CLINICAL RESEARCH

Is exercise good for high blood pressure?

R G WILCOX, T BENNETT, A M BROWN, I A MACDONALD

Abstract

Ten men with uncomplicated essential hypertension (mean standing blood pressure 165/109 mm Hg) and 10 normal controls matched for age and weight were studied for the hypotensive potential of moderate exercise. Tests were conducted on a treadmill set to induce a steady heart rate of 120 beats/min and performed over five 10-minute periods separated by three minutes' rest and finishing with 30 minutes' sitting quietly in a chair.

During exercise the mean systolic pressures were identical in the hypertensive patients and controls (175 ± SEM 5 mm Hg), the controls therefore sustaining an appreciably greater increase in pressure. During the 30-minute rest period after the tests both the control and hypertensive groups showed a significant and sustained fall in absolute systolic pressures as compared with pre-exercise values ($p < 0.001$), the mean percentage reductions being 22% and 25% respectively.

If a fall in blood pressure after exercise is maintained for four to 10 hours, then a "good walk" twice a day might be reasonable treatment for mild hypertension. Studies are continuing to determine the amount of exercise needed and the duration for which the reduction in blood pressure is maintained.

Introduction

In epidemiological studies increasing systolic and diastolic blood pressures correlate with increasing cardiovascular morbidity and mortality at all ages and in both sexes.[1] While controlled clinical trials may be deficient with regard to patient selection in respect of age and sex distribution, they have shown that benefit accrues from the pharmacological reduction of very high blood pressure.[2] For persons with more modestly raised blood pressure, however, the absolute need for blood-pressure reduction is not entirely clear, despite recent trials.[3 4] Furthermore, the economic consequences and biological uncertainties of long-term pharmacological treatment of such persons urge that alternative treatments should be examined. These have included salt restriction, weight reduction, and behavioural methods.[5] One other possibility that so far has received scant attention is the hypotensive potential of moderate exercise.

In a prospective study (not strictly controlled) twice-weekly walking and jogging exercise of 30-35 minutes for one year effected a mean fall in blood pressure of 13/12 mm Hg in a group of hypertensive men, compared with a fall of 0/6 mm Hg in a normotensive control group.[6] A more recent, personal anecdote suggested that repetitive moderate exercise of short duration resulted in a reduction in pressure which lasted between four and 10 hours after each session.[7]

During a study of the metabolic changes induced by intermittent low-level exercise in hypertensive men treated with beta-adrenoceptor antagonists we observed profound falls in blood pressure throughout the rest periods after exercise. We therefore exercised a matched group of untreated normotensive male volunteers and report here the comparison between them and the placebo-treated hypertensive patients. Analysis of the metabolic changes in the hypertensive patients treated with beta-adrenoceptor antagonists will be reported later.

Patients and methods

Ten men with sustained mild uncomplicated essential hypertension (standing diastolic pressure between 100 and 125 mm Hg, phase 5) and 10 male volunteers matched for age and weight (recruited from friends and hospital staff) took part in the study. Only two of the hypertensive men had been treated for hypertension, and in these treatment was discontinued at least eight weeks before the study. None of the volunteers had any known past or current medical problems and none was taking any drugs.

All the exercise tests were carried out in a temperature-controlled laboratory (18°C) after fasting for eight to 12 hours. After being weighed each subject lay supine and a venous cannula was inserted into the left antecubital vein and kept patent by a slow infusion of

Medical School, Queen's Medical Centre, Nottingham NG7 2UH
R G WILCOX, MRCP, lecturer in medicine
T BENNETT, PHD, reader in physiology and pharmacology
A M BROWN, PHD, lecturer in physiology and pharmacology
I A MACDONALD, PHD, lecturer in physiology and pharmacology

isotonic saline (mean total volume infused 40 ml). Ten and 20 minutes later venous blood was withdrawn for biochemical analysis and the blood pressure measured in the other arm with a Hawksley random-zero sphygmomanometer. The subjects then stood for five minutes on a treadmill before beginning the exercise test; heart rate and a single-lead electrocardiogram were recorded and displayed continuously from chest electrodes.

The exercise protocol comprised walking on the treadmill set at a slope of 10% for five 10-minute periods separated by rest periods of three minutes sitting on a chair. Treadmill speed was determined previously as that required to induce a steady heart rate of about 120 beats/min, a level of exercise which we confirmed to be aerobic by intermittent venous blood lactate measurements and respiratory gas analysis. After the last exercise period the subjects sat quietly for 30 minutes. At regular intervals during exercise venous blood was withdrawn (mean total volume removed 220 ml), timed samples of expired gases analysed, and heart rate and blood pressure measured by sphygmomanometry. Blood pressure was measured and heart rate recorded regularly during the 30-minute rest period and, finally, after standing for one minute.

Expired respiratory gases were analysed using a Morgan 901 mark 2 carbon dioxide meter and a Servomex type OA 137 oxygen meter. Volume was measured with a Parkinson-Cowan industrial gas meter and corrected to standard temperature and pressure, dry. Whole blood lactate concentrations were determined fluorometrically[8] and plasma catecholamine values measured using high performance liquid chromatography with electrochemical detection.[9]

The study was approved by the hospital ethical committee. Statistical analysis was by paired and unpaired Student's t tests, as appropriate.

Results

The hypertensive patients and controls differed significantly in resting blood pressure ($p<0.001$; unpaired t test) but were otherwise similar (table I). As judged by oxygen consumption and lactate and catecholamine concentrations the two groups sustained a similar and constant level of exercise over the whole period of the experiment, with no statistically significant differences between any of the measured variables (table II). Mean treadmill speed was 2·5 mph (range 2·2-2·8) for the hypertensive group and 2·4 mph (range 2·2-2·7) for the control group. The mean intravascular fluid loss was 180 ml and the mean net weight loss 350 g for both groups.

There was no significant difference between the groups in resting, exercise, or post-exercise heart rates (figure). In both groups, however, the mean heart rates after exercise remained about 5-10 beats/min faster than before.

Though resting blood pressures were significantly different between the control and hypertensive groups, the mean systolic pressures during exercise were the same (175 ± SEM 5 mm Hg; figure). Thus both the absolute and percentage increases in mean systolic pressure in the control group (35 mm Hg; 25% of resting value) were larger than in the hypertensive group (10 mm Hg; 6% of resting value).

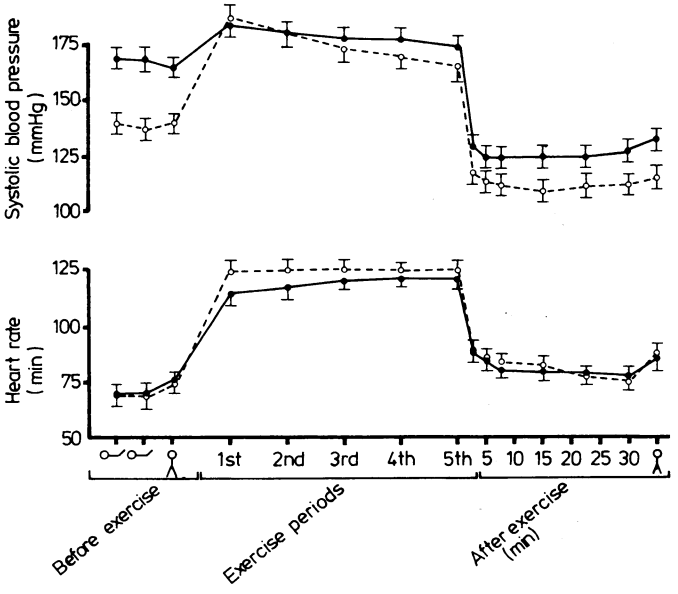
TABLE I—*Clinical details of hypertensive patients and controls*

		Hypertensives (n = 10)	Controls (n = 10)
Mean age in years (range)		50 (31-65)	46 (37-58)
Mean weight in kg (SE)		81·4 (3·7)	82·6 (2·5)
Mean pre-exercise heart rate/min ± SEM	Supine	70 ± 2	69 ± 4
	Standing	75 ± 4	74 ± 3
Mean pre-exercise blood pressure (mm Hg) ± SEM	Supine	168 ± 4/105 ± 2	137 ± 5/83 ± 2
	Standing	165 ± 3/109 ± 1	140 ± 4/90 ± 2

TABLE II—*Measured variables of exercise intensity in hypertensive patients and controls. Results are means ± SEM*

		Hypertensives	Controls
Oxygen consumption (ml/kg/min)		18·5 ± 0·9	19·7 ± 0·8
Lactate (μmol/l)	Before exercise	618 ± 51	748 ± 57 (n = 9)
	Fifth exercise	797 ± 58	806 ± 66 (n = 8)
Noradrenaline (nmol/l)	Before exercise, supine	2·36 ± 0·32	2·60 ± 0·38 (n = 9)
	Before exercise, standing	4·31 ± 0·53	4·12 ± 0·54 (n = 9)
	Fifth exercise	5·03 ± 0·37	5·53 ± 0·49 (n = 8)
Adrenaline (nmol/l)	Before exercise, supine	0·62 ± 0·14	0·36 ± 0·07 (n = 9)
	Before exercise, standing	0·89 ± 0·35	0·66 ± 0·10 (n = 9)
	Fifth exercise	1·18 ± 0·14	0·87 ± 0·19 (n = 8)

Conversion: SI to traditional units—Lactate: 1 μmol/l ≈ 0·009 mg/100 ml. Noradrenaline: 1 nmol/l ≈ 0·17 ng/ml. Adrenaline: 1 nmol/l ≈ 0·18 ng/ml.



Changes in heart rate and systolic blood pressure before, during, and after five exercise periods in patients and controls (n = 10 in each group; results are means ± SEM). ●——● Hypertensive patients. ○- - -○ Volunteer controls.

During the rest period after exercise there was a significant and sustained fall in systolic pressures in both groups compared with pre-exercise values (mean control pre-exercise value 140 ± SEM 4 mm Hg, resting 110 ± 5 mm Hg; mean hypertensive pre-exercise value 165 ± 3 mm Hg, resting 125 ± 4 mm Hg; $p<0.001$, paired t tests). Most of the fall in systolic pressure after exercising occurred during the first two to five minutes of rest (figure). Although the absolute post-exercise systolic pressure was lower in the controls than in the hypertensive group, the mean percentage reductions compared with pre-exercise values were similar (−22% and −25%, respectively).

Diastolic blood pressures were also significantly lower in both groups during the post-exericse period than before exercise, mean values ranging from 83 to 87 mm Hg in the hypertensive group and from 71 to 73 mm Hg in the controls ($p<0.001$; paired t tests). During the recovery period all the hypertensive patients had a diastolic pressure consistently below 100 mm Hg, and in nine the pressure remained below 95 mm Hg. On standing, diastolic pressure increased above 100 mm Hg in four of the hypertensive patients (range 100-110 mm Hg) but remained in the range 86-96 mm Hg in the remaining six.

The reduction in blood pressure after exercise did not correlate with either the pre-exercise pressures or the reduction in body weight. Nor did it depend on the small change in intravascular volume, for the same observations were made in two subjects from whom a complete set of blood samples could not be obtained.

Discussion

We have confirmed, in part, the anecdotal observation of Fitzgerald[7] that a period of moderate aerobic exercise may result in a significant reduction in post-exercise blood pressure. This is not comparable to hypotension seen in subjects exercised to exhaustion.

During dynamic exercise there is a profound vasodilatation in the working skeletal muscle with a concurrent reduction of

perfusion in other vascular beds.[10] Cutaneous vasodilatation will occur, however, when central body temperature rises. Venous return is augmented by the pumping action of the exercising muscles and by the increased abdominothoracic movements of hyperpnoea. During the post-exercise period, however, venous return falls dramatically owing to the discontinuance of mechanical pumping effects, while skeletal-muscle and cutaneous vasodilatation persists. Hence a fall in systemic arterial systolic and diastolic blood pressures is not surprising.

Our findings of particular interest, however, were that blood pressures increased less during exercise and showed a greater fall after exercise in the hypertensive patients than in the controls. The greater fall in blood pressure after exercise might be explained by greater vasodilatation owing to the higher plasma adrenaline concentrations in the hypertensive patients. The mean plasma adrenaline concentrations in the two groups were not significantly different, however, and also there is evidence that raised plasma adrenaline concentrations may lead to hypertension.[11] We believe that our findings are entirely consistent with the observations of Mancia *et al* on the cardiovascular effects of carotid sinus suction.[12] They showed that hypertension is a more effective buffer against a rise in arterial pressure than it is against a fall in arterial pressure and that the opposite is true in normotensive subjects.

Studies are now in progress to determine the magnitude and duration of exercise needed to bring about the fall in blood pressure and the time for which the reduction is maintained. If, as Fitzgerald[7] found in himself, blood pressure remains lowered for between four and 10 hours then it may well be that a "good walk" twice daily would prove to be a reasonable alternative treatment for some patients with mild hypertension.

We thank Astra Pharmaceuticals Ltd, St Albans, UK, and AB Hässle, Molndal, Sweden, for financial support.

Requests for reprints should be addressed to: Dr R G Wilcox, Department of Medicine, Medical School, Queen's Medical Centre, Clifton Boulevard, Nottingham NG7 2UH.

References

1 Kannel WB, Gordon T, Schwartz MJ. Systolic versus diastolic blood pressure and risk of coronary heart disease. *Am J Cardiol* 1971;**27**: 335-40.

2 Veterans Administration Co-operative Study Group on Antihypertensive Agents. Effects of treatment on morbidity in hypertension. Results in patients with diastolic blood pressures averaging 115 through 129 mm Hg. *JAMA* 1967;**202**:116-22.

3 Hypertension Detection and Follow-up Program Co-operative Group. Five-year findings of the Hypertension Detection and Follow-up Program. I. Reduction in mortality of persons with high blood pressure, including mild hypertension. *JAMA* 1979;**242**:2562-71.

4 Australian Therapeutic Trial in Mild Hypertension. *Lancet* 1980;i:1261-7.

5 Shapiro AP, Schwartz GE, Redmond DP, Ferguson DCE, Weiss SM. Non-pharmacologic treatment of hypertension. *Ann NY Acad Sci* 1978;**304**:227-35.

6 Boyer JL, Kasch FW. Exercise therapy in hypertensive men. *JAMA* 1970;**211**:1668-71.

7 Fitzgerald W. Labile hypertension and jogging: new diagnostic tool or spurious discovery? *Br Med J* 1981;**282**:542-4.

8 Lloyd B, Burin J, Smythe P, Alberti KGMM. Enzymic fluorometric continuous-flow assays for blood glucose, lactate, pyruvate, alanine, glycerol and 3-hydroxy-butyrate. *Clin Chem* 1978;**24**:1724-9.

9 Green JH, Macdonald IA. The influence of intravenous glucose on body temperature. *Q J Exp Physiol* 1981;**66**:465-73.

10 Rowell LB. Human cardiovascular adjustments to exercise and thermal stress. *Physiol Rev* 1974;**54**:75-159.

11 Brown MJ, Macquin I. Is adrenaline the cause of essential hypertension? *Lancet* 1981;ii:1079-82.

12 Mancia G, Ferrari A, Gregorini L, *et al*. Control of blood pressure by carotid sinus baroreceptors in human beings. *Am J Cardiol* 1979;**44**: 895-902.

(*Accepted 6 July 1982*)

Reversal of aplastic anaemia secondary to systemic lupus erythematosus by high-dose intravenous cyclophosphamide

M J WALPORT, W N HUBBARD, G R V HUGHES

Abstract

Aplastic anaemia is rare as a primary feature of systemic lupus erythematosus and is more commonly a complication of treatment with cytotoxic drugs. Three years after starting treatment for systemic lupus erythematosus a 22-year-old woman developed bone-marrow depression. Azathioprine was thought to be responsible and was withdrawn. The aplastic anaemia worsened despite treatment with prednisolone. In view of clinical and serological evidence of lupus disease activity the patient was given high-dose intravenous cyclophosphamide and the aplastic anaemia responded in a sustained manner.

In such cases of continued disease activity high-dose immunosuppressive agents may prove effective.

Rheumatology Unit, Hammersmith Hospital, London W12 0HS
M J WALPORT, MA, MRCP, registrar
W N HUBBARD, MA, MB, senior house officer
G R V HUGHES, MD, FRCP, senior lecturer and consultant physician

Introduction

Leucopenia and thrombocytopenia due to increased peripheral destruction of leucocytes and platelets are major features of systemic lupus erythematosus. Bone-marrow aplasia is rare, however, and is more commonly a complication of cytotoxic drug treatment than of the disease itself. We describe a patient with severe systemic lupus erythematosus in whom bone-marrow aplasia was thought to be due to disease activity. Treatment with high-dose "pulse" intravenous cyclophosphamide resulted in return to normal blood counts.

Case report

A 22-year-old woman presented in 1978 with fatigue, polyarthralgia, and malar rash. Investigations showed a haemoglobin concentration of 6·8 g/dl, white cell count of $3{\cdot}0 \times 10^9$/l, antinuclear antibody titre of 1/2560, DNA binding of 90% (normal less than 30%), and C4 of 16% (normal 60-130%). Systemic lupus erythematosus was diagnosed and treatment started with non-steroidal anti-inflammatory drugs and subsequently prednisolone. Her disease remained clinically and serologically active, and in 1979, after the development of focal nephritis, azathioprine (2·5 mg/kg/day) was added to her treatment.