Tohoku J. Exp. Med., 2005, **207**, 263-270

Comparison of Brachial-Ankle Pulse Wave Velocity in Japanese and Russians

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[1]Department of Medicine and Science in Sports and Exercise, Tohoku University Graduate School of Medicine, Sendai, Japan,
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LIU, H., YAMBE, T., ZHANG, X., SAIJO, Y., SHIRAISHI, Y., SEKINE, K., MARUYAMA, M., KOVALEV, Y.A., MILYAGINA, I.A., MILYAGIN, V.A. and NITTA, S. *Comparison of Brachial-Ankle Pulse Wave Velocity in Japanese and Russians*. Tohoku J. Exp. Med., 2005, **207** (4), 263-270 —— Pulse wave velocity (PWV) is a well-known indicator of arterial stiffness and a marker of the presence of vascular lesions. Cardiovascular mortality in Russia has become the highest in the world. The Japanese are enjoying long lives, and the mortality caused by cardiovascular diseases has thus far remained at lower levels than that in Russia. In this study, we focused on brachial-ankle pulse wave velocity (baPWV) obtained from normal human subjects in Russia as well as in Japan, and compared their respective cardiovascular risks. We evaluated baPWV in 337 Japanese and 138 Russian healthy subjects. The baPWV was recorded using a PWV diagnosis device. BaPWV was measured between 2 locations of the arterial tree. The baPWV in the Russian group was significantly higher than that obtained in the Japanese of two groups categorized by age (40-59 years and 60- years). Further, body mass index (BMI), systolic blood pressure (SBP) and diastolic blood pressure in the Russian group were significantly higher than those obtained in Japanese in three age groups (under 39 years, 40-59 years, and 60- years). Moreover, the baPWV indicated a positive correlation with age, BMI and SBP in both Japanese and Russians, although the increasing trend of the baPWV against age of the Russian group had a larger value than that of the Japanese. Therefore, we suggest that arterial stiffness might be promoted earlier in the Russian group, which might be the main cause of the increased cardiovascular risk in Russia. ——— brachial-ankle pulse wave velocity; atherosclerosis; Japanese; Russians
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Received June 3, 2005; revision accepted for publication September 13, 2005.
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Arterial stiffness can occur in the absence of atherosclerosis and plays important roles in the development of atherosclerosis. Pulse wave velocity (PWV) is known to be an indicator of arterial stiffness and a marker of vascular damage. There have been many reports about the relationship between PWV and the development of atherosclerotic disease. Recent studies have demonstrated that PWV is not only a risk marker of cardiovascular disease, but also its prognostic predictor (Tomiyama et al. 2003; Altun et al. 2004; Choi et al. 2004; Fujiwara et al. 2004; Mitchell et al. 2004; Schmitt et al. 2004; Stewart et al. 2004; Woodside et al. 2004).

PWV is the velocity of a pulse wave traveling a given distance between 2 sites in the arterial system. Recently, a new, simple device to measure brachial-ankle pulse wave velocity (baPWV) has been developed using pressure cuffs wrapped on the brachium and ankle. BaPWV has potential as a new marker of cardiovascular risk; compared to conventional markers, it is easy to obtain and serves as an indicator of either atherosclerotic cardiovascular risk or severity of atherosclerotic vascular damage. Thus, it is useful for screening the general population (Ogawa et al. 2003; Yamashina et al. 2003; Yokoyama et al. 2003).

During recent years a rapid increase in cardiovascular mortality in Russia has been reported. Mortality from cardiovascular diseases in Russia is the highest in the world. In recent years the average lifespan of Russians has decreased more and more, and at least 55% of Russians die from cardiovascular events. The age-standardized male and female mortality rates from cardiovascular diseases in Russia are 751 and 453 per 100,000 (Malyutina et al. 2004).

On the other hand, in Japan, cardiovascular mortality declined markedly between the 1960s and 1970s, mainly as a result of the improvement of hypertension management. Since the 1980s, presumably as the influence of an increasingly westernized lifestyle, the risk factors of atherosclerosis and preclinical atherosclerosis have been increasing. Still, the Japanese population has one of the longest life expectancies in the world and low levels of cardiovascular mortality have been achieved (Martikainen et al. 2001).

Therefore, we established the hypothesis that Russians, having a higher cardiovascular risk, would show higher PWV values than Japanese. In this study, we focused on the baPWV obtained from normal (healthy) subjects in Russia and in Japan, and compared their cardiovascular risks.

Materials and Methods

Subjects

Three hundreds thirty seven normal Japanese subjects and 138 normal Russian subjects participated in this study. The data on the Japanese were collected at Tohoku University, Sendai. The data on the Russians were collected at the Smolensk State Medical Academy, Smolensk. To generate a healthy sample, participants were excluded for the following reasons: hypertension (defined as systolic blood pressure [SBP] $\geqq$ 140 mmHg, diastolic blood pressure [DBP] $\geqq$ 90 mmHg, or drug treatment for hypertension), endocrine disease, significant renal or hepatic disease, coronary artery disease, arrhythmias, cerebrovascular disease, or use of medication for diabetes mellitus or hyperlipidemia. Written informed consent was obtained from all participants, and the study protocol was approved by the Ethics Committee of Tohoku University, Graduate of Medicine and School of Medicine, Japan.

Measurement of PWV

The subjects were examined while resting in the supine position. After at least a 5-min bed rest, baPWV was recorded using an automated device (VaSeraVS-1000, Fukuda Denshi, Tokyo) (Watanabe et al. 2005). The device recorded baPWV, blood pressure (BP), electrocardiogram and heart sounds simultaneously. Electrocardiogram electrodes were placed on both wrists, and a heart sound microphone was placed on the left sternal border. Cuffs to measure baPWV were wrapped around both upper arms and ankles, and connected to a plethysmographic sensor that determines volume pulse form. Volume waveforms were stored for a sampling time of 10 s with automatic gain analysis and quality adjustment. This instrument simultaneously records the baPWV on the left and right sides. The highest baPWV on both sides were determined, and subsequent statistical analyses were performed using these values (Tomiyama et al. 2005).

Statistical Analysis

Data are expressed as means ± S.D. All statistical analyses were performed with StatView-5 software (SAS Institute Inc., Cary, NC, USA). Student's *t*-test was used to examine statistical difference of baPWV or body mass index (BMI) between Russian subjects and Japanese subjects. Multiple linear regression analysis was performed to evaluate the association between baPWV and age, BMI, SBP or DBP in Japanese and Russian subjects. Pearson's correlation coefficient analysis was used to assess the relation between PWV and other variables in Japanese and Russian subjects. $P < 0.05$ was regarded as statistically significant.

Results

Comparison of baPWV, BMI, SBP and DBP between Japanese and Russians

The characteristics of subjects are classified according to three age groups in Table 1. BaPWV in Japanese subjects showed significantly lower values than those in Russian subjects of two age groups (40-59 years and 60- years). BMI in Japanese subjects were significantly lower than those in Russian subjects of three age groups (-39 years, 40-59 years, and 60- years). SBP or DBP were also significantly lower in Japanese subjects in all three age groups.

Correlation of baPWV with age, BMI, SBP and DBP in Japanese and Russians

Table 2 shows the results of multiple regression analysis including baPWV and age, BMI, SBP or DBP. Age, BMI and SBP were significantly associated with baPWV, whereas DBP showed no significant association.

BaPWV showed a significant positive corre-

Table 2. *Multiple regression analysis of the factors associated with baPWV*

	Variables	ß	*p* value
Japanese			
	Age	0.29	0.001
	BMI	0.18	0.01
	SBP	0.17	0.004
	DBP	0.1	0.1
Russians			
	Age	0.65	0.001
	BMI	0.15	0.027
	SBP	0.23	0.014
	DBP	0.07	0.44

BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

Table 1. *Characteristics of subjects*

		Age -39	Age 40-59	Age 60-
n	Japanese	224	83	30
	Russians	72	54	12
Age (years)	Japanese	25.8 ± 6.7	48.7 ± 5.3	67.0 ± 5.7
	Russians	26.8 ± 6.4	48.3 ± 4.3	66.3 ± 5.3
BMI (kg/m^2)	Japanese	20.9 ± 2.2 *	22.4 ± 2.3 *	23.3 ± 2.5 *
	Russians	22.9 ± 4.2	27.4 ± 4.9	26.8 ± 2.3
BaPWV (m/sec)	Japanese	11.04 ± 1.26	12.32 ± 1.25 *	15.24 ± 1.97 *
	Russians	11.23 ± 1.31	13.05 ± 1.34	16.65 ± 1.36
SBP (mmHg)	Japanese	118.75 ± 10.51 *	121.13 ± 8.77 *	126.93 ± 8.57 *
	Russians	123.98 ± 10.64	126.39 ± 8.65	135.68 ± 6.09
DBP (mmHg)	Japanese	73.18 ± 8.33 *	78.05 ± 6.97 *	78.2 ± 7.46 *
	Russians	77.01 ± 7.32	83.37 ± 5.3	85.58 ± 4.5

Data represent mean ± S.D. $^*p < 0.05$ (Student's *t*-test).

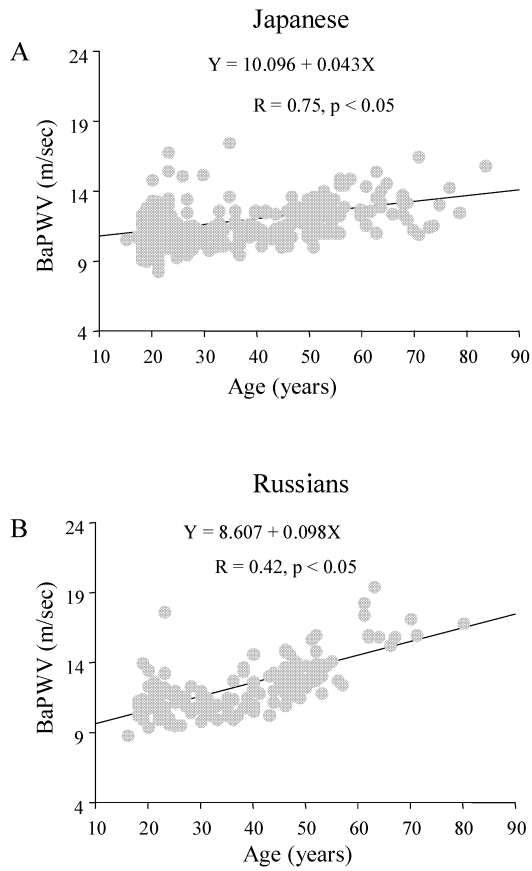

Fig. 1. Relations between baPWV and age in 337 Japanese subjects (A) and 138 Russian subjects (B).

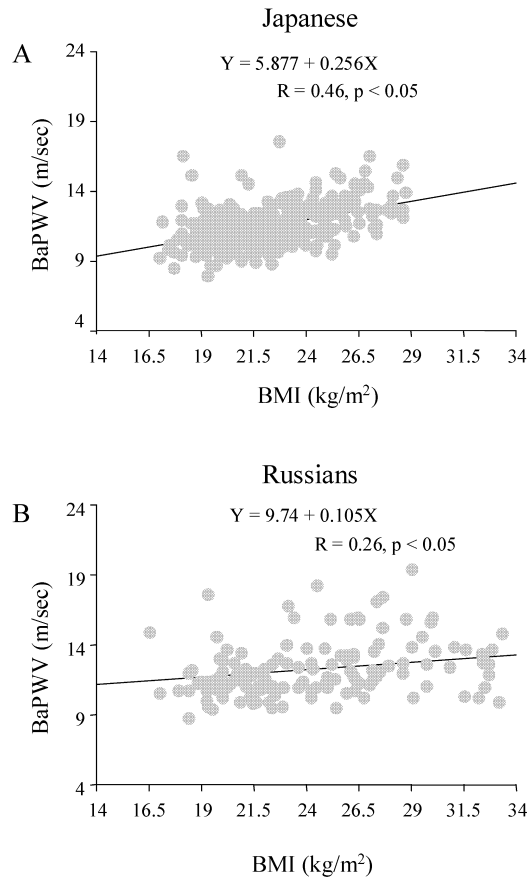

Fig. 2. Relations between baPWV and BMI in 337 Japanese subjects (A) and 138 Russian subjects (B).

lation with age in Japanese subjects ($r = 0.75$, $p < 0.05$) (Fig. 1A) and Russian subjects ($r = 0.42$, $p < 0.05$) (Fig. 1B). However, the straight-line slopes of regression of baPWV vs age in Russian subjects (Y = 8.607 + 0.098X) were obviously larger than those in Japanese subjects (Y = 10.096 + 0.043X).

BaPWV also showed a mild, but significant positive correlation with BMI in Japanese subjects ($r = 0.46$, $p < 0.05$) (Fig. 2A) and Russian subjects ($r = 0.26$, $p < 0.05$) (Fig. 2B).

BaPWV showed a significant positive correlation with SBP in Japanese subjects ($r = 0.32$, $p < 0.05$) (Fig. 3A) and Russian subjects ($r = 0.46$, $p < 0.05$) (Fig. 3B).

The straight-line slopes of regression of baPWV vs SBP in Russian subjects (Y = 1.565 + 0.088X) were obviously larger than those in Japanese subjects (Y = 6.206+ 0.045X).

Correlation of BP with age in Japanese and Russians

BP showed a significant positive correlation with age in Japanese subjects ($r = 0.27$, $p < 0.05$) (Fig. 4A) and Russian subjects ($r = 0.46$, $p < 0.05$) (Fig. 4B). The straight-line slope of regression of BP versus age in Russian subjects (Y = 84.853 + 0.249X) was obviously larger than that in Japanese subjects (Y = 85.258 + 0.135X).

Discussion

The synergistic effect of hypertension and arterial stiffness may appear as a higher PWV value. Increased arterial stiffness, as reflected by an increased PWV, results in aggravation of atherosclerosis via an increased stress on the arterial

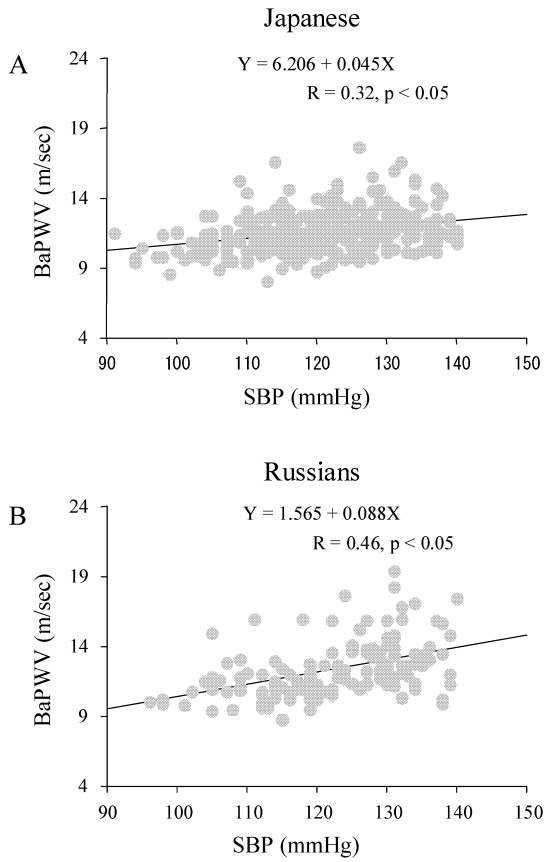

Fig. 3. Relations between baPWV and SBP in 337 Japanese subjects (A) and 138 Russian subjects (B).

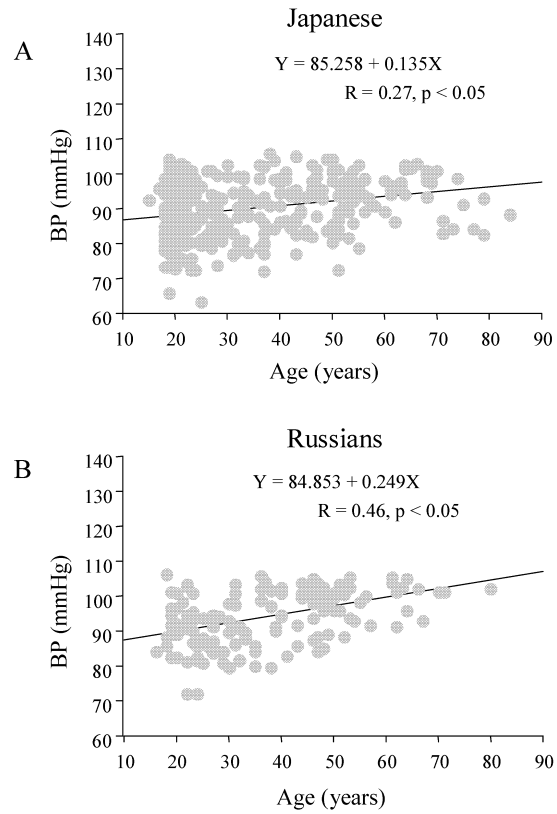

Fig. 4. Relations between BP and Age in 337 Japanese subjects (A) and 138 Russian subjects (B).

wall. The degree of elevation of PWV may correspond to the degree of atherosclerotic change: a very high PWV may indicate that the atherosclerotic process is already well established (Ogawa et al. 2003; Yokoyama et al. 2003). Thus, an increased PWV was associated with atherosclerotic risk factors (Altun et al. 2004; Fujiwara et al. 2004; Tomiyama et al. 2004).

In this study, we compared the baPWV of Japanese and Russians for the first time. Our major finding in this study is that baPWV of Russians has higher values than those of Japanese. Therefore, our results suggest that Russians have a higher risk for atherosclerotic diseases than Japanese.

We also examined the correlation between baPWV and age. BaPWV showed significantly positive correlation with age in both Japanese and Russians. This is consistent with previous investigations (Fujiwara et al. 2004; Mitchell et al. 2004). The significant positive correlation found between PWV and age indicates that arteries become less elastic with age, and arterial stiffening was observed with increasing age (Oren et al. 2003). Aging induces structural and functional abnormalities such as arterial wall hypertrophy and degeneration or disorganization of the medial layer. These changes increase PWV because of increased arterial stiffness (Tomiyama et al. 2003).

Russian subjects were found to have higher values of baPWV compared with Japanese subjects matched for age groups. The straight-line slopes of regression of baPWV vs age were obviously larger in Russian subjects than in Japanese subjects. These results suggest that the increase

of baPWV with age occurred earlier, the development of atherosclerosis was faster, and an overall higher cardiovascular risk was shown in Russians than in Japanese. This trend may be associated with the differences in their lifestyles.

Obesity might adversely affect cardiovascular health through association with dyslipidemia, hypertension, and inflammation. Obesity is one of the factors that define the metabolic syndrome, and it might also exert adverse affects on the vascular system by increasing arterial stiffness (Anuurad et al. 2003). In this study, we found a mild but significant correlation between baPWV and BMI both in Russians and Japanese. This significant correlation found between baPWV and BMI showed that arteries become less elastic with BMI and arterial stiffening is observed with increasing BMI. Excess body weight has both short- and long-term effects on the vascular system. The association between excess body weight and increased vascular stiffness is present in adults, and the vascular effects of obesity occur at a very early stage of vascular aging (Anuurad et al. 2003).

Russian subjects were found to have a larger increase in BMI compared with Japanese subjects matched by age. Previous reports have shown that Japanese also have lower levels of obesity and total cholesterol than many Western European countries (Martikainen et al. 2001). As for obesity in Japanese, the population of the morbidly obese is much smaller than among Europeans and Americans (Ogura et al. 2004). However, recently the Japanese lifestyle, especially regarding dietary habits, has changed drastically, with changes resembling those that have occurred in Western countries. These changes in the Japanese lifestyle have caused an increase in the rate of obesity in Japan in the past half century. The influence of Western culture is greater in Japan than in other parts of Asia (Notzon et al. 1998).

In this study, we found a significant correlation between baPWV and SBP both in Russians and Japanese. These findings showed that arterial stiffening was observed with increasing SBP. The straight-line slopes of regression of baPWV vs SBP in Russian subjects are obviously larger than in Japanese subjects, and SBP in Japanese subjects are significantly lower than that in Russian subjects in three age groups. These results suggest that the increase of BP with age was earlier and a higher cardiovascular risk was shown in Russians than in Japanese.

The higher baPWV values in Russians may be caused by their unhealthy lifestyles. In Russians, heavy alcohol consumption and binge drinking are common, and very high total cholesterol levels and high rates of smoking have been shown (Men et al. 2003; Perlman et al. 2003; Cai et al. 2004). Total cholesterol was positively related to arterial stiffness (Kontopoulos et al. 2003), and smoking caused short-time increases in arterial wall stiffness for smokers in habitual (Eguchi et al. 2004). Therefore, Russians have a higher overall risk for cardiovascular diseases than Japanese. These factors are also consistent with their high mortality from cardiovascular diseases in Russia. Designing interventions to change health behaviors in Russia will be important for combating these diseases. In Japan, risk factors of atherosclerosis and preclinical atherosclerosis are increasing as the influence of a westernized lifestyle increases. The PWV values of Japanese-Americans in Hawaii were greater than those of the Japanese living in Japan. A westernized lifestyle may play an important role in increased PWV (Shokawa et al. 2005). A healthy lifestyle is thus also considered to be important for Japanese to decrease the risk of cardiovascular diseases.

On the other hand, it is known that smoking and lack of exercise are atherosclerotic risk factors (Boreham et al. 2004; Eguchi et al. 2004). We have no information about smoking rate or exercise frequency of subjects in this study. However, we will examine them in our future studies.

In summary, our data suggest that the increase of baPWV with age was earlier, the development of atherosclerosis was faster, and a cardiovascular risk was higher in Russians than in Japanese. This may be associated with the differences in their lifestyles.

Acknowledgments

This work was partly supported by a Grant-in-aid for Scientific Research (11480253), a Research Grant for Cardiovascular Diseases from the Ministry of Health and Welfare and Program for Promotion of Fundamental Studies in Health Science of Organizing for Drug ADR Relief, R & D Promotion and Product Review of Japan, and Health and Labour Sciences Research Grants for Research on Advanced Medical Technology.

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