INTERNAL MEDICINE

ORIGINAL ARTICLE

Effects of Long-term Physical Training on the Bearers of a Float during the Nagasaki Kunchi Festival

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Abstract

Objective The Nagasaki Kunchi Festival is one of the most famous festivals in Nagasaki. The bearers the floats that are used in this festival undergo long-term training for the performance. However, there have not been any studies on the effects of this training on the health of the float bearers.

Methods Thirty-four men ranging in age from 20 to 49 years (mean age: 35.7±7.6 years) were included in the study. We examined the following parameters before and after the training: body weight (BW), body mass index (BMI), body fat percentage, muscle volume, systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), pulse pressure (PP), bearing power, arterial pressure volume index (API), and arterial velocity pulse index (AVI).

Results For all participants, the BW, BMI, body fat percentage, and PR were significantly decreased, and the muscle volume and bearing power were significantly increased after the training; however, there were no significant changes in the SBP, DBP, PP, API, or AVI. In the participants with hypertension, in addition to decreases in BW, BMI, body fat percentage, PR, and PP, the SBP, DBP, and API were significantly decreased after the training.

Conclusion Training for bearing a float during Nagasaki Kunchi effectively improved the body structure of all participants and reduced the BP and API in participants with hypertension.

Key words: arterial stiffness, exercise, festival, hypertension, life style modification

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Introduction

The Nagasaki Kunchi Festival, held every October, is one of the most famous festivals in Nagasaki, Japan. It began as a celebration of the autumn harvests in the late 16th century and became a shrine festival when Suwa Shrine was founded in 1634. Several types of dances are performed during the festival as dedications to the shrine's deity. One of these festival dances is a float parade. The Shachidaiko, one of the Nagasaki Kunchi floats, weighs approximately 750 kg, and includes children playing Japanese drums. Thirty-eight bearers dance while carrying the float (an approximately 20-kg load per bearer). They carry, walk, and run with the float, and turn it and toss it into the air from the level of the bearers' knees to 1 m above the level of their heads during their 20-minutes performance. This performance is a demanding physical activity for the bearers. Float bearers are selected from healthy adult men, and they have to train for approximately 9 months before the festival. However, no studies have examined the effects of the training for the performance on the body structure and physiological parameters of the Nagasaki Kunchi float bearers.

In the present study, we assessed the effects of the training on blood pressure (BP), arterial stiffness, physical activity, and body measurements of Nagasaki Kunchi float bearers.

Materials and Methods

The Ethics Committee at Nagasaki University Hospital approved the protocol for this study, which was conducted in accordance with the Declaration of Helsinki (approval number 15062616).

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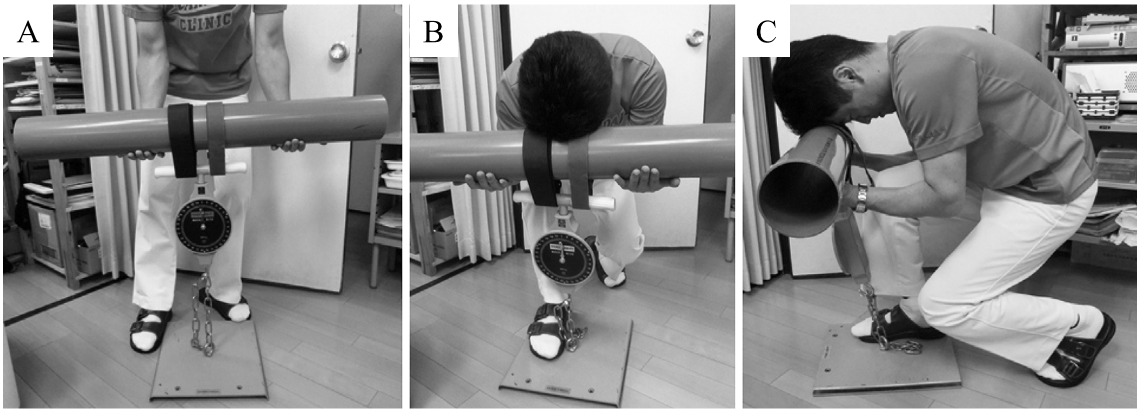

Figure 1. Device for measuring bearing power. A: Front view of the device; B: Front view of the float bearer posture at the start of the bearing power measurement; C: Lateral view of the float bearer posture at the start of the bearing power measurement.

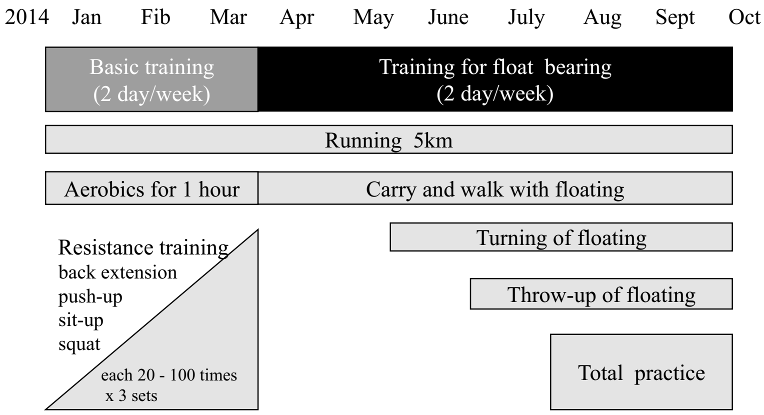

Figure 2. Training protocol for float bearers from Ginya Town participating in the 2014 Nagasaki Kunchi Festival.

Study population and analysis

Among the 38 bearers of the Shachidaiko from Ginya Town that participated in the 2014 Nagasaki Kunchi, 34 healthy men ranging in age from 20 to 49 years (mean age ± standard deviation [SD]: 35.7±7.6 years) and without any apparent diseases were examined after agreeing to participate in this study and providing informed consent. The following parameters were assessed before and nine months after the beginning of the training: body weight (BW), body mass index (BMI), body fat percentage, muscle volume, systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), pulse pressure (PP), arterial pressure volume index (API) and arterial velocity pulse index (AVI). The body fat percentage and muscle volume were measured using a weight and body composition analyzer (Infy BS-229; Terraillon, France). The API for assessing the peripheral arterial stiffness and AVI for assessing central arterial stiffness were measured using a Pasesa AVE-1500 (Shisei Datum, Tokyo, Japan). We also measured the bearing power using a custom-made device comprising a metallic plate, chain, dynamometer, straps, and bar (Fig. 1A). The bearing power was measured from a crouching position as the participant attempted to push up the bar of the device (Fig. 1B and C). This posture is similar to the posture float bearers assume when about to toss the float.

For the festival held in October, float bearers train for nine months according to the schedule shown in Fig. 2. Briefly, from January to March, the bearers train two days per week. This initial training includes a 5-km run, resistance training (push-ups, sit-ups, back extensions, squats; gradually increase, 1 set of each 20 times [2 weeks], 1 set of each 50 times [2 weeks], one set of each 100 times [2 weeks], 2 sets of each 100 times [2 weeks], and three sets of each 100 times [4 weeks]), and aerobics with instructors for 1 hour. In April, they begin training for bearing the float in addition to running 5 km. From April to May, they walk while carrying the float without drums or children on it. Starting in June, they practice turning the float in addition to both carrying and walking with it five days a week. In July, they begin the training for tossing the float with drums and children into the air. Finally, in August, they practice the dance performance. One doctor participated in the training and assessed the exercise level of the training using a Borg scale of 13-15. He also measured the exercise intensity of the performance for 20 minutes using a mobile oxygen ana-

Table 1. Changes in Parameters before and after the Training for All Participants.

n=34	Before	After	p value
Body weight (kg)	74.6 ± 8.6 (56.8 - 98.6)	72.9 ± 8.6 (55.6 - 93.8)	0.004
Body mass index	24.7 ± 2.8 (20.1 - 32.5)	24.1 ± 2.7 (18.9 - 31.0)	0.003
Body fat percentage (%)	26.2 ± 5.2 (14.6 - 39.7)	22.1 ± 4.9 (12.4 - 34.3)	<0.001
SBP (mmHg)	135.6 ± 14.2 (110.0 - 168.0)	132.2 ± 10.1 (112.0 - 152.0)	0.117
DBP (mmHg)	82.27 ± 10.44 (62.0 - 112.0)	79.0 ± 13.2 (48.0 - 106.0)	0.058
PR (beats/min)	75.1 ± 13.9 (53 - 105)	69.7 ± 9.7 (51 – 92)	0.015
PP (mmHg)	53.3 ± 11.2 (33 - 83)	52.9 ± 12.9 (29 – 85)	0.429
API	29.4 ± 4.5 (23.0 - 40.0)	27.7 ± 4.5 (17.0 - 35.0)	0.064
AVI	14. 7 ± 4.0 (8.0 - 25.0)	15.1 ± 3.4 (9.0 - 24.0)	0.293
Muscle volume (%)	31.5 ± 2.7 (24.9 - 36.9)	32.2 ± 3.0 (26.3 - 40.7)	0.005
Bearing power (kgw)	56.8 ± 16.9 (34.0 - 95.0)	65.6 ± 16.6 (40.0 - 96.0)	0.006

SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, PP: pulse pressure, API: arterial pressure volume index, AVI: arterial velocity pulse index

Table 2. Comparison of Parameters between Participants with and without Hypertension.

	HT (n=13)	NHT (n=21)	p value
Age	37.9 ± 9.1 (22 - 49)	34.3 ± 6.4 (20 - 44)	0.092
Body weight (kg)	78.6 ± 8.9 (67.2 - 98.6)	72.2 ± 7.6 (56.8 - 83.7)	0.056
Body mass index	25.9 ± 2.9 (22.0 - 32.5)	24.0 ± 2.5 (20.1 - 28.2)	0.058
Body fat percentage (%)	27. 5 ± 5.2 (22.5 - 39.7)	25.4 ± 5.2 (14.6 - 37.4)	0.330
SBP (mmHg)	147.5 ± 12.5 (123.0 - 168.0)	127.9 ± 8.7 (110.0 - 139.0)	<0.001
DBP (mmHg)	90.8 ± 9.0 (75.0 - 112.0)	76.8 ± 7.2 (62.0 - 87.0)	<0.001
PR (beats/min)	74.6 ± 12.5 (53 - 92)	75.4 ± 14.7 (58 - 105)	0.440
PP (mmHg)	56.8 ± 14.7 (33 - 83)	51.1 ± 7.5 (37 - 69)	0.082
API	31.3 ± 4.1 (26.0 - 39.0)	28.2 ± 4.4 (23.0 - 40.0)	0.031
AVI	15.7 ± 4.5 (12.0 - 25.0)	14.0 ± 3.6 (8.0 - 25.0)	0.316
Muscle volume (%)	32.4 ± 2.6 (28.7 - 36.9)	31.1 ± 2.7 (24.9 - 35.7)	0.207
Bearing power (kgw)	57.0 ± 18.8 (34.0 - 82.0)	58.4 ± 17.9 (40.0 - 95.0)	0.896

HT: hypertension group, NHT: non-hypertension group, SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, PP: pulse pressure, API: arterial pressure volume index, AVI: arterial velocity pulse index

lyzer, MetaMax II (Cortex Biophysik, Leipzig, Germany). The peak VO_2 was 56 mL/min/kg, which indicated 16 metabolic equivalents.

Statistical analysis

All of the values are expressed as the mean ± SD. The data were compared between the two groups using a paired t-test. Univariate and multivariate linear regression analyses (stepwise method) were used to evaluate any correlations of the parameters related to the blood pressure, API, and AVI in the present study. p values <0.05 were considered to be significant.

Results

For all of the participants, the BW, BMI, PR, and body fat percentage were significantly decreased, while the muscle volume and bearing power were significantly increased after the training; however, there were no significant changes in the SBP, DBP, PP, API, and AVI (Table 1). Thirteen of the 34 (38%) participants had hypertension, defined as an SBP≥140 mmHg and/or a DBP≥90 mmHg based on 1 clinical session of blood pressure evaluation. The participants with hypertension were not using anti-hypertensive drugs.

These hypertensive patients all gave their informed consent based on the current Japanese Society of Hypertension guideline for the management of hypertension, and we informed them of the disadvantages of engaging in only physical exercise for 9 months with respect to risk reduction of cardiovascular diseases. However, they declined to take any anti-hypertensive agents during the training. The doctor who participated in the training alerted these subjects when they had physical deconditioning, and they had no symptoms or health problems during and after the training.

Only the SBP, DBP and API were significantly different between the participants with and without hypertension (Table 2). After conducting total population analyses, we then separately analyzed the data for the participants with and without hypertension.

In the hypertensive participants, the BW, BMI, and body fat percentage were significantly decreased (Table 3) after the training. Furthermore, the SBP, DBP, PR and PP were also significantly decreased (SBP: 12.5±13.2 mmHg, DBP: 3.9±6.7 mmHg, PR: 6.2±12.1 beats/min, PP: 9.3±11.5 mmHg) (Table 3). Seven of the 13 (54%) participants with hypertension had normal BP after the training. The API was significantly decreased after the training, although the AVI

Table 3. Changes in Parameters before and after the Training in Participants with Hypertension.

n=13	Before	After	p value
Body weight (kg)	78.6 ± 8.9 (67.2 - 98.6)	75.3 ± 7.8 (65.4 - 93.8)	<0.001
Body mass index	25.9 ± 2.9 (22.0 - 32.5)	24.9 ± 2.4 (21.4 - 31.0)	0.007
Body fat percentage (%)	27. 5 ± 5.2 (22.5 - 39.7)	23.7 ± 4.4 (17.6 - 34.3)	<0.001
SBP (mmHg)	147.5 ± 12.5 (123.0 - 168.0)	135.1 ± 8.8 (118.0 - 152.0)	0.003
DBP (mmHg)	90.8 ± 9.0 (75.0 - 112.0)	86.9 ± 10.0 (74.0 - 106.0)	0.012
PR (beats/min)	74.6 ± 12.5 (53 - 92)	68.4 ± 9.9 (51 - 87)	0.049
PP (mmHg)	56.8 ± 14.7 (33 - 83)	47.5 ± 114 (22 – 69)	0.008
API	31.3 ± 4.1 (26.0 - 39.0)	28.2 ± 4.2 (22.0 - 35.0)	0.003
AVI	15.7 ± 4.5 (12.0 - 25.0)	15.9 ± 3.8 (11.0 - 24.0)	0.500
Muscle volume (%)	32.4 ± 2.6 (28.7 - 36.9)	32.3 ± 2.5 (28.6 - 36.3)	0.363
Bearing power (kgw)	57.0 ± 18.8 (34.0 - 82.0)	62.9 ± 16.7 (40.0 - 96.0)	0.027

SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, PP: pulse pressure, API: arterial pressure volume index, AVI: arterial velocity pulse index

Table 4. Changes in Parameters before and after the Training in Participants without Hypertension.

n=21	Before	After	p value
Body weight (kg)	72.2 ± 7.6 (56.8 - 83.7)	71.4 ± 8.9 (55.6 - 88.0)	0.12
Body mass index	24.0 ± 2.5 (20.1 - 28.2)	23.7 ± 2.8 (18.9 - 28.2)	0.103
Body fat percentage (%)	25.4 ± 5.2 (14.6 - 37.4)	21.1 ± 4.9 (12.4 - 30.2)	<0.001
SBP (mmHg)	127.9 ± 8.7 (110 - 139)	130.3 ± 10.6 (112 - 146)	0.105
DBP (mmHg)	76.8 ± 7.2 (62 - 87)	74.1 ± 12.8 (48 - 99)	0.213
PR (beats/min)	75.4 ± 14.7 (58 - 105)	70.5 ± 9.5 (56 - 92)	0.074
PP (mmHg)	51.1 ± 7.5 (37 - 69)	56.2 ± 12.6 (37 - 85)	0.043
API	28.2 ± 4.4 (23.0 - 40.0)	27.4 ± 4.8 (17.0 - 34.0)	0.288
AVI	14.0 ± 3.6 (8.0 - 25.0)	14.5 ± 3.1 (9.0 - 22.0)	0.308
Muscle volume (%)	31.1 ± 2.7 (24.9 -35.7)	32.3 ± 2.7 (26.3 - 40.7)	<0.001
Bearing power (kgw)	58.4 ± 17.9(40.0 - 95.0)	68.1 ± 16.6 (40.0 - 95.0)	0.026

SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, PP: pulse pressure, API: arterial pressure volume index, AVI: arterial velocity pulse index

did not change significantly (Table 3). The bearing power was significantly increased, but the muscle volume did not change significantly (Table 3).

In the normotensive participants, the SBP, DBP, PR, API, and AVI did not significantly change, but the BW, BMI and body fat percentage were significantly decreased, and the PP, muscle volume, and bearing power were significantly increased (Table 4).

Table 5 shows the statistically significant correlation between the parameters related to blood pressure, API, and AVI as evaluated by the univariate and multivariate analysis data of these significantly correlated parameters. A univariate linear regression analysis demonstrated the following: 1) SBP was positively correlated with PP, API, and AVI; 2) DBP was positively correlated with age and BMI; 3) API was positively correlated with SBP and PP; and 4) AVI was positively correlated with age and SBP. A multiple linear regression analysis showed significant correlations between the following: 1) SBP with PP and API, 2) DBP with age and BMI, 3) API with SBP, and 4) AVI with age.

Discussion

The present study demonstrated that the nine-month training for the Nagasaki Kunchi Festival float bearers significantly decreased the BW, BMI, body fat percentage, and PR and significantly increased the muscle volume and bearing power in all participants. There have been several reports on the efficacy of training for performers in Japanese festivals (1). In particular, the physical fitness level of the participants in the Yosakoi Soran dance festival in Hokkaido was improved by dance practices twice a week for four months (1). While no data are available on the BMI or body fat percentage of the festival participants in these previous studies, exercise may play a pivotal role in the treatment of overweight adults. Furthermore, a combination of resistance training and aerobic exercise is more useful for increasing lean body mass than either alone (2). The training regimes in the present study included aerobic exercise and resistance training, and this combination of exercise seemed to have a positive effect on body structure.

Our study also demonstrated that the training significantly decreased the SBP (12.5±13.2 mmHg) and DBP (3.9±6.7 mmHg) in participants with hypertension but not in normotensive participants. Previous studies have shown that exercise reduced the BP in both adults with normal BP as well as those with hypertension (3, 4), and that the decrease in the BP due to exercise was greater in hypertensive patients than in normotensive subjects (5). Thus, the present study confirmed that the BP-lowering effect of the training for the Nagasaki Kunchi Festival is also more prominent in hypertensive participants than in normotensive ones.

Table 5. Univariate and Multivariate Linear Regression Analysis of the Parameters before the Training in All Participants.

	Univariate linear regression				Multivariate linear regression			
Variables	R^2	$\beta_{standard}$	β	p value	R^2	$\beta_{standard}$	β	p value
SBP								
PP	0.456	0.688	0.846	<0.001	0.519	0.131	0.600	0.003
API	0.325	0.589	1.828	<0.001		0.310	0.964	0.039
AVI	0.097	0.354	1.399	0.043		0.131	0.518	0.320
DBP								
Age	0.142	0.411	0.553	0.012	0.238	0.402	0.541	0.014
BMI	0.095	0.3515	1.326	0.045		0.347	1.289	0.035
API								
SBP	0.325	0.589	1.828	<0.001	0.327	0.449	0.144	0.032
PP	0.239	0.512	0.203	0.002		0.204	0.081	0316
AVI								
Age	0.206	0.479	0.250	0.004	0.302	0.481	0.222	0.004
SBP	0.097	0.354	0.090	<0.043		0.246	0.062	0.115

SBP: systolic blood pressure, PP: pulse pressure, API: arterial pressure volume index, AVI: arterial velocity pulse index, DBP: diastolic blood pressure, BMI: body mass index

Although aerobic exercise is effective for reducing the BP (4.6-mmHg decrease in SBP, 2.6-mmHg decrease in DBP) (3), a meta-analysis of randomized controlled trials showed that resistance training itself has a BP-lowering effect (3.87-mmHg decrease in SBP, 3.6-mmHg decrease in DBP) (6). In comparison with previous studies using only aerobic exercise or resistance training (3, 6), the combination of aerobic exercise and resistance training in the present study appeared to be more effective on lowering the BP in hypertensive participants than either alone.

The appropriate exercise intensity for lowering BP in hypertensive subjects has not been elucidated, and a previous report suggests that exercise programs should be individualized, including individualized intensity, frequency, time, and type (7). Although there is little supporting evidence, an exercise intensity of 50% of maximum oxygen intake (13 on the Borg scale) is recommended in many guidelines (8). Because the exercise intensity in the present study matched this level, the training for the Nagasaki Kunchi Festival seems to provide beneficial effects for safely lowering BP in hypertensive participants.

In the present study, the API, an index for peripheral arterial stiffness, was significantly decreased as a result of the training only in participants with hypertension. However, the AVI, an index for central arterial stiffness, did not significantly change in any subjects. Only two previous reports have investigated the effect of exercise on the arterial stiffness in prehypertensive or stage-1 hypertensive subjects (9, 10), and the effect of resistance training on the central and peripheral arterial stiffness remains controversial. Beck et al. (9) suggested that resistance and endurance training for 8 weeks reduced the peripheral arterial stiffness but not central arterial stiffness in young (aged 18-35 years; mean age: approximately 21 years) prehypertensive subjects. Collier et al. (10) showed that aerobic exercise decreased both central and peripheral arterial stiffness, although resistance training increased both of them in prehypertensive or stage-1 hypertensive subjects (mean age: 48.2 years) after 4 weeks of training. Our results for hypertensive subjects were the same as those reported by Beck et al., although there are some differences between the studies, including the characteristics of the study participants (Japanese in our study vs. American in the Beck et al. study), the older mean age of subjects (mean age of 35 years vs. 21 years), and longer training period (9 months vs. 4-8 weeks) as well as the different types of exercise and different measurements of arterial stiffness. Previous reports have suggested that peripheral arterial stiffness increased but central arterial stiffness was within the normotensive range in young prehypertensive subjects (9, 11). The present study also demonstrated that the API, an index for peripheral arterial stiffness, was significantly higher in hypertensive participants than in normotensive participants, although there was no significant difference in the AVI, an index for central arterial stiffness, between these participants. Thus, the nine-month training for the Nagasaki Kunchi Festival may be effective for ameliorating increased peripheral arterial stiffness but not central arterial stiffness in relatively young hypertensive subjects.

A meta-analysis of the effects of resistance training on arterial stiffness showed that high-intensity resistance training is associated with increased arterial stiffness in young subjects with low baseline levels of arterial stiffness (12). Thus, the high-intensity resistance training included in the training for the Nagasaki Kunchi Festival may be related to the unchanged arterial stiffness in participants without hypertension.

Among the total participants in the present study, SBP was significantly correlated with API, and DBP was correlated with BMI. Thus, the mechanism of BP decrease may be different between the SBP and DBP. The present study also demonstrated that the pulse rate was significantly decreased after the training in all of the participants as well as in the participants with hypertension. Given that the sympathetic nervous system plays in important role in essential hypertension (13), the suppression of the sympathetic nerve activity by the training may be one cause of the drop in the

BP in the present study.

Lifestyle modifications other than exercise, such as salt intake restriction, the Dietary Approaches to Stop Hypertension (DASH) diet, weight loss, smoking cessation, and restriction of alcohol intake also decrease the BP (8). Given that these factors were not examined in the present study, their effects on the study participants remain uncertain. However, Blumenthal et al. (14) reported that exercise was effective in reducing the BP in people with mild hypertension, and that the addition of a behavioral weight loss program enhanced this effect. The present study suggests that the BP-lowering effect of our training for the Nagasaki Kunchi float bearers with hypertension may be induced by the exercise itself and the weight loss related to the exercise.

Previous studies have shown that visceral fat is associated with the prevalence and incidence of hypertension (15, 16). Unfortunately, we did not measure the waist circumference or any laboratory data on lipid or glucose metabolism. However, the decrease in visceral fat due to training may be related to the reduction in BP in the hypertensive participants, as the BW, BMI, and body fat percentage significantly decreased after the training.

In conclusion, the 9-month training for the Nagasaki Kunchi Festival float bearers was thus found to be effective for improving the body structure of all participants and for reducing the BP and peripheral arterial stiffness in the participants with hypertension.

Study limitations

Several limitations associated with the present study warrant mention. The present study had a low number of participants. However, increasing the number of participants is difficult in this case, as 59 groups from different towns are registered for the festival and divided into 7 sets, with only 1 group from each set performing their specific dance every 7 years. Furthermore, only men can be float bearers, making it impossible to include women in the present study. To include the API and AVI data in the present study, we used the clinically evaluated BP obtained in a single session at the same time as the API and AVI measurement. Thus, white-coat hypertension may be included in this study. Moreover, the participants were somewhat excited because they were selected as members of the traditional festival, and they had a firm sense of mission to perform successfully. Thus, they may have had a higher BP than usual.

Author's disclosure of potential Conflicts of Interest (COI).
Koji Maemura: Honoraria, Boehringer Ingelheim, Daiichi Sankyo, Bayer, MSD and Takeda.

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