European Heart Journal (2012) **33**, 452–466
doi:10.1093/eurheartj/ehr432

CLINICAL RESEARCH
Prevention

Physical activity levels, ownership of goods promoting sedentary behaviour and risk of myocardial infarction: results of the INTERHEART study

Claes Held[1,2]*, Romaina Iqbal[3], Scott A. Lear[4], Annika Rosengren[5], Shofiqul Islam[2], James Mathew[6,7], and Salim Yusuf[2]

[1]Departments of Medical Sciences and Cardiology, Uppsala Clinical Research Center, Uppsala University, Uppsala, Sweden; [2]Population Health Research Institute, Hamilton, Ontario, Canada; [3]Departments of Community Health Sciences and Medicine, Aga Khan University, Pakistan; [4]Department of Biomedical Physiology and Kinesiology, Faculty of Health Sciences, Simon Fraser University, Vancouver, British Columbia, Canada; [5]Department of Emergency and Cardiovascular Medicine, Institute of Medicine, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden; [6]Columbia St. Mary's, Milwaukee, WI, USA; and [7]Department of Medicine, University of Iowa College of Medicine, Iowa City, IA, USA

Received 3 June 2011; revised 20 October 2011; accepted 2 November 2011

See page 425 for the editorial comment on this article (doi:10.1093/eurheartj/ehr363)

Aims To evaluate the association between occupational and leisure-time physical activity (PA), ownership of goods promoting sedentary behaviour, and the risk of myocardial infarction (MI) in different socio-economic populations of the world. Studies in developed countries have found low PA as a risk factor for cardiovascular disease; however, the protective effect of occupational PA is less certain. Moreover, ownership of goods promoting sedentary behaviour may be associated with an increased risk.

Methods In INTERHEART, a case–control study of 10 043 cases of first MI and 14 217 controls who did not report previous angina or physical disability completed a questionnaire on work and leisure-time PA.

Results Subjects whose occupation involved either light [multivariable-adjusted odds ratio (OR) 0.78, confidence interval (CI) 0.71–0.86] or moderate (OR 0.89, CI 0.80–0.99) PA were at a lower risk of MI, whereas those who did heavy physical labour were not (OR 1.02, CI 0.88–1.19), compared with sedentary subjects. Mild exercise (OR 0.87, CI 0.81–0.93) as well as moderate or strenuous exercise (OR 0.76, CI 0.69–0.82) was protective. The effect of PA was observed across countries with low, middle, and high income. Subjects who owned both a car and a television (TV) (multivariable-adjusted OR 1.27, CI 1.05–1.54) were at higher risk of MI compared with those who owned neither.

Conclusion Leisure-time PA and mild-to-moderate occupational PA, but not heavy physical labour, were associated with a reduced risk, while ownership of a car and TV was associated with an increased risk of MI across all economic regions.

Keywords Physical activity • Risk factors • Myocardial infarction • Cardiovascular disease

Introduction

Regular physical activity (PA) has been shown to reduce the risk of cardiovascular (CV) disease.[1–3] While an increase in leisure-time activity has been reported in some industrialized countries, work-related activity has decreased, potentially leading to an overall decrease in total PA.[4] This is a concern as physical inactivity and a sedentary lifestyle are associated with obesity[5] and CV disease.[6,7] Many studies have found an association between PA during leisure time and CV disease.[8,9] In contrast, the association with work-related activity is less clear.[10,11] However, few studies have evaluated the different aspects of PA both at work and

* Corresponding author. Tel: +46 186119508, Fax: +46 18515570, Email: claes.held@ucr.uu.se

during leisure time in relation to CV risk, although this strategy has been advocated.[12] Therefore, there is a need to assess the importance of both occupation-related and leisure-time PA.

In recent years, a sedentary lifestyle has become increasingly common in many developing countries, and with it, the incidence of metabolic syndrome, diabetes, and CV disease has also risen.[13] The increase in a sedentary lifestyle may be explained by many factors, such as increasing urbanization, a higher level of mechanization at work, societal changes into more motorized transportation, a societal structure that discourages walking but encourages the use of PA limiting devices (cars, escalators, and elevators), and the widespread availability of appliances that promote sedentary behaviour such as the television (TV) and computers. Most data on activity are based on studies conducted in Western countries, with few data from other regions of the world. This may be particularly relevant as the patterns of activities may differ in different settings, e.g. leisure-time activity may be higher in high-income countries and work-related activity may be higher in low- and middle-income countries.

In a recent case–control study (INTERHEART),[14] regular PA was shown to reduce the risk of acute myocardial infarction (MI) by 14% and the population attributable risk (PAR) for the lack of PA was 12.2%. The purpose of this study was to provide a more thorough analysis of the role of PA as reported in INTERHEART. Specifically, the association between PA and its components (work and leisure activity) with the risk of MI globally and across various subgroups and different regions of the world was explored. Furthermore, we have evaluated a few markers of sedentary lifestyle, i.e. household ownership of goods, such as a car and a TV, respectively, and their relation to CV risk factors and to the risk of an MI.

Methods

The background and main results from INTERHEART have been presented previously.[14] In summary, it was a standardized case–control study, including 15 152 cases of first MI and 14 820 age- and sex-matched controls from 262 centres, involving 52 countries in Asia, Europe, the middle east, Africa, Australia, North America, and South America. Cases of first MI presenting within 24 h of symptom onset were eligible to participate in the study. Cases presenting with cardiogenic shock or history of any major chronic disease were excluded. At least one age- (±5 years) and sex-matched control without a history of CV disease was recruited per case. These controls were selected either from the community or from the recruiting hospital. A community-based control was either a visitor or a relative of a patient from a non-cardiac ward or an unrelated visitor of another cardiac patient. A hospital-based control was defined as those at the same centre with illnesses not obviously related to coronary heart disease or its risk factors. Cases were excluded if they had unstable angina ($n = 1531$), if an MI could not be confirmed ($n = 205$), if they had a history of a previous MI ($n = 695$), or if they had insufficient data ($n = 260$). Seventy-four controls were excluded because of insufficient data, and 109 had a history of a previous MI. Of the remaining 27 098 participants, 347 patients were excluded as data on PA were missing. In the present analyses, we excluded 2137 patients with known angina pectoris and 764 patients suffering from physical disability or who were on social security, and not expected to be physically active. Thus, the remaining 24 260 participants (10 043 cases and 14 217 controls) could be evaluated for the study.

Exposure variable

Physical activity during work was assessed by asking the participants how active they had been at work with the following categorical responses: mainly sedentary, predominantly walking at one level, mainly walking including walking uphill or lifting heavy objects, heavy physical labour, and subjects who do not work. Participants who chose not working as a response were excluded from the analysis on work-related activity ($n = 8861$; 37%). For leisure-time activity, participants had four possible responses to select from. These were: mainly sedentary (sitting activities, e.g. sitting, reading, watching TV), mild exercise (minimal effort activities, e.g. yoga, fishing, easy walking), moderate exercise (moderate effort, e.g. walking, bicycle riding, or light gardening at least 4 h/week), and strenuous exercise (heartbeats rapidly, e.g. running/jogging, football, vigorous swimming). For this analysis, individuals who reported moderate exercise and strenuous exercise were grouped together. An additional question 'Do you play sports or exercise during your leisure time?' was asked as a yes or no response question. Of those who responded yes to this question, a secondary question enquired about the number of hours per week spent in exercise and number of months per year that the individual carried out the exercise. Individuals who reported no exercise per week were used as the reference group. The question on the number of hours per week and the number of months per year of exercise was converted into the number of minutes of exercise per week as a continuous variable. The continuous variable obtained was then converted into a categorical variable with >0–30, >30–60, >60–150, >150–210, and >210 min/week of exercise. These latter two categories correspond to general recommendations/guidelines for PA of at least 150 min/week.[15]

Household level ownership of goods was assessed by an yes/no response to a question that asked about household's ownership of a car, motorcycle, bicycle, radio/stereo, TV, other land, computer, and livestock/cattle ownership.

Measurement of covariates

Data from the 52 participating countries were grouped into the following seven regions for this analysis; these regions included North America and Western Europe, Central Europe, Middle East, Africa, South Asia, South East Asia, and South America. Smoking was recorded as never used, current users, and former users. Country-specific cut-offs were used for categorizing individuals into five levels of household income. Education was assessed as a categorical variable with five categories (no education, Grade 1–8, Grade 9–12, trade school, or college/university). Self-reported diabetes and hypertension status were assessed as dichotomous variables with yes and no as possible answers. For this particular analysis, we used yes and no response variables for psychosocial factors (including depression, global stress, financial stress, and locus of control), fruit and vegetable intake and alcohol intake (at least once weekly). For the analysis stratified by country level income status, we created a variable with three categories (low, middle, and high) of socio-economic position status for those countries using World Bank classification (http://web-worldbank-org).

Statistical analysis

We conducted univariate analyses using standard measures of central tendency and dispersion. Subgroups were compared using *t*-tests for continuous variables and χ^2 tests for categorical variables to understand the association of PA and other exposures of interest with MI. About 14% cases and 5% controls did not have an exact matched pair. As a result, we used unconditional logistic regression (as opposed to conditional one to save unmatched data),[14] to identify the degree of association between the MI and key exposure (work and leisure-time PA) adjusting for the covariates at various levels. Initial models were adjusted for age, sex, and region but subsequent models were adjusted for other conventional risk factors (e.g. BMI, fruit and vegetable intake, education and smoking) which were found to be associated with PA and MI. Waist-hip-ratio (WHR) was found to be a strong risk factor for MI in one of the main INTERHEART study.[16] For this reason, we adjusted for WHR in the current analysis. Additional adjustments were done for other risk factors (alcohol intake ≥1/week and psychosocial factors) that were found to be associated with MI in a prior analysis of INTERHEART.[14] In addition to household income, models were adjusted for education. For analyses stratified by type of country (low, middle, and high income), age (young vs. old), and sex (males vs. females), we used the Genmod procedure in SAS which allowed us to adjust for covariates in the overall data. Strata-specific odds ratio (OR) estimates were obtained from models with interaction as opposed to direct stratification and was also adjusted for all potential confounders. All analyses were conducted in SAS version 9.2 (SAS, Cary, NC, USA) and all tests were two-sided. Graphical representations were prepared using S-PLUS version 6. We also computed PAR for leisure-time-related PA (top categories vs. the bottom, e.g. sedentary behaviour) with MI. Population attributable risk was determined by a method based on unconditional logistic regression. Population attributable risk's were calculated using Interactive Risk Attributable Program version 2.2 software (US National Cancer Institute, 2002) and were adjusted for potential confounders.

Results

A total of 24 260 participants (10 043 cases and 14 217 age- and sex-matched controls) were included in these analyses. In *Table 1*, univariate comparisons of cases and controls are shown. Cases were more often sedentary during leisure time (61.0 vs. 54.4%; $P < 0.001$) and at work (35.9 vs. 33.6%; $P < 0.001$). A greater proportion of cases did heavy physical labour at work (10.2 vs. 7.8%; $P < 0.0001$).

Figure 1 shows the proportion of cases and controls across the categories of occupation (*Figure 1A*) and leisure-time-related (*Figure 1B*) PA by country income levels in the world. Overall, for both work- and leisure-time-related PA, cases were more sedentary than controls in all country income categories. The proportion of people who were sedentary was greatest in low-income countries and decreased gradually from middle- to high-income countries. Strenuous activity during leisure-time PA was most common in high-income countries.

Risk factors by occupational activity and country income level

Risk factors were investigated in control subjects only in order to provide an indicator of population differences in levels of PA. In *Table 2*, these are shown by country level income and by

Table 1 Frequency of physical activity variables for cases and controls

	Controls (*n* = 14 200), *n* (%)	Cases (*n* = 9805), *n* (%)	Total	*P*-value
Low income	2155 (59.5)	1467 (40.5)	3622	
Middle income	8960 (59.9)	5995 (40.1)	14955	
High income	3085 (56.8)	2343 (43.2)	5428	
Work-related activity	*n* = 8928	*n* = 6159	*n* = 15087	
Mainly sedentary	2995 (33.6)	2209 (35.9)	5204	<0.0001
Walking at one level	3442 (38.6)	2053 (33.3)	5495	
Walking, climbing, and lifting	1797 (20.1)	1267 (20.6)	3064	
Heavy physical labour	694 (7.8)	630 (10.2)	1324	
Leisure-time activity	*n* = 14198	*n* = 9802	*n* = 24000	
Mainly sedentary	7718 (54.4)	5983 (61.0)	13701	<0.0001
Mild exercise	3740 (26.3)	2388 (24.4)	6128	
Moderate and strenuous exercise	2740 (19.3)	1431 (14.6)	4171	
Duration of leisure-time activity	*n* = 14143	*n* = 9780	23923	
No leisure-time activity	10926 (77.3)	8282 (84.7)	19208	<0.0001
0–30 min/week	124 (0.88)	77 (0.79)	201	
>30–60 min/week	356 (2.5)	166 (1.7)	522	
>60–150 min/week	676 (4.8)	313 (3.2)	989	
>150–210 min/week	458 (3.2)	223 (2.3)	681	
>210 min/week	1603 (11.3)	719 (7.4)	2322	
Markers of a sedentary lifestyle	*n* = 12751	*n* = 9016	*n* = 21767	
Owns no car, no TV	807 (6.3)	725 (8.0)	1532	<0.0001
Owns either car or TV	7903 (62.0)	5279 (58.6)	13182	
Owns TV and car	4041 (31.7)	3012 (33.4)	7053	

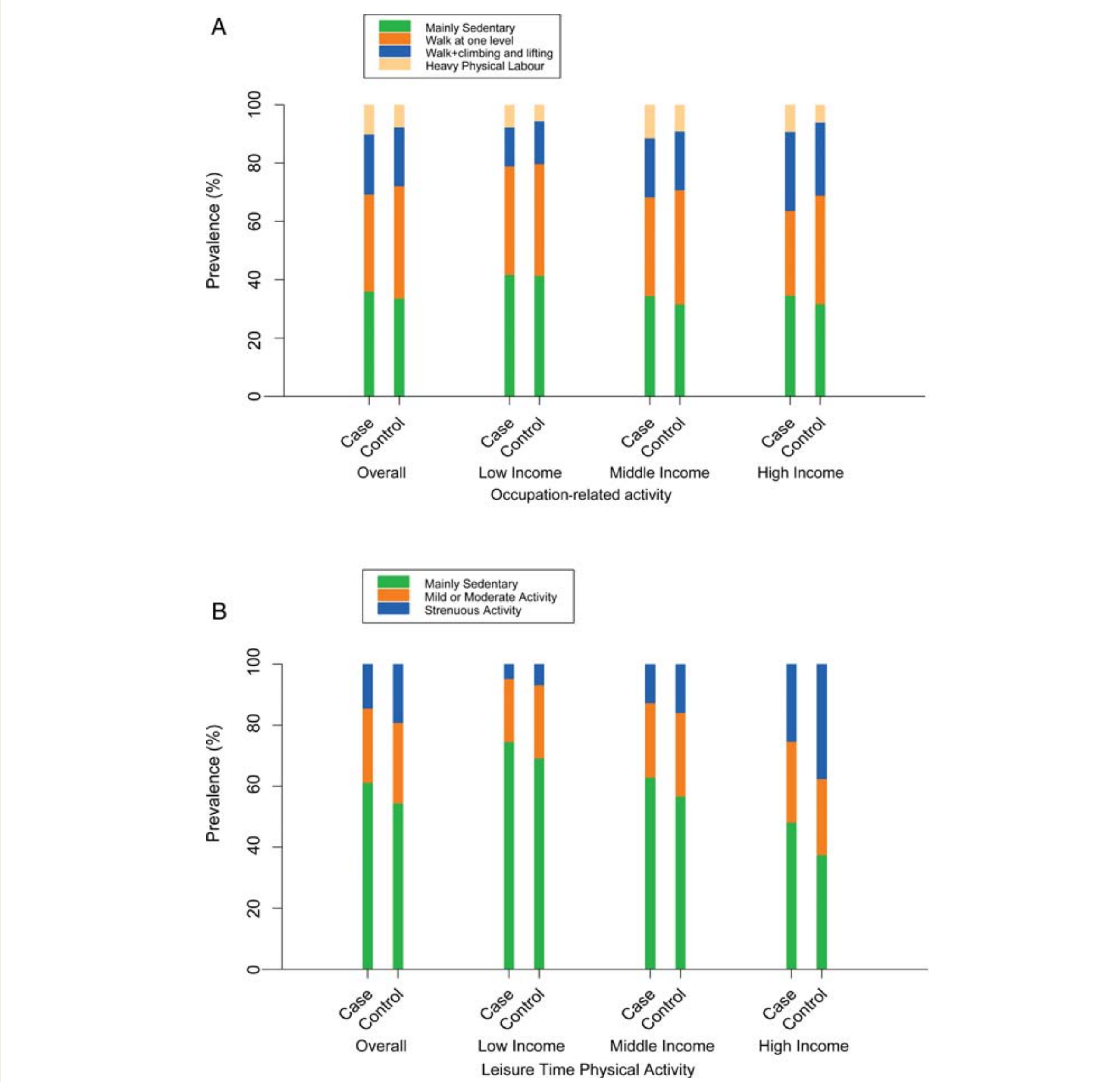

Figure 1 Proportion of cases and controls who are sedentary, or physically active at various categories of occupation-related (*A*) and leisure-related (*B*) physical activity by country level income.

categories of work PA. A greater proportion was sedentary in low-income countries (41%), while people in high-income countries were the least sedentary at work (33%, $P < 0.001$). Overall, the prevalence of hypertension and diabetes decreased with increasing work activity, as did body mass index (BMI). Similarly, daily consumption of fruits and vegetables decreased, whereas the proportion of current smokers increased. Stress and depression increased with increasing work activity. In low-income countries, a larger proportion of people who did heavy physical labour (45%) had no car or TV compared with those who did sedentary work (7.8%).

Risk factors by leisure activity and country income level

The proportion of people who were sedentary during leisure time was greater (69%) in low- compared with high-income countries (37%, $P < 0.001$) (*Table 3*). Moderate or strenuous exercise were more common in high (38%)- than in low (7%)-income countries. Higher levels of activity were associated with a lower prevalence of diabetes and smoking, in high-income countries only (*P* for interaction for current smoking <0.0001 and for diabetes 0.009). Daily consumption of fruits/vegetables increased across categories of increasing PA and from low- to high-income countries, but more

Table 2 Risk factors by work activity and type of country in control subjects

	Mainly sedentary	Mild work activity	Moderate work activity	Strenuous work	*P*-value for heterogeneity
Low income, *n* (%)	753 (41.3)	701 (38.4)	268 (14.7)	104 (5.7)	
Middle income, *n* (%)	1612 (31.5)	1999 (39.1)	1031 (20.2)	469 (9.2)	
High income, *n* (%)	628 (31.6)	741 (37.3)	498 (25.0)	121 (6.1)	
Age (years), mean (SD)					
Low income	50.9 (10.5)	49.7 (10.4)	49.5 (9.9)	50.3 (10.2)	0.232
Middle income	53.7 (10.9)	52.2 (10.3)	51.6 (10.4)	51.3 (10.2)	
High income	51.2 (10.0)	51.0 (10.0)	50.7 (9.7)	49.2 (9.5)	
SBP (mmHg), mean (SD)					
Low income	125.5 (14.2)	123.2 (13.5)	123.4 (13.3)	123.0 (11.1)	0.237
Middle income	128.0 (16.4)	126.5 (15.7)	126.1 (15.5)	125.7 (16.7)	
High income	129.6 (15.4)	129.5 (17.0)	130.5 (16.4)	128.6 (14.8)	
ApoB/ApoA1 (mmol/L), mean (SD)					
Low income	0.88 (0.37)	0.87 (0.32)	0.85 (0.26)	0.82 (0.21)	0.008
Middle income	0.79 (0.30)	0.79 (0.40)	0.81 (0.37)	0.76 (0.32)	
High income	0.86 (0.30)	0.83 (0.29)	0.78 (0.25)	0.77 (0.30)	
BMI (kg/m^2), mean (SD)					
Low income	25.6 (3.9)	24.7 (3.8)	25.1 (3.8)	23.4 (4.0)	0.027
Middle income	26.0 (4.1)	25.8 (4.1)	25.6 (4.3)	25.0 (3.7)	
High income	27.2 (4.3)	26.7 (4.5)	26.4 (4.3)	26.4 (3.8)	
WHR, mean (SD)					
Low income	0.92 (0.06)	0.92 (0.06)	0.92 (0.07)	0.91 (0.07)	0.006
Middle income	0.91 (0.09)	0.91 (0.09)	0.91 (0.09)	0.92 (0.08)	
High income	0.92 (0.07)	0.91 (0.07)	0.91 (0.08)	0.92 (0.06)	
Current smokers, *n* (%)					
Low income	173 (23.5)	165 (24.6)	81 (31.9)	32 (35.6)	0.156
Middle income	509 (31.9)	717 (36.0)	377 (36.9)	196 (42.2)	
High income	171 (27.8)	203 (27.9)	138 (28.2)	52 (44.1)	
Hypertension, *n* (%)					
Low income	100 (13.3)	93 (13.3)	21 (7.8)	3 (2.9)	0.0045
Middle income	332 (20.6)	320 (16.0)	164 (16.0)	66 (14.1)	
High income	113 (18.0)	136 (18.4)	74 (14.9)	8 (6.6)	
Diabetes, *n* (%)					
Low income	74 (9.8)	55 (7.9)	16 (6.0)	6 (5.8)	0.413
Middle income	111 (6.9)	97 (4.9)	47 (4.6)	12 (2.6)	
High income	58 (9.3)	64 (8.7)	21 (4.2)	4 (3.3)	
Fruit and vegetable consumption, *n* (%)					
Low income	216 (28.9)	185 (26.7)	65 (24.5)	21 (20.6)	0.43
Middle income	687 (43.5)	724 (36.6)	366 (36.2)	141 (30.5)	
High income	337 (54.4)	391 (53.8)	263 (53.5)	51 (42.5)	
Alcohol consumption ($\geq$1 times/week), *n* (%)					
Low income	83 (11.1)	78 (11.2)	37 (13.8)	15 (14.7)	0.003
Middle income	478 (29.8)	525 (26.4)	277 (27.0)	132 (28.3)	
High income	198 (31.7)	238 (32.3)	216 (43.6)	40 (33.6)	
Owns TV and car, *n* (%)					
Low income	256 (34.0)	151 (21.5)	45 (16.8)	4 (3.9)	$<$0.0001
Middle income	564 (37.4)	625 (33.2)	261 (27.7)	77 (17.6)	
High income	382 (69.3)	367 (59.4)	224 (62.4)	39 (39.8)	

Continued

Table 2 *Continued*

	Mainly sedentary	Mild work activity	Moderate work activity	Strenuous work	*P*-value for heterogeneity
Owns no TV or car, *n* (%)					
Low income	59 (7.82)	96 (13.69)	60 (22.39)	47 (45.19)	<0.0001
Middle income	35 (2.32)	71 (3.77)	64 (6.79)	50 (11.42)	
High income	18 (3.27)	27 (4.37)	15 (4.18)	12 (12.24)	
Education <9 years, *n* (%)					
Low income	125 (16.6)	181 (25.8)	98 (36.7)	80 (76.9)	<0.0001
Middle income	448 (27.8)	641 (32.1)	404 (39.2)	265 (56.7)	
High income	78 (12.4)	137 (18.6)	117 (23.5)	48 (39.7)	
Low family income, *n* (%)					
Low income	63 (8.4)	61 (8.8)	33 (12.5)	29 (27.9)	0.026
Middle income	270 (17.0)	386 (19.5)	319 (31.5)	188 (40.7)	
High income	126 (20.2)	179 (24.6)	134 (27.6)	60 (51.7)	
Stress, *n* (%)					
Low income	291 (38.6)	280 (39.9)	120 (44.8)	55 (52.9)	0.421
Middle income	571 (35.5)	695 (34.8)	418 (40.5)	195 (41.7)	
High income	228 (36.3)	306 (41.4)	208 (41.8)	58 (47.9)	
Depression, *n* (%)					
Low income	123 (18.0)	126 (21.3)	46 (19.3)	25 (26.0)	0.067
Middle income	268 (17.1)	301 (15.4)	190 (19.1)	85 (18.8)	
High income	80 (13.6)	119 (17.3)	80 (17.2)	13 (11.8)	

SD, standard deviation. First three rows give the number of individuals in each of the SES and physical activity categories. In those cells, proportions were computed for each physical activity category within each SES (denominator is the total number within each SES). For all other factors (e.g. smoking diabetes, hypertension, etc.), proportions were computed using the frequency for each cell divided by the total number presented in the corresponding cell in the first three rows. Due to some missing values in different risk factors, the percentage might differ slightly from direct calculation.

so in high-income countries (*P* for interaction <0.0001). There was a positive association between ownership of a car and a TV and categories of leisure-time PA in all country income levels ($P < 0.0001$) and most prevalent in active people in high-income countries (81%). Low education status was associated with less leisure-time PA levels, across all categories of country income.

Risk factors by markers of sedentary lifestyle (ownership of car and/or television)

Among all items asked for, ownership of a car, radio/stereo, and a home was associated with an increased risk of MI (*Table 4*) and TV ownership was of borderline significance ($P = 0.054$). Ownership of livestock/cattle was associated with lower risk of MI. The analyses focused on car and TV ownership, both factors promoting sedentary behaviour. Common cardiac risk factors stratified by household possession of a car and/or a TV of the control group are presented in *Table 5*. Overall, possession of neither a car nor a TV was rare; 15, 5, and 4% in low-, middle-, and high-income levels, respectively, while corresponding values for ownership of both were 25, 25, and 64%, respectively. Systolic blood pressure (SBP) tended to increase with ownership of both car/TV vs. no ownership. Similarly, BMI increased gradually with a degree of ownership in all country income strata. Diabetes was more common among those with ownership of both car and TV in low- and middle-income countries, but not in high-income countries (*P* for heterogeneity <0.0001). Daily consumption of fruits and vegetables and alcohol consumption >1 time/week increased with degree of ownership and from low- to high-income countries ($P < 0.0001$). Low family income and education <9 years were both strongly inversely related to the ownership of a car and/or a TV in all country level income strata but more so in low-income countries (*P* for interaction <0.0001).

Occupation and leisure-time-related physical activity and risk of myocardial infarction

Figure 2 and *Table 6* presents the OR for the risk of an MI with 95% confidence intervals (CI) for occupation and leisure-time activity, respectively. An inverse association between categories of occupation PA levels and the risk of MI was noted for walking at one level and for walking uphill and lifting objects. Using sedentary subjects as reference in the fully adjusted model [*Table 6*, footnote (c)], the OR was 0.78 (CI 0.71–0.86) for walking at one level and 0.89 (CI 0.80–0.90) for walking including walking uphill and lifting objects. There was no association between heavy physical labour and the

Table 3 Risk factors by leisure activity and type of country in control subjects

	Mainly sedentary	Mild exercise	Moderate and strenuous exercise	*P*-value for heterogeneity
Low income, *n* (%)	1489 (69.1)	518 (24.0)	148 (6.9)	
Middle income, *n* (%)	5075 (56.7)	2453 (27.4)	1430 (16.0)	
High income, *n* (%)	1154 (37.4)	769 (24.9)	1162 (37.7)	
Age (years), mean (SD)				
Low income	52.2 (11.6)	51.7 (10.8)	51.7 (10.2)	<0.0001
Middle income	58.1 (12.0)	57.8 (11.6)	55.5 (11.5)	
High income	53.8 (12.6)	58.7 (13.0)	59.5 (11.9)	
SBP (mmHg), mean (SD)				
Low income	124.8 (14.7)	125.4 (14.5)	125.9 (14.4)	0.474
Middle income	128.4 (17.3)	129.6 (17.6)	130.0 (18.0)	
High income	131.3 (17.5)	133.9 (17.9)	133.6 (18.3)	
ApoB/ApoA1 (mmol/L), mean (SD)				
Low income	0.88 (0.36)	0.84 (0.29)	0.82 (0.29)	<0.0001
Middle income	0.77 (0.29)	0.79 (0.39)	0.78 (0.32)	
High income	0.85 (0.29)	0.78 (0.26)	0.75 (0.24)	
BMI (kg/m^2), mean (SD)				
Low income	25.3 (4.1)	24.8 (3.3)	25.0 (3.4)	<0.0001
Middle income	25.6 (4.1)	26.0 (4.2)	25.8 (3.9)	
High income	27.4 (4.9)	26.7 (4.3)	26.0 (3.7)	
WHR, mean (SD)				
Low income	0.92 (0.06)	0.91 (0.07)	0.92 (0.07)	<0.0001
Middle income	0.91 (0.09)	0.91 (0.08)	0.91 (0.08)	
High income	0.93 (0.07)	0.91 (0.08)	0.90 (0.08)	
Current smokers, *n* (%)				
Low income	332 (23.5)	124 (24.7)	34 (23.3)	<0.0001
Middle income	1578 (31.3)	628 (25.8)	383 (26.7)	
High income	357 (31.7)	176 (23.1)	190 (16.5)	
Hypertension, *n* (%)				
Low income	178 (12.0)	81 (15.6)	20 (13.5)	0.561
Middle income	1158 (22.8)	625 (25.5)	333 (23.4)	
High income	251 (21.8)	187 (24.4)	230 (19.8)	
Diabetes, *n* (%)				
Low income	145 (9.7)	47 (9.1)	15 (10.1)	0.009
Middle income	315 (6.2)	175 (7.1)	89 (6.2)	
High income	116 (10.1)	74 (9.7)	62 (5.3)	
Fruit and vegetable consumption, *n* (%)				
Low income	411 (28.0)	131 (25.5)	62 (42.8)	<0.0001
Middle income	1990 (39.7)	970 (40.2)	608 (43.2)	
High income	502 (43.9)	455 (60.1)	818 (71.6)	
Alcohol consumption (≥1 times/week), *n* (%)				
Low income	131 (8.9)	62 (12.0)	43 (29.1)	<0.0001
Middle income	998 (19.8)	608 (24.9)	425 (29.9)	
High income	244 (21.3)	297 (38.8)	668 (57.8)	
Owns TV and car, *n* (%)				
Low income	349 (23.4)	126 (24.3)	56 (37.8)	<0.0001
Middle income	1006 (20.9)	601 (27.0)	432 (34.5)	
High income	503 (50.3)	366 (66.8)	598 (81.1)	

Continued

Table 3 *Continued*

	Mainly sedentary	Mild exercise	Moderate and strenuous exercise	P-value for heterogeneity
Owns no TV or car, n (%)				
Low income	263 (17.7)	41 (7.9)	10 (6.8)	<0.0001
Middle income	222 (4.6)	119 (5.3)	69 (5.5)	
High income	57 (5.7)	18 (3.3)	3 (0.4)	
Education <9 years, n (%)				
Low income	475 (31.9)	119 (23.0)	17 (11.6)	0.009
Middle income	2471 (48.8)	938 (38.3)	507 (35.5)	
High income	361 (31.3)	196 (25.5)	207 (17.8)	
Low family income, n (%)				
Low income	195 (13.2)	26 (5.1)	11 (7.6)	<0.0001
Middle income	1335 (26.6)	646 (26.8)	369 (26.6)	
High income	476 (41.6)	209 (27.7)	289 (25.7)	
Stress, n (%)				
Low income	619 (41.6)	201 (38.8)	60 (40.5)	0.0001
Middle income	1608 (31.7)	868 (35.4)	620 (43.4)	
High income	478 (41.5)	316 (41.1)	510 (43.9)	
Depression, n (%)				
Low income	276 (20.5)	81 (18.5)	26 (19.1)	0.005
Middle income	784 (15.8)	377 (15.8)	293 (20.9)	
High income	193 (18.4)	120 (16.2)	185 (16.2)	

SD, standard deviation. First three rows give the number of individuals in each of the SES and physical activity categories. In those cells, proportions were computed for each physical activity category within each SES (denominator is the total number within each SES). For all other factors (e.g. smoking diabetes, hypertension, etc.), proportions were computed using the frequency for each cell divided by the total number presented in the corresponding cell in the first three rows. Due to some missing values in different risk factors, the percentage might differ slightly from direct calculation.

Table 4 **Association between household ownership variables and the risk of MI**

	Controls, n = 14 204	Cases, n = 9946	Odds ratio (95% CI)	P-value
Home	11377 (80.2)	7853 (79.1)	1.16 (1.08–1.25)	0.0001
Car	4097 (32.1)	3059 (33.9)	1.14 (1.06–1.24)	0.0006
Motorcycle	2251 (15.9)	1346 (13.6)	0.99 (0.91–1.09)	0.8923
Bicycle	6349 (44.7)	4055 (40.9)	1.06 (1.00–1.13)	0.0558
Radio/stereo	12522 (88.16)	8558 (86.1)	0.88 (0.80–0.97)	0.0083
Television	133.0 (93.6)	9131(91.8)	1.14 (1.00–1.30)	0.0544
Other land	3058 (21.5)	1938 (19.5)	0.93 (0.86–1.00)	0.0585
Computer	3403 (24.0)	2030 (20.5)	0.95 (0.87–1.03)	0.1802
Livestock/cattle ownership	989 (7.8)	536 (5.6)	0.78 (0.68–0.88)	0.0001

Model adjusted for age, sex, country level income, smoking, alcohol, education, household income, WHR, hypertension, diabetes, psychosocial factors, fruit intake, and vegetable intake.

risk of MI [OR 1.02 (CI 0.88–1.19)]. For leisure-time PA, we observed a graded inverse association between categories of increasing leisure-time activity and risk of MI (*Table 6* and *Figure 2*). The ORs for mild-to-moderate activity were 0.87 (CI 0.81–0.93) and for strenuous activity 0.76 (0.69–0.82) compared with the mainly sedentary group ($P < 0.001$ for trend). Moderate or strenuous leisure-time PA was consistently associated with lower risk of MI in all country income categories.

Table 7 shows the OR for MI for occupation-related and leisure-time PA by country income level. Mild occupation-related PA

Table 5 Risk factors by markers of sedentary lifestyle (possession) and type of country in control subjects

	No car, no TV	TV or car	Car and TV	*P*-value for heterogeneity
Low income, *n* (%)	314 (14.6)	1311 (60.8)	531 (24.6)	
Middle income, *n* (%)	413 (5.0)	5852 (70.5)	2041 (24.6)	
High income, *n* (%)	80 (3.5)	740 (32.3)	1469 (64.2)	
Age (years), mean (SD)				
Low income	54.2 (12.6)	51.3 (11.2)	52.6 (10.6)	<0.0001
Middle income	58.1 (12.5)	58.7 (11.8)	54.1 (10.9)	
High income	45.2 (10.6)	55.2 (13.5)	55.9 (11.8)	
SBP (mm Hg), mean (SD)				
Low income	123.7 (16.7)	124.2 (13.3)	127.9 (16.0)	0.0035
Middle income	127.1 (18.6)	128.9 (17.7)	129.2 (17.1)	
High income	127.1 (15.4)	132.5 (18.5)	133.5 (17.8)	
ApoB/ApoA (mmol/L), mean (SD)				
Low income	0.87 (0.33)	0.89 (0.50)	0.86 (0.31)	<0.0001
Middle income	0.79 (0.44)	0.76 (0.33)	0.84 (0.36)	
High income	0.84 (0.40)	0.80 (0.29)	0.80 (0.26)	
BMI (kg/m^2), mean (SD)				
Low income	23.7 (4.0)	24.9 (3.7)	26.5 (3.9)	0.074
Middle income	24.6 (4.3)	25.4 (3.9)	26.7 (4.1)	
High income	25.6 (3.9)	25.6 (4.2)	27.2 (4.3)	
WHR, mean (SD)				
Low income	0.92 (0.07)	0.91 (0.07)	0.92 (0.06)	<0.0001
Middle income	0.91 (0.10)	0.90 (0.09)	0.93 (0.09)	
High income	0.92 (0.07)	0.92 (0.07)	0.91 (0.08)	
Current smoking, *n* (%)				
Low income	76 (26.2)	290 (23.1)	125 (24.2)	0.1827
Middle income	126 (31.3)	1755 (30.1)	550 (27.2)	
High income	26 (34.7)	228 (31.3)	359 (25.0)	
Hypertension, *n* (%)				
Low income	32 (10.2)	144 (11.0)	103 (19.4)	−0.0005
Middle income	64 (15.6)	1399 (23.9)	515 (25.3)	
High income	9 (11.5)	156 (21.1)	288 (19.7)	
Diabetes, *n* (%)				
Low income	15 (4.8)	132 (10.1)	60 (11.3)	0.0005
Middle income	19 (4.6)	347 (5.9)	170 (8.4)	
High income	5 (6.4)	83 (11.2)	113 (7.7)	
Daily fruit and vegetables consumption, *n* (%)				
Low income	30 (9.7)	350 (26.9)	224 (43.0)	0.0023
Middle income	98 (24.4)	2204 (38.3)	973 (48.3)	
High income	22 (29.3)	345 (47.2)	885 (61.3)	
Alcohol consumption (≥1/week), *n* (%)				
Low income	17 (5.5)	156 (12.0)	63 (12)	<0.0001
Middle income	86 (21.1)	1179 (20.2)	598 (29.5)	
High income	10 (13.0)	164 (22.3)	627 (43.1)	
Education (<9 years), *n* (%)				
Low income	213 (67.8)	352 (26.9)	47 (8.9)	<0.0001
Middle income	325 (78.9)	2910 (49.8)	477 (23.4)	
High income	27 (34.6)	297 (40.2)	261 (17.8)	

Continued

Table 5 *Continued*

	No car, no TV	TV or car	Car and TV	*P*-value for heterogeneity
Low family income, *n* (%)				
Low income	104 (33.3)	124 (9.5)	4 (0.8)	<0.0001
Middle income	249 (62.7)	1621 (28.1)	295 (14.7)	
High income	55 (70.5)	327 (44.6)	281 (19.3)	
Stress, *n* (%)				
Low income	165 (52.6)	504 (38.4)	211 (39.7)	<0.0001
Middle income	200 (48.7)	1715 (29.3)	872 (42.7)	
High income	23 (29.5)	302 (40.8)	609 (41.5)	
Depression, *n* (%)				
Low income	89 (30.2)	193 (16.8)	101 (21.3)	0.0005
Middle income	92 (23.2)	919 (16.0)	316 (16.0)	
High income	3 (5.6)	117 (17.7)	252 (17.7)	

SD, standard deviation. First three rows give the number of individuals in each of the SES and physical activity categories. In those cells, proportions were computed for each physical activity category within each SES (denominator is the total number within each SES). For all other factors (e.g. smoking diabetes, hypertension, etc.), proportions were computed using the frequency for each cell divided by the total number presented in the corresponding cell in the first three rows. Due to some missing values in different risk factors, the percentage might differ slightly from direct calculation.

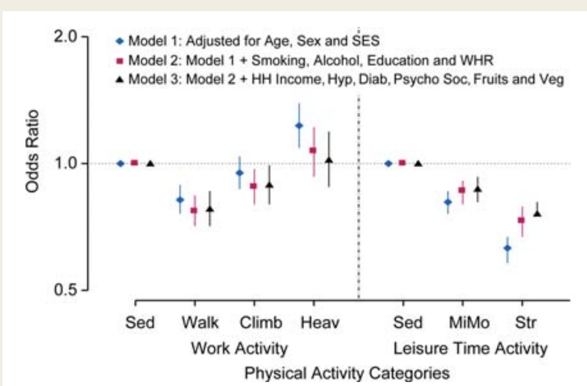

Figure 2 Association expressed as odds ratio (95% confidence interval) between occupation- and leisure-time-related PA and risk of myocardial infarction, with different adjustment models.

appeared to be protective in middle- and high-income countries. Moderate PA was associated with a reduction in MI risk in low- and middle-income countries only. Heavy physical labour was not associated with a lower risk of MI in any country income level.

For individuals who reported exercising (structured PA) during leisure time, the risk of MI was evaluated by categories of the duration of activity in minutes/week with those not doing any activity as reference (*Table 8*). In the fully adjusted model of multivariable analyses, the OR of MI for those who were active >0–30 min/week was 0.92 (CI 0.67–1.28) and decreased to OR 0.72 (CI 0.59–0.90) for >30–60 min/week, OR 0.78 (CI 0.67–0.91) for >60–150 min/week, OR 0.75 (CI 0.62–0.91) for >150–210 min/week, and OR 0.71 (CI 0.63–0.79), for subjects exercising >210 min/week, respectively.

Ownership of markers of sedentary behaviour and risk of myocardial infarction

Figure 3 indicates markers of sedentary lifestyle (ownership of TV, car, or both) and OR for having an MI. Ownership of either a car or a TV was not associated with the risk of MI (OR 1.10, 95% CI 0.92–1.31) in the fully adjusted model. Corresponding risk of MI for ownership of both a car and a TV showed a significantly increased risk with OR 1.27 (95% CI 1.05–1.54) vs. no ownership. This association was seen mainly in low- and middle-income countries.

Evaluating the association between ownership of a car or a TV and being sedentary, the OR for sedentary PA at work increased to an OR 2.10 (95% CI 1.78–2.47) compared with no ownership. Ownership of both a car and a TV increased the OR of being sedentary to 4.34 (95% CI 3.38–5.58) in low-income countries. The association between ownership and sedentary PA was consistent but attenuated across higher country income levels with OR 3.79 (95% CI 2.84–5.05) for both a car and a TV in middle, and OR 1.87 (95% CI 1.28–2.73), in high-income countries, respectively. Ownership of a car and a TV was inversely related to being sedentary during leisure time with the greatest reduction OR 0.18 (95% CI 0.12–0.26) in high vs. 0.45 (CI 0.35–0.59) in low country income levels compared with no ownership of a car or a TV.

The computed PAR for MI in individuals with sedentary behaviour compared with the top two categories of overall leisure-time PA was 28% (CI 24–33%).

In general, the analyses stratified by sex showed results consistent with the overall analyses. The OR reduction for the risk of MI was greater in women than in men. For work-related activity, the *P*-values for heterogeneity were non-significant (*Figure 4*). For mild

Table 6 Association between occupation and leisure-time-related physical activity and the risk of acute myocardial infarction

	OR model[a]	OR model[b]	OR model[c]
Work related activity			
Mainly sedentary	1.00	1.00	1.00
Walking at one level	0.82 (0.76–0.89)	0.77 (0.71–0.84)	0.78 (0.71–0.86)
Walking, climbing and or lifting	0.95 (0.87–1.04)	0.88 (0.80–0.97)	0.89 (0.80–0.99)
Heavy physical labour	1.23 (1.09–1.39)	1.07 (0.93–1.22)	1.02 (0.88–1.19)
Leisure-time physical activity			
Mainly sedentary	1.00	1.00	1.00
Mild activity	0.81 (0.76–0.86)	0.86 (0.80–0.91)	0.87 (0.81–0.93)
Moderate and strenuous activity	0.63 (0.58–0.68)	0.73 (0.67–0.79)	0.76 (0.69–0.82)

[a]Model adjusted for age, sex, and country level income.
[b]Model adjusted for age, sex, country level income, smoking, alcohol, education, and WHR.
[c]Model adjusted for age, sex, country level income, smoking, alcohol, education, household income, WHR, hypertension, diabetes, psychosocial factors, fruit intake, and vegetable intake.
OR, odds ratio.

Table 7 Association between occupation and leisure-time-related physical activity and risk of AMI by country income status

	Low income OR[a]	Middle income OR[a]	High income OR[a]	*P*-value for interaction
Work-related activity				
Mainly sedentary	1.00	1.00	1.00	0.0074
Walking at one level	0.99 (0.81–1.20)	0.74 (0.65–0.83)	0.71 (0.58–0.87)	
Walking, climbing, and/or lifting	0.81 (0.61–1.07)	0.82 (0.71–0.95)	1.08 (0.87–1.33)	
Heavy physical labour	0.97 (0.67–1.42)	0.96 (0.80–1.16)	1.21 (0.87–1.68)	
Leisure-time physical activity				
Mainly sedentary	1.00	1.00	1.00	0.4329
Mild activity	0.92 (0.76–1.12)	0.83 (0.76–0.90)	0.97 (0.82–1.15)	
Moderate and strenuous activity	0.74 (0.52–1.04)	0.74 (0.66–0.83)	0.81 (0.69–0.94)	

[a]Models adjusted for age, sex, smoking status, alcohol intake, education, household income, WHR, hypertension, diabetes, psychosocial factors, fruit intake and vegetable intake.

Table 8 Association between the duration of leisure-time physical activity and the risk of MI

Duration of leisure-time activity	OR model[a]	OR model[b]	OR model[c]
No activity	1.00	1.00	1.00
>0–30 min/week	0.79 (0.60–1.06)	0.91 (0.67–1.24)	0.92 (0.67–1.28)
>30–60 min/week	0.60 (0.50–0.72)	0.69 (0.57–0.84)	0.72 (0.59–0.90)
>60–150 min/week	0.59 (0.51–0.68)	0.73 (0.63–0.85)	0.78 (0.67–0.91)
>150–210 min/week	0.61 (0.52–0.72)	0.75 (0.63–0.89)	0.75 (0.62–0.91)
>210 min/week	0.56 (0.51–0.62)	0.66 (0.60–0.73)	0.71 (0.63–0.79)

[a]Model adjusted for age, sex, and country level income.
[b]Model adjusted for age, sex, country level income, smoking status, alcohol, education, and WHR.
[c]Model adjusted for age, sex, country level income, smoking status, alcohol intake, education, household income, WHR, hypertension, diabetes, psychosocial factors, fruit intake, and vegetable intake.

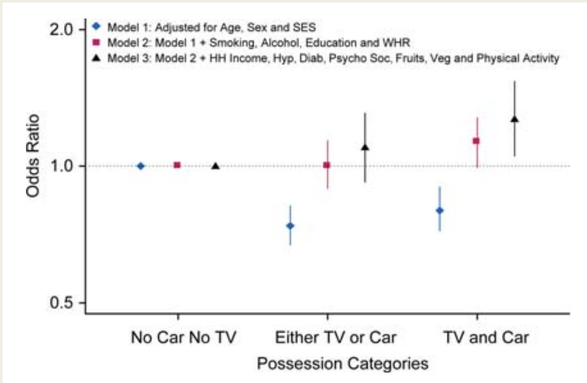

Figure 3 Association expressed as odds ratio (95% confidence interval) between ownership of a car and/or a TV and risk of myocardial infarction, with different adjustment models.

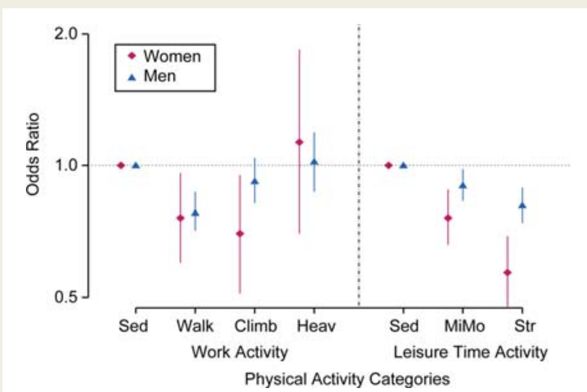

Figure 4 Association expressed as odds ratio (95% confidence interval) between occupation- and leisure-time-related PA and risk of myocardial infarction in males and females, with different adjustment models.

leisure-time activity vs. sedentary, the OR for females was 0.76 (CI 0.66–0.88) and 0.90 (CI 0.83–0.98) for males. Corresponding OR for moderate or strenuous leisure-time activity vs. sedentary was 0.57 (CI 0.47–0.69) and 0.81 (CI 0.74–0.89), for females and males, respectively; *P*-value for heterogeneity <0.01.

Figure 5 shows the results to be consistent in those in older (females ≥65 years and males ≥55 years) vs. younger categories (females <65 years and males <55 years), OR for mild leisure-time PA 0.88 (0.79–0.97) for young and 0.85 (0.77–0.94) for older. For moderate or strenuous leisure-time PA, OR was 0.80 (0.71–0.90) for younger and 0.71 (0.63–0.80) for older (*P* for heterogeneity 0.39).

Discussion

In the present analysis, we evaluated the association between categories of occupation- and leisure-time-related PA as well as the

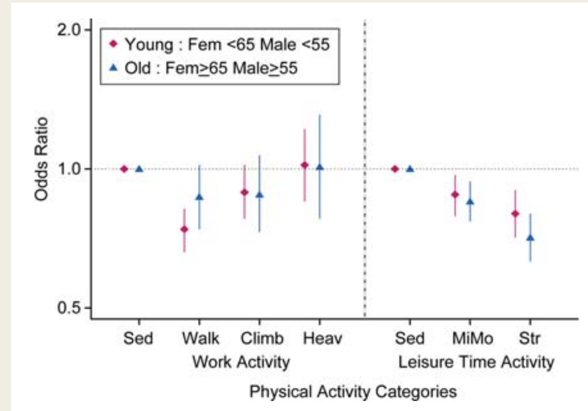

Figure 5 Association expressed as odds ratio (95% confidence interval) between occupation- and leisure-time-related PA and risk of myocardial infarction in younger (females <65, males <55 years) and in older (females ≥65 years, males ≥55 years), with different adjustment models.

duration of activity with CV risk factors and to the risk of developing an MI. In addition, household ownership of markers of sedentary lifestyle, such as car and a TV and their relation to the risk of MI, was evaluated. Increasing levels of occupation and leisure-time PA were inversely associated with most of the CV risk factors and were also independently related to a reduced risk of MI. Strenuous occupation-related PA was, however, not significantly associated with decreased risk. These relationships were consistent in both sexes and across young and elderly. The PAR for MI attributed to PA was 28%. Categories of increasing levels of leisure-time PA were consistently associated with decreased risk of MI across low-, middle-, and high-income countries. Ownership of a car and a TV was associated with higher blood pressure, higher BMI, and with prevalence of diabetes. Furthermore, it was associated with a two- to five-fold increase in the odds of sedentary work-related PA in low/middle-income countries, whereas an inverse relationship was found for leisure-time PA. Finally, ownership of a car and a TV was independently associated with the risk of an MI.

The results of this study extend previous findings of the protective effects of leisure-time PA in developed countries to low-, middle-, and high-income countries. Furthermore, ownership of a car and a TV, both markers of sedentary lifestyle, was independently related to the prevalence of risk factors, to sedentary PA at work, and to the risk of an MI.

Our study found that being sedentary at work was significantly associated with several markers of risk for an MI, such as high BMI, more frequent smoking, education, and ownership of a car and a TV, and there were trends for more hypertension and diabetes. Similar observations were made for leisure-time sedentary behaviour with significantly higher BMI, more frequent smoking, hypertension, diabetes, low education, and low family income. These were consistent in low-, middle-, and high-income countries.

The proportion of sedentary subjects at work and during leisure time was greatest in low-income countries and progressively lower in middle- and high-income countries. These differences in PA patterns were most pronounced regarding leisure-time activity. This may partly be explained by differences in education and other socio-economic factors. In addition, this may also reflect differences in cultures and in climate. The likelihood of a subject performing leisure-time PA in tropical or hot climate zones is lesser than in more temperate areas of the world. For work-related PA, we did not see a trend for more strenuous activity in lower income countries.

While numerous studies have indicated a protective effect of leisure-time PA,[1–3] the benefits of occupation-related PA are less clear. Indeed, the studies that first highlighted the benefits of PA were conducted in the workplace[17]; yet, more recent studies have failed to demonstrate an association.[18–20] We report that the protective effect of PA was more profound when performed during leisure time as opposed to PA performed at work. In addition, our results indicate that strenuous occupational activity was not associated with a protective effect on MI. This does not seem to be an effect of socio-economic status, since we also adjusted for education. While we do not have data on the specific types of heavy physical labour the participants were doing, it is possible that these activities were limited to anaerobic activities such as heavy lifting. In the ESTHER study, participants with either no or heavy PA had an increased risk of CV disease at 50 years of age after adjusting for age, sex, smoking, BMI, and education.[21] It is postulated that PA which is aerobic in nature such as walking is more beneficial in connection with CV health, compared with anaerobic PA or isometric in nature, such as lifting heavy objects.[22] In addition, the lack of benefit of occupational PA may also have been influenced by an unhealthy environment, e.g. high temperatures or high emotional stress. Furthermore, even though regular PA is associated with reduced lifetime risk for MI, the acute risk of MI may be actually increased during bouts of PA, and strenuous activities (i.e. shovelling snow) have been associated with MI.[23] This is mainly relevant to individuals with episodic PA, although an attenuated association is found also in subjects with high levels of habitual PA.[24] It is possible that some of the case participants in INTERHEART may have experienced their MI while actively engaging in strenuous activity, which together with the above studies may in part explain the lack of benefit of strenuous occupational activity.

When analysing the benefits of participating in specific exercise activity, we observed benefits in patients participating in even minimal amounts of activity (from 0 to 30 min/week). This protective effect had a relative risk reduction of around 30% and persisted after adjustment for socio-demographics and traditional risk factors. However, there was no clear additional benefit towards a further risk reduction when weekly exercise activity exceeded 60 min/week. Given previous reports indicating a dose–response protective effect of exercise duration,[25] this result was somewhat unexpected. It is possible that our ability to detect a dose–response relationship may be limited by the simplicity of our questionnaire and the patient's interpretation of what 'exercise' may be. Similar results have been reported by others[26] with a clear reduction in the risk of MI of about a 25% for non-strenuous leisure-time activity below the median, but no further benefit was observed for activity beyond the median time. Our findings support the recommendations of the current guidelines espousing the benefits of even small amounts of exercise activity in improving health and reducing risk for disease.[27]

The protective effect of PA was consistently observed in both males and females, and in young and old. However, the benefits across different regions were less clear. This discrepancy may be due to differences at the societal level, as those regions with greater industrialized development tended to exhibit protective effects with respect to leisure-time activity, while the less developed regions had greater benefits with respect to occupational-related activity. The lack of a protective benefit of occupational activity in developed countries may be due to the fact that the physical demands in most occupations have decreased resulting in a lack of heterogeneity and small sample sizes at the varying levels of occupational activity. At the same time, these countries have been reporting increasing levels of leisure-time PA participation. Conversely, occupational demands in developing countries are much greater and the opportunity to participate in leisure-time PA is much less. This result is a novel contribution of the INTERHEART study and indicates that the use of overall or total measures of PA may not be appropriate across regions/cultures, and as reported here, they may actually mask the beneficial effects of the various domains of PA. These data suggest that campaigns for increasing opportunities for PA may need to be different in different regions.

Our findings that possession of goods (both a car and a TV) promoting sedentary behaviour is related to a less optimal CV risk profile confirm other findings. We have also shown an independent association between ownership to an increased risk of MI which is a novel finding. We do not know the subjects' extent or duration of driving their cars which probably plays a role, and this study cannot prove causality. However, our findings support the recommendation to encourage the use of alternative transportation modes, such as public transport, walking, and bicycling as a method to promote PA for people. Although we do not have information on the duration of TV watching in this study, extensive TV use that reduces leisure-time PA leads to an increased risk of MI. Time spent driving cars or spent TV watching and relation to prognosis needs to be confirmed in prospective studies.

Limitations

As INTERHEART participants were recruited post-MI, these results are limited to individuals who have survived their event. However, previous studies have indicated that the protective effect of PA is even greater with respect to fatal MI.[28] It must also be recognized that not all individuals in the main INTERHEART study could be assessed in this study. We excluded subjects expected to be unable to be normally physically active (physical disability/social security) and a few hundred cases were excluded due to unavailable data on PA. In addition, some participants did not work and could only be partially evaluated. However, over 24 000 participants were evaluated with complete data in which PA was reported both at work and during leisure time. A limitation of our work is that the exposure variable, i.e. different aspects of PA, was based on recall. As a result, we are unable to determine whether participants either under- or over-reported their PA levels. In a study investigating recall bias in assessment of PA in relation with MI, intense occupational activity was not accurately reported.[29] Additionally, we were unable to assess the intensity of PA by quantitative means such as the use of MET scores as others have done. Another limitation is that we did not include PA related to commuting (either by motorized vehicles or by walking or cycling) in our assessment which has been reported to be related to the risk of MI by others.[30,31] As mentioned above, assessing these domains of PA may be important when conducting cross-regional/cultural comparisons as well as possible differences in perceptions of PA across cultures. However, our simple assessment of PA was able to uncover the substantial protective effects of PA across a variety of populations. We must also acknowledge the potential problem with multiple comparisons and the risk of chance findings.

The main strength of this study is the large number of cases and controls, men and women of all ages, and individuals from all regions across the world, and thus its global generalizability. By using simple questions that asked about two domains of PA, i.e. occupation-related PA and activity during leisure time, we were able to assess associations between PA and risk of MI.

In conclusion, the INTERHEART study shows that mild-to-moderate PA at work and any level of PA during leisure time reduce the risk of an MI, independent of other traditional risk factors in men and women in most regions of the world and in countries with low-, middle-, or high-income levels. These data extend the importance of PA and confirm a consistent protective effect of PA across all country income levels in addition to the known benefits of modifying traditional risk factors. Furthermore, ownership of a car and a TV that promotes sedentary behaviour was found to be independently associated with the risk of MI. Daily moderate PA should be encouraged for both men and women of all ages as a preventive act against the development of CV disease.

Acknowledgements

The expeditive help and administrative support from Sumathy Rangarajan is greatly acknowledged.

Funding

The INTERHEART study was funded by the Canadian Institutes of Health Research, the Heart and Stroke Foundation of Ontario, the International Clinical Epidemiology Network (INCLEN), and through unrestricted grants from several pharmaceutical companies [with major contributions from AstraZeneca, Novartis, Hoechst Marion Roussel (now Aventis), Knoll Pharmaceuticals (now Abbott), Bristol–Myers Squibb, and Sanofi-Sythelabo], and additionally by various national bodies in different countries: Chile—Universidad de la Frontera, Sociedad Chilena de Cardiologia Filial Sur; Colombia—Colciencias, Ministerio de Salud; Croatia—Croatian Ministry of Science and Technology; Guatemala—Liga Guatemalteca del Corazon; Hungary—Astra Hassle, National Health Science Council, George Gabor Foundation; Iran—Iran Ministry of Health; Italy—Boehringer Ingelheim; Japan—Sankyo Pharmaceutical, Banyu Pharmaceutical, Astra Japan; Kuwait—Endowment Fund for Health Development in Kuwait; Pakistan—ATCO Laboratories; Philippines—Philippine Council for Health Research and Development, Pfizer Philippines Foundation, Astra Pharmaceuticals and the Astra Fund for Clinical Research and Continuing Medical Education, Pharmacia and Upjohn; Poland—Foundation PROCLINICA, State Committee for Scientific Research; Singapore—Singapore National Heart Association; South Africa—MRC South Africa, Warner-Parke-Davis Pharmaceuticals, Aventis; Sweden—Grant from the Swedish State under LUA Agreement, Swedish Heart and Lung Foundation; Thailand—The Heart Association of Thailand, Thailand Research Fund; USA—King Pharma.

Conflict of interest: none declared.

References

1. Erlichman J, Kerbey AL, James WP. Physical activity and its impact on health outcomes. Paper 1: The impact of physical activity on cardiovascular disease and all-cause mortality: an historical perspective. *Obes Rev* 2002;**3**:257–271.
2. Hu G, Tuomilehto J, Silventoinen K, Barengo NC, Peltonen M, Jousilahti P. The effects of physical activity and body mass index on cardiovascular, cancer and all-cause mortality among 47 212 middle-aged Finnish men and women. *Int J Obes (Lond)* 2005;**29**:894–902.
3. Katzmarzyk PT, Janssen I, Ardern CI. Physical inactivity, excess adiposity and premature mortality. *Obes Rev* 2003;**4**:257–290.
4. Knuth AG, Hallal PC. Temporal trends in physical activity: a systematic review. *J Phys Act Health* 2009;**6**:548–559.
5. Pietilainen KH, Kaprio J, Borg P, Plasqui G, Yki-Jarvinen H, Kujala UM, Rose RJ, Westerterp KR, Rissanen A. Physical inactivity and obesity: a vicious circle. *Obesity (Silver Spring)* 2008;**16**:409–414.
6. James WP. WHO recognition of the global obesity epidemic. *Int J Obes (Lond)* 2008;**32**(Suppl. 7):S120–S126.
7. Blair SN, Morris JN. Healthy hearts—and the universal benefits of being physically active: physical activity and health. *Ann Epidemiol* 2009;**19**:253–256.
8. Haapanen N, Miilunpalo S, Vuori I, Oja P, Pasanen M. Association of leisure time physical activity with the risk of coronary heart disease, hypertension and diabetes in middle-aged men and women. *Int J Epidemiol* 1997;**26**:739–747.
9. Salonen JT, Slater JS, Tuomilehto J, Rauramaa R. Leisure time and occupational physical activity: risk of death from ischemic heart disease. *Am J Epidemiol* 1988;**127**:87–94.
10. Gutierrez-Fisac JL, Guallar-Castillon P, Diez-Ganan L, Lopez Garcia E, Banegas Banegas JR, Rodriguez Artalejo F. Work-related physical activity is not associated with body mass index and obesity. *Obes Res* 2002;**10**:270–276.
11. Kristal-Boneh E, Harari G, Melamed S, Froom P. Association of physical activity at work with mortality in Israeli industrial employees: the CORDIS study. *J Occup Environ Med* 2000;**42**:127–135.
12. Khaw KT, Jakes R, Bingham S, Welch A, Luben R, Day N, Wareham N. Work and leisure time physical activity assessed using a simple, pragmatic, validated questionnaire and incident cardiovascular disease and all-cause mortality in men and women: The European Prospective Investigation into Cancer in Norfolk prospective population study. *Int J Epidemiol* 2006;**35**:1034–1043.
13. Abubakari AR, Bhopal RS. Systematic review on the prevalence of diabetes, overweight/obesity and physical inactivity in Ghanaians and Nigerians. *Public Health* 2008;**122**:173–182.
14. Yusuf S, Hawken S, Ounpuu S, Dans T, Avezum A, Lanas F, McQueen M, Budaj A, Pais P, Varigos J, Lisheng L. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;**364**:937–952.
15. WHO. Global Recommendations on Physical Activity for Health. 2010. http://www.who.int/dietphysicalactivity/physical-activity-recommendations-18-64years.pdf.
16. Yusuf S, Hawken S, Ounpuu S, Bautista L, Franzosi MG, Commerford P, Lang CC, Rumboldt Z, Onen CL, Lisheng L, Tanomsup S, Wangai P Jr, Razak F, Sharma AM, Anand SS. Obesity and the risk of myocardial infarction in 27,000 participants from 52 countries: a case–control study. *Lancet* 2005;**366**:1640–1649.
17. Morris J, Heady J, Raffle P, Roberts C, Parks J. Coronary-heart disease and physical activity of work. *Lancet* 1953;1053–1057.
18. Fransson E, De Faire U, Ahlbom A, Reuterwall C, Hallqvist J, Alfredsson L. The risk of acute myocardial infarction: interactions of types of physical activity. *Epidemiology* 2004;**15**:573–582.
19. Wennberg P, Lindahl B, Hallmans G, Messner T, Weinehall L, Johansson L, Boman K, Jansson JH. The effects of commuting activity and occupational and leisure time physical activity on risk of myocardial infarction. *Eur J Cardiovasc Prev Rehabil* 2006;**13**:924–930.
20. Besson H, Ekelund U, Brage S, Luben R, Bingham S, Khaw KT, Wareham NJ. Relationship between subdomains of total physical activity and mortality. *Med Sci Sports Exerc* 2008;**40**:1909–1915.
21. Raum E, Rothenbacher D, Ziegler H, Brenner H. Heavy physical activity: risk or protective factor for cardiovascular disease? A life course perspective. *Ann Epidemiol* 2007;**17**:417–424.

22. Hoekstra T, Boreham CA, Murray LJ, Twisk JW. Associations between aerobic and muscular fitness and cardiovascular disease risk: the northern Ireland young hearts study. *J Phys Act Health* 2008;**5**:815–829.
23. Mittleman MA, Siscovick DS. Physical exertion as a trigger of myocardial infarction and sudden cardiac death. *Cardiol Clin* 1996;**14**:263–270.
24. Dahabreh IJ, Paulus JK. Association of episodic physical and sexual activity with triggering of acute cardiac events: systematic review and meta-analysis. *JAMA* 2011;**305**:1225–1233.
25. Lee IM, Sesso HD, Paffenbarger RS Jr. Physical activity and coronary heart disease risk in men: does the duration of exercise episodes predict risk? *Circulation (Online)* 2000;**102**:981–986.
26. Lovasi GS, Lemaitre RN, Siscovick DS, Dublin S, Bis JC, Lumley T, Heckbert SR, Smith NL, Psaty BM. Amount of leisure-time physical activity and risk of nonfatal myocardial infarction. *Ann Epidemiol* 2007;**17**:410–416.
27. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation* 2007;**116**: 1081–1093.
28. O'Connor GT, Buring JE, Yusuf S, Goldhaber SZ, Olmstead EM, Paffenbarger RS, Hennekens CH. An overview of randomized trials of rehabilitation with exercise after myocardial infarction. *Circulation* 1989;**80**:234–244.
29. Fransson E, Knutsson A, Westerholm P, Alfredsson L. Indications of recall bias found in a retrospective study of physical activity and myocardial infarction. *J Clin Epidemiol* 2008;**61**:840–847.
30. Hamer M, Chida Y. Active commuting and cardiovascular risk: a meta-analytic review. *Prev Med* 2008;**46**:9–13.
31. Wennberg P, Wensley F, Johansson L, Boman K, Di Angelantonio E, Rumley A, Lowe G, Hallmans G, Jansson JH. Reduced risk of myocardial infarction related to active commuting: inflammatory and haemostatic effects are potential major mediating mechanisms. *Eur J Cardiovasc Prev Rehabil* 2010;**17**: 56–62.