutes after the end of exercise, but decreased to 79 ± 11 beats/min, returning nearly to the pre-exercise level, after 12 minutes, and remained stable until a 20 minutes post-exercise.

DISCUSSION

Habitual exercise is considered to be an important factor for the prevention and treatment of cardiovascular disorders in old age and lifestyle-related diseases such as diabetes mellitus and hyperlipidemia. Habitual aerobic exercise has been demonstrated to prevent age-associated increases in arterial stiffness and to improve increased arterial stiffness in middle-aged and aged individuals with no history of habitual exercise[9].

The PWV, calculated non-invasively and easily by simultaneous sphygmomanometry in the 4 limbs, is the velocity of vascular conduction of the pulse due to ejection of blood by the heart. Since it reflects the degree of hardening of the arterial wall, it has been put to wide clinical use.

In this study, baPWV was measured continuously in healthy middle-aged individuals from before to after short-time exercise to evaluate the physiologic changes associated with short-time exercise. Sugawara et al. reported that baPWV decreased significantly 3 minutes after short-time low to medium-intensity exercise in young males[10]. However, according to our review of the literature, there have been no reports of continuous monitoring of baPWV for a period after exercise.

We measured baPWV continuously for 20 minutes after the end of exercise. It decreased in 5 of the 7 subjects 3 minutes after exercise and remained significantly reduced until 20 minutes after the end of exercise despite the recovery of HR to the pre-exercise level. These results suggest the persistence of the improvement in arterial stiffness even after the recovery of HR.

Similar to our results, Naka et al. reported that PWV was reduced by about 10%, 1 hour after maximal symptom-limited treadmill exercise in normal volunteers[11].

Some studies have compared carotid artery stiffness between young and middle-aged subjects who practiced muscle training and those who did not. They reported greater carotid artery stiffness in middle-aged subjects than in young subjects correlated and in both young and middle-aged subjects who practiced muscle training compared to those who did not, and related the increase in the stiffness of the central artery to concentric hypertrophy[12, 13].

Further evaluation of the physiological benefits and harm according to the intensity and content of exercise is considered to be needed before conducting exercise intervention for the prevention of lifestyle-related diseases in middle-aged and aged individuals.

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REFERENCES

1) Mohiaddin RH, Underwood SR, Borgren HG, et al.: Regional aortic compliance studied by magnetic resonance imaging: the effects of age, training and coronary artery disease. Br Heart J, 1989, 62: 90–96. [Medline] [CrossRef]
2) Belz GG: Elastic properties and wendkessel function of the human aorta. Cardiovasc. J Drugs Ther, 1995, 9: 73–83.
3) Fang J, Madheven S, Cohen H, et al.: Measures of blood pressure and myocardial infarction in treated hypertensive patients. J Hypertens, 1995, 13: 413–419. [Medline] [CrossRef]
4) Asmar R, Benetos A, Topouchian J, et al.: Assessment of arterial distensibility by automatic pulse wave velocity measurement. Validation and clinical application studies. Hypertension, 1995, 26: 485–490. [Medline]
5) Nakano H, Okazaki K, Ajiro Y, et al.: Clinical usefulness of measuring pulse wave velocity in predicting cerebrovascular disease: Evaluation from a cross-sectional and longitudinal follow-up study. J Nihon Med Sch, 2001, 68: 490–497. [Medline] [CrossRef]
6) Gates PE, Tanaka H, Graves J, et al.: Left ventricular structure and diastolic function with human aging. Relation to habitual exercise and arterial stiffness. J Eur Heart, 2003, 24: 2213–2220. [CrossRef]
7) Cameron JD, Dart AM: Exercise training increases total systemic arterial compliance in humans. Am J Physiol, 1994, 266: H693–701. [Medline]

8) Bertovic DA, Waddell TK, Gatzka CD, et al.: Muscular strength training is associated with low arterial compliance and high pulse pressure. Hypertension, 1999, 33: 1385–1391. [Medline]
9) Miyachi M, Donato AJ, Yamamoto K, et al.: Greater age-related reductions in central arterial compliance in resistance-trained men. Hypertension, 2003, 41: 130–135. [Medline] [CrossRef]
10) Sugawara J, Otsuki T, Tanabe T, et al.: The effects of low-intensity single-leg exercise on regional arterial stiffness. Jpn J Physiol, 2003, 53: 239–241. [Medline] [CrossRef]
11) Naka KK, Tweddel AC, Parthimos D, et al.: Arterial distensibility: acute changes following dynamic exercise in normal subjects. Am J Physiol Heart Circ Physiol, 2003, 284: H970–978. [Medline]
12) Kass DA, Saeki A, Tunin RS, et al.: Adverse influence of systemic vascular stiffening on cardiac dysfunction and adaptation to acute coronary occulusion. J Circ, 1996, 93: 1533–1541.
13) Kingwell B A, Berry K L, Cameron J D, et al.: Arterial compliance increases after moderate-intensity cycling. Am J Physiol, 1997, 273: H2186–2191. [Medline]