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Do snacks of exercise lower blood pressure? A randomised crossover trial

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Abstract

Aim To assess whether four 10-minute 'snacks' of exercise per day are as effective at lowering blood pressure as 40 minutes of continuous moderate exercise, when compared with no exercise.

Method Single blind randomised crossover trial of three 'exercise' regimes in general practice. Participants—35 hypertensive adults without complications. Interventions—regimes included 4×10-minute episodes of brisk walking per day, 40 minutes continuous brisk walking per day, and no brisk walking. Each regime lasted 4 days with 10 days of no exercise in between. Outcomes—change of systolic and diastolic blood pressure.

Results Mean age 53 years and mean baseline blood pressure 166/103 mmHg. Systolic blood pressure changed by: –7.5 mmHg (95%CI: –8.9, –6.0) with 40-minutes regime; –7.3 mmHg (95%CI: –8.7, –5.8) with 4×10-minutes regime; and +1.0 mmHg (95%CI: –0.4, 2.5) with 'no brisk walking' regime ($p<0.001$). Diastolic blood pressure reduced by –4.0 mmHg (95%CI: –5.0, –3.0) with 40 minutes regime; –5.4 mmHg (95%CI: –6.4, –4.4) with 4×10 minutes regime; and –0.2 mmHg (95%CI: –1.2, 0.8) with 'no brisk walking' regime ($p<0.001$).

Conclusion Four 10-minute snacks of brisk walking were as effective as 40 minutes of continuous brisk walking per day at reducing blood pressure. This has implications for public health messages and advice to patients with hypertension.

Evidence shows that moderate-intensity physical activity (such as walking) can help control blood pressure,[1–4] and that blood pressure reductions with exercise are greatest amongst those with hypertension.[5,6]

While 30 to 40 minutes of continuous moderate-intensity physical activity on several days per week is adequate to reduce blood pressure in the medium term, 10 minutes is inadequate.[7]

Additional evidence shows that cardiorespiratory fitness (VO_2 max) can improve as much with several short episodes as with one continuous episode of moderate exercise (when energy expenditure remains constant),[8] although to date the same has not been confirmed for change in blood pressure. Specifically, previous studies of normotensive adults have compared three episodes of 10 minutes against 30 minutes of continuous brisk walking per day but they were not able to demonstrate significant changes in blood pressure compared with a control.[9,10] In addition, further research into the effects of 'fractionisation' of exercise was recommended.[8]

Time is a major barrier for people achieving regular exercise for health benefit.[11] However, if regular moderate exercise could be achieved in 'snacks' throughout the

day, recommended levels of exercise for blood pressure and other health benefit may be more achievable, particularly for those people with pre-existing risk factors such as hypertension.

Our study aims to determine whether four 10-minute 'snacks' of exercise are as effective at reducing blood pressure in hypertensive participants as 40 minutes of continuous exercise per day (when compared with no exercise).

Methods

Design—A randomised crossover design was used within one primary healthcare practice with three general practitioners in Auckland, New Zealand. The Auckland Ethics Committee approved the study protocol and written informed consent was obtained from all participants.

Subjects—All adults with the diagnosis of hypertension were identified by the practice. Those fulfilling eligibility criteria and considered suitable for participation by their usual general practitioner, were invited to take part in the study.

Inclusion criteria consisted of a systolic blood pressure of at least 140 mmHg or diastolic blood pressure of at least 85 mmHg 10 days after withdrawal of any antihypertensive medication; and able to do 'no exercise' during the 10-day run-in period prior to the study.

Exclusion criteria consisted of a cardiovascular or unstable condition, progressive or debilitating medical condition, acutely unwell, physically active occupation, unable to understand English, or considered unsuitable by their general practitioner to participate in the study or withdraw temporarily from their antihypertensive medication.

Following the protocol used in a previous study,[7] participants were asked to reduce their antihypertensive medication under the supervision of their general practitioner so that they would be receiving no antihypertensive medication 10 days prior to the start of the study .The usual general practitioner was notified if the blood pressure exceeded 160 mmHg systolic or 95 mmHg diastolic during the run-in period and throughout the trial.

The recommendation to enrol or continue in the study in these circumstances was made by their general practitioner. Usual antihypertensive medication was recommenced after the 6-week study.

Study protocol—Following a 10-day period of no exercise, the participants were randomised if they complied with the no-exercise run-in protocol and fulfilled eligibility criteria. Eligible participants undertook three 'exercise' regimes in an order randomly determined using numbered opaque envelopes. Each sealed envelope was handed to the participant who was told not to disclose the order to the assessor. A different researcher undertook prior computer-randomisation and prepared the envelopes.

The intervention regimes included advice given by the researcher based in primary care to achieve 4 x 10-minute episodes of brisk walking per day, 40 minutes continuous brisk walking per day, and no brisk walking. Participants were encouraged to set a pace that made them 'puff' and increased their heart rate. Participants were also asked not to do any other exercise outside of the regimes and not to change their diet over the course of the study.

Primary outcome measures were change in systolic and diastolic blood pressure with each regime. A researcher who was blind to allocated random order carried out all measures. The usual general practitioners were also blind to allocation of randomisation.

A calibrated Speidal and Keller OSZ5 electronic sphygmomanometer was used to measure all baseline and follow-up pulses and blood pressures. On each occasion, these measures were taken after at least 5 minutes of sitting quietly. Three readings were taken and the average of the second and third readings was used for analysis, according to a previously used research protocol.[12]

Each regime lasted 4 days with 10 days of no exercise in between each regime. Blood pressure was measured before, and the day after, each regime—at least 12 hours after any exercise and at a similar time of day.

To provide an indication of intensity of exercise undertaken during the regimes, heart rates were recorded electronically immediately following a short 'brisk walk' and compared with resting heart rate after completion of the trial.

Sample size calculations—Twenty-five participants were required to detect a statistically significant difference in change of 7 mmHg systolic or diastolic blood pressure when comparing results of either exercise regime with those of control.

Achievable change in blood pressure following 4 days of 40-minutes of moderate intensity exercise was obtained from previous research.[7] The standard deviation of change in blood pressure with exercise (11 mmHg) was also obtained from previous research.[12]

Statistical analysis—The differences between blood pressure measurements before and after each exercise regime were compared for the three regimes using a generalised linear model in SPSS (version 11.5) statistical software. Differences between each pair of regimes were analysed using post-hoc Student-Newman-Keuls and Bonferroni tests that allowed for multiple comparisons. All participants were analysed according to randomisation sequence. Only those that completed the study were included in the analysis. A conservative intention to treat sensitivity analysis was also undertaken where no change in blood pressure was assumed for all regimes of randomised participants who did not complete the study.

Intensity of usual brisk walking was estimated using percent estimated maximum heart rate, equal to (exercise heart rate – resting heart rate)/(estimated maximum heart rate – resting heart rate)*100.[13]

Maximum heart rate was estimated using the formula (220-age) for males and (226-age) for females.[14] Percent heart rate reserve is closely numerically related to VO_2reserve and can be used to estimate intensity of exercise. It has been suggested that less than 25% represents very light activity; 25–44% is light activity; 45–59% is moderate activity; and 60–84% is hard activity.[13]

Results

Figure 1 shows the recruitment process. Of the 165 patients that were potentially eligible to participate in the study, 105 patients declined involvement or did not adhere to the 10-day run-in protocol of no exercise. A further 25 were excluded by the general practitioner because of medical exclusion criteria or concern about elevated blood pressure prior to enrolment. Thirty-five patients were randomised and 31 completed the study.

Table 1 shows the baseline characteristics of the participants by randomised initial regime and overall. Fifty-four percent (19/35) were female and 97% (34/35) were on antihypertensive medication prior to the study.

Table 1. Mean baseline characteristics of study participants by randomised initial regime and overall

Characteristic	40 minutes first (SD*) [N=12]	4×10 minutes first (SD*) [N=11]	No exercise first (SD*) [N=12]	Overall (SD*) [N=35]
Age in years	56 (12)	51 (14)	52 (9)	53 (12)
Systolic blood pressure in mmHg	164 (13)	165 (12)	170 (14)	166 (13)
Diastolic blood pressure in mmHg	107 (11)	100 (8)	101 (5)	103 (8)
Body mass index in kg/m^2	27.7 (4.2)	27.5 (4.0)	27.6 (4.5)	27.6 (4.1)

* Standard deviation

Figure 1. Process of recruitment, randomisation and follow-up of the trial

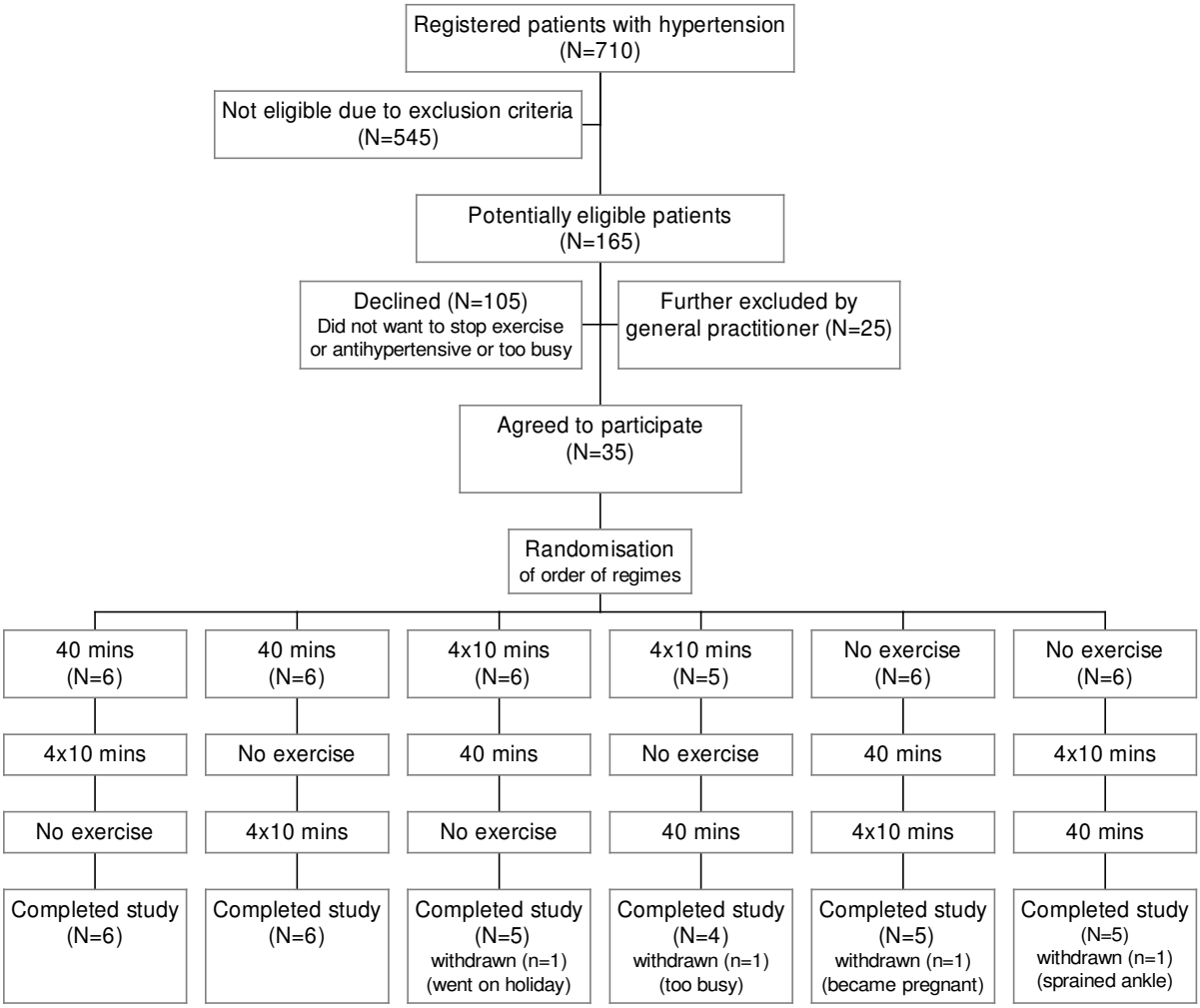

Table 2. Mean blood pressure and pulse at enrolment baseline and before and after each regime (N=31)

Variable	Systolic blood pressure mmHg (SD*)	Diastolic blood pressure mmHg (SD*)	Heart rate beats/min (SD*)
Baseline	165.7 (13.4)	103.0 (8.2)	77.6 (7.2)
Before 40 min regime	166.0 (13.4)	102.6 (8.2)	78.2 (7.3)
After 40 min regime	158.6 (13.1)	98.6 (8.2)	74.8 (8.2)
Before 4×10min regime	165.7 (13.2)	102.0 (8.6)	77.3 (6.9)
After 4×10min regime	158.4 (13.2)	96.6 (8.9)	76.6 (7.4)
Before 'rest'[#] regime	165.3 (13.5)	102.6 (7.7)	77.4 (7.8)
After 'rest'[#] regime	166.4 (14.0)	102.4 (7.6)	78.0 (8.1)
Immediate post-exercise	176.2 (11.9)	102.8 (7.5)	100.6 (8.5)

* Standard deviation; [#] 'rest' regime refers to the 4 days of no exercise.

Table 2 shows mean heart rate and blood pressures at enrolment, prior to and following each regime, and immediately post-exercise. Blood pressure returned to baseline levels between regimes after 10 days of no exercise.

Table 3 shows the changes in systolic and diastolic blood pressure with each regime. There was a significant difference between the three regimes in change of systolic blood pressure ($p<0.001$) and change in diastolic blood pressure ($p<0.001$).

Table 3. Changes in systolic and diastolic blood pressure for three daily exercise regimes

Outcome	Change in blood pressure with each walking regime		
	40 minutes: Mean (95%CI*) [N=31]	**4×10 minutes:** Mean (95%CI*) [N=31]	**No exercise:** Mean (95%CI*) [N=31]
Systolic blood pressure in mmHg	–7.5 (–8.9, –6.0)	–7.3 –8.7, –5.8)	+1.0 (–0.4, 2.5)
Diastolic blood pressure in mmHg	–4.0 (–5.0, –3.0)	–5.4 (–6.4, –4.4)	–0.2 (–1.2, 0.8)

* Confidence interval.

A Student-Newman-Keuls post-hoc test showed that there was no significant difference between the effect of 40 and 4×10 minutes of exercise on systolic blood pressure ($p=0.9$) although diastolic blood pressure dropped significantly more in the 4×10 minutes regime than in the 40-minute regime ($p<0.05$).

Both exercise regimes produced significantly greater drops in systolic and diastolic blood pressure than with 'no exercise' ($p<0.05$). Mean intensity of brisk walking was estimated to be light to moderate. Mean heart rate following exercise was 68% (standard deviation 6.0) of maximum heart rate. Mean percent heart rate reserve was 41% (standard deviation 9.4).

Apart from one participant who sprained her ankle just prior to commencing the first regime, there were no other reports of adverse events during the study period or during the 2 months subsequent to the study.

Table 4 shows a conservative Bonferonni analysis comparing each pair of regimes to produce incremental estimates. Table 4 also includes an intention to treat sensitivity analysis, where no change in blood pressure was assumed for all regimes of the four who did not complete the study. Significant differences between the groups ($p<0.001$) were found but with lower estimated incremental change.

Table 4. Bonferonni analysis of incremental effect on blood pressure of different exercise regimes, including sensitivity analysis[#]

Systolic blood pressure mmHg	Per protocol analysis Mean (95% CI*) [N=31]	Sensitivity analysis Mean (95% CI*) [N=35]
40 minutes vs No exercise	–8.5 (–11.1, –6.0)	–7.5 (–10.0, –5.1)
4×10 minutes vs No exercise	–8.3 (–10.9, –5.6)	–7.4 (–9.8, –4.9)
40 minutes vs 4 x 10 minutes	–0.2 (–2.8, 2.4)	–0.2 (–2.6, 2.3)
Diastolic blood pressure mmHg		
40 minutes vs No exercise	–3.8 (–5.5, –2.1)	–3.4 (–4.9, –1.8)
4×10 minutes vs No exercise	–5.2 (–6.9, –3.5)	–4.0 (–6.2, –3.0)
40 minutes vs 4×10 minutes	1.4 (–0.3, 3.1)	1.2 (–0.3, 2.8)

* Confidence interval; [#] An intention to treat analysis, where no change in blood pressure was assumed for missing data.

Discussion

This study has demonstrated that four 10-minute snacks of brisk walking are as effective as 40 minutes of continuous brisk walking per day at reducing blood pressure in the short term when compared with no exercise amongst adults with hypertension. This has implications for advice to patients with hypertension and public health messages.

The intervals between the 10-minute episodes of brisk walking were not known, nor were the rates of adherence with the respective protocols. Despite this, significant blood pressure reductions were found in both exercise regimes compared with no exercise. The intensity of exercise was estimated from immediate post-exercise pulse, rather than heart rate monitoring during exercise, which may have underestimated the intensity.[13] However, the walking pace achieved in this study represented that which the participants considered 'brisk' and was manageable during their every-day lives, which enhances generalisability of results to a real-life setting.

Many hypertensive participants did not participate because they did not want to do 'no exercise' for most of the 6-week study period. Others did not want to stop their medication temporarily, were too busy to participate, or were considered unsuitable by their general practitioner. The resulting low rate of participation may limit external validity of results. However, this is an efficacy trial and there is no obvious reason to believe results would have been different for those who declined participation.

The randomised crossover design used in the study was appropriate, and an unbiased assessment was ensured by blind evaluation of blood pressure and the use of electronic sphygmomanometers. A conservative intention to treat analysis did not change results overall, and 'snacks' and 'continuous' exercise lowered systolic and diastolic blood pressures by similar amounts.

The time course of this study was appropriate and adequate to demonstrate clinically significant reductions in blood pressure and has been used previously.[7] It is not clear whether these blood pressure reductions are acute or chronic effects of exercise. Previous studies of single episode light or moderate exercise amongst hypertensive subjects have recorded acute reductions of blood pressure that can last between 12

and 22 hours.[15,16] Whether acute or chronic response, regular moderate intensity walking is likely to be useful in blood pressure management of hypertensive patients.

Blood pressure reductions that last beyond the acute phase can be achieved after as few as three exercise sessions and disappear within 1–2 weeks of no exercise.[3] This is consistent with findings from the present study, which showed that baseline blood pressures were regained 10-days after each exercise regime.

Reduction of blood pressure was achieved with light to moderate intensity exercise, which is consistent with previous research where energy expenditures as low as 40% maximum capacity have reduced blood pressure both acutely and in the medium term.[3,5] Indeed, there is some suggestion that light to moderate exercise (35%–79% maximum heart rate) may be more effective at lowering blood pressure than high intensity exercise.[6]

Health practitioners may feel more comfortable advising short episodes of light to moderate exercise to hypertensive patients, as these patients are likely to be at higher risk of cardiovascular events during vigorous exercise.[6] Lighter intensity exercise is also associated with fewer musculoskeletal adverse effects. In addition, shorter episodes of lighter exercise may be more achievable and sustainable by patients than longer or more vigorous exercise.

The magnitude of blood pressure reductions with moderate exercise was also consistent with previous studies.[6,7,10] If snacks of exercise could be achieved on a regular basis and if the resulting blood pressure reduction of 8.3/5.2 mmHg could be sustained, an individual's cardiovascular risk would be reduced markedly, and the potential population effect would be significant if the message was delivered effectively.

In a review of nine major observational studies including 420,000 individuals with baseline diastolic blood pressures of between 70 and 110 mmHg, a reduction of 5 mmHg diastolic blood pressure was associated with reductions of 34% in the incidence of stroke and 21% in the incidence of coronary heart disease.[17]

Adding physical activity to the treatment regime of hypertensive patients may also reduce the costs and adverse effects of anti-hypertensive medications as well as improving quality of life of patients.[6] There is evidence that 10-minute episodes of brisk walking are adequate to improve psychological wellbeing.[9]

The trend of greater reductions in diastolic blood pressure with short episodes of exercise than with long continuous episodes is interesting and not inconsistent with previous findings, although we do not know the regime adherence rates. Greater increases in VO_2 max were achieved with 3×10 minutes compared with 30 minutes of brisk walking several times per week in a previous crossover trial.[9]

The implication for clinicians and public health advisers is that four 10-minute 'snacks' of moderate exercise daily are sufficient to lower blood pressure at least in the short term. The positive results from this study may encourage otherwise inactive individuals (who cannot do 40 minutes of continuous activity) to increase their physical activity and hence reduce their blood pressure with resulting health gains.

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