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# Health-enhancing physical activity and the prevention of chronic diseases – An epidemiological review

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## Summary

**Objectives:** To review the epidemiological evidence on the health-enhancing physical activity recommendation of the Centers for Disease Control and Prevention (CDC) and the American College for Sports Medicine (ACSM).

**Methods:** Review of papers written in English and German, issued after the release of the CDC/ACSM recommendation (i. e. after 1995), restricted to adults and to their physical health. Due to the large body of published data, no systematic review was performed. Instead, a representative cross-section of the published studies is presented.

**Results:** The international epidemiological evidence supports the CDC/ACSM recommendation as a reasonable public health message.

**Conclusions:** According to this recommendation, the daily accumulation of 30 minutes of physical activity of moderate intensity – independent of the context of physical activity (e. g. transport, leisure) – provides substantial benefits across a broad range of health outcomes for sedentary men and women. Nevertheless some controversial issues need further address.

**Keywords:** Health-enhancing physical activity – Epidemiology – Chronic diseases – Moderate intensity.

There is compelling evidence that physical activity (PA) enhances health (Marti & Hättich 1999; Jakes & Wareham 2003; Schlicht 2003; Dishman et al. 2004). However, only few studies examined the minimum effective dose of PA to prevent detrimental health effects (Haskell 1994). Older PA prescriptions from Sports Medicine recommend: „...a run of 5 km, according to your performance. It corresponds to 30 to 40 min

of jogging or brisk walking from 1 to 1½ hours to protect your heart” (Rost 1994 (translation by the authors)). From a public health point of view, this dose seems too vigorous. We have to consider that about 50 % of the adults in Germany and other European countries do not engage in any sports whatsoever and 30 % are hardly physically active (Mensink 2002). Consequently, some authors guess that PA recommendations which prescribe high volumes of PA are a barrier to the implementation of an active lifestyle (Troost et al. 2002).

Organisations like the American *Centers for Disease Control and Prevention* (CDC), the German *Robert Koch Institute* or the Swiss *Federal Office of Sports* as well as the *American College of Sports Medicine* recommend 30 min or more of moderately intense PA on all or most days of the week (Pate et al. 1995; Martin & Marti 1998; Mensink 2003). The particular purpose of the recommendation is to provide a minimal dose of PA which prevents diseases, premature death and promotes good health (Haskell 1994; ACSM 2000; Oja 2004). The term health-enhancing physical activity recommendation (HEPA) is most often used to refer to this topic (Oja 2004). The recommended amount of PA can be achieved by engaging in a variety of moderate intensity activities fitting best into daily life. Those activities include sports during leisure time, so-called lifestyle activities during housework and occupational periods, and commuting to and from workplace. In addition, it seems that already three active bouts of 8 to 10 min per day are sufficient to reduce health risks (Pate et al. 1995; Oja 2004).

Our narrative review is based on epidemiological data. It presents evidence-based information on the HEPA recommendation (Pate et al. 1995). The material presented in this review addresses the following three questions: Is it sufficient to accumulate 30 min of moderately intense PA per day? Is the health enhancing or risk reducing effect independent of the context of activity (commuting, leisure time, and housework).

Are there different effects depending on the activity dimensions (frequency, duration, intensity)?

## Methods

### *Independent variable (Exposure)*

The independent variable here is physical activity (PA). The term is used in accordance with international health research (Sallis & Owen 1999). PA comprises all types of muscular activity with a substantial increase of energy expenditure (Shephard 2003). In epidemiological research as well as in sports and exercise science, the type (e.g. aerobic, resistance training) and the context of PA (e.g. housework, transport, leisure time, occupation) are distinguished. Furthermore, PA is commonly defined using the three dimensions duration (e.g. minutes, hours), frequency (e.g. times per week) and intensity (Montoye et al. 1996). The intensity is most often expressed in absolute terms: Common are metabolic equivalents relative to a resting state (MET) (Ainsworth et al. 2000) or ratings of the stress provoked by a given load of work. The Borg Rating of Perceived Exertion Scale determines the subjective intensity (Borg 1998). The total amount of activity composes intensity, duration, and frequency. Total amount of PA or volume of PA is used interchangeably. Both are defined as the amount of energy realised in a given time frame (MET-hours/week, MET-min/week, kcal/week or kcal/kg body size/week) (Howley 2001; Samitz & Baron 2002).

### *Outcome variables*

Risk parameters of mortality and morbidity (main emphasis on all-cause mortality and incidence of Cardiovascular Disease (CVD) are used as the main outcome variables here. For large-scale epidemiological studies lacking specific endpoints we also consider information on surrogate parameters (e.g. VO<sub>2</sub> max).

### *Identifying source material*

We have used PubMed to identify peer-reviewed literature and searched studies by reviewing reference-lists of pertinent articles. Our search is limited: (1) We review papers published in English and German language. (2) We look for those articles published after the proclamation of the HEPA recommendation (Pate et al. 1995). (3) We restrict our review to adults and to their physical health. Due to the large body of published data no systematic review was performed. We present a representative cross-section of the published studies and of information. A selection bias may not to be excluded.

### *Assessment of evidence*

To assess the evidence of the study results, we review solely prospective cohort studies. With regard to evidence based medicine (EBM), the formal level of evidence corresponds to level 2b (Oxford Centre for evidence based-medicine). Concerning the dose-response symposium 2001 (Bouchard 2001), the quality of evidence is category C. Some information on the internal quality of the studies can be obtained from Tables 1–5. They include information on the measurement procedure of PA, the sample (including inclusion/exclusion criteria), the design and the outcome (including length of follow-up), the main findings of each study and a comment (including the adjustment for confounding).

To underline our public health perspective, we are mainly interested in large-scale observational studies. We know that observational studies are often affected by bias and confounding. This makes the interpretation of an association of PA and disease more complicated.

In some sections we refer to randomised controlled studies and to cross-sectional studies to underpin our rationale for specific conclusions. Surveys are justified to generate hypotheses. Based on this type of studies it is not allowed to determine a temporal sequence of cause and effect. Experimental studies recruit only small samples and focus most often on surrogate parameters. They are important to understand the underlying mechanisms of the covariation of health endpoints and PA (mediator variables).

## Review

### *Rationale of the recommendation*

The HEPA recommendation (Pate et al. 1995) postulates a curvilinear dose-response relationship between the volume of PA and health outcomes. This assumption is supported for all-cause and CVD mortality (Haskell 1994; Blair & Connelly 1996; Oja 2001; Bauman 2004), for men and for women alike (e.g. Mensink et al. 1996; Villeneuve et al. 1998; Weller & Corey 1998; Andersen et al. 2000).

Low and moderate intensity activities often result in a low volume of PA (e.g. gardening, household chores, walking). Only a minority – particularly young and middle aged men – engages in vigorous intensity activities (see Sallis & Owen 1999). Higher intensities of PA may provoke a significant risk of detrimental events and harms (e.g. sudden cardiac death; see Dickhuth & Schlicht 1997). Light to moderate intensity activities are therefore more recommendable than vigorously intense PA (Bassuk & Manson 2003).

The HEPA recommendation refers to the volume of PA but not to its different dimensions (e.g. intensity, duration, fre-

quency) of PA (Oja 2004). To underpin the evidence-base of the health enhancing effect on all-cause and CVD mortality it is useful to have a glance on selected studies examining the specific dimensions of PA. For this we summarise crucial issues with regard to the intensity, duration and accumulation.

#### *The intensity of PA*

Experimental trials show a lower risk of cardiovascular risk factors with both low and moderate intensity PA (Haskell 1994; Blair & Connelly 1996; Shephard 1997; Bassuk & Manson 2003; Oja 2004). Studies on walking – as the most frequently performed leisure time PA – confirm these findings (Morris & Hardman 1997; Asikainen et al. 2002a).

In epidemiological studies there are conflicting findings in regard to mortality (Table 1). Analyses of the Harvard Alumni Health Study only observe a substantial risk reduction with vigorous intense PA, a small effect of moderate intense PA and no influence of low intense PA (Lee & Paffenbarger 2000). The Caerphilly Study affirms these results (Yu et al. 2003) and also the British Civil Servants-Studies give partial support for these findings (Morris 1996).

Other studies find a risk reduction for mortality only with moderate intensity PA (Leon et al. 1997; Villeneuve et al. 1998). Detailed analyses of the Harvard Alumni Health Study show an inverse association of perceived exertion and coronary heart disease (CHD). This applies also to those men who did not achieve an energy expenditure of 1 000 kcal per week or those who performed activities with less than 3 METs (Lee et al. 2003). The protective effect of regular walking as well as the risk reduction of climbing stairs should be highlighted here (Morris et al. 1990; Lee & Paffenbarger 2000).

Some recently published studies emphasise a reduced risk on different outcomes for low and moderate intensity PA. In the Women Health Study (Lee et al. 2001) regular walking reduces risk of CHD among women who practice no vigorous activities. In several female cohorts the incidence of type 2 diabetes, CHD and CVD occurrences is reduced in a comparable amount for both moderately and vigorously intense PA (Hu et al. 1999; Manson et al. 1999; Manson et al. 2002). The Health Professionals Follow-up Study pointed out that brisk walking is associated with a risk reduction for those men who performed less than one hour per week of vigorously intense PA. The averaged intensity lowers the CHD risk. This is independent on the total volume and true for moderately intense activities and it grows even more substantial for those of vigorous intensity (Tanasescu et al. 2002).

Some findings indicate that the covariance between health endpoints und PA is moderated by age and sex (Morris 1996; Bucksch 2005). Cross sectional findings of the German Cardiovascular Prevention Study reveal that even light intensity

PA is related significantly to a favourable lower cardiovascular risk profile at older age (Mensink et al. 1999).

#### *The Duration of PA*

In Table 2 we review epidemiological studies examining the effect of load duration. In a study of the first author, total duration of less than one hour of sports activities per week decreased the risk of mortality. In females the risk ratio for 1 to 2 h per week is 0.69 (95 %-CI: 0.48–0.98). In men the corresponding risk ratio is 0.64 (95 %-CI: 0.50–0.82) (Bucksch & Helmert 2004). Mensink et al. (1996) report a more substantial risk reduction. A comparable result is revealed in the MONICA-site Augsburg (Klein et al. 2001). In addition, own data show that the risk of premature death is reduced by practising moderately intense PA 2.5 h per week in leisure time. But this was only observed for the female sample (Bucksch 2005).

Additional and important information are found by international authors. The meta-analysis of Oguma & Shinoda-Tagawa (2004) shows a risk reducing effect for the incidence of CVD-occurrences walking one hour per week (yet less than one hour per week). In the Women's Health Study, the duration of a walking-unit has a more pronounced effect than the intensity (in terms of walking pace). There is a risk reducing effect of 14 % for CVD at up to 60 min per week of PA. One to one and a half hour per week bisects the risk (Lee et al. 2001).

In the well known Nurses' Health Study, Hu et al. (1999) find a dose-response relationship for several endpoints and the duration of walking-units. The Health Professional Follow-Up Study reveals a protective influence on the incidence of CHD with a half hour walk (0.82; 95 % CI: 0.67–1.00). Similar to the study of Hu et al. (1999), the intensity (walking pace) seems to be more important than the duration of the PA-units (Tanasescu et al. 2002).

In the Women's Health Initiative Study the duration of 1.25 to 2.5 h per week of brisk walking yields an 18 % risk reduction on breast cancer (0.82; 95 % CI: 0.68–0.97). The risk of CVD occurrences is already reduced by the duration of one hour of walking. A longer total duration is associated with additional effects (Manson et al. 2002; McTiernan et al. 2003). Commuting to and from work reduces the risk of (type 2) diabetes in a Finnish cohort study. The effect is most pronounced for at least 30 min walking or cycling per day (Hu et al. 2003b).

#### *Frequency and accumulation of PA*

There are only a few epidemiological findings which can be cited for the direct effect of intermittent PA and the frequency of PA (see Table 3). Some authors argue that in many observational studies – offering health gains – activity has been performed at least partly in an intermittent manner (e.g.

Table 1 Overview of epidemiological studies (effect of intensity)

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Bucksch & Helmert 2004 (Germany)	Questionnaire: average duration per week of 15 sports activities over the previous three months (MET-hours per week), a combined frequency-duration question on doing sports	3742 men and 3445 women aged 30–69 years	Prospective cohort (Life expectancy survey); Within the 14-year follow-up 300 female and 643 male death (all causes) occurred	Volume of sports activities no: 1.00 low: 0.92 (0.70–1.23) moderate: 0.89 (0.69–1.17) high level: 0.61 (0.44–0.84) p for trend <.01	Adjustment: age, smoking, diet, alcohol use, social class, BMI, cardiovascular risk factor-index, chronic disease-index
Bucksch 2005 (Germany)	Questionnaire: average duration per week of 18 leisure time activities over the previous three months (including cycling, walking, gardening)	3742 men and 3445 women aged 30 and 69 years	Prospective cohort (Life expectancy survey); Within the 14-year follow-up 300 female and 643 male death (all causes) occurred	Volume of cycling, walking and gardening No: 1.00 Low: 0.98 (0.76–1.17) Moderate: 0.80 (0.63–1.00) High level: 0.91 (0.74–1.13) p for trend = .20 p for trend <.001	Adjustment: age, smoking, diet, alcohol use, social class, BMI, cardiovascular risk factor-index, chronic disease-index, volume of sports activities  Risk estimates for those persons which performed no sports activities were similar
Hu et al. 1999 (USA)	Questionnaire: Average duration per week of walking and 7 further common PA. The usual walking pace was separately collected	70 102 women aged 40–65 years free of type 2 diabetes, cancer, and CVD	Prospective cohort (Nurses' Health Study); within the 8-year Follow-up 1419 Diabetes (type 2) cases occurred	Walking for women who did not perform vigorous-intense PA Quintile 1 (<0.5 MET-h/week): 1.00 Quintile 2 (0.6–2.0): 0.95 (0.79–1.15) Quintile 3 (2.1–3.8): 0.80 (0.65–0.99) Quintile 4 (3.9–9.9): 0.81 (0.66–1.01) Quintile 5 (>=10): 0.74 (0.59–0.93) p for trend = .01 Usual walking pace: <3.2 km/h: 3.2–4.8: >4.8:	Adjustment: age, time period, cigarette smoking, menopausal status, parental history of diabetes, alcohol consumption, history of hypertension, and history of high cholesterol level, BMI; additional adjustment of the duration per week of walking for the analysis on walking pace  Equivalent energy expenditure (MET-h/week) from walking and vigorous activity resulted in comparable magnitudes of risk reduction; an increase of 5 MET-h/week: 0.92 (0.88–0.95) for walking and 0.95 (0.92–0.98) for vigorously intense PA
Lee & Paffenbarger 2000 (USA)	Questionnaire: Leisure PA energy expenditure (blocks walked daily, number of flights of stairs climbed daily, a list of up to five sports or recreational activities);	13 485 men (mean age 57.5 years) free of CVD, COPD and cancer	Prospective cohort (Harvard Alumni Health Study); during the 15-year follow-up 2 539 deaths were documented (all causes)	Walking (km/week) <5: 5–<10: 10–<20: >=20: p for trend: .004	Adjustment: age, BMI, cigarette smoking, alcohol consumption, early (<65 years) parental death, and each component of PA

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
				<p>Climbing stairs (storey/week)</p> <p>&lt;10: 1.00 0.89 (0.80–1.00) 0.89 (0.79–0.99) 0.82 (0.74–0.91) p for trend: .001</p> <p>Low intense PA: &lt;630 kJ/week 630–&lt;1 680 kJ/week: 0.91 (0.74–1.12) 680–&lt;3 150 kJ/week: 0.93 (0.71–1.22) 3 150–&lt;6 300 kJ/week: 1.07 (0.79–1.46) &gt;=6 300 kJ/week: 1.17 (0.83–0.64) p for trend: .72</p> <p>Moderate intense PA: &lt;630 kJ/week: 1.00 1.05 (0.90–1.23) 630–&lt;1 680 kJ/week: 0.89 (0.75–1.05) 1 680–&lt;3 150 kJ/week: 0.82 (0.70–0.96) &gt;=3 150 kJ/week: 0.97 (0.85–1.10) p for trend: .07</p> <p>Vigorous intense PA: &lt;630 kJ/week: 1.00 0.89 (0.77–1.02) 630–&lt;1 680 kJ/week: 0.82 (0.70–0.96) 1 680–&lt;3 150 kJ/week: 0.82 (0.71–0.96) &gt;=3 150 kJ/week: 0.77 (0.67–0.89) p for trend &lt;.001</p>	
Lee et al. 2001 (USA/ Puerto Rico)	Questionnaire: average time on 8 groups of recreational activities during the past year; the usual pace of walking and the number of flights of stairs were collected separately	39 372 women >=45 years free of self-reported CHD, cerebrovascular diseases and cancer (other than nonmelanoma skin cancer)	Prospective cohort (Women's Health Study); during the mean 5-year follow-up 244 CHD cases occurred	<p>Women who reported no vigorous recreational activities (n = 22 865)</p> <p>No regular walking: 1–59 min/week: 1–1.5 h/week: &gt;=2 h/week: p for trend &lt;.001</p>	Adjustment: age, randomised treatment assignment, smoking status, consumption of alcohol, saturated fat, fibre, and fruits and vegetables, menopausal status, use of postmenopausal hormones, and parental history of myocardial infarction at <60 years of age

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Lee et al. 2003 (USA)	Questionnaire: Leisure PA energy expenditure (blocks walked daily, number of flights of stairs climbed daily, a list of up to five sports or recreational activities); the perceived exertion as a proxy for relative intensity was additionally measured (BORG-Scale)	7337 men (mean age 66); free of CVD, diabetes and cancer	Prospective cohort (Harvard Alumni Health Study); during 8-year follow-up 551 cases of CHD occurred	<p>Total energy expenditure: &lt;1 000 kcal/week: 1.00 1000–2499: 0.87 (0.70–1.08) &gt;=2500: 0.92 (0.75–1.14) p for trend: .29</p> <p>Absolute intensity of the most intense sports or recreational activity &lt;3 METs: 1.00 3–6: 1.07 (0.87–1.32) &gt;6: 0.89 (0.69–1.15) p for trend = .44</p> <p>Relative intensity of the most intense sports or recreational activity: Nothing to weak: 1.00 Moderate: 0.86 (0.66–1.13) Somewhat strong: 0.69 (0.51–0.94) Strong to maximal: 0.72 (0.52–1.00) p for trend = .02</p> <p>Relative intensity (see above) for a total energy expenditure &lt;1 000 kcal/week Nothing to weak: 1.00 Moderate: 0.76 (0.54–1.06) Somewhat strong: 0.51 (0.32–0.82) Strong to maximal: 0.62 (0.34–1.09) p for trend: .009</p> <p>Relative intensity (see above) for a total energy expenditure &gt;=1 000 kcal/week Nothing to weak: 1.00 Moderate: 1.12 (0.63–1.99) Somewhat strong: 0.93 (0.52–1.68) Strong to maximal: 0.85 (0.47–1.54) p for trend = .06</p> <p>Relative intensity (see above) for a total energy expenditure &gt;=1 000 kcal/week Nothing to weak: 1.00 Moderate: 0.74 (0.52–1.04) Somewhat strong: 0.53 (0.31–0.89) Strong to maximal: 0.41 (0.19–0.88) p for trend = .002</p>	<p>Adjustment: age, cigarette smoking, intake of alcohol, red meat, and vegetables, early parental mortality; BMI, history of hypertension, history of high cholesterol, and history of diabetes mellitus</p> <p>Adjustment: age, cigarette smoking, intake of alcohol, red meat, and vegetables, early parental mortality; BMI, history of hypertension, history of high cholesterol, and history of diabetes mellitus Further adjustment of the total energy expenditure did not alter the risk estimates</p> <p>Adjustment: age, cigarette smoking, intake of alcohol, red meat, and vegetables, early parental mortality; BMI, history of hypertension, history of high cholesterol, and history of diabetes mellitus Further adjustment of the total energy expenditure did not alter the risk estimates</p> <p>Adjustment: age, cigarette smoking, intake of alcohol, red meat, and vegetables, early parental mortality</p>

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Leon et al. 1997 (USA)	Questionnaire: a wide range of leisure time PA; the number of occasions per month and the average duration over the previous 12 months were collected	12138 men aged 35–57 with high CVD-risk	Prospective cohort (Multiple Risk Factor Intervention Trial); during 16-year Follow-up 1904 death occurred (all causes)	<p>Relative intensity (see above) for at least moderate absolute intensity</p> <p>Nothing to weak: 1.00</p> <p>Moderate: 1.09 (0.63–1.89)</p> <p>Somewhat strong: 0.87 (0.49–1.53)</p> <p>Strong to maximal: 0.87 (0.49–1.54)</p> <p>p for trend = .09</p> <p>Relative intensity (see above) for no moderate absolute intensity</p> <p>Nothing to weak: 1.00</p> <p>Moderate: 0.74 (0.52–1.04)</p> <p>Somewhat strong: 0.53 (0.31–0.89)</p> <p>Strong to maximal: 0.41 (0.19–0.88)</p> <p>p for trend = .09</p>	<p>Adjustment: age, intervention group, years of education, number of cigarettes per day, serum cholesterol, diastolic blood pressure, BMI</p> <p>Those people which were in deciles 2–4 performed mainly leisure time PA of low and moderate intensity</p>
Manson et al. 1999 (USA)	Questionnaire: average amount of time spent per week during the previous year in different recreational activities; in addition average number of flights of stairs they climbed each week and the usual walking pace was collected	72 488 women aged 40–65 free of diagnosed CVD and cancer	Prospective cohort (Nurses' Health Study); during 8-year follow-up 645 newly diagnosed cases of CVD were documented	<p>Deciles (minutes per day)</p> <p>1 (0–9): 1.00</p> <p>2–4 (10–36): 0.85 (0.73–0.99)</p> <p>5–7 (37–75): 0.87 (0.75–1.02)</p> <p>8–10 (76–359): 0.83 (0.71–0.97)</p> <p>Energy expenditure of vigorous exercise for those women which only required a low level of walking Met-h/week (0–0.6)</p> <p>0–0.6 MET-h/week: 1.00</p> <p>0.7–6.9: 0.78 (0.55–1.09)</p> <p>&gt;=7.0: 0.76 (0.49–1.17)</p> <p>Energy expenditure of walking for those women which only required a low level of vigorous exercise Met-h/week (0–0.6)</p> <p>0–0.6: 1.00</p> <p>0.7–6.9: 0.84 (0.67–1.06)</p> <p>&gt;=7.0: 0.74 (0.57–0.97)</p>	<p>Adjustment: age, period during the study, smoking status; BMI, menopausal status, parental history with respect to myocardial infarction before the age of 60 years, multivitamin-supplement use, vitamin E supplement use, alcohol consumption, history of hypertension, history of diabetes, history of hypercholesterolemia, and aspirin use.</p>

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Manson et al. 2002 (USA)	Questionnaire: recreational PA was in detail assessed on the frequency and the duration of walking and several other types of activity (strenuous, moderate, mild); in addition the pace of walking and the number of hours per day spending in sedentary behaviour were collected	73 743 postmenopausal women aged 50–79 years free of diagnosed CVD and cancer	Prospective cohort (Women's Health Initiative Observational Study); during a mean 5.9-year follow-up 1551 newly diagnosed cases of CVD were documented	<p>Quintile of energy expenditure of walking: 0 MET-h/week: 1.00 0.1–2.5: 0.91 (0.78–1.07) 2.6–5.0: 0.82 (0.69–0.97) 5.1–10.0: 0.75 (0.63–0.89) &gt;10: 0.68 (0.56–0.82) p for trend &lt;.001</p> <p>Quintile of energy expenditure of vigorous exercise Q 1 (lowest): 1.00 Q 2: 0.91 (0.72–1.04) Q 3: 0.81 (0.63–1.06) Q 4: 0.85 (0.64–1.13) Q 5: 0.76 (0.58–1.00) p for trend = .01</p>	<p>Adjustment: age, smoking status, race or ethnic group, level of education, family income, BMI, waist-to-hip ratio, level of alcohol intake, parental history of premature myocardial infarction, age at menopause, use or non-use of hormone-replacement therapy, percentage of calories from saturated fat, number of servings of fruit and vegetables per day, and dietary fibre intake</p> <p>The risk estimated remained unchanged after simultaneously inclusion of walking and vigorous exercise in one model</p> <p>The RR of CVD was 1.68 (1.07–2.64) among women who spent at least 16 h per day sitting with the reference of those who spent less than 4 h per day</p>
Morris et al. 1990; Morris 1996 (UK)	Questionnaire: Leisure time during the previous 4 weeks	9376 men aged 45–64 years free of known coronary disease	Prospective cohort (British Civil Servants); during mean 9-year follow-up 474 myocardial infarction occurred	<p>Episodes in previous 4 weeks Vigorous sports Incidence per 1 000 person years: 0 (episodes) 1–3 4–7 at least 8 p for trend &lt;.0005</p> <p>Non vigorous sports Incidence per 1000 person years: 0 (episodes) 1–3 7–7 11–11 &gt;=12 p for trend &gt;.05</p>	<p>Adjustment: age According to non-vigorous sports: Results were similar when men also reporting vigorous sports are excluded; age-specific analyses show that moderately intense PA lowers only the risk of coronary events in the 55–64 aged men</p>

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Tanasescu et al. 2002 (USA)	Questionnaire: Leisure time was assessed every 2 years between 1986 and 1996; the average time per week spent in leisure activities was collected; in addition walking pace was recorded	44452 men aged 40–75 years free of CVD and cancer other than nonmelanoma skin cancer	Prospective cohort (Health Professionals' Follow-up Study); follow-up at 2-year intervals from 1986 through; 1700 new cases of CVD were identified	Average exercise intensity: low (1–3 METs): 1.00 moderate (4–5.9 METs): 0.94 (0.83–1.04) high (>=6 METs): 0.83 (0.74–0.97) p for trend = .02	Adjustment: age, alcohol consumption, smoking, family history of myocardial infarction, nutrient intake, presence of diabetes, high cholesterol levels, hypertension at baseline, BMI, physical activity volume in MET-hours per week and intensity in METs included in same model
				Walking among men who did not perform vigorous exercise regularly (i.e., <=1 h/week): lowest Quintile (0–1.19): 1.00 1.20–3.49: 1.00 (0.83–1.21) 3.50–6.99: 0.90 (0.74–1.10) 7.00–14.74: 1.02 (0.84–1.23) >=14.75 MET-h/week): 0.82 (0.67–1.00) p for trend = .04	Adjustment: age, alcohol consumption, smoking, family history of myocardial infarction, nutrient intake, presence of diabetes, high cholesterol levels, hypertension at baseline
Villeneuve et al. 1998 (Canada)	Questionnaire: a comprehensive list of PA including household chores and leisure time activities was provided; the number of occasions per month and the average duration in minutes during the previous 12 months were collected	6246 men and 8196 women aged 20–69 years free of self reported CVD	Prospective cohort (Canada Fitness Survey); a total of 1116 deaths [all-causes] (614 men and 502 women) were observed during the 7-year Follow-up	Average daily energy spent on non-vigorous leisure activities (<6 MET) in men per week: 1.00 0.81 (0.59–1.17) 0.70 (0.44–1.13) 1.5 to <3: 0.82 (0.53–1.27) >=3: Average daily energy spent on non-vigorous leisure activities (<6 MET) in women 1.00 0.97 (0.69–1.36) 0.87 (0.57–1.33) >=3: 0.72 (0.43–1.21)	Adjustment: age and smoking status

Table 1 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Yu et al. 2003 (Wales)	Trained interviewers asked subjects about the type and duration of their leisure activities during the previous 12 months; the job-related activity was collected with an own questionnaire	1975 men aged 49–64 years without historical or clinical evidence of CHD at baseline	Prospective cohort; during 11-year follow-up 252 deaths were recorded (all-causes); deaths resulting from congenital anomalies or injury and poisoning were censored for analyses of all-cause mortality (3% of all deaths)	Total activity during leisure time 0.0–161.6 kcal/day: 1.00 161.8–395.3: 0.79 (0.58–1.08) 395.5–2747.2: 0.76 (0.56–1.04) p for trend = .083	Adjustment: age, diastolic blood pressure, BMI, smoking status, social class, family history of CHD among first degree relatives before age 55, history of diabetes mellitus in the past 5 years, job PA class RRs of CHD- and CVD-mortality tend towards the same direction
				Job PA lowest Quartile: 1.00 second: 1.38 (0.95–2.00) third: 1.38 (0.93–2.03) highest: 1.10 (0.73–1.64) p for trend = .71	Adjustment: see above as well as employment status and total leisure activity RRs of CHD- and CVD-mortality tend towards the same direction
				Energy expenditure of combined light and moderate activity during leisure 0.0–133.0 kcal/day: 1.00 133.0–342.6: 0.95 (0.69–1.31) 342.7–2743.23: 1.04 (0.76–1.43) p for trend < .798	Adjustment: see above as well as heavy intensity activity RRs of CHD- and CVD-mortality tend towards the same direction
				Energy expenditure of heavy intensity activity during leisure 0.0–161.6 kcal/day: 1.00 161.8–395.3: 0.87 (0.65–1.17) 395.5–2747.2: 0.61 (0.43–0.86) p for trend < .006	Adjustment: see above as well as combined light and moderate intensity activity RRs of CHD- and CVD-mortality tend towards the same direction

**Table 2** Overview of epidemiological studies (effect of both frequency and intermittent PA)

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Bucksch & Helmert 2004 (Germany)	Questionnaire: average duration per week of 15 sports activities over the previous three months (MET-hours per week), a combined frequency-duration question on doing sports	3742 men and 3445 women aged 30–69 years	Prospective cohort (Life expectancy survey); Within the 14-year follow-up 300 female and 643 male death (all causes) occurred	Frequency/duration of doing sports Men Women No sport: 1.00 <1 h/week: 0.85 (0.78–0.93) 1–2 h/week: 0.64 (0.50–0.82) >2 h/week: 0.70 (0.54–0.91) p for trend <0.001 p for trend <0.01	Adjustment: age, smoking, diet, alcohol use, social class, BMI, cardiovascular risk factor-index, chronic disease-index
Bucksch 2005 (Germany)	Questionnaire: average duration per week of 18 leisure time activities over the previous three months (including cycling, walking, gardening)	3742 men and 3445 women aged 30 and 69 years	Prospective cohort (Life expectancy survey); Within the 14-year follow-up 300 female and 643 male death (all causes) occurred	At least 2.5 h/week of PA of <6 METs compared to less than 2.5 h/week Men: 0.90 (0.77–1.01) Women: 0.65 (0.51–0.82)	Adjustment: age, smoking, diet, alcohol use, social class, BMI, cardiovascular risk factor-index, chronic disease-index, vigorous PA  Risk estimates for those persons which did perform no PA of ≥6 METs, were similar;
Hu et al. 1999 (USA)	Questionnaire: Average duration per week of walking and 7 further common PA. The usual walking pace was separately collected	70 102 women aged 40–65 years free of type 2 diabetes, cancer, and CVD	Prospective cohort (Nurses' Health Study); within the 8-year Follow-up 1419 Diabetes (type 2) cases occurred	Walking for women who did not perform vigorous-intense PA Quintile 1 (<0.5 MET-h/week): 1.00 Quintile 2 (0.6–2.0): 0.95 (0.79–1.15) Quintile 3 (2.1–3.8): 0.80 (0.65–0.99) Quintile 4 (3.9–9.9): 0.81 (0.66–1.01) Quintile 5 (≥10): 0.74 (0.59–0.93) p for trend = .01	Adjustment: age, time period, cigarette smoking, menopausal status, parental history of diabetes, alcohol consumption, history of hypertension, and history of high cholesterol level, BMI; additional adjustment of the duration per week of walking for the analysis on walking pace  Equivalent energy expenditure (MET-h/week) from walking and vigorous activity resulted in comparable magnitudes of risk reduction; an increase of 5 MET-h/week: 0.92 (0.88–0.95) for walking and 0.95 (0.92–0.98) for vigorously intense PA
Hu et al. 2003b (Finland)	Questionnaire: occupational, leisure time PA, walking and cycling to work (occupational PA is categorized on intensity levels and transport PA referred to the duration	7 392 women and 6898 men aged 35–64 years free of diabetes (type 2), stroke and CHD	Prospective cohort; during the a mean 12-year follow-up 200 male and 173 female case of diabetes mellitus occurred	Walking or cycling to and from work Men Women 0 min/day: 1.00 1–29: 1.00 (0.71–1.42) >=30: 0.75 (0.46–1.23) p for trend = .501	Adjustment: age, study year, systolic blood pressure, smoking status, education, other two physical activities and BMI  Occupational and leisure time PA lowers also the risk
Klein et al. 2001 (Germany)	Combined frequency-duration question on doing sports for the winter term	4233 men aged 25–74	Prospective cohort (MONICA-Augsburg); Follow-up from 1984–1998; 439 death were recorded (all causes);	no sport: 1.00 <1 h/week: 0.88 (n.s.) 1–2 h/week: 0.77 (n.s.) >2 h/week: 0.74 (significant)	Adjustment: alcohol use, years of education, smoking, BMI, regular health examinations, blood pressure, total cholesterol, HDL-cholesterol, heart rate; self-rated health

Table 2 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Lee et al. 2001 (USA/ Puerto Rico)	Questionnaire: average time on 8 groups of recreational activities during the past year; The usual pace of walking and the number of flights of stairs were collected separately	39 372 women >=45 years free of self-reported CHD, cerebrovascular diseases and cancer (other than nonmelanoma skin cancer)	Prospective cohort (Women's Health Study); during the mean 5-year follow-up 244 CHD cases occurred	Women who reported no vigorous recreational activities (n = 22 865) No regular walking: 1–59 min/week: 1–1.5 h/week: >=2 h/week: p for trend < .001	Adjustment: age, randomised treatment assignment, smoking status, consumption of alcohol, saturated fat, fibre, and fruits and vegetables, menopausal status, use of postmenopausal hormones, and parental history of myocardial infarction at <60 years of age
Manson et al. 2002 (USA)	Questionnaire: recreational PA was in detail assessed on the frequency and the duration of walking and several other types of activity (strenuous, moderate, mild); in addition the pace of walking and the number of hours per day spending in sedentary behaviour were collected	73 743 postmenopausal women aged 50–79 years free of diagnosed CVD and cancer	Prospective cohort (Women's Health Initiative Observational Study); during a mean 5.9-year follow-up 1551 newly diagnosed cases of CVD were documented	Quintile of energy expenditure of vigorous exercise Q (lowest): Q 2: Q 3: Q 4: Q 5: p for trend = .01	Adjustment: age, smoking status, race or ethnic group, level of education, family income, BMI, waist-to-hip ratio, level of alcohol intake, parental history of premature myocardial infarction, age at menopause, use or non-use of hormone-replacement therapy, percentage of calories from saturated fat, number of servings of fruit and vegetables per day, and dietary fibre intake  The risk estimated remained unchanged after simultaneously inclusion of walking and vigorous exercise in one model
Mensink et al. 1996 (Germany)	Questionnaire: combined frequency-duration question on doing sports	1061 men and 1212 women aged 40–69 years	Prospective cohort; 5–8 years of follow-up; 110 deaths (all causes) occurred	no sport: 1.00 <1 h/week: 0.49 (0.26–0.95) 1–2 h/week: 0.57 (0.30–1.09) >2 h/week: 0.36 (0.16–0.79)	Adjustment: age, systolic blood pressure, total serum cholesterol, BMI, smoking
Tanasescu et al. 2002 (USA)	Questionnaire: Leisure time was assessed every 2 years between 1986 and 1996; the average time per week spent in leisure activities was collected; in addition walking pace was recorded	44 452 men aged 40–75 years free of CVD and cancer other than nonmelanoma skin cancer	Prospective cohort (Health Professionals' Follow-up Study); follow-up at 2-year intervals from 1986 through; 1700 new cases of CVD were identified	Walking among men who did not perform vigorous exercise regularly (i.e., <=1 h/week): Lowest Quintile (0–1.19): 1.20–3.49: 3.50–6.99: 7.00–14.74: >=14.75 MET-h/week): p for trend = .04  14.75 MET-h/week approximately 3.5 h/week or a half a hour per week of brisk walking	Adjustment: age, alcohol consumption, smoking, family history of myocardial infarction, nutrient intake, presence of diabetes, high cholesterol levels, hypertension at baseline  Adjustment for walking volume in MET-hours per week and walking pace in the same model: the RRs for walking pace remain unchanged; for the volume of walking the RRs are attenuated Adjustment: age, country, employment status, tobacco and alcohol consumption, educational level and BMI

**Table 3** Overview of epidemiological studies (effect of both frequency and intermittent PA)

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Lee et al. 2000 (USA)	Questionnaire: Leisure PA energy expenditure (blocks walked daily, number of flights of stairs climbed daily, a list of up to five sports or recreational activities); average time spent on each episode of every sport or recreational activity: 1–15; 16–30; 31–45; 46–60; >60min	7307 men (mean age 66.1 years) free of CVD and cancer	Prospective cohort (Harvard Alumni Health Study); during the 5-year follow-up 482 cases of CVD occurred	No leisure time PA: 1–15 min: 16–30 min: 31–45 min: 46–60 min: >60 min: p for trend = 0.68  <4200 kJ/week: 4200–8399 kJ/week: 8400–12 599 kJ/week: 12 600–16 799 kJ/week: >=16 800 kJ/week: p for trend = 0.09	Adjustment: age and total energy expenditure      Adjustment: age and duration per exercise episode
Lee et al. 2004 (USA)	Questionnaire: Leisure PA energy expenditure (blocks walked daily, number of flights of stairs climbed daily, a list of up to five sports or recreational activities);	8421 men (mean age 66) free of CVD, diabetes and cancer	Prospective cohort (Harvard Alumni Health Study); during 9-year follow-up 1 234 death occurred (all causes)	<500 kJ/week (sedentary) 500–999 kJ/week (insufficiently): >=1 000 kJ/week: (Weekend warrior: energy expended by participation in sports/recreation 1–2 times/week) >=1 000 kJ/week:	Adjustment: age
Sundquist et al. 2004 (Sweden)	Questionnaire: Frequency of leisure time PA	1792 women and 1414 men >=65 years	Prospective cohort; during 12-year follow-up 925 female and 881 male deaths (all causes) occurred	None: Occasionally: Once a week: Twice a week: Vigorously at least twice a week:	Adjustment: gender, age, education, smoking habits, BMI, diabetes, hypertension, self-rated health

walking, climbing stairs, gardening, repair work) (Hardman 1999).

The effect of short versus long bouts of PA was examined in the Harvard Alumni Study. The duration of single bouts is inversely associated with CHD. Bouts of 15, 30 or 45 min cause comparable risk reductions. An independent effect for the duration exhales due to the adjustment of total volume of PA. The other way round the effect of total volume remained unchanged. These findings emphasise the similar influence of intermittent and continuous bouts of PA (Lee et al. 2000).

In contrast to the popular opinion it seems not necessary to perform continuous bouts lasting 20 to 40 min to provoke physiological adaptation. Five to ten minutes might be sufficient. Reviews from Blair & Connelly (1996), Shephard (1997) or Hardman (1999) and Hardman (2001) and studies of walking (Asikainen et al. 2002b; Murphy et al. 2002; Osei-Tutu & Campagna 2005) came up with further evidence with regard to physiological functioning and fitness-related outcomes. Here, two randomised trials of accumulated daily stair climbing are remarkable (one ascent takes 2 min!). Over a 7-week period the cardio-respiratory fitness, the HDL-cholesterol, the total/HDL-cholesterol ratio was improved and the LDL-cholesterol was reduced (Boreham et al. 2000; 2005).

In a further analysis of the Harvard Alumni Study the authors were especially interested in the “Weekend Warriors”. Those persons achieve the recommended 1 000 kcal per week within one or two bouts of PA. They are compared to regularly physically active persons who achieve the recommended 1 000 kcal per week in more than two bouts of activity. With regard to all-cause mortality, regular physical activity seems to be more recommendable but men without risk factors (e. g. blood pressure, smoking) also benefit from the weekend-warrior pattern (Lee et al. 2004). Even an occasional practise of PA (less than one a week) in leisure time is shown to reduce the risk of all-cause-mortality in a Swedish cohort study with men and women aged 65 and older (Sundquist et al. 2004).

#### *The Context of PA*

A further characteristic of the health-enhancing PA recommendation emphasises that the context of PA does not matter. In a German sample, lifestyle (e. g. gardening, walking) as well as sports activities in leisure time reduce the risk for women. For men, the volume of sports activities seems to be more important than lifestyle activities (Bucksch & Helmert 2004; Bucksch 2005).

In the following paragraph we will take a closer look at housework and commuting to and from work.

#### *Housework*

In the baseline of the British Women’s Heart and Health Study,

heavy housework, in contrast to brisk walking and physical exercise, has no independent effect on cardio-respiratory fitness and obesity. For self-reported poor health status, coronary heart disease, and respiratory diseases, odds ratio is reduced for all types of activity and independent of age (Lawlor et al. 2002). The Work, Lipids and Fibrinogen (WOLF)-Study confirms these findings for men and women (Fransson et al. 2003). Other studies show a beneficial association between cardiovascular risk factors and housework as well as leisure time activities (Greendale et al. 1996, Ma et al. 2003). These findings are based on cross-sectional data.

Prospective cohort studies provide valuable information (Table 4). The Canada Fitness Survey provides detailed data for PA (including non-leisure activities) in a sample of 6620 women. These activities are responsible for 82 % (on average) of the total PA. The risk of all-cause and CVD mortality is reduced compared to the risk estimates of leisure-time PA only (Villeneuve et al. 1998; Weller & Corey 1998). These findings are confirmed in a Finnish male cohort with regard to all-cause and CVD mortality. The distinct association between PA and health outcome is evident when PA is precisely measured (including chores and activities of daily living). The lack of a significant association with a global one-item assessment might be due to the higher misclassification. Forestry work, gardening, and repair work during leisure time show protective effects on mortality (Haapanen et al. 1996). Two hours per day of standing or walking around at home (ambulation) is inversely associated with the risk of obesity and type 2-diabetes in the well known Nurses’ Health Study. This effect is neither moderated by the amount of PA nor by sedentary living habits or nutrition. But it is only a suggestion that ambulation reflects PA in household. Activities are not assessed precisely (e. g. by an accelerometer). Only a global question on the duration of standing and sitting around at home has been used in the study of Hu et al. (2003a).

#### *Commuting to work*

For the population at working-age, commuting to and from work might be an easy way to stay healthy (Oja et al. 1998). Commuting to and from work yields a relative risk of 0.72 (95 %-CI: 0.57–0.91) for all-cause mortality in a Danish cohort study (Andersen et al. 2000). The effect is adjusted for leisure time PA. A Japanese prospective cohort study shows an independent risk reduction for walking to work in regard to the incidence of hypertension (Hayashi et al. 1999). Commuting by bike or on foot reduces the risk of all-cause and CVD mortality without adjusting for other domains of PA in a recent Finnish cohort study (Hu et al. 2004). Further findings on diabetes find an inverse relationship of commuting independent of occupational and leisure time activities in healthy men

Table 4 Overview of epidemiological studies (effect of housework)

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Haapanen et al. 1996 (Finland)	Questionnaire: weekly frequency and average duration of activities of different domains (e.g. repair work, strenuous domestic chores, gardening, outdoor-activities, recreational forestry work, sports, conditioning activities, and commuting to work with seasonal weighting (volume of PA); additional weekly frequency of different types of PA.	1072 men aged 35–63 years	Prospective cohort; within the 10,6-year follow-up 168 death (all causes) and 63 death (CVD)	Leisure time forestry work (all-cause mortality) At least some monthly activity: 1.00 No activity: 2.98 (1.44–6.14)  Leisure time forestry work (CVD-mortality) At least some monthly activity: 1.00 No activity: 4.32 (1.34–13.91)  Repair work (all-cause mortality) Upper Third: 1.00 Middle Third: 1.52 (0.83–2.78) Lower Third: 2.30 (1.28–4.14) p for trend = .011  Repair work (CVD-mortality) Upper Third: 1.00 Middle Third: 1.08 (0.45–2.55) Lower Third: 2.49 (1.13–5.49) p for trend = .012	Adjustment: age, diseases or symptoms, marital, smoking, and employment status  There is an inverse dose-response association between both all-cause and CVD-mortality with total volume of PA
Hu et al. 2003a (USA)	Average weekly time spent: sitting at home while watching TV or VCR; sitting at work or away from home while driving at work, and other sitting at home; standing or walking around at home or at work; in addition see Hu et al. 1999	Diabetes-analysis: 68 497 Frauen aged 30–55 years free of Diabetes (type 2), cancer and CVD; Obesity-analysis: restricted to women with BMI >=30 (n = 50277)	Prospective cohort (Nurses' Health Study); during the 6-year follow-up 1 515 cases of diabetes (type 2) occurred and 3 757 women get a BMI of at least 30	Risks of developing obesity: (Hours standing or walking around at home per week) 0–1: 1.00 2–5: 0.99 (0.79–1.23) 6–20: 0.87 (0.70–1.08) 21–40: 0.78 (0.62–0.97) >40: 0.77 (0.61–0.96) p for trend<.001  Risks of developing type 2 diabetes: (Hours standing or walking around at home per week) 0–1: 1.00 2–5: 1.15 (0.81–1.62) 6–20: 1.05 (0.76–1.47) 21–40: 0.91 (0.64–1.27) >40: 0.86 (0.60–1.22) p for trend<.001	Adjustment: Age, smoking, alcohol consumption, dietary covariates, hormone use and metabolic equivalents; for the diabetes-analysis further adjustment for family history of diabetes  Percentage changes in risks of developing diabetes: Each 2 h/day increment in time spent standing or walking around at home: –12 % (7–16)
Weller & Corey 1998 (Canada)	See Villeneuve et al. 1998; the calculation of energy expenditure differed because all reported activities were used	6620 women aged >=30 years without known heart disease	Prospective cohort (Canada Fitness Survey); during 7-year follow-up 449 deaths (all causes) were documented	Energy expenditure (kcal per kg per day): leisure activities: Lowest quartile: 1.00 Second: 0.91 (0.66–1.25) Third: 0.94 (0.72–1.23) Highest: 0.89 (0.67–1.17)  Energy expenditure (kcal per kg per day): non-leisure activities: Lowest quartile: 1.00 Second: 0.66 (0.50–0.87) Third: 0.68 (0.51–0.89) Highest: 0.71 (0.50–0.87)	Adjustment: age Controlling for marital status, education level, income, self-reported health status and tobacco use did not alter the risk estimates

Table 5 Overview of epidemiological studies (effect of commuting to work)

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Andersen et al. 2000 (Denmark)	Questionnaire: leisure time, occupational PA, sports participation, and bicycling to work over the previous year	17 265 men and 13 375 women aged 20–93 years	3 pooled prospective cohort studies; within the 14-year (mean) follow-up 2 881 female and 5 668 male death (all causes) occurred	Leisure time PA: Sedentary: 1.00 Low: 0.68 (0.64–0.71); Moderate: 0.61 (0.57–0.66); high level: 0.53 (0.41–0.63)  Bicycling to work: 0.72 (0.57–0.91)	Adjustment: age und sex  Occupational PA only beneficial in women  Adjustment: leisure time PA, age, sex, educational level, BMI, blood lipid levels, blood pressure, smoking
Hayashi et al. 1999 (Japan)	Questionnaire on leisure time PA and duration of walking to work	6 017 Japanese men aged 35–60 years free of hypertension and (type 2) diabetes	Prospective cohort; with in the 16-year Follow-up 626 cases of hypertension occurred	Walking to work 0–10 11–20 >=21 min p for trend = 0.02 continuous variable (per 10 min): 0.88 (0.79–0.98)	Adjustment: age, BMI, alcohol consumption, leisure-time physical activity, smoking status, fasting plasma glucose level, systolic blood pressure, and diastolic blood pressure.
Hu et al. 2003b (Finland)	Questionnaire: occupational, leisure time PA, walking and cycling to work (occupational PA is categorized on intensity levels and transport PA referred to the duration	7 392 women and 6 898 men aged 35–64 years free of diabetes (type 2), stroke and CHD	Prospective cohort; during the a mean 12-year follow-up 200 male and 173 female case of diabetes mellitus occurred	Walking or cycling to and from work  Men 1 0 min/day: 1.00 (0.71–1.42) 1–29: 0.75 (0.46–1.23) >=30: P for trend = 0.501  Women 1 0.94 (0.63–1.43) 0.57 (0.34–0.96) P for trend = 0.105	Adjustment: age, study year, systolic blood pressure, smoking status, education, other two physical activities and BMI  Occupational and leisure time PA lowers also the risk
Hu et al. 2004 (Finland)	Questionnaire: occupational, leisure time PA, walking and cycling to work (occupational PA is categorized on intensity levels and transport PA referred to the duration	3 316 women and men aged 25–74 years with Diabetes (type 2)	Prospective cohort; During the mean 18.5 year Follow-up 903 deaths (CVD) were documented	Walking or cycling to work: 0 min/day: 1–29: >=30: p for trend = .002  0 min/day: 1–29: >=30: p for trend = .27	Adjustment: age, sex, study year, BMI, systolic blood pressure, cholesterol, and smoking  Adjustment: age, sex, study year, BMI, systolic blood pressure, cholesterol, smoking, and for other 2 physical activities  Leisure time and occupational PA independently lower the risk of CVD-mortality; simultaneously doing 1, 2, or 3 types of moderate or high commuting, occupational, and leisure time PA reduced CVD mortality

Table 5 – continued

Reference	Measurement of PA	Sample	Design and outcome	Main findings	Comment
Wagner et al. 2002 (France/Northern Ireland)	Questionnaire: amount of PA performed during the previous year, according to different domains of PA (occupational, walking or cycling to work and leisure time activity)	9758 men aged 50–59 years free of CHD	Prospective cohort (The Prospective Epidemiological Study of Myocardial Infarction); during 5-year follow-up 167 hard CVD events were recorded	High-intensity leisure time activities performed 0.92 (0.63–1.32) Leisure time PA for a difference of 10 MET-h/week: 0.92 (0.86–0.99) Walking or cycling to work 1.19 (0.81–1.76)  Leisure time PA for a difference of 10 MET-h/week in men who did not perform high-intensity leisure time PA: 0.90 (0.82–0.99)	Adjustment: other two physical activities, age, country, employment status, tobacco and alcohol consumption, educational level and BMI  Adjustment: age, country, employment status, tobacco and alcohol consumption, educational level and BMI

and women (Hu et al. 2003b). The Prospective Epidemiological Study of Myocardial Infarction (PRIME)-Study reveals an inverse effect for leisure time PA. In contrast, commuting is not independently associated with the risk reduction of angina pectoris and fatal coronary occurrences (Wagner et al. 2002).

## Discussion

In our article we provide review of epidemiological studies from different parts of the world gaining an insight into the empirical substantiation of the HEPA recommendation. We especially addressed prospective cohort studies. They offer the best evidence from observational studies for a cause-and-effect conclusion. The evidence level reviewed here is category C (Bouchard 2001). We have to keep in mind that the selected studies use different methodologies and samples at different times. This fact makes them hardly comparable. So, whether or not PA may cause different outcomes is not trivial to decide. But there are additional criteria (e.g. biological plausibility, consistency) to make a judgement more plausible. So, our decisions are based on the totality of evidence (Rothman 2002). Most of the results reveal similar conclusions. By this, they support the consistency of a significant association between PA and health outcomes.

The HEPA recommendation pursues a public health policy. The recommendation differs in an important manner from older recommendations aiming at fitness goals (Hardman & Stensel 2003; Oja 2004).

All things considered, several health benefits of moderately intense PA are evident for the elderly, for women and for less fit and inactive people. Middle-aged men might gain some benefits from more vigorous intensities.

One reason for this difference could be traced back to the fact that middle-aged men in particular practice high amounts of PA. Hence, observational studies could not find an effect for activities with low and moderate intensity (Shephard 1997; Lee 2003, 2004; Haskell 2004). A second reason may be partly attributable to a measurement bias (Jakes & Wareham 2003; Dishman et al. 2004). Compared to vigorously intense PA low and moderate intensity activities can only be assessed imprecisely. Consequently, the moderate intense PA might be underestimated leading to an attenuation of the true association towards the null finding (Lee & Paffenbarger 1996).

There are further limitations. In most observational cohort studies intensity is expressed in absolute terms (MET). This is only a crude measure of intensity not reflecting the individual load (Howley 2001; Shephard 2003). Some analyses of the Harvard Alumni Study assess relative intensity and underpin the significance of moderate intensity PA for the prevention of CHD in the elderly (Lee et al. 2003). Specific recom-

mentations focusing on the individual level of fitness might be promising (ACSM 1998; Lee et al. 2003; Haskell 2004). An example was originated by the European Heart Network (1999).

Duration and frequency cannot be evaluated separately in most cases. In most studies information on duration and frequency are collected simultaneously (e. g. total duration or MET-hours per week). Ignoring these methodological restrictions, current findings document the preventive effect of being active for 30 min a day with a moderate intensity. Overall, findings from large-scale studies on the accumulation of three daily bouts of at least 10 min are scarce. Further research is warranted here. Findings from experimental trials looking for the effect on surrogate parameters suggest that the total amount of energy expenditure is the important determinant for a broad range of health outcomes (Hardman 1999, Oja 2004).

One further issue on the HEPA recommendation is the preventive effect of PA independent of the context of PA. For commuting to and from work growing evidence from prospective cohort studies underpins the beneficial effect. But the confounding of other physical activities hamper causal conclusions from these studies.

For housework, some cohort studies highlight a beneficial effect on mortality. But both the definition and the assessment of housework varies and the effect is only weakly evidenced. Some data raise a controversial issue on the HEPA recommendation. Due to the assessment of all PA of one's daily life, most people guess they reach the recommended 30 min (Ainsworth et al. 1999; Lawlor et al. 2002; Rütten et al. 2004). A low-dose-recommendation may either justify inactivity or provokes low increases of PA by doing short daily life activities of low intensity (Fuchs 2003). In fact, these will fail in gathering health benefits. On the other hand and from a public health vantage point, there is need of a PA recommendation

which motivates the general public to become more active. In particular, sedentary persons might shrink away from long lasting bouts with vigorously intense PA (Jakicic et al. 1999; Perri et al. 2002). However, this more psychological argument is not sufficient for a recommendation on the population level. A recommendation might even raise unfounded hopes when a low level of activity would proved ineffective for health gains.

Finishing, we will have a look to the dose-response relationship. Kohl (2001) and Lee & Skerrett (2001) describe an inverse and linear relationship between the volume of PA and CVD and all-cause mortality. Other dose-response associations (e.g. rectangular-, J- or U-shaped) are likewise being noted for further outcomes (Marti & Hättich 1999; Kesaniemi et al. 2001; Dishman et al. 2004; Oja 2004). The optimal dose of PA to stay healthy remains unclear. A recent study of Di Loreto et al. (2005) found out that the HEPA recommendation is valid for type 2 diabetic subjects in the prevention of CHD risk. The data reveal a significant dose-response relation for the volume of energy expenditure. But the threshold for full benefits was observed in a group which attained between 21 and 30 MET-hours/week.

All in all epidemiologists agree that moderate intensity PA producing an additional energy expenditure of 750 kcal to 2 000 kcal per week reduces the risk of CVD and of premature death (Dishman et al. 2004). Women and men who are free of diseases and important risk factors seem to gain additional benefits from doing more than the recommended 30 min per day. They profit from higher volumes and vigorous intensities (Bassuk & Manson 2003; Bauman 2004; Blair et al. 2004; Lee 2004). So, at the end of our review, we agree with other authors (e.g. Blair et al. 2004) that for sedentary men and women the risk of a broad spectrum of diseases could be decreased following the HEPA recommendation.

## Zusammenfassung

### Gesundheitsförderliche körperliche Aktivität und die Prävention chronischer Krankheiten – ein epidemiologischer Review

**Fragestellung:** Übersicht über die epidemiologische Evidenz bezüglich der Empfehlung zur gesundheitsförderlichen körperlichen Aktivität, die von den Centers for Disease Control and Prevention (CDC) und des American College auf Sports Medicine (ACSM) veröffentlicht wurde.

**Methoden:** Der Review bezieht englisch- und deutschsprachige Publikationen ein, die nach der Veröffentlichung der CDC/ACSM-Empfehlung im Jahre 1995 erschienen sind und im Erwachsenenalter den Nutzen für die Prävention chronisch-degenerativer Krankheiten untersuchen. Aufgrund der großen Anzahl der Publikationen wurde kein systematischer Review vorgenommen. Der Beitrag nimmt allerdings ausgewählte repräsentative Studien zum Forschungsstand in den Blick.

**Ergebnisse:** Sowohl unter Berücksichtigung der internationalen epidemiologischen Befundlage als auch des Bemühens, große Teile der erwachsenen Bevölkerung zu mehr Aktivität zu motivieren, lässt sich die Empfehlung von CDC/ACSM als eine akzeptable Public Health Botschaft begründen.

**Schlussfolgerungen:** Nach der CDC/ACSM-Empfehlung reicht es aus, im Laufe des Tages insgesamt 30 Minuten moderat intensiv körperlich aktiv zu sein – unabhängig vom Kontext der Aktivität (z. B. Transport, Freizeit) –, um einem breiten Spektrum chronisch-degenerativer Erkrankungen bei inaktiven Frauen und Männern vorzubeugen. Eine Reihe widersprüchlicher Befunde bleiben jedoch unklar und bedürfen weiterer Forschungsbemühungen.

## Résumé

### Promotion de la santé et prévention des maladies chroniques par l'activité physique – revue épidémiologique

**Objectifs:** Effectuer une revue de l'évidence épidémiologique soutenant les recommandations en faveur de l'activité physique comme facteur de promotion de la santé (recommandations des Centers for Disease Control and Prevention (CDC) et de l'American College for Sports Medicine (ACSM)).

**Méthodes:** Revue de la littérature publiée en anglais et en allemand, parue après l'émission des recommandations des CDC / ACSM (soit après 1995), et ciblant les adultes et leur santé physique. En raison de l'abondance de cette littérature, ce n'est cependant pas une revue systématique qui a été effectuée. Seul un échantillon représentatif des publications a été étudié.

**Résultats:** Les données épidémiologiques internationales suggèrent que les recommandations des CDC/ACSM représentent un message de santé publique raisonnable.

**Conclusions:** Selon ces recommandations, la pratique d'un total de 30 min d'activité physique quotidienne d'intensité modérée – indépendamment du contexte de sa pratique (par ex. transports, loisirs) – offre des bénéfices substantiels pour la santé des hommes et femmes sédentaires. Il reste que certains aspects de ces recommandations doivent encore être approfondis.

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