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ORIGINAL ARTICLE

Accumulation of physical activity: blood pressure reduction between 10-min walking sessions

S Park[1], LD Rink[2] and JP Wallace[3]

[1]*Division of Sports Science, Korea Institute of Sport Science, Seoul, Korea;* [2]*Department of Medicine, Indiana University Medical Center, Bloomington, IN, USA and* [3]*Clinical Exercise Physiology Laboratory, Department of Kinesiology, Indiana University, Bloomington, IN, USA*

The accumulation of intermittent bouts of physical activity (PA) has been found to reduce blood pressure (BP) in prehypertension and hypertension. Yet, the BP response among several short sessions within the accumulation of PA in a single day has not been examined. The purpose of the study was (1) to investigate the BP reduction during the rest periods following three successive 10-min walking sessions accumulated over a 3-h period in prehypertensive adults and (2) to observe the role of autonomic modulation during the rest periods following each short PA session. Adults with prehypertension (131.9 ± 4.7/82.5 ± 6.4 mm Hg) participated in the study. BP using ambulatory monitoring and autonomic modulation through heart rate variability (HRV) using Holter monitoring were measured at baseline and during the rest periods following three short sessions (three 10-min treadmill walks at 50% of peak oxygen uptake (VO_2peak); at least 50 min apart) over a 3-h period. Variables of BP and autonomic modulation were averaged for the baseline and for the rest periods following each 10-min walk. One-way analysis of variance with repeated measures was used to test the differences over time in BP and HRV ($P < 0.05$). A significant main effect was found in systolic BP ($P = 0.039$), whereas none was found in diastolic BP ($P = 0.630$). Systolic BP was decreased following the third short session (−4.0 ± 7.4 mm Hg) compared to baseline. No significance was found in any of the autonomic modulation variables. In conclusion, accumulating intermittent bouts of PA, as short as 10 min, total 30-min walk sessions may reduce systolic BP in prehypertension.

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Introduction

A public health strategy to prevent hypertension is warranted as the lifetime risk of developing hypertension is about 90%.[1] The primary prevention of hypertension has been promoted to the population, particularly in adults with prehypertension (defined as systolic blood pressure (BP) of 120–139 mm Hg and/or diastolic BP of 80–89 mm Hg),[1] which is associated with an increase in cardiovascular morbidity and mortality.[2–4] Lifestyle modifications, including regular physical activity (PA), are the only recommended treatment for prehypertension.[1,5] The PA recommendation for the treatment of both prehypertension and hypertension includes the accumulation of 30 min or more of moderately intense PA in most, preferably all, days of the week.[1,6] Yet, the scientific evidence has neglected the accumulation aspects of PA in the treatment of hypertension and prehypertension.[1,6,7] The American College of Sports Medicine Position Stand on exercise and hypertension stated that there is limited evidence regarding the accumulation of several short sessions of PA on BP reduction[6]. This limited scientific evidence led to our work in the accumulation of PA as a treatment for prehypertension.[8,9]

We have investigated the effects of the accumulation of PA in prehypertension and hypertension[8,9] First, we[8] examined the effects of the accumulation of lifestyle PA in prehypertension and hypertension. The accumulation of lifestyle PA over a 12-h period significantly reduced systolic BP in adults with prehypertension (−6.6 ± 2.3 mm Hg for 6 h) and hypertension (−12.9 ± 4.3 mm Hg for 8 h). For the second study,[9] we took this field study[8] into the laboratory for a more controlled investigation. We

Correspondence: Dr S Park, Division of Sports Science, Korea Institute of Sport Science, 223-19 Kongneung-Dong, Nowon-Gu, Seoul 139-242, Korea.
E-mail: saejpark@sports.re.kr
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compared the BP reduction following the accumulation of PA (four 10-min walks at 50% of peak oxygen uptake; VO_2peak) to the BP reduction following a single continuous PA session (one 40-min walk at 50% of VO_2peak) in prehypertension. Greater reductions in both systolic and diastolic BP were found following the accumulation of PA (-5.4 ± 1.7 mm Hg of systolic for 11 h; -3.4 ± 1.3 mm Hg of diastolic for 10 h) than following a single continuous PA session (-5.6 ± 1.6 mm Hg of systolic for 7 h; -3.1 ± 0.2 mm Hg of diastolic for 7 h) in adults with prehypertension. From our two previous studies, the accumulation of intermittent PA on BP reduction was found to be effective.[8,9] The effectiveness of accumulation of PA on BP reduction might be the residual effects of the successive several short bouts of PA sessions. Yet, the BP response between the short sessions during the accumulation of PA has not been reported.

A sustained reduction in resting BP following a single bout of aerobic exercise has been defined as post-exercise hypotension.[10] The mechanisms of post-exercise hypotension are not fully understood at this time; however, autonomic modulation assessed by heart rate variability (HRV) has been widely utilized as one of the possible mechanisms of postexercise hypotension.[11,12] HRV is a non-invasive method for evaluating autonomic modulation, which describes changes in the balance between sympathetic and parasympathetic influences.[13] In our previous study, the autonomic modulation was associated with BP reduction following the accumulation of PA.[9] Thus, autonomic modulation assessed by HRV was observed following each successive short session of PA in this study.

The purpose of the study was to investigate the BP reduction and autonomic modulation as a possible mechanism for the post-exercise hypotension during the rest periods following each 10-min PA session within the accumulation of PA over a 3-h period in adults with prehypertension. We hypothesized (1) the BP following each successive 10-min session of PA would be lower than the BP following previous sessions in adults with prehypertension; and (2) the autonomic modulation, measured by power spectral analysis of the HRV, would be different following each successive short session of PA in adults with prehypertension.

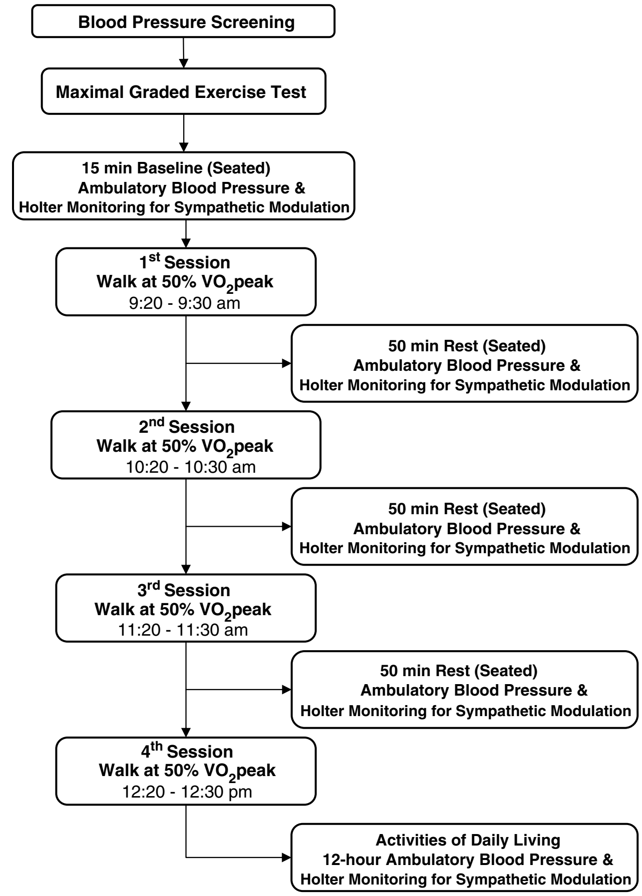

Figure 1 Study design. Subjects initially participated blood pressure screening. The maximal graded exercise test was preceded. At least a week later, three 10-min physical activity sessions including 15-min baseline measurement were performed.

Materials and methods

This is a substudy to compare the BP reduction following the accumulation of several short sessions vs one continuous session.[9] The study design is shown in Figure 1. Following the BP screening, participants were asked to complete a maximal graded exercise test. At least a week later, three 10-min PA sessions including 15-min baseline measurement were performed. Adults with prehypertension participated in the study. Ambulatory BP and Holter monitoring began for a baseline period before the PA sessions, and continued during PA and rest periods. For PA, subjects were asked to walk on a motor-driven treadmill for 10 min at 50% of VO_2peak four times in a 4-h period. Subjects were seated for the rest periods after the first three 10-min walking sessions. After the fourth session, instead of a seated rest period, subjects left the laboratory and engaged in their activities of daily living for 12 hours. The BP reduction and autonomic modulation following the end of the fourth PA stimulus were reported for a 12-h period in our previous study.[9] In this study, we evaluated BP response and autonomic modulation during the rest periods after the first three successive, yet separate 10-min walking sessions. The study was approved by the Bloomington Campus Committee for the Protection of Human Subjects at Indiana University. Each participant was given informed consent before participation in the study. The study was carried out through the Clinical Exercise Physiology Laboratory in the Department of Kinesiology at Indiana University.

Participants
The participants were recruited through public service announcements on radio stations, press releases in the local newspaper and flyers at local health fairs and the Indiana University Adult Fitness Program. Inclusion criteria were adults with prehypertension. Prehypertension was defined as 120–139 mm Hg of a mean systolic screening BP and/or 80–89 mm Hg of a mean diastolic BP taken from at least two readings on 2 separate days, 3 days apart.[9] Exclusion criteria included (1) previously diagnosed as hypertension or taking antihypertensive medications, (2) significant cardiovascular disease, (3) significant dysrhythmia, (4) brachial artery bruits, (5) cardiac or renal transplant or (6) medications such as antiarrhythmic drugs or low-dose muscarinic receptor blockers including atropine and scopolamine that affect the HRV.[9] Clearance by the subjects' primary physician was required before participation in this study including maximal graded exercise testing.

The number of subjects was estimated on the basis of power analysis (power: >0.80; effect size using partial Eta squared: >0.41),[14] using the previous study for BP with a similar study design,[8] testing PA treatment in adults with prehypertension.

Blood pressure screening
For all participants, three BP measurements were taken in the seated position on 2 separate days, 3 days apart (a total of six measurements) using a Trimline from PyMaH Corp. (Sommerville, NJ, USA).[8] Each participant was seated for at least 10 min in a chair, feet on the floor, and arm supported at heart level.[1] The participant was asked to avoid caffeine, exercise and smoking for at least 30 min before measurement.[1] An appropriate sized cuff (cuff bladder encircling at least 80% of the arm) was used to ensure accuracy.[1] On the first day, BP was taken in both arms to detect possible differences due to peripheral vascular disease; the arm with the highest BP was used for the screening.[15]

Maximal graded exercise test
The purpose of maximal graded exercise test was to measure physical work capacity to standardize the submaximal intensity of the PA sessions. A fasting blood draw and a standard resting 12-lead electrocardiogram (EKG) preceded the maximal graded exercise test to establish risk for the graded exercise test. The graded exercise test was performed on a treadmill with a speed between 2.5 and 4.0 m.p.h. The speed remained constant throughout the test, whereas the grade increased 1.0% every minute until a maximal voluntary effort was achieved. BP (by auscultation) and heart rate (by EKG) was measured every minute. The EKG was monitored continuously. Expired gases were measured online breath-by-breath using a 2900 Metabolic Measurement Cart (SensorMedics, Corp., Yorba Linda, CA, USA). VO_2peak was obtained during the symptom-limited maximal exercise test. VO_2-peak is defined as the highest VO_2 obtained from the symptom-limited maximal exercise test.

Treatments
Successive short PA sessions were proceeded by a 15-min baseline period. The focus of this study was the three rest periods following the first three 10-min walking sessions over a 3-h period. The mode of PA was walking on a motorized treadmill and the intensity of each PA session was at 50% VO_2peak. VO_2 was measured during the second through the fourth minutes of the first walking session to confirm the intensity of PA. The work rate was adjusted, if it was not within $\pm 10\%$ of the target VO_2. Then, VO_2 was measured during the sixth through the eighth minutes of the next work interval to confirm the new PA intensity. Heart rate (via EKG) and BP (via auscultation) was measured throughout the PA intervention.

Baseline period. The participant reported to the lab between 0830 and 0900 h approximately 15 min before the time when the monitors would be activated for the study. After being fitted for the monitors, the participants completed a sitting baseline rest period for 15 min.

Accumulation of short sessions of physical activity intervention. The duration of each short bout of PA was 10 min; the first between 0900 and 0930 h, the second between 1000 and 1030 h and the third between 1100 and 1130 h. Each short session was followed by the 50-min rest period in the seated position.

Ambulatory blood pressure monitoring
The Accutracker II (Suntech Medical Instruments Inc., Raleigh, NC, USA) was used for the ambulatory BP measurements. The Accutracker II has been validated in accordance to the standards of the British Hypertension Society and the American Association for Medical Instrumentation.[16] The ambulatory BP cuff was worn on the non-dominant arm. Electrode wires and BP tubing were taped securely to the chest. The cuff inflation for each measurement was 30 mm Hg greater than the previous reading, and the cuff deflation was set at $3\,mm\,Hg\,s^{-1}$.[1] The sampling intervals were (1) every 5 min for the 15-min baseline period; (2) every 5 min for the first 20 min of the 50-min rest period among the first three 10-min walking sessions; and (3) every 10 min for the remainder of the 50-min rest period among the first three 10-min walking sessions. No repeat measurement was taken.

Ambulatory BP data were manually reviewed for missing and erroneous readings, which is described in our previous study.[9] Ambulatory BP data were averaged during the baseline period and for the last 40 min of the rest periods between each short session of PA.

Holter monitoring
The Aria Digital Recorder (Del Mar Reynolds Medical Inc., Irvine, CA, USA) was used to observe autonomic modulation through power spectral analysis of HRV. The EKG was analysed for the baseline period and the rest periods following the first three 10-min walking sessions. The data from Aria Digital Recorder was scanned on a computer-assisted Holter system (Impresario, Solo Holter analysis software, Del Mar Reynolds Medical Inc., Irvine, CA, USA) for variables of HRV. Manual editing of the R-R interval data was performed to ensure correct identification and classification of every QRS complex.[17] Artifact and ectopic beats were removed for the R-R interval calculation. The data were then used for the power spectral analysis of HRV.

Heart rate variability is a non-invasive tool to assess, not to directly measure, autonomic function. Frequency-domain measures of HRV were assessed using the Fast Fourier Transform. The total power was calculated by the s.d. of the R-R interval (<0.1 Hz). HRV of the total nominal record was computed using the whole range of high frequency power (0.15–0.40 Hz), low frequency power (0.04–0.15 Hz) and very low frequency power (0.003–0.04 Hz). The physiological roles of its components are not yet fully understood. High frequency component is known to be related to parasympathetic activity, but the association of low-frequency component and the low-frequency/high-frequency ratio is still controversial.[17] Normalized (%) values were calculated. Normalized units represent the relative value of each power component in proportion to the total power minus the very low-frequency component. The ratio of low-frequency power to high-frequency power was determined. Normalized low-frequency power, high-frequency power and the ratio of low to high frequency were averaged for the baseline period and for the last 40 min of the rest periods between 10-min walking sessions.

Statistical methods
Data were expressed as means ± s.d. Statistical analyses were performed by using descriptive statistics, and the analysis of variance with repeated measures. Descriptive statistics were performed to describe the characteristics of subjects. The variables were sex, age, body mass index (BMI), screening systolic and diastolic BP, and VO_2peak. One-way analysis of variance with repeated measures was used to test whether the variables of BP and autonomic modulation differed over time. Mauchly's test of sphericity was non-significant. Tukey was used for *post hoc* comparisons. Pearson correlations were used to evaluate the contribution of confounding variables (such as age, BMI and VO_2peak) on screening BP. The level of significance was set at $P<0.05$. The SPSS software (SPSS 13.0) was used for all statistical analyses.

Results

Participants
Twenty-six adults were screened for the study; five were found to be ineligible during the BP screening process; four had normal BP and one had hypertension. Twenty-one prehypertensive adults who were qualified based on screening BP participated in the study. One participant did not complete the study because of time constraints. Twenty adults with prehypertension completed the study. Demographics of the participants are summarized in Table 1.

Exercise stimulus
The 20 participants who completed the study performed a maximal voluntary effort on the exercise test as verified by reaching 107.7 ± 6.0% predicted maximal heart rate (220-age). The intensity of PA was 51.9 ± 2.5% of VO_2peak.

Blood pressure reduction
As results of Pearson correlations, screening blood pressures were not significantly associated with age ($r=-0.441$ for systolic; $r=-0.155$ for diastolic), BMI ($r=0.127$ for systolic; $r=0.049$ for diastolic) and maximal VO2 ($r=-0.084$ for systolic; $r=0.175$ for diastolic). Thus, age, BMI and maximal VO2 were not used as covariates in the study. The ambulatory BP for the baseline period and three rest periods after 10-min walking sessions are illustrated in Figure 2. The number of ambulatory BP measurements was three in the baseline period and seven in the rest period following each short sessions of PA intervention. The ambulatory BP for

Table 1 Demographics of subjects

Variables	
Number	20
Sex (men/women)	15/5
Race	18 Caucasian, 2 Asian
Age (years)	47.2 ± 13.1
Weight (kg)	84.5 ± 19.6
Height (cm)	176.3 ± 7.6
Body mass index (kg m^{-2})	27.0 ± 5.2
VO_{2peak} (ml kg^{-2} min^{-1})	34.5 ± 7.3
Screening systolic blood pressure (mm Hg)	131.9 ± 4.7
Screening diastolic blood pressure (mm Hg)	82.5 ± 6.4

Values were expressed as mean ± s.d.

the baseline period and the last 40 min of the rest period were averaged for the analysis. The beginning time for the analyses of the ambulatory measurements were 9:00 ± 0:13 for baseline, 9:42 ± 0:18 following the first short session, 10:41 ± 0:13 following the second short session and 11:42 ± 0:18 following the third short session. The mean BP for baseline and rest periods are listed in Table 2.

The mean baseline BP and mean BP for the rest periods following short PA sessions was analysed by one-way analysis of variance with repeated measures. A significant main effect was found in systolic BP ($P = 0.039$), whereas no main effect was found in diastolic BP ($P = 0.630$). Further analyses revealed that systolic BP was significantly decreased following the third 10-min walking session (−4.0 ± 7.4 mm Hg) compared with the baseline systolic BP.

Autonomic modulation
Autonomic modulation measured by HRV was averaged for the baseline period and for the rest periods following short PA sessions. The values of

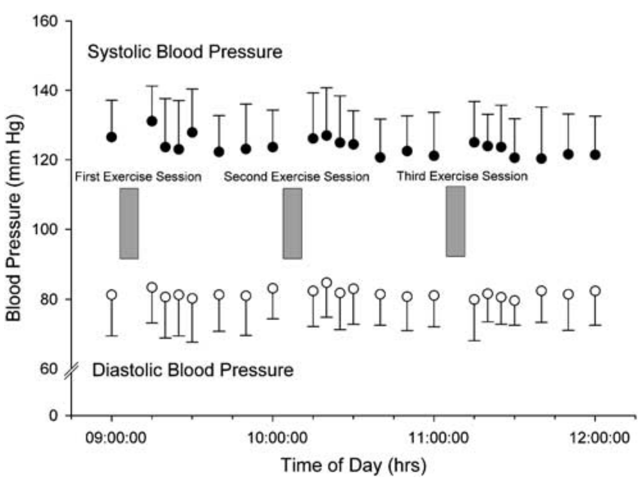

Figure 2 Blood pressure during the baseline and the three rest periods following the short physical activity sessions in prehypertension. Baseline blood pressure was averaged for 15 min. Physical activity sessions are illustrated by shaded area. The data points following the shaded physical activity session were blood pressure in the rest periods following the short sessions. ● represents systolic blood pressure and ○ represents diastolic blood pressure. Bars represent s.d.

normalized high-frequency power, normalized low-frequency power and the ratio of low to high-frequency power are summarized in Table 3. No significance was found in any of these HRV variables.

Discussion

This is the first study to report the BP response during the rest periods between short PA sessions in the accumulating 30-min of physical activity as a treatment for prehypertension. In this study, we found a significant reduction in systolic BP following the third 10-min PA session, but no difference in diastolic BP. This finding may be particularly pertinent to discussion on the efficacy of updated PA recommendation, moderate-intensity aerobic activity such as brisk walk can be accumulated toward the 30-min minimum by performing bouts each lasting 10 or more minutes, for public health.[18]

Our finding in systolic BP reduction following the first two successive bouts was similar to other studies investigating other health outcomes during the rest periods between two short sessions.[19,20] Other investigators[19,20] who observed the rest periods between successive exercise sessions found similar responses between two sessions. In these studies, excess post-exercise oxygen consumption (EPOC) was studied during the rest periods following two short sessions vs one long session.[19,20] Kaminsky *et al.*[22] investigated EPOC following a 50-min exercise session at 70% maximal VO_2 compared with two 25-min exercise sessions separated by 30 min of sitting rest. The magnitude of EPOC was similar to the two rest periods following the short sessions; and similar to the magnitude following the continuous session. Almuzaini *et al.*[19] also reported the EPOC following a 30-min exercise session to two 15-min exercise sessions, separated by 6 h and found similar results with Kaminsky *et al.*[20] Although both Kaminsky *et al.*[20] and Almuzaini *et al.*[19] found no residual effect in EPOC between the rest periods of the short sessions, we found the residual effect of successive sessions in BP reduction. This difference in successive sessions in our study might be due to the specific variable we measured, BP, or due to the number of rest periods

Table 2 Ambulatory blood pressure

	Baseline	*Rest period following the first session*	*Rest period following the second session*	*Rest period following the third session*
Systolic blood pressure (mm Hg)	126.6 ± 10.6	123.9 ± 11.4	123.5 ± 10.4	122.6 ± 10.5*
Diastolic blood pressure (mm Hg)	81.0 ± 8.4	81.2 ± 10.8	82.3 ± 8.4	81.6 ± 7.8

Values of blood pressure were averaged for 15-min baseline and the last 40 min of the rest period following short physical activity sessions.
Values were expressed as mean ± s.d.
*Denotes significant differences from baseline blood pressure at $P < 0.05$.

Table 3 Sympathetic modulation by heart rate variability

	Baseline	*Rest period following the first session*	*Rest period following the second session*	*Rest period following the third session*
Normalized low-frequency power (%)	80.0 ± 5.9	80.1 ± 10.2	80.1 ± 11.5	78.6 ± 15.2
Normalized high-frequency power (%)	18.0 ± 5.1	17.8 ± 9.2	17.8 ± 10.3	19.1 ± 13.7
Ratio of low to high frequency	4.9 ± 1.8	6.0 ± 3.6	6.3 ± 4.1	6.7 ± 4.6

Values of heart rate variability were averaged for 15-min baseline and the last 40 min of the rest period following short physical activity sessions. Values were expressed as mean ± s.d.

we utilized, three. In the current experiment, we carefully designed the study to observe the residual effects of successive sessions in the accumulating three 10-min PA sessions on BP during the rest periods as a treatment for prehypertension. We found a significant difference in systolic BP following the third session. In other words, the accumulation of the first two sessions was not sufficient stimulus to induce a statistically significant BP reduction; however, the addition of the third session decreased systolic BP. Thus, it might demonstrate residual effects of successive 10-min walking sessions on BP reduction. Furthermore, the reductions in BP following the accumulation of PA that we observed in our previous studies might be explained by this residual effect of successive short PA sessions.[8,9]

The duration of the rest periods following the three successive PA sessions in this study were affected by the fact that it was a substudy of our previously published work,[23] which the accumulation of PA (four 10-min sessions) was effective in lowering systolic and diastolic BP associated with the changes in autonomic modulation assessed by HRV.[9] The caution is needed to parallel this study to our previous work,[21] because the last (the fourth) 10-min session was not included in this study. In this study, the duration of the rest period was 50 min and the duration of the monitoring period was the last 40 min of the rest period. This 50-min rest period enabled the optimal time period for ambulatory BP monitoring in our previous study.[9] If we had extended the rest periods to 2–3 h, our ambulatory monitoring following the accumulation of PA would have been reduced to 4–7 h as in our previous study,[9] compromising the ability to detect a BP reduction for the entire stimulus before the subjects went to bed. We designed this study after determining the limitations of the previous study.[9] The first 10 min of the 50 min was not included in the rest period data, because it may have been elevated as a result of the recovery from exercise (Figure 2). Looking at our hourly data from our previous exercise studies,[8,22,23] we found that the reduction in BP for the first hour following exercise is not as great as the subsequent hours. Thus, we may have compromised our ability to detect a significant BP reduction during the rest period, if we had included the first 10 min.

The mechanisms of post-exercise hypotension are not fully understood at this time; however, autonomic modulation assessed by HRV has recently received increased focus as a possible mechanism.[9,11,12] As a result of the accumulation of four 10-min sessions of PA over a 4-h period,[9] the reduction in BP was correlated with changes in autonomic modulation; although in this study, autonomic modulation during the rest period did not appear to be affected by 10-min sessions of PA in our study even though we found changes in systolic BP. These findings are similar to those reported by Legramante *et al.*[24] who found no significant changes in autonomic modulation, although they elicited a significant 11.9 mm Hg reduction in systolic BP and a 5.3 mm Hg reduction in diastolic BP. In their study,[24] both post-exercise (graded exercise to 87% of predicted maximum heart rate) BP and HRV were measured for 5 min between 60 to 90 min following a single session of exercise. Also, Pober *et al.*[25] found no significant increase in parasympathetic activity at 1, 3 and 6 h after 60 min of cycle ergometry at 65% of VO_2peak. They did, however, find a significant decrease in sympathetic activity between 6 and 22 h following the exercise. Thus, it appears as though the change in autonomic modulation lags behind the change in early stage of post-exercise hypotension (1–2 h following the exercise). If the lag is a true phenomenon, perhaps autonomic modulation assessed by HRV might not be the method to assess the mechanisms of the early stage post-exercise hypotension. Therefore, the reduced BP cannot be fully explained by the autonomic modulation using HRV[26,27] although an increased baroreflex sensitivity with or without resetting, reduced neural sympathetic drive and exhaustion of circulating vasoactive substances may play roles. In the future study, baroreflex sensitivity assessment, which utilizes beat-to-beat BP data might be a more appropriate non-invasive measure of sympathetic modulation.

Although this study was carefully designed to observe the BP response during the rest periods between short PA sessions in the accumulating 30 min of PA as a treatment for prehypertension, a few limitations of this study should be discussed. First, the number of subjects was rather small to control for important covariates, such as age and BMI. Age, BMI and VO_2peak were not used as covariates of the BP following PA sessions in the study, because screening BP were not significantly associated with those possible covariates. Thus, the generalization of the results of this study should be restricted. Future study investigating the effects of intermittent bouts of PA on BP needs to evaluate post-exercise hypotension with the adjustment of covariates such as age and BMI. Second, although our BP screening protocol conformed to the recommendation of the World Health Organization,[28] avoidance of caffeine, exercise for at least 30 min before measurement may be not sufficiently long to prevent screening BP from potentially being biased by these life style factors. Thus, our screening BP might be considered as a limitation of our study. Third, this investigation focused on the BP reduction following the acute PA sessions, or post-exercise hypotension. BP reactivity during successive PA sessions, however, might play important roles for the BP reduction, which we were unable to present. More research is needed for BP reactivity.

In conclusion, three 10-min walking sessions were effective in reducing systolic BP (4 mm Hg) in prehypertension. Although the BP reduction from our study seems relatively small, even 3 mm Hg reduction in systolic BP has been reported to reduce mortality substantially, and to give an 8% reduction in stroke and 5% reduction in coronary heart disease.[1] Also, this immediate and favourable response associated with three 10-min walking sessions may encourage the public to participate in a more active lifestyle. Furthermore, several 10-min walking sessions may be more effective than continuous exercise, because the multiple sessions may promote adherence and may fit better into a busy schedule for most Americans. To conclude, intermittent PA sessions, as short as 10-min walking session, presented a residual effect on BP reduction in prehypertension. The residual effect of successive sessions on BP reduction might attribute to the effectiveness of the accumulation of PA on BP reduction. Continued investigation of the mechanisms of BP reduction is warranted.

What is known about this topic

- The accumulation of physical activity reduces blood pressure in prehypertension and hypertension.
- In 2007, physical activity and public health recommendation has been updated to clarify moderate intensity aerobic exercise such as brisk walking can be accumulated toward the 30-min minimum from bouts lasting 10 or more minutes.
- No literature exists on the blood pressure responses between 10-min walking sessions.

What this study adds

- Accumulating three 10-min walking reduces systolic blood pressure in prehypertension.
- The fractionization of physical activity treatment is efficacious for the treatment of prehypertension.

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