Physical activity to prevent cardiovascular disease

How much is enough?

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ABSTRACT

OBJECTIVE To review the role of physical activity in primary prevention of cardiovascular (CV) diseases with particular attention to the intensity and amount of physical activity needed to benefit health.

QUALITY OF EVIDENCE MEDLINE was searched for articles published in the indexed English literature from January 1991 to December 2000 using key words related to physical activity (eg, exercise, physical fitness), CV and coronary artery disease (CAD) risk factors (eg, diabetes, hypertension, hyperlipidemia, obesity). Findings were supplemented by consensus documents and other published literature. Most articles described prospective observational studies.

MAIN MESSAGE Clear evidence indicates an inverse linear dose response between amount of physical activity and all-cause mortality, total CV disease, and CAD incidence and mortality. The minimal effective dose is unclear, but physical activity that results in energy expenditure of approximately 4200 kJ•week^{-1} appears to be associated with substantial benefits. Physical activity need not be vigorous to benefit health.

CONCLUSION Moderate activity, such as brisk walking for 30 to 60 minutes a day most days of the week, is associated with significant reductions in the incidence and mortality of CV disease.

RÉSUMÉ

OBJECTIF Examiner le rôle de l'activité physique dans la prévention primaire des maladies cardiovasculaires en insistant sur l'intensité et la quantité d'activité physique requises pour qu'elle soit bénéfique pour la santé.

QUALITÉ DES DONNÉES Une recension a été effectuée des ouvrages en anglais fichés dans MEDLINE de janvier 1991 à décembre 2000 à l'aide des mots clés associés à l'activité physique (p. ex. exercice, conditionnement physique), aux facteurs de risque de maladies cardiovasculaires et de coronaropathies (p. ex. diabète, hypertension, hyperlipidémie, obésité). Aux articles recensés se sont ajoutés des documents consensuels et d'autres ouvrages publiés. La majorité des articles décrivaient des études d'observation prospectives.

PRINCIPAL MESSAGE Des données probantes précises indiquent une réponse linéaire inversement proportionnelle entre la quantité d'activité physique et la mortalité toutes causes confondues, le nombre total de maladies cardiovasculaires, l'incidence et la mortalité de coronaropathies. La dose minimale efficace n'est pas précise mais l'activité physique qui se traduit par une dépense d'énergie équivalant à 4200 kilojoules par semaine[1] semble associée à des bienfaits substantiels. Il n'est pas nécessaire que l'activité physique soit vigoureuse pour être bénéfique pour la santé.

CONCLUSION Une activité modérée, comme une marche rapide de 30 à 60 minutes par jour la plupart des jours de la semaine, est associée à des réductions considérables de l'incidence des maladies cardiovasculaires et de la mortalité afférente.

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CME

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Regular participation in physical activity promotes good health and reduces the risk of cardiovascular (CV) disease.[1-8] But how much physical activity is needed to optimize these benefits? In 1995, the United States Centers for Disease Control and Prevention, in collaboration with the American College of Sports Medicine (ACSM), introduced a change in how we view the amount of activity necessary for good health.

A panel reviewed pertinent physiologic, epidemiologic, and clinical evidence and recommended an accumulation of 30 minutes of moderate physical activity most days of the week.[6] This recommendation, reflected in the United States Surgeon General's report[7] and Health Canada's P*hysical Activity Guide to Healthy Active Living*[9] (guide), contrasts with previous recommendations that advocated vigorous exercise for at least 20 minutes continuously three times a week.[10] While the amount of energy expended by minimal adherence to current or previous recommendations appears similar, there are two major differences. Current emphasis is on moderate rather than vigorous activity, and the value of many short sessions of activity each day is acknowledged.

Given that family physicians see patients regularly over time, they are in an ideal position to educate patients as to the benefits of regular physical activity and to counsel them on how to increase the amount they exercise daily. This review highlights evidence that forms the basis for Health Canada's guide and supports the promotion of physical activity in family medicine.

Quality of evidence

MEDLINE was searched from January 1991 to December 2000 using key words related to physical activity (eg, exercise, physical fitness) and CV disease and coronary artery disease (CAD) risk factors (eg, diabetes, hypertension, hyperlipidemia, obesity). The search was restricted to indexed English-language literature. The initial search identified 3452 articles; adding the terms "energy expenditure" and "exercise intensity" reduced the number of articles to 39. We also checked the reference lists of papers for additional articles not identified by the search. Most of the literature in this area described prospective observational studies. Our findings were supplemented by consensus documents.

Four types of studies were examined: observational cross-sectional studies, epidemiologic follow-up studies, non-randomized experimental studies, and randomized controlled trials (RCTs). Four evidence categories were used[11]: category A was assigned when there was a rich body of data from RCTs; category B when there was a limited body of data from RCTs; category C when data supporting conclusions were from non-randomized, cross-sectional, or prospective observational studies; and category D when advice or recommedations were valuable but not backed up by significant data.[11]

Physical activity characteristics

Before reviewing the evidence on health outcomes related to physical activity, it is important to define frequency, duration, and intensity, the terms typically used to describe the activity needed to bring about a particular response. Frequency simply identifies how many days per week one should participate in activity. Current public health recommendations suggest that physical activity take place on most days of the week.[4-9] These recommendations represent a subtle shift from the more traditional recommendation of three to five times per week, which was often cited as the required frequency for improving CV fitness.[10]

Similarly, the traditional recommendation of 20 to 60 minutes of continuous movement on a given day[12] has been modified. Current recommendations call for an accumulation of up to 60 minutes of activity on a given day.[6,9] For some health benefits, it does not appear to matter how the minutes of activity are accumulated.[8,13-16] Intermittent activity spread throughout the day might be even more beneficial to health outcomes.[16-18]

Exercise intensity refers to the effort associated with a specific activity. Various parameters have been used to characterize intensity (**Table 1**[11]). While several studies[19-22] have documented that vigorous activity is associated with lower all-cause mortality, current emphasis is on promoting moderate activity.[4-7,9,18]

The product of intensity, duration, and frequency yields the amount of activity. A typical measure of amount of activity is total energy expenditure, which can be expressed in kilojoules per week ($kJ \cdot week^{-1}$). Several recent reviews have emphasized that, for health benefits, the total amount of physical activity is more important than the specifics of intensity, frequency, and duration.[2,3,20-25] For example, the

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Table 1. **Various ways of rating physical activity intensity**

RATING	LIGHT ACTIVITY	MODERATE ACTIVITY	VIGOROUS ACTIVITY
VO_2 reserve (%)*	20-39	40-59	>60
Metabolic equivalents (METs)†	<3	3-6	>6
Maximum heart rate (%)‡	55-64	65-74	>75
Heart rate reserve (%)§	20-39	40-59	>60
Rating of perceived exertion‖	Fairly light	Somewhat hard	Hard

VO_2 reserve—VO_{2max} - VO_{2rest} where VO_2 represents oxygen uptake at rest (VO_{2rest}) or during peak activity (VO_{2max}).
†*Metabolic equivalents: 1 METs = 3.5 mL·kg^{-1}·min^{-1}.*
‡*Heart rate maximum—HR_{max} = 220-age in years.*
§*Heart rate reserve—([HR_{max} - HR_{rest}] · %) + HR_{rest}, where HR_{max} = 220-age in years; % refers to desired training intensity.*
‖*Borg's original 6-20 scale.*[11]

1994-1995 Canadian National Population Health Survey defined moderate physical activity as an accumulated energy expenditure about 3000 to 6000 kJ (for a 70-kg person) each week because this level of activity was associated with a significant decrease in chronic-disease morbidity.[19]

The beneficial effects of physical activity on health have been observed with regard to all-cause mortality[6,20-22] and several disease risk factors.[2,3,23-25] Some groups have also suggested a minimum threshold of physical activity for improving health.[6,20,22-25] For instance, the United States Surgeon General's report on physical activity suggested that the activity threshold associated with positive health-related outcomes was >625 kJ·day^{-1} on most days of the week.[7] The Harvard Alumni study identified a significant reduction in age-adjusted mortality when regular physical activity exceeded an expenditure of 4200 kJ·week^{-1}.[16] Others suggest that even less physical activity could have some health benefits.[15,18,25]

Physical activity and health outcomes

All-cause morbidity and mortality. An exhaustive review of the relationship between physical activity and all-cause mortality supports the suggestion of an inverse linear relationship with amount of activity (category C).[26] Moderate levels of regular physical activity are associated with lower mortality rates in older and younger men and women (**Table 2**[3,15,18,20,27-35]). Data from the Harvard Alumni study[16] indicate that an energy expenditure of approximately 4200 kJ·week^{-1} is associated with a 30% reduction in all-cause mortality.[16] In two Finnish studies, those in the lowest quartile of weekly physical activity (<3350 kJ·week^{-1}) were found to have a significantly higher risk of all-cause and CV mortality relative to those in the highest quartile of activity (>8800 kJ·week^{-1}).[20,31] The Honolulu Heart Program study[36] provided evidence that regular, moderate physical activity was associated with remaining free of more than eight serious chronic diseases over 12 years of follow up.

Cardiovascular diseases. Regular activity is acknowledged as an important strategy for both prevention and rehabilitation of CAD.[2,37,38] In Canada, the age-adjusted 2-year incidence of heart disease is less than 1% for moderately active people and 2.3% for their sedentary counterparts.[37] Studies support the suggestion of an inverse relationship between weekly amount of physical activity and both incidence and mortality of all CV disease and CAD (category C) (**Table 2**[3,15,18,20,27-35]).[8,39] Data from the Harvard Alumni study suggest CV mortality is inversely related to an energy expenditure of 2100 to 8400 kJ·week^{-1}.[3,16] While some studies[40,41] suggest that more vigorous exercise is necessary to benefit CV health, the American Heart Association's Committee on Exercise and Cardiac Rehabilitation emphasizes moderate physical activity as a means of achieving the greatest health benefits.[2]

Hypertension. Evidence from RCTs indicates that regular moderate physical activity is effective in lowering blood pressure (BP) in both normotensive and hypertensive people (category A).[40] In a recent meta-analysis of 68 study groups and 2674 subjects, Fagard[41] concluded that the BP-lowering effect of activity is small but significant in normotensive people and that the net effect was more pronounced in hypertensive patients (**Table 3**[40]). The BP-lowering effects of activity appear to occur at a low threshold; effects are noted with moderate activity.[23,40-44] Several groups have suggested that mild to moderate activity is as effective as vigorous exercise at lowering BP.[6,8,44]

Stroke. There is little research into the influence of physical activity on ischemic stroke. Sacco et al[33] used a case-control design to study the relationship between leisure-time physical activity and ischemic stroke among elderly men and women. These authors reported that the odds ratio (OR) of stroke decreased substantially (from 0.42 to 0.31) with increasing activity levels. Others have suggested a non-linear U-shaped relationship with little benefit associated with more

Table 2. **Relationship between physical activity and all-cause and cardiovascular morbidity and mortality:** *Selected population-based studies.**

STUDIES	STUDY DESIGN AND SUBJECTS (YEARS OF FOLLOW UP)	PHYSICAL ACTIVITY	OUTCOMES	MAIN FINDINGS: ADJUSTED RELATIVE RISK (95% CI)
Menotti and Seccareccia, 1985[39]	Observational cohort: 99 029 men aged 40-59 y (5)	Occupational activity 1. Sedentary 2. Moderate 3. Heavy	Fatal MI	1. 1.0 (referent) 2. 0.65 3. 1.00
Paffenbarger et al, 1986 (Harvard Alumni Study)[3]	Observational cohort: 16 936 men aged 35-74 y (12-16)	LTPA index: energy used in walking, climbing stairs, sport and recreation	All-cause mortality	2092 kJ•week^{-1} 1.0 (referent) 2093-4185 0.73 4186-6278 0.73 6279-8371 0.63 8372-10 464 0.62 10 465-12 557 0.52 12 558-14 650 0.46 ≥ 14 651 0.62
Leon et al, 1987 (MRFIT)[15]	Observational cohort: 12 138 men aged 35-57 y at high risk of CAD (7)	LTPA questionnaire: intensity codes used to approximate energy expenditure	Fatal and non-fatal MI	Compared with lowest tertile Tertile 1 1.0 (referent) Tertile 2 0.73 (0.59-0.91) Tertile 3 0.87 (0.70-1.07)
Slattery et al, 1989[57]	Observational cohort: 3043 middle-aged men free of CVD (17-20)	LTPA questionnaire: weekly energy expenditure	Fatal and non-fatal MI	Compared with > 8372 kJ•week^{-1} < 1050 1.21 (1.03-1.42) 1051-4186 1.08 (1.01-01.15) 4187-8371 1.04 (1.01-1.08) ≥ 8372 1.0 (referent)
Linsted et al, 1991[38]	Observational cohort: 9484 men aged ≥ 30 y (26)	Self-reported LTPA 1. Low 2. Moderate 3. High	CVD mortality	Compared with low activity at age 50 1. 1.0 (referent) 2. 0.61 (0.50-0.74) 3. 0.66 (0.50-0.78)
Paffenbarger et al, 1993 (Harvard Alumni Study)[18]	Observational cohort study: 10 269 men aged 45-84 y (9)	LTPA index: energy used in walking, climbing stairs, sport and recreation	All-cause mortality	2092 kJ•week^{-1} 1.0 (referent) 2093-4185 0.73 (0.54-0.95) 4186-6278 0.71 (0.53-0.96) 6279-8371 0.64 (0.46-0.92) 8372-10 464 0.57 (0.40-0.87) 10 465-12 557 0.74 (0.50-1.12) 12 558-14 650 0.81 (0.52-1.32) ≥ 14 651 0.52 (0.39-0.75)
Paffenbarger et al, 1986 (Harvard Alumni Study)[3]	Observational cohort: 16 936 men aged 35-74 y (12-16)	LTPA index: energy used in walking, climbing stairs, sport and recreation	All-cause mortality	Compared with walking < 5 km•week^{-1} 5-14 0.78 > 14 0.67 Compared with climbing stairs < 20 floors • week^{-1} 20-54 0.79 > 54 0.75 Compared with no sport or recreation Light (< 4.5 METs) 1.10 Moderate (>4.5 METs) 0.63
Lee et al, 1995 (Harvard Alumni Study)[58]	Observational cohort: 17 321 men, mean age of 46 y (26)	Nonvigorous and vigorous† energy expenditure from walking, climbing stairs, sport and recreation	All-cause mortality	Vigorous activities compared with < 630 kJ•week^{-1} (referent) • 630-1679 0.88 (0.82-0.96) • 1680-3149 0.92 (0.89-1.02) • 3150-6299 0.87 (0.77-0.99) • ≥ 6300 0.87 (0.78-0.97)

Table 2 continued...

STUDIES	STUDY DESIGN AND SUBJECTS (YEARS OF FOLLOW UP)	PHYSICAL ACTIVITY	OUTCOMES	MAIN FINDINGS: ADJUSTED RELATIVE RISK (95% CI)
Haapanen et al, 1996[20]	Observational cohort: 1072 men	Reported LTPA based on estimated energy expenditure (kJ•week^{-1}) 1. 0-3349 2. 3350-6279 3. 6280-8791 4. > 8791	All-cause and CVD mortality	All-cause 1. 2.74 (1.46 - 5.14) 2. 1.10 (0.55 - 2.21) 3. 1.74 (0.87 – 3.50) 4. 1.0 (referent) CVD 1. 3.58 (1.45 – 8.85) 2. 0.99 (0.34 – 2.87) 3. 1.59 (0.56 – 4.49) 4. 1.0 (referent)
Haapanen et al, 1997[27]	Observational cohort: 842 men and 953 women aged 35-63y	Reported LTPA based on index score from questionnaire 1. Low 2. Medium 3. High	Incidence of coronary heart disease	Men 1. 1.98 (1.22-3.23) 2. 1.33 (0.78-2.27) 3. 1.0 (referent) Women 1. 1.25 (0.72-2.15) 2. 0.73 (0.38-1.39) 3. 1.0 (referent)
Kujala et al, 1998[59]	Observational twin cohort: 7925 men and 7977 women aged 25-64y	LTPA 1. Sedentary 2. Occasional exercisers 3. Conditioned exercisers	All-cause mortality	Compared with sedentary 1. 1.0 (referent) 2. 0.80 (0.69-0.91) 3. 0.76 (0.59-0.98)
Sacco et al, 1998[37]	Matched case control: 489 men and 618 women	Self-reported intensity 1. None 2. Light or moderate 3. Heavy Self-reported duration (hours•week^{-1}) 1. None 2. < 2 3. 2-5 4. > 5	Cerebral infarction morbidity; ischemic stroke	Intensity 1. 1.0 (referent) 2. 0.39 (0.26-58) 3. 0.23 (0.10-054) Duration 1. 1.0 (referent) 2. 0.42 (P<0.05) 3. 0.35 (P<0.05) 4. 0.31 (P<0.05)
Lee et al, 1999[60]	Observational cohort: 21 823 men	Self-reported LTPA (times•week^{-1}) 1. None 2. 1 3. 2-4 4. ≥ 5	Ischemic stroke	1. 1.0 (referent) 2. 0.90 (0.66-1.22) 3. 0.95 (0.74-1.22) 4. 0.97 (0.71-1.32)
Lee and Paffenbarger, 2000[61]	Observational cohort: 13 485 men, mean age 57.5y	LTPA index: energy used in walking, climbing stairs, sport or recreation	All-cause mortality	Compared with < 4200 kJ•week^{-1} 4201-8399 0.80 (0.72-0.88) 8400-12 599 0.74 (0.65-0.83) 12 600-16 799 0.80 (0.69-0.93) ≥ 16 800 0.73 (0.64-0.84)

CI—confidence interval, CAD—coronary artery disease, CVD—cardiovascular disease, LTPA—long-term physical activity (kJ•week^{-1}), METS—metalbolic equivalents, MI — myocardial infarction
**Studies were selected on the basis of their relevance and effect (number of citations in consensus documents since 1990). Preference was given to more recent papers with large sample sizes and well designed cohort studies. All energy expenditure data were converted to kJ•week^{-1}.*
†Nonvigorous—<6METs, vigorous—>6METs.

vigorous activity.[27,29] In a recent review, Kohl[39] noted that only six of 14 studies supported an inverse relationship between physical activity and overall risk of stroke. Several of these studies, however, were unable to separate out the various subtypes of stroke. Taken together, the studies suggest that the relationship between physical activity and risk of stroke is unclear.

Type 2 diabetes. Regular physical activity appears to lower the risk of developing type 2 diabetes (category C).[2,26,45-47] Cross-sectional studies note an

Table 3. **Net changes in blood pressure in response to exercise**

BLOOD PRESSURE (MM HG)	NO. OF STUDY GROUPS	NET CHANGE γ (95% CI*)
Overall	68	
• Systolic		-3.4 (-4.5 to -2.3)
• Diastolic		-2.4 (-3.2 to -1.6)
Normotensive	52	
• Systolic		-2.6 (-3.7 to -1.5)
• Diastolic		-1.8 (-2.6 to -1.1)
Hypertensive	16	
• Systolic		-7.4 (-10.5 to -4.3)
• Diastolic		-5.8 (-8.0 to -3.5)

Data from Fagard.[41]
CI—Confidence interval.
**Systolic pressure ≥140 mm Hg or diastolic pressure ≥90 mm Hg.*

inverse relationship between amount of physical activity (kJ·week^{-1}) and reduced risk of developing type 2 diabetes.[31,47] Mayer-Davis et al[48] reported a progressive stepwise increase in insulin sensitivity by quintiles of energy expenditure from lowest to highest quintile among middle-aged men and women with normal to mild type 2 diabetes. Evidence from clinical trials suggests that moderately intense activity improves glucose control, but the magnitude of improvement is generally modest. If an effect on glycosylated hemoglobin is obtained, the decrease is generally 0.5% to 1.0%.[49-51]

Hypercholesterolemia. Among the proposed mechanisms for regular physical activity's protective effect against CAD is a favourable effect on high-density lipoprotein cholesterol and a reduction in triglycerides.[4,6,7] Evidence supporting this relationship comes from cross-sectional and longitudinal epidemiologic studies as well as experimental exercise-training studies (category B).[52-58] Cross-sectional studies have consistently demonstrated what appears to be a positive dose response between amount of activity and plasma HDL cholesterol and an inverse association with triglyceride levels.[51-55]

Normalization of lipid profiles with activity seems to depend on amount of activity rather than intensity. Kokkinos and Fernhall[24] found a systematic stepwise increase in HDL cholesterol and a decrease in triglycerides with increasing energy expenditure. The exact quality and quantity of exertion required to increase HDL cholesterol is not well defined. Studies that have demonstrated an increase in HDL cholesterol employ exercise prescriptions involving moderate activity with an energy expenditure of >3350 to 4200 kJ·week^{-1}.[56]

Editor's key points

- Physical activity has been shown to reduce cardiovascular (CV) mortality, but how much exercise is required? Good evidence indicates an inverse linear dose-response between amount of physical activity and all-cause mortality and incidence and mortality of CV disease.
- The effective dose, which appears to be higher than that previously recommended, is about 4200 kJ·week^{-1}.
- This translates into moderate activity, such as brisk walking for 30 to 60 minutes daily most days of the week.

Points de repère du rédacteur

- Il a été démontré que l'activité physique réduisait la mortalité due aux maladies cardiovasculaires, mais faut-il en faire beaucoup? De bonnes données probantes font valoir une réaction linéaire inverse entre la quantité d'activité physique et le taux de mortalité toutes causes confondues ainsi que l'incidence de coronaropathies et de la mortalité afférente.
- La dose efficace, qui semble un peu plus élevée que celle recommandée antérieurement, se situe à environ 4 200 kilojoules par semaine[1].
- Ceci se traduit par une activité modérée comme une marche rapide de 30 à 60 minutes par jour presque tous les jours de la semaine.

Some evidence suggests that more vigorous activity leads to additional benefits.[53,54]

Obesity. In Canada, an estimated 35% of men and 27% of women can be considered obese (body mass index ≥27 kg/m^2).[59] There is evidence (category A) of a linear relationship between amount of physical activity and amount of weight lost in studies of ≤16 weeks' duration (when diet is controlled).[8,60,61] In trials lasting 24 weeks or more, however, the relationship has not been proven.[34,35] While regular activity is associated with reduction of abdominal and visceral fat and prevention of weight gain over time, there is insufficient evidence to determine a dose-response relationship.[61]

Limitations

Much of the research reviewed was cross-sectional or longitudinal studies rather than RCTs. These studies had diverse methods for measuring and categorizing physical activity. The few RCTs available were focused on North American and European subjects

with little regard for the effects of race, social class, or ethnicity on key outcome variables. We acknowledge that this paper did not examine the potential risks of engaging in activity. It is widely recognized that, with increasing intensity and amount of activity, there is greater risk of injury, and that intensity is the main contributor to exercise-induced medical complications.[8]

Conclusion

Current evidence indicates that the positive health effects of physical activity occur at a low threshold and require a minimum energy expenditure of only 4200 kJ•week^{-1}. This amount of activity is achievable through adherence to current recommendations from Health Canada that call for an accumulation of 30 to 60 minutes of moderate activity (eg, brisk walking) on most days of the week.

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