Accumulation of physical activity leads to a greater blood pressure reduction than a single continuous session, in prehypertension

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Background Despite limited research, the accumulation of physical activity has been recommended for the treatment of prehypertension.

Objectives To compare the duration and magnitude of blood pressure reduction after accumulated physical activity with that after a single session of continuous physical activity, and to investigate sympathetic modulation as a possible mechanism for the reduction in blood pressure after each acute session.

Methods Prehypertensive adults ($n = 21$) participated in a randomized crossover design. Ambulatory blood pressure and heart rate variability (Holter monitoring) were measured for 12 h after accumulated physical activity (4 × 10-min walks (1/h for 4 h) at 50% of $\dot{V}O_{2peak}$), continuous physical activity (40-min walk at 50% of $\dot{V}O_{2peak}$) and control treatments. Blood pressure and heart rate variability after each activity treatment were compared with the respective periods from the control treatment. Heart rate variability was correlated with reduction in blood pressure.

Results Systolic blood pressure (SBP) was reduced for 11 h after accumulated physical activity ($P < 0.01$), and for 7 h after continuous physical activity ($P < 0.05$). Diastolic blood pressure (DBP) was reduced for 10 h after accumulated physical activity ($P < 0.05$) and for 7 h after continuous physical activity ($P < 0.05$). With accumulated physical activity, the differences in normalized low-frequency ($r = 0.517$, $P < 0.01$) and high-frequency ($r = -0.503$, $P < 0.05$) power were correlated with reduction in SBP and the differences in normalized low-frequency ($r = 0.745$, $P < 0.001$), high-frequency ($r = -0.738$, $P < 0.001$) powers, and low frequency : high frequency ratio ($r = 0.756$, $P < 0.001$) were correlated with reduction in DBP. With continuous physical activity, the difference in low frequency : high frequency ratio ($r = 0.543$, $P < 0.05$) was correlated with reduction in DBP.

Conclusion The accumulation of physical activity appears to be more effective than a single continuous session in the management of prehypertension. Sympathetic modulation was associated with reduced blood pressure after each session. *J Hypertens* 24:1761–1770 © 2006 Lippincott Williams & Wilkins.

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Keywords: ambulatory blood pressure, post-exercise hypotension, fractionization of exercise, heart rate variability

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Introduction

In 2003, 45 million adults with prehypertension were added to the patient population in need of treatment for high blood pressure [1]. Lifestyle modification [1,2], including regular exercise, physical activity, or both, is the only recommended treatment for prehypertension and for the prevention of prehypertension progressing to hypertension [3]. Although scientific evidence supports the effectiveness of regular exercise in the treatment of hypertension [4–6], research on exercise and physical activity as treatments for prehypertension is incomplete [7]. Recently, the accumulation of at least 30 min of moderately intense physical activity on most, if not all days of the week has been recommended as the new ‘exercise’ guidelines for both prehypertension and hypertension [1,2], yet the evidence on the efficacy of physical activity in reducing blood pressure has come from studies utilizing continuous exercise sessions [1,2,8] rather than the accumulation of physical activity. This limited scientific evidence supporting the efficacy of the accumulation of physical activity precipitated our recent work in the treatment of prehypertension and hypertension through physical activity [9].

Previously, we investigated the effects of the accumulation of one day of lifestyle physical activity in prehypertension and hypertension [9]. The accumulation of one day of lifestyle physical activity over a 12-h period was found to reduce systolic blood pressure (SBP) in prehypertensive adults (by 6.6 mmHg for 6 h) and hypertensive adults

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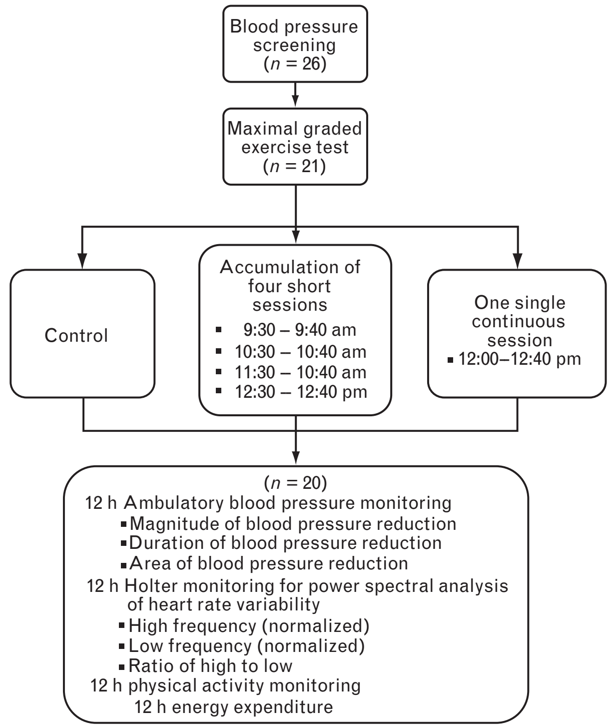
(by 12.9 mmHg for 8 h). The results of that study were noteworthy for the treatment of both prehypertension and hypertension. However, the limitations of that field study were that: the participants accumulated 4–6 h of lifestyle physical activity, which is well beyond the recommendations [1,2]; the types of lifestyle physical activity were not controlled, which made it difficult to interpret the specific activity accounting for the blood pressure reduction; the post-activity monitoring period was limited to only 6–8 waking hours, which may have affected the duration of the blood pressure reduction. Consequently, our next step was to take the field study into the laboratory for a more controlled investigation and to investigate possible mechanisms of the reduction in blood pressure.

A sustained reduction in blood pressure after a single bout of aerobic exercise has been defined as post-exercise hypotension [10,11]. The mechanisms of post-exercise hypotension are not fully understood at present; however, sympathetic modulation has been investigated [10,11]. The term 'sympathetic modulation' describes changes in the balance between sympathetic and parasympathetic influences, or the sympathovagal balance [12]. The autonomic mechanisms of post-exercise hypotension during the activities of daily living have not been investigated.

The purposes of this study were to compare the magnitude and duration of the reduction in blood pressure after the accumulation of physical activity with that observed after a single session of continuous physical activity, and to observe the association between the reduction in blood pressure and the changes in sympathetic modulation after each physical activity treatment, in adults with prehypertension. We hypothesized that the magnitude and duration of the reduction in blood pressure after the accumulation of physical activity would not differ from that after a single session of continuous physical activity in adults with prehypertension, and that the reduction in blood pressure would be associated with the change in sympathetic modulation after each physical activity treatment (that is, an increase in parasympathetic tone and a decrease in sympathetic tone).

Fig. 1



Study design, including dependent variables and participants' progression through the study.

Methods

Study design

Figure 1 illustrates the randomized, crossover study design. The two physical activity sessions were separated by at least 7 days, to avoid a training effect [13,14]. The following variables were measured during the 12-h period after each treatment: blood pressure, using ambulatory blood pressure monitoring; heart rate variability, using Holter monitoring for sympathetic modulation; energy expenditure, using an accelerometer. The study was approved by the Bloomington Campus Committee for the Protection of Human Subjects at Indiana University. Each participant gave informed consent before participating in the study. The study was carried out through the Clinical Exercise Physiology Laboratory in the Department of Kinesiology at Indiana University.

Study participants

Adults with prehypertension were recruited for this study. Inclusion criteria consisted of a mean screening blood pressure of 120–139 mmHg systolic or 80–89 mmHg diastolic, or both. Exclusion criteria included significant cardiovascular disease, significant dysrhythmia, brachial artery bruits, cardiac or renal transplant, or medications such as antiarrhythmic drugs or low-dose muscarinic receptor blockers, including atropine and scopolamine, which affect the heart rate variability [15]. Clearance by the participant's primary physician was required before they took part in the study.

The number of individuals studied was estimated on the basis of power analysis (power: >0.80; effect size using partial η^2: > 0.41) [16], using the previous study for blood pressure with a similar study design [9] testing a physical activity treatment in adults with prehypertension.

Blood pressure screening

Three blood pressure measurements were taken on two separate days, 3 days apart (a total of six measurements), using a mercury sphygmomanometer and an appropriately sized cuff with the individual in the seated position [9,13,14]. Each participant was seated for at least 5 min in a chair, feet on the floor, and arm supported at the level of the heart [1]. The participant was asked to avoid caffeine, exercise, and smoking for at least 30 min before the measurements were made [1]. On the first day, blood pressure was taken in both arms, to detect possible differences attributable to peripheral vascular disease [9,13,14]. The arm with the highest blood pressure was used for the screening [17].

Maximal graded exercise test

The purpose of the maximal graded exercise test was to measure physical work capacity, to ensure the intensity of the physical activity sessions. Before the test, fasting blood was withdrawn and a standard resting 12-lead electrocardiogram (ECG) was recorded, to establish risk for the graded exercise test. The test was performed on a motor-driven treadmill at a speed between 4 and 6.4 km/h (2.5 and 4.0 miles/h). The speed remained constant throughout the test and the grade increased by 1.0% every 1 min until a maximal voluntary effort was achieved. Blood pressure (by auscultation) and heart rate (by ECG) were measured every 1 min. The ECG was monitored continuously. Expired gases were measured online breath-by-breath using a 2900 Metabolic Measurement Cart (SensorMedics, Corp., Yorba Linda, California, USA). Peak oxygen uptake (VO_{2peak}) was defined as the greatest oxygen uptake (VO_2) obtained from the maximal exercise test.

Treatments

The treatments included the accumulation of four short sessions of physical activity over a 4-h period, a single session of continuous physical activity, and a control. The mode of physical activity was walking on a motorized treadmill and the intensity of physical activity was 50% VO_{2peak}. VO_2 was measured during minutes 2–4 of each session, to confirm the intensity of the physical activity. If the VO_2 were not within $\pm$ 10% of the target VO_2, the work rate was adjusted and VO_2 was measured during minutes 6–8 of the next work interval, to confirm the new intensity of physical activity. Heart rate (ECG) and blood pressure (auscultation) were measured throughout the physical activity treatments. We attempted to end all three treatments at the same time of day.

Single continuous physical activity treatment

The single continuous 40 min of physical activity began between 1130 and 1230 h.

Accumulated physical activity treatment

The duration of each short session of physical activity was 10 min; the first began between 0900 and 0930 h, the second between 1000 and 1030 h, the third between 1100 and 1130 h, and the last between 1200 and 1230 h.

Control treatment

For the control treatment, the participant reported to the laboratory between 1200 and 1230 h, approximately 15 min before the time at which the monitors would have been activated for the physical activity treatments. Control data were collected for the same 12-h time period as the other two treatments [9,13].

Ambulatory blood pressure monitoring

The Accutracker II (Suntech Medical Instruments, Inc., Raleigh, North Carolina, USA), validated in accordance with the standards of the British Hypertension Society and the American Association for Medical Instrumentation [18], was used for all ambulatory measurements. The sampling interval was 15 $\pm$ 5 min for a 12-h period after the treatments (1300–0100 h). One repeat measurement was taken if the first measurement was unsuccessful. The monitor was programmed to take no readings after the 12-h collection period. The cuff inflation for each measurement was 30 mmHg greater than the previous reading, and the cuff deflation was set at 3 mmHg/s [1].

Ambulatory blood pressure data were reviewed manually for missing and erroneous readings, as described previously [9,13,14]. Readings were purged if data were missing, SBP was lower than diastolic blood pressure (DBP), SBP was > 240 mmHg or < 50 mmHg, DBP was > 140 mmHg or < 40 mmHg, heart rate was > 150 beats/min or < 40 beats/min, or SBP, DBP and heart rate deviated by $\pm$ 50 mmHg, $\pm$ 20 mmHg and 30 beats/min, respectively, from surrounding values. The numbers of recordings taken and edited were reported.

Ambulatory blood pressure data were averaged each hour for the 12-h period after each treatment. The duration of the reduction in blood pressure was determined by calculating the cumulative sum of the reduction for each hour, as reported previously [9]. The cumulative sum of blood pressure reductions was then plotted for each hour with the 95% confidence limits for the initial slope. The duration of the reduction in blood pressure was considered to be the time period in which the reduction remained within the 95% confidence limits of the regression. Once the duration was determined, the magnitude of the reduction in blood pressure was averaged over the duration of the reduction found for each activity treatment, and was compared with the respective periods from the control treatment [9].

To compare the efficacy of the accumulated and the continuous physical activity treatments, we used the 'areas of the blood pressure reduction curve'. These were defined as the area between the physical activity and control blood pressure curves for the duration of the reduction in blood pressure [9,13]. The area between the blood pressure curve and the time axis (x axis) was calculated by summing the area of successive trapezoids, corresponding to each blood pressure reading. The total area below the physical activity treatment curve was subtracted from the total area under the control curve to obtain the area between the curves.

Holter monitoring

The Aria Digital Recorder (Del Mar Reynolds Medical, Inc., Irvine, California, USA) was used to observe sympathetic modulation through heart rate variability. The ECG data were collected for the 12-h period after each treatment. The data from the Aria Digital Recorder were scanned on a computer-assisted Holter system (Impresario, Solo Holter analysis software, Del Mar Reynolds Medical, Inc.) for variables of heart rate variability. Manual editing of the R–R interval data was performed to ensure correct identification and classification of every QRS complex [15]. Artifact and ectopic beats were removed for the R–R interval calculation. The data were then used for power spectral analysis of heart rate variability.

Frequency-domain measures of heart rate variability were assessed using the fast Fourier transform. The total power was calculated by the standard deviation of the R–R interval (< 0.1 Hz). Heart rate variability of the total nominal 12-h record was computed using the entire range of high-frequency power (0.15–0.40 Hz), low-frequency power (0.04–0.15 Hz), and very-low-frequency (0.003–0.04 Hz) power. Normalized values (expressed as %) were calculated for low-frequency power and high-frequency power. 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 to high-frequency was also determined.

Heart rate variability data were averaged each hour for the 12-h period after all the treatments. The duration (h) of the reduction in blood pressure for each blood pressure variable was then utilized for the duration of each heart rate variability variable. For example, if the duration of the reduction in SBP was 7 h, the heart rate variability data were averaged for the same 7 h. The change in heart rate variability was calculated as the difference between the control and physical activity treatments. The change in variables of heart rate variability was used in the correlations with the reduction in blood pressure.

Accelerometer

Energy expenditure was measured to control statistically for variations in activities of daily living as a covariate if significant differences were found among the 12 h of monitoring after the three treatments. An RT3 (Stayhealthy, Inc., Monrovia, California, USA), three-dimensional (tri-axial) accelerometer was used for a 12-h collection period after all three treatments. The output from each accelerometer was reported, along with a composite three-dimensional signal called 'vector magnitude'. The software provides an estimation of activity and total energy expenditure based on age, height, weight and sex of the individual. The RT3 was programmed (using mode 3) to sample data every 1 s and to average data over a 1-min period. Energy expenditure was averaged for the 12-h period.

Preparation of study participants

The ambulatory blood pressure cuff was worn on the nondominant arm. Seven ECG electrodes (three for ambulatory blood pressure monitoring and four for Holter monitoring) were placed on the chest. The RT3 was firmly attached to a belt on the hip at the anterior axillary line of the dominant leg. Participants were asked to document the following: time of sleep, time at work, time of meals, and time and type of leisure physical activity. They were also asked to do the same for activities of daily living after all treatments. Instructions for the entire 12-h period included not to exercise, not to take a shower, not to use an electric blanket, not to operate a lawn mower, a vacuum cleaner or any equipment that causes vibration, to replace electrodes with new electrodes when electrodes became loose, and to relax and straighten out the arm during the recording interval.

Statistical analysis

Data are expressed as means ± standard error of the mean (SE). Statistical analyses were performed using descriptive statistics, paired t-tests and analysis of variance (ANOVA) for repeated measures. Descriptive statistics were performed on the variables of sex, age, body mass index (BMI), screening SBP and DBP, and $\dot{V}O_{2peak}$. A one-way ANOVA with repeated measures was used to test the differences in energy expenditure from the accelerometry for the activities of daily living after each treatment. Paired t-tests were used to test the difference in the magnitude of the reduction in blood pressure (mean blood pressure for the respective duration) between each physical activity and the control treatment, and to compare the area of the reduction in blood pressure between the two activity treatments. Pearson correlations were used to evaluate the contribution of confounding variables (such as amount of physical activity, age and BMI) on the magnitude of the reduction in blood pressure, and to investigate the association between the magnitude of the reduction in blood pressure and the change in sympathetic modulation. The level of significance was $P < 0.05$. The SPSS software (SPSS 13.0; SPSS Inc., Chicago, Illinois, USA) was used for all statistical analyses.

Results

Study participants

Twenty-six adults were screened for the study; five were found to be ineligible during the blood pressure screening process (four presented with normal blood pressure and one presented with hypertension). Twenty-one adults with prehypertension were eligible for participation in the study on the basis of the screening process. One participant did not complete the study because of time constraints. Twenty adults with prehypertension (15 men and five women) with a mean age of 47.2 ± 2.92 years completed the study. Participants had mean screening blood pressure $131.9 \pm 1.1/82.5 \pm 1.42$ mmHg, BMI 27.0 ± 1.2 kg/m^2, and VO_{2peak} 34.5 ± 1.64 ml/kg per min.

Physical activity stimulus

The 20 participants who completed the study performed a maximal voluntary effort on the exercise test as verified by reaching $107.7 \pm 1.3\%$ of predicted maximal heart rate. Each physical activity treatment was separated by 16.7 ± 2.3 days. The intensities of both activity treatments were similar (accumulation $= 51.9 \pm 0.6\%$ of VO_{2peak}; continuous $= 51.7 \pm 0.63\%$ of VO_{2peak}).

Energy expenditure after all three treatments

The energy expenditure was measured to determine the consistency of the activities of daily living during the 12-h monitoring period after each treatment session. No significant difference ($P = 0.894$) was found among the three treatment sessions: the energy expenditures for 12 h after the control, the accumulated physical activity, and the single sessions of continuous physical activity treatment were 351.1 ± 38.3, 348.5 ± 32.6 and 335.1 ± 36.3 kcal, respectively. Therefore, blood pressure data were not examined using energy expenditure as a covariate.

Blood pressure reduction

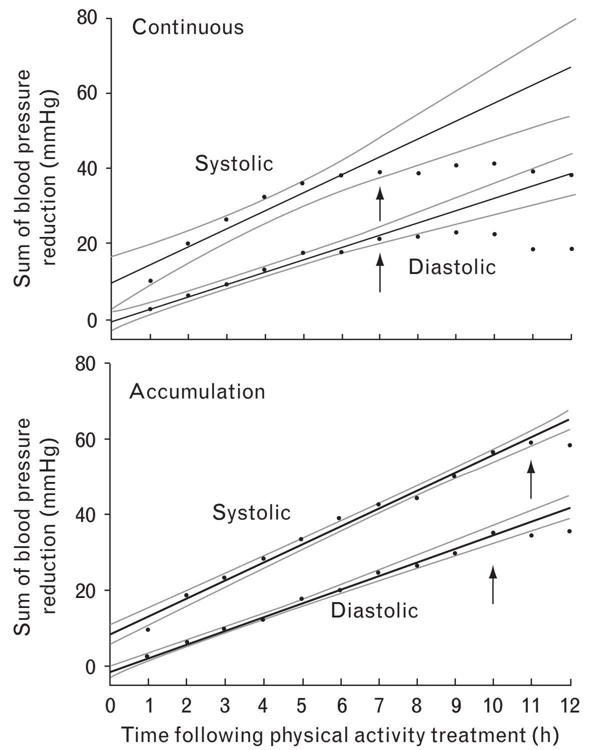
Ambulatory blood pressure monitoring data are summarized in Table 1. There was no significant difference in the number of blood pressure measurements and the percentage of blood pressure analyzed among the three ambulatory sessions. The cumulative sums of the hourly mean reductions in SBP and DBP for the accumulated physical activity and the single continuous physical activity were plotted to determine the duration of the reduction in blood pressure (Fig. 2). The durations of the reductions in SBP and DBP were both 7 h after the single continuous physical activity; however, those after the accumulated physical activity were 11 h and 10 h, respectively.

Table 1 Ambulatory blood pressure monitoring

	Control treatment	Accumulated physical activity	Single continuous physical activity
Starting time (h:min)	12:42 ± 0:05	12:48 ± 0:05	12:56 ± 0:04
BP measurements taken (*n*)	55.2 ± 1.3	52.4 ± 1.2	53.4 ± 1.1
BP analyzed (%)	93.8 ± 1.6	92.0 ± 2.3	91.6 ± 1.8

Values are expressed as mean ± SE. BP, blood pressure.

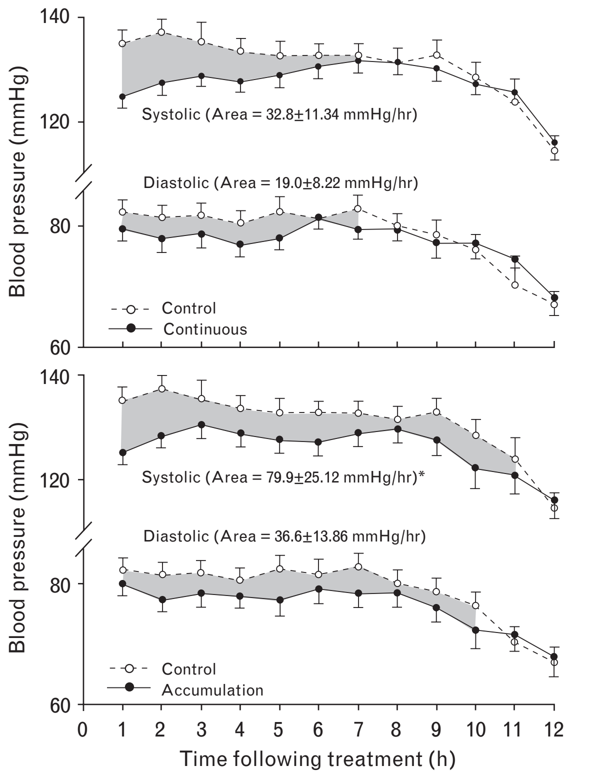
Fig. 2



Regression (solid line) and 95% confidence limits (dotted line) for the initial slope of the reduction in blood pressure after a single session of continuous physical activity (upper graph) and accumulated physical activity (lower graph) in adults with prehypertension. See text for the calculation used to determine the plot. The duration of the reduction in blood pressure (from time point ↑) was determined as the time at which the accumulated hourly blood pressure reduction was within the 95% confidence limits.

The hourly mean SBP and DBP after all three treatments and the area between the activity treatment and control blood pressure curves are illustrated in Fig. 3. After the single session of continuous physical activity, both the 7-h mean SBP and the 7-h mean DBP were significantly decreased compared with the blood pressure after the control treatment for the corresponding time periods (SBP by 5.6 ± 1.6 mmHg, $P = 0.002$; DBP by 3.1 ± 0.2 mmHg, $P = 0.020$). Similarly, after the accumulated physical activity, the 11-h mean SBP and 10-h mean DBP were also decreased compared with the blood pressures after the control treatment for the corresponding time periods (SBP by 5.4 ± 1.7 mmHg, $P = 0.005$; DBP by 3.4 ± 1.3 mmHg, P=0.022). In addition, the area of the reduction in SBP after the accumulated physical activity treatment was significantly greater ($P = 0.045$) than that after the single continuous physical activity treatment. No significant difference was found in the area of the reduction in DBP between the two activity treatments.

Fig. 3



Hourly systolic and diastolic blood pressures in adults with prehypertension. Upper graph: After the single session of continuous physical activity (●) and control treatment (○). Lower graph: After the accumulated physical activity (●) and control treatment (○).

Association between the magnitude of reduction in blood pressure and the change in sympathetic modulation

The hourly mean heart rate and variables of heart rate variability after all three treatments are illustrated in Fig. 4. The decrease in mean heart rate for the duration (7 h) associated with reductions in SBP and DBP after the single continuous physical activity session was 2.7 ± 1.4 beats/min; those for the duration of the reductions in SBP (11 h) and DBP (10 h) after the accumulated physical activity session were 1.4 ± 1.0 and 1.4 ± 1.0 beats/min, respectively. The change in mean heart rate was not significantly correlated with the magnitude of the reduction in SBP ($r = -0.210$ for continuous physical activity; $r = 0.187$ for the accumulated physical activity).

The association between the magnitude of the reduction in blood pressure and the change in sympathetic modulation measured by heart rate variability is illustrated in Figs 5 and 6. For the continuous physical activity (Fig. 5), the change in the low-frequency : high-frequency power ratio was significantly correlated only with the magnitude of DBP. For the accumulation of physical activity (Fig. 6), however, the change in normalized low frequency and high frequency between the control and the physical activity treatments was significantly correlated with the magnitude of the SBP, and the change in normalized low frequency, high frequency, and low-frequency : high-frequency power ratio was significantly correlated with the magnitude of the DBP.

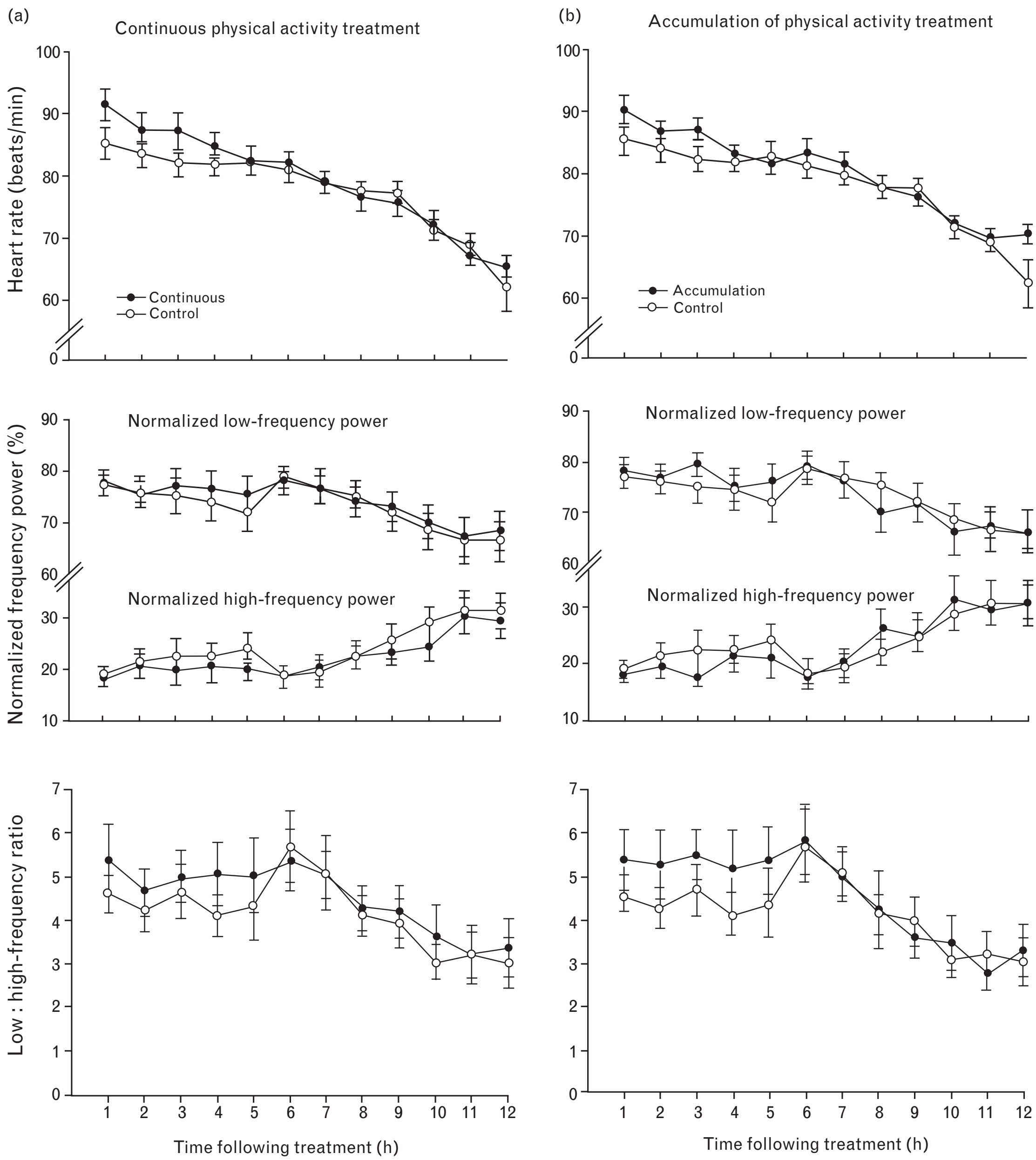
Discussion

This is the second study to investigate reduction in blood pressure as a primary outcome after accumulated physical activity in prehypertension [9]. In our study, unexpected, yet provocative, findings were obtained – mainly, a greater reduction in SBP after accumulated physical activity than after a single session of continuous physical activity in adults with prehypertension, and an association between the reduction in blood pressure and the change in sympathetic modulation (a decrease in sympathetic tone and an increase in parasympathetic tone), independent of confounding variables such as physical activity, age and BMI.

We expected the reduction in blood pressure to be similar for both activity treatments, according to the findings of previous studies of fractionization [19–22]. The term 'fractionization' [23] is used to describe comparison between a single continuous exercise or physical activity session and several short bouts of the exercise or physical activity. Fractionization has been utilized to observe variables of health and fitness, such as maximal oxygen uptake ($\dot{V}O_{2max}$) [19,21] and blood lipids [20,22]. Several short bouts of exercise were reported to be as effective as one continuous exercise with respect to these variables [19–22]. Although blood pressure is one of the major risk factors for coronary heart disease, it has not been the focus of the fractionization literature as a primary outcome.

Blood pressure has been observed as a secondary outcome in fractionized exercise training studies in which two or three short sessions were compared with one continuous exercise session [19,21]. Murphy and Hardman [21] randomly assigned 12 women to three 10-min walks, one 30-min walk at 70–80% of maximal heart rate, or a control group, for 10 weeks. Although the reduction in blood pressure observed in that study was not statistically significant, it exhibited trends similar to those in our study: the 3×10-min group reduced their SBP by 7.4 ± 7.3 mmHg, whereas the 1×30-min group reduced SBP by 4.6 ± 5.9 mmHg. In the earlier study [21], the reduction in blood pressure was not significant, which may be attributed to the study's lack of statistical power. Asikainen *et al.* [19] also investigated blood pressure reduction after 15 weeks of training,

Fig. 4

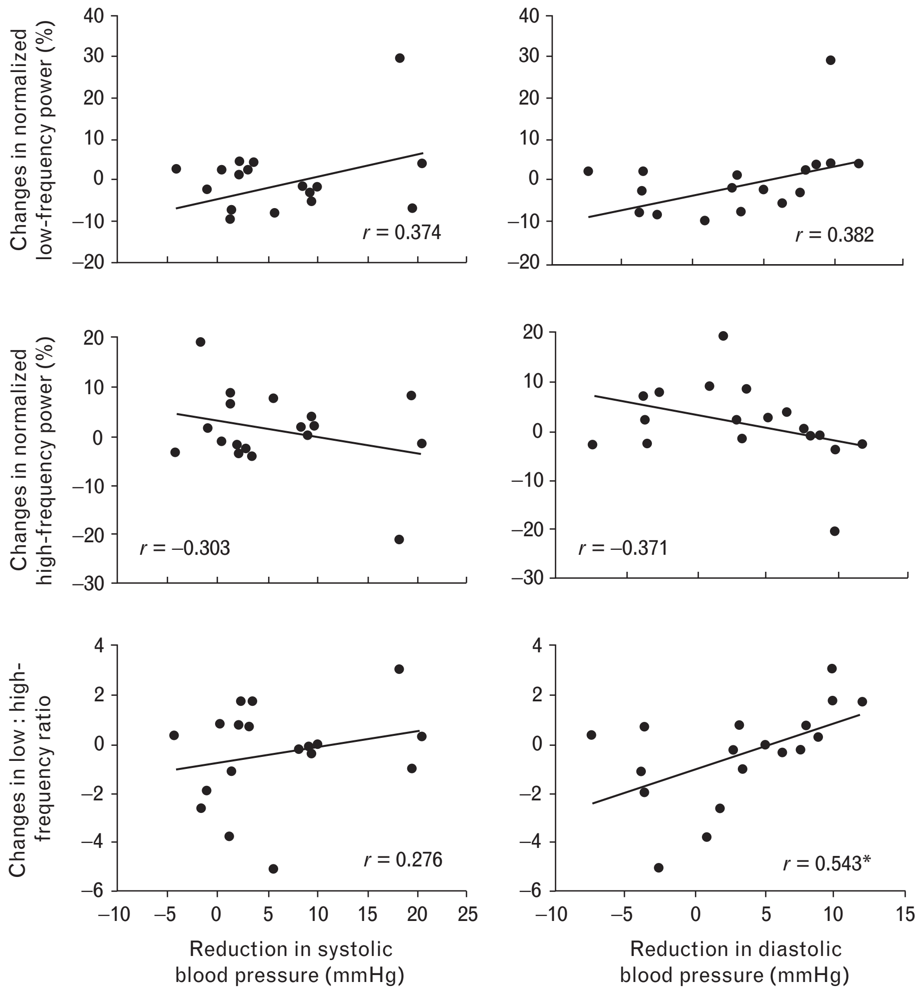


Hourly mean variables of heart rate variability in adults with prehypertension. (a) After the single session of continuous physical activity (●) and control treatment (○). (b) After the accumulated physical activity (●) and control treatment (○).

comparing two short bouts and one continuous bout of walking (65% of $\dot{V}O_{2max}$). They, similarly, found no significant reduction in blood pressure in either exercise group compared with the control group, but DBP was reduced (by 3.0 mmHg) when the exercise groups were combined. However, the individuals studied in both of these training investigations included normotensive and hypertensive persons, exhibiting a wide range of blood pressures. The inclusion of non-responding normotensive individuals may have confounded the results. Not only was blood pressure a primary outcome in our study; adults with prehypertension were the target population, thus optimizing our findings.

Chronic exercise is well known for its ability to restore impaired autonomic nervous system in various populations [15,24], including hypertension [25]. Sympathetic

Fig. 5

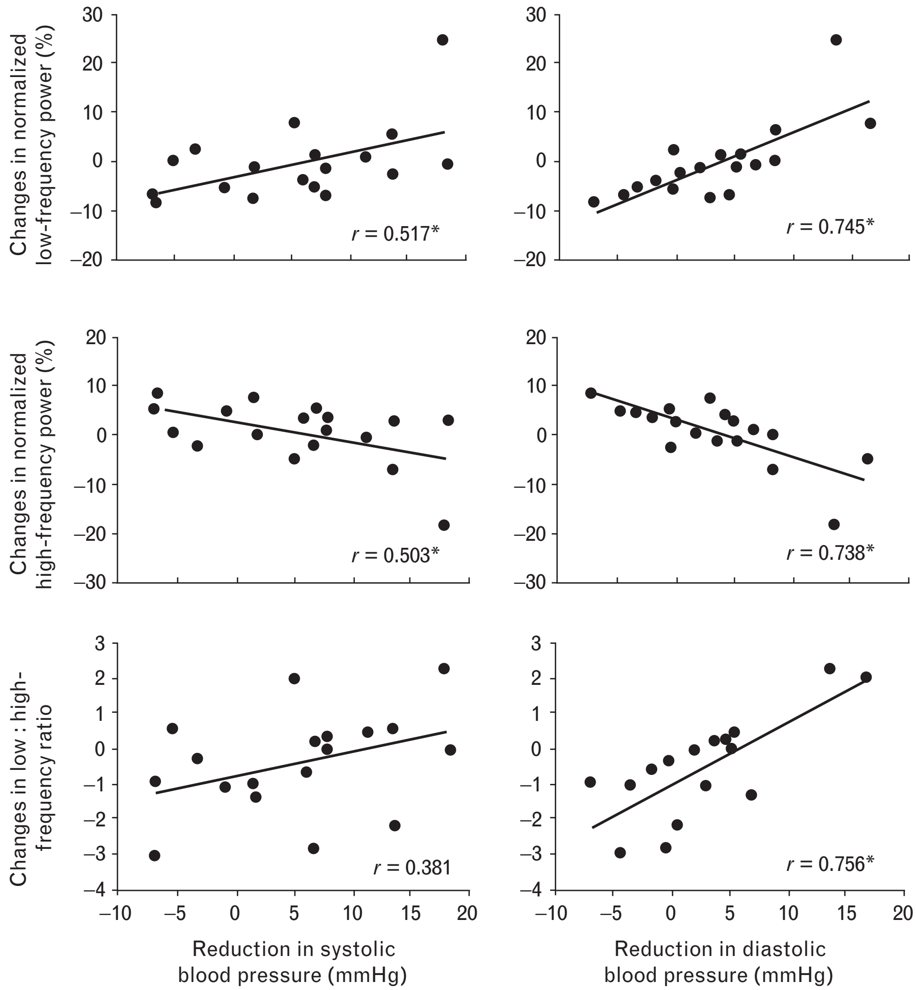


Association between the reduction in blood pressure and the change in sympathetic modulation after a single session of continuous physical activity. The change in sympathetic modulation was calculated as [(variables of heart rate variability from the control treatment) minus (variables of heart rate variability from a single continuous physical activity session)]. *Significant correlation ($P < 0.05$).

modulation has been examined only for a relatively short (15–180 min) period of time [26] after acute exercise. Recently, the changes in sympathetic modulation were observed several hours after cessation of acute submaximal exercise [27]. In addition, the reduction in blood pressure after acute exercise persists for up to 11–12 h in hypertension [2]. We also observed heart rate variability for 7–11 h, and found a significant association between the reduction in blood pressure and the change in sympathetic modulation. The involvement of the autonomic nervous system as a possible mechanism for the reduction in blood pressure after a single bout of exercise has been found in other studies [28–30].

In conclusion, the accumulation of physical activity led to a greater reduction in blood pressure than a single session of continuous physical activity in prehypertension. Results of our study indicate that as few as four 10-min walking sessions per day is effective in reducing blood pressure in prehypertension. A 5 mmHg reduction in SBP has been reported to reduce mortality substantially, and to give a 14% reduction in stroke and 9% reduction in coronary heart disease [1]. An immediate and favorable response associated with 1 day of physical activity may encourage the public to participate in physical activities in their daily routine. Several 10-min walking sessions might fit more easily into a daily routine than a single, long continuous session. For future studies, the chronic training effects of the accumulation of physical activity, in addition to adherence to physical activity, need to be investigated in prehypertension.

Fig. 6



Association between the reduction in blood pressure and the change in sympathetic modulation after the accumulation of physical activity. The change in sympathetic modulation was calculated as [(variables of heart rate variability from the control treatment) minus (variables of heart rate variability from the accumulation of physical activity)]. *Significant correlation ($P < 0.05$).

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