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Arterial stiffness is inversely associated with a better running record in a full course marathon race

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Su-Jeen Jung, Jae-Hyoung Park and Sewon Lee. Arterial stiffness is inversely associated with a better running record in a full course marathon race. JENB., Vol. 18, No. 4, pp.355-359, 2014 **[Purpose]** Arterial stiffness is an independent predictor of cardiovascular risk and may contribute to reduced running capacity in humans. This study investigated the relationship between course record and arterial stiffness in marathoners who participated in the Seoul International Marathon in 2012. **[Methods]** A total of 30 amateur marathoners (Males n = 28, Females n = 2, mean age = 51.6 ± 8.3 years) were assessed before and after the marathon race. Brachial-ankle pulse wave velocity (ba-PWV) was assessed by VP-1000 plus (Omron Healthcare Co., Ltd., Kyoto, Japan) before and immediately after the marathon race. Pearson's correlation coefficient was used to determine the relationship between race record and ba-PWV. In addition, Wilcoxon signed rank test was used to determine the difference in ba-PWV between before and after the race. **[Results]** There was no significant change in the ba-PWV of marathoners before and after the race (1271.1 ± 185 vs. 1268.8 ± 200 cm/s, P=0.579). Both the full course record (Pearson's correlation coefficient = 0.416, $P = 0.022$) and the record of half line (Pearson's correlation coefficient = 0.482, $P = 0.007$) were positively related with the difference in ba-PWV, suggesting that reduced arterial stiffness is associated with a better running record in the marathon. **[Conclusion]** These results may suggest that good vascular function contributes to a better running record in the marathon race. **[Key wordsds]** brachial-ankle pulse wave velocity (ba-PWV), exercise, full course marathon, arterial compliance

INTRODUCTION

The protective effect of regular exercise training on the cardiovascular system is well established in humans [5]. Regular exercise can ameliorate metabolic and cardiovascular diseases including type 2 diabetes mellitus and coronary artery disease [3]. A number of studies have reported that endurance trained individuals who have high aerobic capacity exhibited a more favorable vascular change and improved central arterial compliance compared to the sedentary control group [14,16]. However, previous studies have shown that excessive and/or exhaustive exercise increased the risk of coronary heart disease in individuals who performed excessive exercise such as marathon [7,12].

Arterial stiffness is a marker of cardiovascular disease such as arteriosclerosis and an independent predictor of the

corresponding risk for cardiovascular outcomes [1,8]. Acute exercise increased aortic pulse wave velocity in healthy young men during exercise [13], while chronic exercise reduced arterial stiffness [9,14,16]. Interestingly, recent studies have demonstrated higher arterial stiffness or absence of negative impact on vascular function in marathon and ultra-marathon runners, suggesting that long-term strenuous exercise may have a deleterious effect or no impact on the vascular system [2,11,15,17]. Marathon runners must supply enough energy and oxygen for sustained vigorous physical activity for 2-3 hours which may cause arterial stiffness through fatigue of elastin fibers and vascular fibrosis [6,10]. Furthermore, marathon race is an aerobic, extremely vigorous, and competitive exercise that requires intense regular training [10]. Even though the effect of acute and chronic exercise on arterial stiffness has been relatively well elucidated, the relationship

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between arterial compliance and better record in a marathon race is unclear. Therefore, we hypothesized that arterial stiffness is inversely associated with marathon record in amateur runners.

METHODS

Subjects

We recruited marathon runners from a marathon club located at B-Gu in the Gyeonggi Province and they were regular marathon runners. A total of 30 amateur marathoners (Males n = 28, Females n = 2, mean age = 51.6 ± 8.3 years) were assessed before and after the marathon race. Study participants were selected from screening before the study and they were explained about the procedure. All participants were provided a written consent form and the form was provided to ascertain whether the subjects wanted to participate in the study. Before the race, subjects were asked to undergo all assessments and they were instructed to undergo the same assessments immediately after the race. The detailed characteristics of the subjects are presented in Table 1.

Bioimpedance assessment

Body composition was measured using a body composition analyzer (Inbody 720, Biospace, Korea). The machine is a multi-frequency bioelectrical impedance body composition analyzer, which obtains the reading from the body by using an eight-point telepolar electrode method, measuring resistance at 6 different frequencies (1 kHz, 5 kHz, 50 kHz, 250 kHz, 500 kHz, and 1000 kHz) and resistance at three specific frequencies (5 kHz, 50 kHz, and 250 kHz) [4]. According to the manufacturer's guidelines, the subjects were instructed to stand upright and hold the 2 handles of the analyzer, therefore providing contact with a total of 8 electrodes.

Blood pressure assessment

Blood pressure was measured in the brachial artery with an automated device (FT-500R, Jawon Medical, Korea). Prior to the measurement of blood pressure, subjects sat quietly for at least 5 min to ensure accurate measurement. The subjects were seated with their arms supported on a table at the level of the heart and blood pressure was measured twice at a 3 min interval. The average value was calculated and used in this study.

Blood analysis

Blood was obtained from the brachial vein and transferred into heparinized tubes. Standard blood analyses were performed by a clinical laboratory (K hospital) for measuring the lipid levels. In brief, total cholesterol, triglyceride, and LDL cholesterol levels were measured with an Advia 2400 Chemistry System (Siemens, Germany) using enzymatic assay kits (Waco, Japan; Siemens, Germany).

Arterial stiffness

Arterial stiffness, compliance, and central blood pressure were measured in the supine position using a non-invasive device after at least, 10 min rest. Brachial-ankle pulse wave velocity (ba-PWV) was measured according to the manufacturer's protocol using VP-1000 plus (Omron Healthcare CO., Ltd., Kyoto, Japan) with participants in the supine position before and immediately after the marathon race. In brief, electrocardiogram electrodes were placed on both wrists. Occlusion and cuffs were wrapped around both sides of the ankles and brachia. Volume waveforms for the brachium and ankle were stored, and the sampling time was 10 sec for automatic gain analysis.

The marathon course

Thirty runners who registered for the Seoul International Marathon (March 18, 2012) were recruited into the study. All 30 runners had completed the full course (42.195 km) and the course map is provided in Fig. 1.
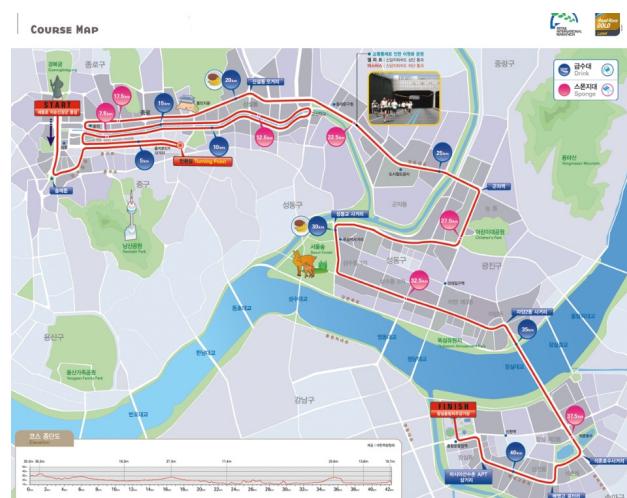

Fig. 1. Course map for the 2012 Seoul International Marathon

The degree of correlation between ba-PWV and marathon records was analyzed using the Pearson's correlation method. Wilcoxon signed rank test was used to determine the difference in ba-PWV between before and after the race. In addition, T-tests were used (paired: pre/post marathon race, unpaired: between separate groups). Results were presented as means ± SD. Data were analyzed using the SPSS version 18.0 statistical program. $p < 0.05$ was considered to be statistically significant.

RESULTS

Marathon running did not alter the basic characteristics of subjects

Basic and clinical characteristics of the participants are presented in Tables 1 and 2. Before the marathon race, both male and female runners were similar in age, echocardiography, total cholesterol, triglyceride levels, body mass index (BMI), waist to hip ratio (WHR), fat mass, and body fat. In addition, there were no differences in systolic, diastolic,

Table 1. Baseline Characteristics of Subjects

Variables	Males (N = 28)	Females (N = 2)	P value
Age (years)	52.0 ± 8.3	46.5 ± 9.2	0.552
Echocardiography			
LVEF (%)	62.6 ± 9.2	52.0 ± 3.1	0.128
E/A	1.27 ± 0.28	1.31 ± 0.5	0.709
E/E'	7.76 ± 1.94	6.44 ± 1.86	0.812
LDL cholesterol (mg/dL)	106.7 ± 20.8	101.0 ± 12.4	0.016
Total cholesterol (mg/dL)	191.8 ± 22.0	193.3 ± 22.9	0.876
Triglyceride (mg/dL)	80.9 ± 33.1	68.5 ± 14.2	0.448
Body Weight (kg)	67.1 ± 5.3	59.3 ± 1.1	< 0.001
BMI (kg/m^2)	23.1 ± 1.5	23.0 ± 1.0	0.921
WHR	0.885 ± 0.028	0.885 ± 0.021	1.0
Muscle mass (kg)	31.2 ± 3.1	23.6 ± 1.5	0.035
Fat mass (kg)	11.7 ± 3.9	16.5 ± 1.5	0.057
Body fat (%)	17.4 ± 5.34	27.8 ± 3.0	0.076
Systolic Blood Pressure (mmHg)	125.2 ± 15.1	117.5 ± 5.0	0.197
Diastolic Blood Pressure (mmHg)	76.4 ± 11.2	78.0 ± 5.7	0.768
Central Blood Pressure (mmHg)	128.7 ± 17.3	125.5 ± 9.2	0.712
Brachial-ankle pulse wave velocity (cm/s)	1286.8 ± 181	1051.3 ± 29	< 0.001

Values are expressed as means ± SD
BMI, body mass index; E/A, early (E) and late (A) diastolic filling velocities; LVEF, left ventricular ejection fraction; WHR, waist to hip ratio.

Table 2. Changes after the Seoul International Marathon Race

| Variables	Pre-marathon	Post-marathon	P value
Systolic blood pressure (mmHg)	124.7 ± 14.7	121.0 ± 11.6	0.259
Diastolic Blood pressure (mmHg)	76.5 ± 10.9	74.9 ± 7.9	0.494
Brachial ankle pulse wave velocity (cm/s)	1271.1 ± 185	1268.8 ± 200	0.579

Values are expressed as means ± SD; n = 30
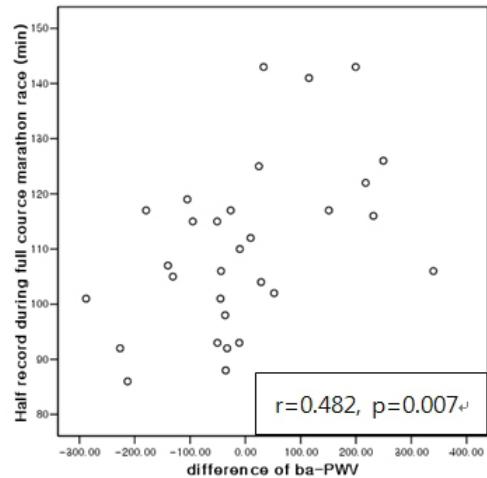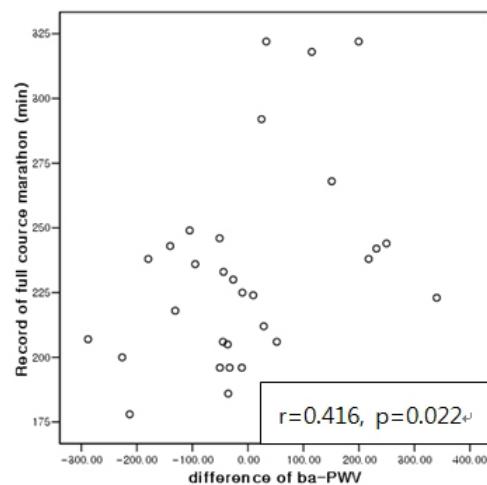
Fig. 2. Correlation between course record and difference in ba-PWV. n = 30

and central blood pressure as well as ba-PWV. However, female marathoners had a lower LDL cholesterol level, body weight, and muscle mass as compared to male marathoners (Table 1). We also measured the systolic, diastolic blood pressure and ba-PWV after the marathon race. There were no changes in these parameters (Table 2).

ba-PWV is inversely associated with marathon record

To examine whether there is a relationship between arterial stiffness and marathon record in participants, we used a measure of the linear correlation. Interestingly, full course record was significantly related to the difference in ba-PWV (Pearson's correlation coefficient = 0.416, $p = 0.022$). In addition, the half course record was also correlated with the difference in ba-PWV (Pearson's correlation coefficient = 0.482, $p = 0.007$) (Fig. 2).

DISCUSSION

The main novel finding of this study was that better record in a marathon race is inversely related to arterial stiffness in amateur marathon runners. It is well known that arterial stiffness increases with ageing even in healthy individuals suggesting that in ageing subjects the large conduit vessels may lose their ability to dilate in response to the metabolic demand such as during exercise [14,16]. Therefore, we hypothesized that reduced arterial stiffness improves the record in a marathon race because an increase in arterial compliance may contribute to an increase in blood and oxygen supply in an extreme exercise situation such as a marathon race. Indeed, our results showed that arterial stiffness was inversely associated with the race record, suggesting that reduced arterial stiffness may increase blood and oxygen supply to the active skeletal muscles under extreme exercise conditions. In our present study, an acute bout of marathon running did not alter arterial stiffness in amateur marathoners. Vaitkevicius et al. have suggested that an exercise intervention to improve aerobic capacity may mitigate the stiffness of arterial tree in ageing subjects [16]. They also showed that regular aerobic exercise appears to modulate age-associated augmentation of the arterial stiffness in humans [16]. Taken together, chronic exercise has a beneficial effect on arterial stiffness whereas acute exercise may not. In this regard, our findings have a potentially important implication for marathon performance because enhancement of arterial compliance can be a predictor of better record in amateur marathon races.

However, some limitations need to be discussed in view of the present study. Our results are based on a small sample size (n = 30), specifically female marathoners (n = 2). A follow-up study is needed to verify whether there is a gender difference in the relationship. In addition, based on our study design, we cannot establish a causal relationship between race record and arterial compliance. Further mechanistic studies are required in the future.

CONCLUSIONS

In summary, the data from the present study suggest that marathon record was inversely associated with arterial stiffness in an amateur marathon race. An acute bout of marathon running did not alter arterial compliance in marathoners. To the best of our knowledge, this is the first study to demonstrate that marathon record is positively associated with arterial compliance. These findings could contribute to a better understanding of marathon performance related to arterial stiffness under extreme exercise conditions such as marathon.

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