4. Recommendations on physical exercise training

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Abstract

Objective: To provide updated, evidence-based recommendations for health care professionals concerning the effects of regular physical activity on the prevention and control of hypertension in otherwise healthy adults.

Options: People may engage in no, sporadic or regular physical activity that may be of low, moderate or vigorous intensity. For sedentary people with hypertension, the options are to undertake or maintain regular physical activity and to avoid or moderate medication use; to use another lifestyle modification technique; to commence or continue antihypertensive medication; or to take no action and remain at increased risk of cardiovascular disease.

Outcomes: The health outcomes considered were changes in blood pressure and in morbidity and mortality rates. Because of insufficient evidence, no economic outcomes were considered.

Evidence: A MEDLINE search was conducted for the period 1966–1997 with the terms exercise, exertion, physical activity, hypertension and blood pressure. Both reports of trials and review articles were obtained. Other relevant evidence was obtained from the reference lists of these articles, from the personal files of the authors and through contacts with experts. The articles were reviewed, classified according to study design and graded according to level of evidence.

Values: A high value was placed on avoidance of cardiovascular morbidity and premature death caused by untreated hypertension.

Benefits, harms and costs: Physical activity of moderate intensity involving rhythmic movements with the lower limbs for 50–60 minutes, 3 or 4 times per week, reduces blood pressure and appears to be more effective than vigorous exercise. Harm is uncommon and is generally restricted to the musculoskeletal injuries that may occur with any repetitive activity. Injury occurs more often with jogging than with walking, cycling or swimming. The costs include the costs of appropriate shoes, garments and equipment, but these were not specifically measured.

Recommendations: (1) People with mild hypertension should engage in 50–60 minutes of moderate rhythmic exercise of the lower limbs, such as brisk walking or cycling, 3 or 4 times per week to reduce blood pressure. (2) Exercise should be prescribed as an adjunctive therapy for people who require pharmacologic therapy for hypertension, especially those who are not receiving β-blockers. (3) People who do not have hypertension should participate in regular exercise as it will decrease blood pressure and reduce the risk of coronary artery disease, although there is no direct evidence that it will prevent hypertension.

Validation: These recommendations agree with those of the World Hypertension League, the American College of Sports Medicine, the report of the US Surgeon General on physical activity and health, and the US National Institutes of Health Consensus Development Panel on Physical Activity and Cardiovascular Health. These guidelines have not been clinically tested.

Sponsors: The Canadian Hypertension Society, the Canadian Coalition for High Blood Pressure Prevention and Control, the Laboratory Centre for Disease Control at Health Canada, and the Heart and Stroke Foundation of Canada.

The 1989 Canadian Consensus Conference on Non-pharmacologic Approaches to the Management of High Blood Pressure observed that the evidence available at that time on the relation between physical activity and hypertension was not strong.[1] It was concluded that "although there is evidence that regular aerobic activity may result in the lowering of blood pressure in patients or clients with hypertension, definitive recommendations must await further research to determine the intensity, frequency and duration of the activity required to lower blood pressure and to determine how long the benefits can be maintained."[1] Since that time, evidence has become available to address those concerns. This report updates the previous recommendations.

Special supplement

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There are 2 major types of exercise: rhythmic or dynamic and resistive. Rhythmic or dynamic exercise consists of repeated low-resistance movements (e.g., walking or cycling), whereas resistive exercise typically consists of a small number of high-resistance movements (e.g., weight lifting). Most research on hypertension and exercise examines dynamic exercise training.

In assessing exercise, both the frequency and the intensity of the exercise are important. Exercise training is generally categorized as being of low intensity (less than 45% of maximal oxygen uptake), moderate intensity (45% to 60% of maximal oxygen uptake), vigorous intensity (61% to 75% of maximal oxygen uptake[2]) and strenuous intensity (greater than 75% of maximal oxygen uptake). Moderate-intensity exercise, for example, corresponds to an exercise that elicits 60% to 70% of maximal heart rate.[2] In a typical 40-year-old Canadian (of either sex), this corresponds to a heart rate of 110 to 125 beats/min. This can typically be attained by cycling on a stationary bicycle at 75 to 100 W or walking briskly, at 5 to 6 km/h (3 to 4 mi/h).[3] Vigorous-intensity exercise corresponds to activities that elicit 71% to 85% of maximal heart rate or 126 to 150 beats/min in a typical 40-year-old Canadian. Such levels can be achieved by cycling on a stationary bicycle at 120 to 150 W or by jogging at 6 to 8 km/h (4 to 5 mi/h).

The reader is referred to the compendium of physical activities by Ainsworth and coworkers[3] for detailed information on the energy equivalents of several physical activities. Briefly, energy equivalents are measured in METs, which are units of metabolism. At rest, a person spends 1 MET of energy to maintain body functions. Moderate-intensity exercise corresponds to an energetic equivalent of approximately 4 METs for women and 6 METs for men, and vigorous-intensity exercise corresponds on average to 6 METs for women and 8 METs for men (for a synopsis table of these energy expenditures, see Table 2 in Pate and associates[4]). In terms of caloric equivalents, three 55-minute exercise sessions per week (for a weekly total of 165 minutes) at a moderate intensity correspond to an energy expenditure of approximately 600 kcal (2500 kJ) per week for a 55-kg woman and 1200 kcal (5000 kJ) per week for a 70-kg man. Exercising for the same weekly duration at a vigorous intensity represents an energy expenditure of approximately 900 kcal (3800 kJ) per week for a 55-kg woman and 1500 kcal (6300 kJ) per week for a 70-kg man.

The primary objective of the guidelines presented here is to summarize the evidence of the relation between exercise and hypertension, as well as the response of blood pressure to exercise and to advise health care professionals and the public accordingly.

Methods

A complete description of the methods used in developing these guidelines is given in part 1 of this supplement.[5]

The chair and the members of the panel were selected by the Organizing Committee for the lifestyle modification recommendations to obtain a spectrum of health care professionals and scientists with expertise and interest in the areas of hypertension, exercise and health.

A MEDLINE search was performed using the terms exercise, exertion, physical activity, hypertension and blood pressure for English-language studies published between January 1966 and July 1997 and was limited to exercise training trials in hypertensive humans. Additional articles were identified by reviewing the reference lists of the identified articles, were found in the personal files of the panel members and were suggested by other experts. The definition of hypertension in the selected papers varied according to the criteria adopted by the authors.

We included all primary evidence from randomized crossover or controlled trials, as well as nonrandomized controlled trials. We also examined trials that included a detraining control period or an observation control period of at least 4 weeks (during which blood pressure was monitored weekly) in which the exercise interventions lasted at least 4 weeks. The work of the panel was aided by several reports, including the 1996 US Surgeon General's report on physical activity and health,[6] the 1996 National Institutes of Health (NIH) consensus statement on physical activity and cardiovascular health,[7] the 1994 position statement issued by the American College of Sports Medicine[8] and the 1991 consensus statement of the World Hypertension League.[9] Other non-trial materials reviewed by the panel included a meta-analysis[10] and 5 reviews or book chapters,[11–15] one of which included a simplified meta-analysis.[13]

The principles for grading the evidence and developing recommendations were based on those previously used by the Canadian Hypertension Society[16] and are summarized in part 1 of this supplement.[5] An attempt was made to reach consensus on all recommendations. The evidence and the recommendations were presented for comment to the other expert panels, submitted for review to major Canadian organizations and presented at an international conference on preventive cardiology, to allow further national and international input. All revisions were reviewed and assessed by the panel before incorporation into the final document.

Results

Regular exercise and mild hypertension

There is consistent evidence that regular rhythmic physical exercise of the lower extremities decreases both systolic and diastolic blood pressure by 5–7 mm Hg independent of weight loss, alcohol intake or salt intake. Using our established criteria, we identified 26 studies comprising 35 groups or interventions that measured the effects of physical training on blood pressure in a total of 486 patients with mild to moderate hypertension who were not taking any medication[17–42] (Table 1). Most of these studies measured blood pressure with the patient in a seated position; 5 of them also recorded ambulatory blood pressure.[18,28,33,38,41] One additional open trial recorded only ambulatory blood pressure.[43]

Study design and setting

Randomized studies of the effect of exercise training on blood pressure (level II studies, a total of 18 groups or

interventions) found mean reductions in blood pressure (by 5/7 mm Hg) comparable to those reported in nonrandomized studies (level III and IV studies, a total of 17 groups or interventions) (for which the mean reduction in blood pressure was 7/9 mm Hg) (Table 1). This observation agrees with that of Fagard,[44] who found that the amplitude of the reduction in blood pressure with exercise training did not usually differ with study design.

Table 1: Longitudinal studies on the effects of physical exercise training on clinic and/or ambulatory blood pressure (BP) in subjects with essential hypertension

Study design	Level of evidence*	Intervention group: Subjects	Age, yr	Mode†	Duration, wk	Training program: No. of sessions/wk	Duration of sessions, min	Total min/wk	Training intensity‡	BP of intervention group before training, mm Hg: SBP	DBP	Change in BP after training, mm HG: Intervention group SBP	DBP	Control group SBP	DBP
Clinic BP (seated unless specified otherwise)															
RXT[17] ¶	II	7 men, 6 women	44	Cycle	4	3	35	105	65	143	96	–11§	–9§	—	—
					4	7	35	245	65	143	96	–16§	–11§	—	—
RXT[18]	II	8 men, 1 woman	43	Cycle	10	3	45	135	50	152	100	+1	–1	—	—
					10	3	45	135	70	152	100	+3	+3	—	—
RXT[19]	II	8	46	Cycle	10	3	60	180	(50)	154	93	–6§	–4	—	—
					10	3	35	105	(75)	149	96	–7§	–9§	—	—
RCT[20] ¶	II	5 men, 1 woman	44	Comb	12	3	50	150	70	161	105	+7§	+6§	–2	–3
RCT[21]	II	12 men	42	Comb	16	3	50	150	[56]	145	99	–9§	–11§	0	–7§
RCT[22]	II	44 men	30	Walk-jog	16	3	60	180	[64]	146	94	–12	–7§	–6	+3
RCT[23]	II	4 men, 6 women	51	Cycle	10	3	60	180	(50)	156	103	–13§	–5	+2	+1
RCT[24]	II	21	46	Cycle	10	3	60	180	(50)	154	100	–13§	–7§	NA	NA
RCT[25]	II	11	65	Walk-jog	37	3.1	51	158	53	164	94	–21§	–12§	–1	–2
				Comb	37	2.5	51	128	73	157	99	–9	–11§	–1	–2
RCT[26]	II	10 men	44	Comb	10	4	30	120	[60]	137	95	–6	–10§	+1	+1
RCT[27]	II	6	72	Walk-jog	26	3	40	120	80	156	86	–8	–9§	+3	0
RCT[28]	II	24 men, 15 women	44	Walk-jog	16	2.5	35	88	138	141	95	–8§	–6§	–9§	–5§
RCT[29] ¶	II	6	45	Walk-jog	12	3	45	135	45	140	93	–15§	–6§	–1	–3
		7	39	Walk-jog	12	3	45	135	73		91	–4	0	–1	–3
NRCT[30]	III	12 men	41	Walk-jog	12	2.5	35	88	[67]	148	97	–13§	–14§	–3	–11§
NRCT[31]	III	10	56	Comb	12	2.5	42	105	[69]	168	100	–8§	–7	+7	0
NRCT[32]	III	12 men, 5 women	51	Comb	63	3	40	120	[55]	155	101	–19§	–14§	–13	+2
NRCT[33]	III	9 men, 5 women	61	Walk-jog	26	3.5	41	144	[58]	141	92	–7§	–5§	–10§	–7§
		10	63	Walk-jog	52	3.6	50	180	[64]	143	92	–10§	–8§	–7	–7§
NRCT[34]	III	10 women	49	Cycle	10	3	60	180	(50)	150	95	–7	–6§	+2	+2
NRCT[35]	III	2 men, 15 women	48	Cycle	10	3	60	180	(50)	159	96	–8§	–5§	–2	–1
NRCT[36]	III	7 men, 5 women	47	Swim	10	3	45	135	[66]	150	96	–6§	–2	–1	0
DCP[37]	IV	60 men, 17 women	54	Comb	5	7	90	630	[50]	157	98	–14§	–9§	—	—
DCP[38]	IV	14 men, 2 women	35	Walk-jog	26	3.5	44	154	NA	148	82	–10§	–6§	—	—
OCP[39]	IV	27 women	55	Walk-jog	12	3	30	90	[59]	179	113	–20§	–18§	—	—
OCP[40]	IV	5 men, 7 women	46	Cycle	10	3	60	180	(50)	153	103	–14§	–9§	—	—
		9	46	Cycle	20	3	60	180	(50)	157	104	–21§	–14§	—	—
OCP[41]	IV	8	46	Cycle	16	3	30	90	[70]	131	89	–5	–4	—	—
OCP[26]**	IV	7 men	43	Comb	10	4	30	120	[60]	139	96	–9§	–6§	—	—
OCP[42]	IV	2 men, 14 women	45	Cycle	10	3	60	180	(50)	152	96	–9§	–6§	—	—
		2 men, 8 women	46	Cycle	10	3	35	105	(75)	153	99	–3	–5§	—	—
Ambulatory BP (daytime)															
RXT[18]	II	8 men, 1 woman	43	Cycle	10	3	45	135	50	151	96	–6§	–5§	—	—
						3	45	135	70	151	96	–4	–2	—	—
RCT[28]	II	24 men, 15 women	44	Walk-jog	16	2.5	35	88	70	139	86	+1	0	+1	0
NRCT[33]	III	9 men, 5 women	61	Walk-jog	26	3.5	41	144	[58]	142	92	–2	2	0	+2
		10	63	Walk-jog	52	3.6	50	180	[64]	142	92	–7§	–1	–1	+1
DCP[38]	IV	13	35	Walk-jog	26	3.5	44	154	NA	141	89	–5§	–8§	—	—
OCP[41]	IV	7	46	Cycle	16	3	30	90	[70]	131	92	–4	+1	—	—
OT[43]	V	9 men, 7 women	48	Cycle	14	3	45	135	[53]	147	91	+1	0	—	—

Note: NA = not available; RXT = randomized crossover trial; RCT= randomized controlled trial; NRCT = nonrandomized controlled trial; DCP = the same subjects were studied after a detraining control period; OCP = observation control period of at least 4 weeks; OT = open trial, SBP = systolic blood pressure, DBP = diastolic blood pressure.
*Level of evidence according to the Canadian Hypertension Society consensus conference.[16]
†Mode of training: cycle = stationary cycle ergometer; comb = combination of cycle and walking/jogging.
‡Training intensity as percent maximal oxygen uptake; values in parentheses estimated from lactate threshold or from a fixed lactate level; values in square brackets estimated from target exercise heart rate according to the formula of Miller and associates.[2]
§Significant changes reported by authors.
¶ Supine blood pressure group.
**Subjects from the control regimen who then trained.

The results of exercise training did not seem to be affected by the setting. Indeed, several studies used home training programs[25,26,33,38] and found comparable reductions in blood pressure to those in which subjects trained under staff supervision.[17,19,22,23]

Type of exercise

Very few studies have examined the effect of resistive training on blood pressure. A recent review of resistive training (consisting of 3 sessions of circuit weight training per week)[12] identified 3 randomized controlled trials in hypertensive patients,[27,28,45] of which only one study[45] reported a significant decrease in diastolic blood pressure (and in that study the decrease was less than 3 mm Hg). We therefore conclude that resistive exercise is not very effective in reducing blood pressure.

Most of the studies we identified examined the effect of regular dynamic exercise. The recommendations presented here are therefore based on this type of exercise. The training modes were stationary cycling, walking or jogging (and swimming in one study only[36]).

Duration of program

Two studies found significant reductions in blood pressure after only 4 and 5 weeks of training respectively.[17,37] In another study approximately 75% of the antihypertensive effect found after 20 weeks of exercise training occurred in the first 10 weeks.[40] The antihypertensive effect of training persisted as long as the training program (over 1 year in the studies reviewed).[32,33] In contrast, the antihypertensive effect was no longer seen after detraining periods of 10 weeks.[18,19] The antihypertensive effect of training is therefore reversible.

Frequency of sessions

The antihypertensive effect of exercise training is observed when the patient follows a schedule consisting of 3 sessions per week and increases little, if at all, when the patient follows a daily routine. Approximately 75% of the antihypertensive effect that can be obtained by exercising 7 times per week is achieved by exercising only 3 times per week.[17] In studies in which subjects trained at 50% of maximal oxygen uptake, the antihypertensive effects of 3 sessions per week[40] were comparable to those of 7 sessions per week.[37] Thus, daily exercise is not essential to obtain an antihypertensive effect.

Duration of sessions

In the studies examined, the exercise sessions were 30–90 minutes long. Of the 35 groups or interventions from the 26 studies, 31 used moderate- to vigorous-intensity training with cycling, walking or jogging, on a schedule of 2.5 to 4 sessions per week.[17–26,28–35,38–42] In 17 of these groups or interventions,[17–19,26,28–33,38,39,41,42] the subjects trained no longer than 45 minutes per session (mean 38 [range 30–45] minutes). In 11 (67%) of these 17 groups or interventions,[12,19,26,29–32,38,39,42] there were significant decreases in systolic or diastolic blood pressure, or both. Of the 14 groups or interventions in which the intervention group trained for longer than 45 minutes per session (mean 57 [range 50–60] minutes),[19–25,33–35,40,42] 13 (94%) had significant decreases in systolic or diastolic blood pressure, or both.[19,21–25,33–35,40,42] Therefore, training for 50–60 minutes, at moderate to vigorous intensity, is more likely to produce a significant antihypertensive effect than training for 30–45 minutes.

Intensity of exercise

There is evidence that moderate-intensity exercise may be more effective than vigorous exercise in decreasing blood pressure in hypertensive patients. In 17 of the 31 groups or interventions, subjects trained at moderate intensity (mean 53% [range 45% to 60%] of maximal oxygen up-

Table 2: Summary of recommendations for physical exercise to prevent and control hypertension

Recommendations	Grade
For mildly hypertensive people, dynamic exercise (including walking, cycling, noncompetitive swimming) should be prescribed to reduce blood pressure	B
Dynamic exercise of moderate intensity for 50 to 60 minutes, 3 or 4 times per week, is preferable to vigorous exercise because it appears to be more effective in lowering blood pressure	B
Exercise should be prescribed as adjunctive therapy for people who have levels of blood pressure that require pharmacologic therapy, especially for those who are not on ß-blockers	B
For people who do *not* have hypertension or coronary artery disease, exercise reduces blood pressure	B
For people who do *not* have hypertension or coronary artery disease, exercise may reduce the risk of coronary artery disease	D
People who do not have hypertension but have established atherosclerotic disease should become physically active to reduce the risk of death from cardiovascular disease, from re-infarction and from other causes	A

take).[18,19,21,23–26,29,32–35,39,40,42] Significant decreases in systolic or diastolic blood pressure, or both, were reported in 15 (88%) of these 17 groups or interventions.[19,21,23–26,29,32,34,35,39,40,42] Of the 14 groups or interventions in which subjects trained at vigorous or strenuous intensities (mean 70% [range 64% to 80%] of maximal oxygen uptake),[17–20,22,25,27–31,33,41] only 9 (64%) reported significant decreases in systolic or diastolic blood pressure, or both.[17,19,22,25,27,30,31,33,42] In studies that examined the effects of 2 training intensities,[25,29,42] blood pressure measured in a clinical setting decreased to a greater extent in the subjects who trained at a moderate intensity than in those who trained vigorously. One study found no difference in blood pressure changes between moderate- and vigorous-intensity exercise programs.[19] Another study reported a significant decrease in mean daytime ambulatory blood pressure after training at 50% of maximal oxygen uptake but not after training at 70% of maximal oxygen uptake.[18] The evidence reviewed therefore indicates that training at a moderate intensity produces more significant antihypertensive effects than training at a vigorous intensity.

A corollary to this observation is that the effect of physical activity in reducing blood pressure does not depend on increasing maximal oxygen uptake, which typically occurs with training above 60% of maximal oxygen uptake. Several studies that used training intensities below 55% of maximal oxygen uptake found significant reductions in clinic[25,29] and ambulatory[18] blood pressure without any significant changes in maximal oxygen uptake.

Effect of age, sex and race

Age does not seem to have any bearing on the antihypertensive effects of exercise. In the studies reviewed, similar reductions in blood pressure were observed in younger (e.g., 30- to 35-year-old subjects[22,38]) and older (e.g., 60- to 79-year-old subjects[25,27]) age groups (reductions of 11/7 and 10/11 mm Hg respectively). This finding agrees with the results of Fagard and Tipton,[12] who reported that training-induced changes in systolic and diastolic blood pressure did not correlate with age.

For the studies listed in Table 1 that specified the numbers of men and women, there were in total 125 (43%) women and 168 (57%) men. For the studies in which the subjects were exclusively[34,39] or predominantly[35,42] women, the decrease in blood pressure after training was comparable to that reported for studies of men[21,22,26,30] (mean reduction of 9/8 and 10/10 mm Hg respectively).

Race does not appear to influence the effect of regular exercise in reducing blood pressure; comparable antihypertensive effects have been seen among black American,[31] Japanese[19,23,24] and white subjects.[17,22]

Recommendations

- For people with mild hypertension, dynamic exercise (including walking, cycling, noncompetitive swimming and other equivalent leisure activities) should be prescribed to reduce blood pressure (grade B recommendation).
- Moderate-intensity dynamic exercise, in sessions of 50–60 minutes, 3 or 4 times per week, is preferable to vigorous-intensity exercise, as moderate-intensity exercise appears to be more effective in reducing blood pressure (grade B recommendation).

Regular exercise and moderate to severe hypertension

Dynamic training can improve blood pressure in patients with moderate to severe hypertension and reduce the need for medication. In one randomized controlled trial of black American men with severe hypertension,[46] training for 16 weeks not only reduced blood pressure but also was associated with a reduction in left ventricular mass index (level II evidence). This trial allowed for a reduction in antihypertensive drugs between the 16th and 32nd week of training. During that period the authors observed substantial reductions in the doses of antihypertensive medications taken by the subjects; these drugs included diuretics, calcium channel blockers and angiotensin-converting enzyme inhibitors.[46] Thus, it appears that the antihypertensive effects of exercise are additive with those of most antihypertensive medications.

In another study[47] attenuation of the antihypertensive effects of exercise training was reported for a selective β-blocker and a nonselective β-blocker. This suggests that β-blockade may interfere with the antihypertensive effect of exercise.

Physical activity has often been used in conjunction with weight reduction strategies for the treatment of hypertension. Among the studies listed in Table 1 that reported changes in body weight, a significant reduction in body weight (mean reduction 2.6 [range 1.4–4.6] kg) was found in only 4 (13%) of the 30 intervention groups for which there was also a significant reduction in blood pressure after training.[25,33,37,40] In the other intervention groups, the reduction in blood pressure occurred without any significant changes in body weight. This observation emphasizes that the effect of physical exercise in reducing blood pressure occurs independently of a reduction in body weight.

Physical exercise has been a component of interventions involving multiple lifestyle modifications to treat hypertension. Increased physical activity, together with a reduction in caloric intake alone or in combination with a reduction in alcohol intake and with or without a reduction in sodium intake,[48–51] reduces the relative risk of hypertension. Furthermore, in a randomized controlled trial involving hypertensive subjects in which sodium, alcohol and sugar intake were reduced while physical activity and milk intake were increased, the proportion of the intervention group that did

not require pharmacologic therapy was greater than the proportion of the control group that did not.[52]

Recommendation

- Exercise should be prescribed as adjunctive therapy for people who require pharmacologic therapy for hypertension, especially for those who are not receiving β-blockers (grade B recommendation).

Regular exercise in normotensive individuals

To evaluate the relation between blood pressure and physical exercise training in normotensive individuals, this panel relied mainly on a recent meta-analysis.[53] (The major longitudinal cohort studies that address this topic[54,55] were used for background reference only.) That review of 35 human clinical training studies involving a total of 800 intervention subjects and 276 control subjects found that physical training reduced blood pressure in normotensive people.

In patients with established atherosclerotic disease, numerous randomized controlled trials have indicated that exercise training reduces total, cardiovascular and re-infarction mortality rates (level I evidence) (reviewed by Oldridge and associates,[56] O'Connor and collaborators[57] and Berlin and Colditz[58]). In a recent randomized controlled trial, Hambrecht and coworkers[59] reported significantly lower rates of progression of coronary atherosclerotic lesions in an exercise group than in a sedentary control group of patients with coronary artery disease (level I evidence).

Mild-intensity exercise training also has beneficial effects on the lipid profile. Here again, the metabolic changes associated with training are related more to the training volume than to the improvement in maximal oxygen uptake.[60]

Recommendations

- For people who do not have hypertension or coronary artery disease, exercise training is beneficial because it reduces blood pressure (grade B recommendation) and may reduce the risk of coronary artery disease (grade D recommendation).
- People who do not have hypertension but who do have established atherosclerotic disease should become physically active to reduce the risk of death from cardiovascular disease, from re-infarction and from other causes (grade A recommendation).

The recommendations presented in this paper are summarized in Table 2.

Adverse effects

A few studies have provided some insight into adverse events related to activities commonly undertaken to increase physical activity. Most running-related injuries involve the leg and the foot, are self-correcting in a relatively short time and are related to distance running.[61,62] The injury rate appears to increase sharply among people taking more than 4 aerobic classes per week.[63] Exertion may provoke asthmatic attacks, which usually occur after exercise in susceptible individuals. People with underlying cardiovascular disease may experience angina or acute myocardial infarction during vigorous activity. The US Surgeon General's report[6] concluded that, "compared with sedentary people who suddenly begin exercising vigorously, persons who exercise regularly have a lower risk of exercise-related sudden death, although even this group has a transient elevation of risk during and immediately after vigorous exercise. Nonetheless, the net effect of regular physical activity is to decrease the risk of cardiac death."

Interpretation

There is now excellent evidence that mild hypertension can be treated with moderate physical activity. The antihypertensive effect of exercise does not depend on an increase in maximal aerobic capacity, but does correlate with the initial level of activity. The lower the initial level of activity, the greater the expected reduction in blood pressure associated with a given increase in physical activity. This statement on physical activity and blood pressure agrees with the more general US recommendations on physical activity and public health.[4]

The present recommendations differ from those published in 1990[1] mainly because of evidence from a relatively large number of well-controlled studies published since the late 1980s. In addition, our review of the literature identified several studies published before 1990 that were not included in the original review. Thus, the main concerns expressed in the earlier recommendations have been addressed by well-controlled studies on physical exercise and hypertension.

Validation

The present recommendations agree with earlier guidelines indicating that exercise training can reduce blood pressure in hypertensive patients, specifically those of the World Hypertension League,[9] the American College of Sports Medicine,[8] the US Surgeon General[6] and the NIH Consensus Development Panel on Physical Activity and Cardiovascular Health.[7] In accordance with those guidelines, we believe that the evidence indicates that moderate exercise is at least as effective as vigorous exercise for the treatment of hypertension.

Future research

The panel on exercise training and hypertension suggests that additional research is required in a number of areas.

Future research should determine if there are differ-

ences in the additive effects of (1) specific exercise and drug combinations (between and within classes of medication) and (2) combinations of exercise and other non-pharmacologic treatments (e.g., weight loss and stress reduction).

More research is needed to determine if exercise-induced reductions in blood pressure lead to a reduction in various endpoints of cardiovascular disease.

Finally, prospective trials should be conducted to determine if regular exercise in previously sedentary people can prevent hypertension.

Conclusion

Regular dynamic physical exercise, which need not be vigorous and which can be gradually incorporated into everyday activities, can reduce blood pressure by 5 to 10 mm Hg in people with hypertension. Brisk walking is a typical moderate-intensity exercise that can lead to such reductions when practised for 3 hours per week. In addition to reducing hypertension, physical activity improves other cardiovascular risk factors.

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