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The association between occupational physical activity and myocardial infarction – a prospective cohort study

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ABSTRACT

Objective: Recommendations regarding physical activity typically include both leisure time and occupational physical activity. However, the results from previous studies on occupational physical activity and the association to myocardial infarction have been inconsistent. The aim of this study was to investigate if occupational physical activity is associated with the risk of myocardial infarction.

Design: Prospective cohort study.

Participants: Data from the Swedish WOLF study was used, comprising 9,961 employees (6,849 men, 3,112 women, mean age 42.7 years) having no history of myocardial infarction. The participants were categorized into three groups according to their level of occupational physical activity.

Outcome: Data regarding incident myocardial infarction was obtained from the Swedish National Patient Register and the Cause of Death Register. Hazard ratios (HR) were estimated using Cox proportional hazard regression for different levels of occupational physical activity in relation to the risk of myocardial infarction.

Results: During a mean follow-up of 13.1 years, 249 cases of incident myocardial infarction were identified. In analyses adjusted for age, sex and socio-economic status, participants standing and walking more than 50% of their working day had an HR of 1.13 (95% CI, 0.83-1.54), compared to participants seated more than 50% of their working day. The corresponding HR for participants whose work included lifting or carrying was 0.86 (95% CI, 0.59-1.24). Stratified analyses resulted in a significantly decreased risk for young people whose work included lifting or carrying, HR 0.37 (95% CI, 0.17-0.84), compared with younger persons who sat most of their working day.

Conclusion: No clear association between occupational physical activity and the risk of myocardial infarction was observed in the total group of employees in this study. This indicates that occupational physical activity alone is not sufficient to reduce the risk of myocardial infarction.

Strengths and limitations of this study

- This is a large prospective cohort study.
- The study includes working men and women from a variety of occupations.
- The outcome myocardial infarction, is ascertained through nation-wide registers with high coverage.
- The high response rate, together with the distribution between different socioeconomic groups, increases the validity in this study.
- A limitation is that the exposure occupational physical activity, only is measured at baseline.

INTRODUCTION

Ischemic heart disease is the leading cause of global mortality and burden of disease. In 2010, more than 13% of all deaths were due to ischemic heart disease[1, 2]. Physical activity is, known as a preventive factor for ischemic heart disease[3-6]. However, the term physical activity is general and may involve leisure time physical activity, occupational physical activity, commuting and household chores[7]. In more recent research a distinction is often made between leisure time physical activity and occupational physical activity. The findings regarding leisure time physical activity are quite consistent that high levels of physical activity decrease the risk of cardiovascular disease (CVD)[8-12]. In contrast, studies of occupational physical activity and CVD show more inconsistent results, where some studies have shown that high occupational physical activity increases the risk of CVD[11, 13-15], while other results point toward a protective effect of moderate to high occupational physical activity[10, 16, 17]. In the recommendations from WHO regarding physical activity, both leisure time physical activity and occupational physical activity are included, without distinction in the recommendations regarding these different domains of physical activity[18].

The aim of this study was to investigate if occupational physical activity is associated with the risk of myocardial infarction and if the association is modified by age, sex, socio-economic status and leisure time physical activity. In line with the recommendations from WHO regarding physical activity in general, the hypothesis in this study was that occupational physical activity has a protective effect against myocardial infarction.

METHODS

Data used for this study was obtained from the Swedish Work, Lipids and Fibrinogen (WOLF) study[19]. Participants were included for the baseline data collection 1992-1995 in the Stockholm County and 1996-1997 in the counties of Jämtland and Västernorrland. Occupational health service units were invited to participate in the study, 33 out of 36 accepted the invitation. These units served employees from around 60 different companies in several different branches and occupations. The employees who were willing to participate filled in a questionnaire including questions regarding their occupation and work environment, socioeconomic factors, life-style factors, hereditary factors and disease history. In addition, the employees went through a clinical examination including measurements of

blood pressure, height, weight, waist and hip circumference. In total, 10,416 employees both responded to the questionnaire and went through the clinical examination. The response rate was 82 % for the total sample, with higher response rates in Jämtland and Västernorrland, compared to the Stockholm area.

Occupational physical activity

The participants were asked about their occupational physical activity by three questions in the questionnaire: (1) Whether or not they were seated for more than half of their total working hours; (2) If they were lifting or carrying more than 5 kg for at least two hours of their working day; and (3) for women, if they were lifting or carrying more than 20 kg at least five times per working day. For men, the corresponding question was if they were lifting or carrying more than 30 kg at least five times per working day.

Out of these three questions, the participants were categorized into three groups: seated for more than half of their working day and no lifting or carrying (OPA 1); standing or walking for more than half of their working day but with no lifting or carrying (OPA 2); lifting or carrying either 5 kg for at least two hours of their working day, or heavy lifting (20 kg for women and 30 kg for men) at least five times per working day, regardless of if they were seated or standing/walking most of their working day (few were lifting/carrying and were seated most of their working day) (OPA 3).

Myocardial infarction

Data regarding incident myocardial infarction was obtained from the National Patient Register and the Cause of Death Register, using the diagnosis “acute myocardial infarction”, I21 (ICD-10) or 410 (ICD-9).

Potential confounders and mediators

As several factors, such as age, sex, socioeconomic status, smoking, leisure time physical activity, alcohol and consumption of fruit and vegetables, might be associated with both occupational physical activity and the risk of myocardial infarction, these were taken into account in the analyses. Age was used as a continuous variable in all analyses except when

stratifying the analysis by age, where the participants were categorized into three different groups: (1) younger than 45 years old; (2) 45 – 54 years old; (3) 55 years or older. Socioeconomic status was defined from Swedish socioeconomic classification[20], according to the participants' occupation and education. From this classification the participants were categorized into three different socioeconomic groups: (1) manual workers; (2) low and intermediate non-manual workers; (3) professionals. The participants were categorized into three groups regarding their smoking habits at baseline: never smoked, former smokers or current smokers. The participants were asked about their leisure time physical activity by the question "How often do you exercise?" The response options were "never", "very seldom", "sometimes" and "regularly". In the analyses the participants were categorized into three groups where the two least active answers were combined into one group: (1) never or seldom; (2) sometimes; (3) regularly. The participants were categorized into two groups regarding their consumption of fruit and vegetables: whether or not they were eating at least one piece of fruit every day, and whether or not they were eating one portion of vegetables every day. The participants were asked about their average alcohol consumption during the last 12 months. Out of this question the participants were classified into four categories: (1) non-drinking; (2) moderate drinking; (3) intermediate drinking; (4) heavy drinking. Moderate drinking was defined as drinking 1 – 21 units of alcohol per week (men), or 1 – 14 units per week (women). Intermediate drinking was defined as drinking 22 -27 units per week (men), or 15 – 20 units per week (women). Heavy drinking was defined as drinking 28 units alcohol or more per week (men), or 21 units or more per week (women). One unit of alcohol is approximately equivalent to 10 grams of ethanol.

Other aspects may mediate the association between occupational physical activity and myocardial infarction, and therefore the following factors were considered as potential mediators in the analyses. Hypertension was defined as systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg or medical treatment for hypertension according to reported drugs in the questionnaire. Assessment of abdominal obesity was done by measurement of waist circumference during the clinical examination. In the analyses the participants were categorized into three groups according to cut-off points recommended from WHO[21]. For men, the three groups were: (1) ≤ 94 cm; (2) 95 – 102 cm; (3) ≥ 103 cm. The corresponding groups for women were: (1) ≤ 80 cm; (2) 81 – 88 cm; (3) ≥ 89 cm. Hyperlipidemia was defined as total cholesterol > 5 mmol/L.

Statistical analysis

In this prospective cohort study, participants without any history of myocardial infarction at baseline were followed from inclusion date (the day of their clinical examination) until their first myocardial infarction event, migration out of Sweden, death, or end of follow up (December 31, 2008), whichever came first. Data on incidence of myocardial infarction before baseline was obtained from the respondent's disease history in the questionnaire, or from data in the National Patient Register. Data on migration was obtained from the Swedish Tax Agency.

In the present study, 93 participants with a history of myocardial infarction prior to the inclusion date were excluded. Students (n=113), and one participant that emigrated from Sweden before inclusion date (n=1), were also excluded. Participants with missing answers in one or more of the questions regarding physical activity at work (n=248), could not with certainty be categorized in the correct level of occupational physical activity and were therefore excluded. In total, this yielded an analytical sample for this study of n=9,961.

Hazard ratios (HR) were estimated with 95% confidence intervals (95% CI), using Cox proportional hazard regression, for different levels of occupational physical activity in relation to the risk of myocardial infarction. Multivariable regression models included adjustment for age, sex, socioeconomic status, smoking, leisure time physical activity, consumption of fruit and vegetables, and consumption of alcohol. The potential mediators hypertension, abdominal obesity and hyperlipidemia, were also taken into account. Stratified analyses were made for different age groups, for men and women, for different socioeconomic groups, and for different engagement in leisure time physical activity. All analyses were conducted using the statistical program IBM SPSS Statistics version 21.

Ethical considerations

The baseline study of WOLF was approved by the Ethics Committee at Karolinska Institutet, Stockholm (#92-198). All participation in the study was voluntary and with informed consent from the respondents. The record linkages of baseline data with the National Patient Register and the Cause of Death Register was approved by the Regional Ethical Review board in Stockholm (#2006/257-31).

RESULTS

In total, 9,961 people, 6,849 men and 3,112 women, without history of myocardial infarction, were followed during a mean follow-up time of 13.1 years (47 days – 16.9 years). During the follow-up time 249 cases, both fatal and nonfatal, of myocardial infarction was registered, 223 cases among men and 26 cases among women. Table 1 shows baseline characteristics of the study subjects in total, and divided by the three levels of occupational physical activity. Most of the participants in the study belonged to OPA 1 (n=4,997). The other two groups, OPA 2 (n=2,568) and OPA 3 (n=2,396), were quite similar regarding number of participants. The mean age at baseline was 42.7 (range 19 – 70) years. A clear difference was seen in the distribution of men and women in the different levels of OPA, with the lowest proportion of women in OPA 3. As expected, there was also a clear difference in socioeconomic status between the three levels of OPA. Almost 90% of the participants in OPA 3 were manual workers and only 0.9% were professionals. In contrast, only 19% in OPA 1 were manual workers. Some differences in lifestyles factors in the three levels of occupational physical activity were seen at baseline. For example, the highest proportion of current smokers was observed in OPA 3, while the highest proportion of leisure time physical activity were found in OPA 1. The highest frequency of hypertension, hyperlipidemia and abdominal obesity was observed in OPA 3, even though the differences between the three groups were small.

Table 1. Baseline characteristics of study subjects by occupational physical activity.

	Total n = 9,961	OPA 1 n = 4,997	OPA 2 n = 2,568	OPA 3 n = 2,396
Age				
Mean (SD)	42.7 (10.7)	43.2 (10.1)	43.0 (10.9)	41.5 (11.4)
< 45 years, n (%)	5,306 (53.3)	2,602 (52.1)	1,322 (51.5)	1,382 (57.7)
45-54 years, n (%)	3,164 (31.8)	1,701 (34.0)	820 (31.9)	643 (26.8)
≥ 55 years, n (%)	1,491 (15.0)	694 (13.9)	426 (16.6)	371 (15.5)
Sex				
Men, n (%)	6,849 (68.8)	3,075 (61.5)	1,758 (68.2)	2,023 (84.4)
Women, n (%)	3,112 (31.2)	1,922 (38.5)	817 (31.8)	373 (15.6)
Myocardial infarction during follow- up, n (%)	249 (2,5)	116 (2.3)	74 (2.9)	59 (2.5)
Socioeconomic status				
Manual workers, n (%)	4,372 (43.9)	965 (19.3)	1,257 (49.0)	2,150 (89.8)
Low and intermediate non-manual workers, n (%)	4,334 (43.5)	3,008 (60.3)	1,102 (42.2)	224 (9.4)
Professionals, n (%)	1,246 (12.5)	1,017 (20.4)	208 (8.1)	21 (0.9)
Smoking				
Never smoked, n (%)	4,647 (47.8)	2,435 (49.6)	1,209 (48.1)	1,003 (43.5)
Former smoker, n (%)	2,872 (29.5)	1,500 (30.6)	728 (29.0)	644 (27.9)
Current smoker, n (%)	2,207 (22.7)	972 (19.5)	575 (22.9)	660 (28.6)
Leisure time physical activity				
Never or seldom, n (%)	2,479 (24.9)	1,181 (23.7)	609 (23.7)	689 (28.9)
Sometimes, n (%)	3,823 (38.4)	1,787 (35.8)	1,019 (39.7)	1,017 (42.6)
Regularly, n (%)	3,645 (36.6)	2,025 (40.6)	938 (36.6)	682 (28.6)
Consumption of fruit				
One piece or more per day, n (%)	6,160 (63.1)	3,130 (63.5)	1,618 (64.2)	1,412 (60.8)
Consumption of vegetables				
One portion or more per day, (%)	3,250 (34.1)	1,895 (39.1)	792 (32.3)	563 (25.3)
Consumption of alcohol				
Non-drinker, n (%)	490 (5.0)	185 (3.8)	147 (5.8)	158 (6.8)
Moderate, n (%)	8,554 (87.7)	4,408 (89.5)	2,231 (88.7)	1,915 (83.0)
Intermediate, n (%)	312 (3.2)	158 (3.2)	64 (2.5)	90 (3.9)
Heavy, n (%)	394 (4.0)	176 (3.6)	73 (2.9)	145 (6.3)
Hypertension, n (%)	1,569 (15,8)	754 (15.1)	421 (16.4)	394 (16.5)
Abdominal obesity				
M ≤ 94 cm, W ≤ 80 cm, n (%)	6,195 (62.5)	3,133 (63.0)	1,645 (64.4)	1,417 (59.4)
M 95-102 cm W 88-88 cm, n (%)	2,217 (22.4)	1,114 (22.4)	557 (21.8)	546 (22.9)
M ≥ 103 cm, W ≥ 89 cm, n (%)	1,502 (15.2)	727 (14.6)	354 (13.8)	421 (17.7)
Hyperlipidemia, n (%)	6,288 (63,2)	3,143 (62.9)	1,614 (62.9)	1,531 (64.0)

OPA 1 = Seated for more than 50 % of working day, no lifting or carrying. OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying. OPA 3 = Lifting or carrying regardless of seated or standing/walking.

The results of the Cox proportional hazard regressions with occupational physical activity as exposure and myocardial infarction as outcome, are shown in table 2. In the crude analyses, the HR for OPA 2 was 1.30 (95% CI, 0.97-1.74), the corresponding HR for OPA 3 was 1.12 (95% CI, 0.82-1.53), with OPA 1 as the reference category. Adjusting for age, sex and socioeconomic status (model 2) resulted in HR 1.13 (95% CI, 0.83-1.54) for OPA 2 and HR 0.86 (95 % CI, 0.59-1.24) for OPA 3 compared with OPA 1. Adjustment for lifestyle factors (model 3) and other mediating factors such as hypertension, abdominal obesity and hyperlipidemia (model 4), didn't alter the HRs in any major way. Table 2 also contains analyses restricted to those working 35 hours per week or more (n=9,058). In general, the results from these analyses were very similar to the results based on the total sample. A significant increased HR was seen for OPA 2 compared to OPA 1 in the crude analysis, HR 1.37 (95% CI. 1.01-1.87), but after adjusting for age, sex and socioeconomic status (model 2), the HR for OPA 2, was attenuated to 1.18 (95% CI. 0.85-1.63).

Table 2. The association between occupational physical activity and risk of myocardial infarction. Analysis made for the total sample and restricted to those working 35 hours per week or more. Hazard ratios (HR) with 95 % confidence intervals (95% CI).

	Crude	Model 1	Model 2	Model 3	Model 4
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
OPA (Total)	n=9,961	n=9,961	n=9,952	n=9,048	n=8,995
1	1	1	1	1	1
2	1.30 (0.97-1.74)	1.21 (0.90-1.62)	1.13 (0.83-1.54)	1.12 (0.80-1.56)	1.11 (0.80-1.55)
3	1.12 (0.82-1.53)	0.98 (0.71-1.34)	0.86 (0.59-1.24)	0.86 (0.57-1.29)	0.85 (0.57-1.28)
OPA (>35h/week)	n=9,058	n=9,058	n=9,049	n=8,247	n=8,203
1	1	1	1	1	1
2	1.37 (1.01-1.87)	1.27 (0.94-1.75)	1.18 (0.85-1.63)	1.14 (0.80-1.61)	1.13 (0.78-1.61)
3	1.18 (0.85-1.64)	1.04 (0.75-1.45)	0.87 (0.59-1.27)	0.87 (0.57-1.32)	0.85 (0.56-1.30)

OPA 1 = Seated for more than 50 % of working day, no lifting or carrying. OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying. OPA 3 = Lifting or carrying regardless of seated or standing/walking.
Model 1, adjusted for age and sex. Model 2, adjusted for age, sex and socioeconomic status. Model 3, adjusted for age, sex, socioeconomic status and lifestyle factors (smoking, leisure time physical activity, alcohol, fruit and vegetable consumption. Model 4, adjusted for age, sex, socioeconomic status, lifestyle factors and mediating factors (hypertension, abdominal obesity and hyperlipidemia).

Results from stratified analyses, adjusted age, sex and socioeconomic status where applicable, are shown in table 3. The HRs for the different levels of occupational physical activity in relation to myocardial infarction indicates no major differences between men and women. However, the confidence intervals for women compared to men are wider, indicating greater uncertainty due to few cases. Stratified analysis for different socioeconomic groups shows a tendency to a decreased risk for professionals in OPA 2, compared with manual workers and low and intermediate manual workers in OPA 2. However, these analyses are based on subgroups with few participants, which must be considered. Stratifying for different levels of leisure time physical activity showed a tendency towards a reduced risk for participants who are physically active both during work and leisure time, but the result was not statistically significant. When stratifying for age, a reduced risk for myocardial infarction was observed for young participants, aged < 45, in OPA 3 (HR 0.37, 95% CI, 0.17-0.84).

Table 3. The association between occupational physical activity and risk of myocardial infarction. Analyses stratified for age, sex, socioeconomic status and leisure time physical activity. Hazard ratios (HR) with 95 % confidence intervals (95% CI), adjusted for age, sex and socio-economic status, where applicable.

	Age		
	< 45 years n=5,306	45 – 54 years n=3,164	≥ 55 years n=1,491
OPA			
1	1	1	1
2	1.09 (0.56-2.09)	1.50 (0.95-2.35)	0.77 (0.45-1.32)
3	0.37 (0.17-0.84)	1.51 (0.86-2.67)	0.72 (0.40-1.32)
	Sex		
	Men n=6,849	Women n=3,112	
OPA			
1	1	1	
2	1.11 (0.80-1.54)	1.26 (0.52-3.03)	
3	0.85 (0.58-1.25)	0.92 (0.22-3.73)	
	Socioeconomic status		
	Manual workers n=4,372	Low and intermediate non-manual workers n=4,334	Professionals n=1,246
OPA			
1	1	1	1
2	1.28 (0.79-2.06)	1.14 (0.73-1.77)	0.54 (0.16-1.82)
3	0.90 (0.57-1.43)	1.06 (0.46-2.44)	-
	Leisure time physical activity		
	Never/Seldom n=2,479	Sometimes n=3,823	Regularly n=3,645
OPA			
1	1	1	1
2	1.42 (0.82-2.45)	1.35 (0.84-2.16)	0.67 (0.36-1.26)
3	0.83 (0.43-1.59)	1.07 (0.61-1.86)	0.67 (0.30-1.48)

OPA 1 = Seated for more than 50 % of working day, no lifting or carrying. OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying. OPA 3 = Lifting or carrying regardless of seated or standing/walking.

DISCUSSION

In this study, we found no strong associations between occupational physical activity and myocardial infarction, neither when looking at participants with substantial standing and walking at work, nor when looking at participants with lifting or carrying at work, compared with participants who were seated most of their working day. Based on the results from this study, occupational physical activity doesn't seem to have the same association with myocardial infarction which is seen for leisure time physical activity. The hypothesis that occupational physical activity has a protective effect against myocardial infarction could not be confirmed in this study. Neither do the results from this study support the theory that high levels of occupational physical activity would increase the risk of myocardial infarction.

A restriction to full-time workers was made in order to see if the association between occupational physical activity and myocardial infarction would be stronger in this group. The results from the crude analyses showed significant increased risk of myocardial infarction for the participants with substantial standing and walking at work. However this association was attenuated and no longer statistically significant after adjusting for traditional risk factors as age, sex, socioeconomic status and lifestyle factors. In general, the results from the restricted analyses were similar as the results based on the total sample.

Other studies of occupational physical activity and myocardial infarction have showed diverse results. A significant increased risk of myocardial infarction for men with moderate levels of occupational physical activity, was for example observed in the study by Holtermann et al. in the Copenhagen City Heart Study[15]. In comparison with the present study, their categorization of occupational physical activity was quite similar. However, a combination of baseline and follow up measures after five years was used in their categorization of occupational physical activity. Furthermore, in a study by Allesoe et al an increased risk was noted for women with high levels of physical activity at work[14]. In contrast to the present study where a variety of occupations are included, they were only studying nurses.

A significantly reduced risk for myocardial infarction was noted for both men and women with moderate to high levels of occupational physical activity in a Finnish study[16]. They were using quite similar categorization as in the present study. A difference though, is that they started their data collection 20 years earlier than in our study. The two studies differ with regard to number of subjects in the highest level of occupational physical activity, the Finnish study having higher numbers in this category. The differences in results seen between the two

studies may reflect changes over time regarding both occupational physical activity and physical activity in general.

Guidelines about physical activity in general, emphasis the importance of a non-sedentary life-style, in order to protect diseases[18]. However, in a recent study by Moller et al[22], no differences were seen between employees with sedentary and non-sedentary work regarding the risk of ischemic heart disease. It has been proposed that leisure time physical activity and occupational physical activity might have different effect on the cardiovascular system, with leisure time physical activity leading to a training effect on the heart and occupational physical activity leading to an overload on the cardiovascular system[23].

A factor that might affect the risk of myocardial infarction is the participants' level of physical fitness. It has previously been shown that high levels of occupational physical activity don't seem to improve physical fitness[24, 25]. This could be understood from the idea that occupational physical activity in most cases doesn't increase heart rate enough to improve fitness level, and therefore doesn't have positive effect on the cardiovascular system. Research where combination of high levels of occupational physical activity and moderate to high levels of leisure time physical activity have been studied has resulted both in increased[26] and decreased[27] risk of ischemic heart disease. When looking at the baseline characteristics for participants in this study, there is a larger proportion taking part in leisure time physical activity in OPA 1, this proportion decreases in OPA 2 and is at its smallest in OPA 3. Explanations for this may involve that high levels of occupational physical activity leads to fatigue in leisure time, with little energy left to take part in exercise.

Stratifying for different age groups resulted in a significantly reduced risk for participants younger than 45 years old, with work including lifting or carrying. One possible explanation for these findings might be the, in general, higher fitness level seen for younger people, which may allow for a higher level of occupational physical activity. For the middle-aged, 45 to 54 years old, no statistically significant results were seen. Compared to the younger participants the results for this group rather showed a tendency towards an increased risk of myocardial infarction for work including substantial standing and walking. This might has to do with declining functional reserve capacity with older ages[28]. In contrast to the results from the middle-aged group, the results from the group of the oldest participants don't show the same tendency towards increased risk, as seen for the middle-aged. Here, theories about "the healthy worker"[29] might be part of the explanation. In general, all the results from the stratified analyses must be interpreted with caution, due to the few participants in some of the

analyzed subgroups, leading to low precision in estimates and wide confidence intervals, and hence low power to detect a true association.

A strength with the present study is the high response rate, together with the distribution between different socioeconomic groups, which increases the validity in this study and also the ability to generalize the results from this study to the Swedish population as well as to other populations with similarities in working conditions. Data on myocardial infarction was obtained from the National Patient Register and the Cause of Death Register in Sweden which are reliable sources, and therefore implies high reliability for this data[30].

One limitation in the study is that only data from the baseline is used regarding the participants' levels of occupational physical activity. Participants may have changed exposure category during the time of follow-up. Given that a true association exist between occupational physical activity and myocardial infarction, change of exposure category might have attenuated the association in the present study. A follow up of the participants' level of occupational physical activity would therefore further have increased the validity of this study. Another limitation is that the data regarding occupational physical activity is self-reported from the participants. Other ways of assessing occupational physical activity are for example used by Krause et al.[13]. They interviewed the study subjects about their physical activity at work and how many minutes they spent in different activity. Out of these interviews, energy expenditure were calculated. A more objective measurement is tested by Skotte et al.[31] using triaxial accelerometers for detection of physical activity. An objective assessment of occupational physical activity would have been preferable, but is often not feasible to include in large scale epidemiological studies, as this would require extensive resources.

Conclusion

No strong associations between occupational physical activity and the risk of myocardial infarction was observed in this prospective cohort study of 9,961 employees in the total study population. A significant reduced risk were seen for participants younger than 45 years old with work including lifting and carrying, but this result must be interpreted with caution, due to the few participants in the stratified analyses. Based on the results from this study, occupational physical activity in general does not seem to be enough for reducing the risk of

myocardial infarction, which is an important message to people with high levels of occupational physical activity.

Contributorship statement

LA, AK and PJMW were responsible for the baseline data collection, AMJ and EIF were responsible for the conception and the design of the present study. AMJ drafted the first version of the manuscript. All authors interpreted the data and revised the manuscript critically for important intellectual content. All authors read and approved the final version of the manuscript.

Competing interests

There are no competing interests for this publication.

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Data sharing statement

No additional unpublished data from the study is available.

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4, 7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5, 6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	?
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	10, 11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, 8
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13 5, 6
		(*b*) Report category boundaries when continuous variables were categorized	5, 6, 13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15, 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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The association between occupational physical activity and myocardial infarction – a prospective cohort study

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The association between occupational physical activity and myocardial infarction – a prospective cohort study

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ABSTRACT

Objective: Recommendations regarding physical activity typically include both leisure time and occupational physical activity. However, the results from previous studies on occupational physical activity and the association to myocardial infarction have been inconsistent. The aim of this study was to investigate if occupational physical activity is associated with the risk of myocardial infarction.

Design: Prospective cohort study.

Participants: Data from the Swedish WOLF study was used, comprising 9,961 employees (6,849 men, 3,112 women, mean age 42.7 years) having no history of myocardial infarction. The participants were categorized into three groups according to their level of occupational physical activity.

Outcome: Data regarding incident myocardial infarction was obtained from the Swedish National Patient Register and the Cause of Death Register. Hazard ratios (HR) were estimated using Cox proportional hazard regression for different levels of occupational physical activity in relation to the risk of myocardial infarction.

Results: During a mean follow-up of 13.1 years, 249 cases of incident myocardial infarction were identified. In analyses adjusted for age, sex and socio-economic status, participants standing and walking more than 50% of their working day had an HR of 1.13 (95% CI, 0.83-1.54), compared to participants seated more than 50% of their working day. The corresponding HR for participants whose work included lifting or carrying was 0.86 (95% CI, 0.59-1.24). Further adjustment did not alter the results. Stratified analyses resulted in a significantly decreased risk for young people whose work included lifting or carrying, HR 0.37 (95% CI, 0.17-0.84), compared with younger persons who sat most of their working day.

Conclusion: No significant association between occupational physical activity and the risk of myocardial infarction was observed in the total group of employees in this study. Based on the results from this study, occupational physical activity in general does not seem to be enough for reducing the risk of myocardial infarction.

Strengths and limitations of this study

- This is a large prospective cohort study.
- The study includes working men and women from a variety of occupations.
- The outcome myocardial infarction, is ascertained through nation-wide registers with high coverage.
- The high response rate, together with the distribution between different socioeconomic groups, increases the validity in this study.
- A limitation is that the exposure occupational physical activity, only is measured at baseline.

INTRODUCTION

Ischemic heart disease is the leading cause of global mortality and burden of disease. In 2010, more than 13% of all deaths were due to ischemic heart disease[1, 2]. Physical activity is, known as a preventive factor for ischemic heart disease[3-6]. However, the term physical activity is general and may involve leisure time physical activity, occupational physical activity, commuting and household chores[7]. In more recent research a distinction is often made between leisure time physical activity and occupational physical activity. The findings regarding leisure time physical activity are quite consistent that high levels of physical activity decrease the risk of cardiovascular disease (CVD)[8-12]. In contrast, studies of occupational physical activity and CVD show more inconsistent results, where some studies have shown that high occupational physical activity increases the risk of CVD[11, 13-15], while other results point toward a protective effect of moderate to high occupational physical activity[10, 16, 17]. In the recommendations from WHO regarding physical activity, both leisure time physical activity and occupational physical activity are included, without distinction in the recommendations regarding these different domains of physical activity[18].

The aim of this study was to investigate if occupational physical activity is associated with the risk of myocardial infarction and if the association is modified by age, sex, socio-economic status and leisure time physical activity. In line with the recommendations from WHO regarding physical activity in general, the hypothesis in this study was that occupational physical activity has a protective effect against myocardial infarction.

METHODS

Data used for this study was obtained from the Swedish Work, Lipids and Fibrinogen (WOLF) study[19]. Participants were included for the baseline data collection 1992-1995 in the Stockholm County and 1996-1997 in the counties of Jämtland and Västernorrland. Occupational health service units were invited to participate in the study, 33 out of 36 accepted the invitation. These units served employees from around 60 different companies in several different branches and occupations. The employees who were willing to participate filled in a questionnaire including questions regarding their occupation and work environment, socioeconomic factors, life-style factors, hereditary factors and disease history. In addition, the employees went through a clinical examination including measurements of blood pressure, height, weight, waist and hip circumference. In total, 10,416 employees both responded to the questionnaire and went through the clinical examination. The

response rate was 82 % for the total sample, with higher response rates in Jämtland and Västernorrland, compared to the Stockholm area.

Occupational physical activity

The participants were asked about their occupational physical activity by three questions in the questionnaire: (1) Whether or not they were seated for more than half of their total working hours; (2) If they were lifting or carrying more than 5 kg for at least two hours of their working day; and (3) for women, if they were lifting or carrying more than 20 kg at least five times per working day. For men, the corresponding question was if they were lifting or carrying more than 30 kg at least five times per working day.

Out of these three questions, the participants were categorized into three groups: seated for more than half of their working day and no lifting or carrying (OPA 1); standing or walking for more than half of their working day but with no lifting or carrying (OPA 2); lifting or carrying either 5 kg for at least two hours of their working day, or heavy lifting (20 kg for women and 30 kg for men) at least five times per working day, regardless of if they were seated or standing/walking most of their working day (few were lifting/carrying and were seated most of their working day) (OPA 3).

Myocardial infarction

Data regarding incident myocardial infarction was obtained from the National Patient Register and the Cause of Death Register, using the diagnosis “acute myocardial infarction”, I21 (ICD-10) or 410 (ICD-9).

Potential confounders

As several factors, such as age, sex, socioeconomic status, smoking, leisure time physical activity, alcohol and consumption of fruit and vegetables, might be associated with both occupational physical activity and the risk of myocardial infarction, these were taken into account in the analyses. Age was used as a continuous variable in all analyses except when stratifying the analysis by age, where the participants were categorized into three different groups: (1) younger than 45 years old; (2) 45 – 54 years old; (3) 55 years or older. Socioeconomic status was defined from Swedish socioeconomic classification[20], according to the participants’ occupation and education. From this

classification the participants were categorized into three different socioeconomic groups: (1) manual workers; (2) low and intermediate non-manual workers; (3) professionals. The participants were categorized into three groups regarding their smoking habits at baseline: never smoked, former smokers or current smokers. The participants were asked about their leisure time physical activity by the question "How often do you exercise?" The response options were "never", "very seldom", "sometimes" and "regularly". In the analyses the participants were categorized into three groups where the two least active answers were combined into one group: (1) never or seldom; (2) sometimes; (3) regularly. The participants were categorized into two groups regarding their consumption of fruit and vegetables: whether or not they were eating at least one piece of fruit every day, and whether or not they were eating one portion of vegetables every day. The participants were asked about their average alcohol consumption during the last 12 months. Out of this question the participants were classified into four categories: (1) non-drinking; (2) moderate drinking; (3) intermediate drinking; (4) heavy drinking. Moderate drinking was defined as drinking 1 – 21 units of alcohol per week (men), or 1 – 14 units per week (women). Intermediate drinking was defined as drinking 22 -27 units per week (men), or 15 – 20 units per week (women). Heavy drinking was defined as drinking 28 units alcohol or more per week (men), or 21 units or more per week (women). One unit of alcohol is approximately equivalent to 10 grams of ethanol.

Statistical analysis

In this prospective cohort study, participants without any history of myocardial infarction at baseline were followed from inclusion date (the day of their clinical examination) until their first myocardial infarction event, migration out of Sweden, death, or end of follow up (December 31, 2008), whichever came first. Data on incidence of myocardial infarction before baseline was obtained from the respondent's disease history in the questionnaire, or from data in the National Patient Register. Data on migration was obtained from the Swedish Tax Agency.

In the present study, 93 participants with a history of myocardial infarction prior to the inclusion date were excluded. Students (n=113), and one participant that emigrated from Sweden before inclusion date (n=1), were also excluded. Participants with missing answers in one or more of the questions regarding physical activity at work (n=248), could not with certainty be categorized in the correct level of occupational physical activity and were therefore excluded. In total, this yielded an analytical sample for this study of n=9,961.

Hazard ratios (HR) were estimated with 95% confidence intervals (95% CI), using Cox proportional hazard regression, for different levels of occupational physical activity in relation to the risk of myocardial infarction. Multivariable regression models included adjustment for age, sex, socioeconomic status, smoking, leisure time physical activity, consumption of fruit and vegetables, and consumption of alcohol. Stratified analyses were made for different age groups, for men and women, for different socioeconomic groups, and for different engagement in leisure time physical activity. All analyses were conducted using the statistical program IBM SPSS Statistics version 21.

Ethical considerations

The baseline study of WOLF was approved by the Ethics Committee at Karolinska Institutet, Stockholm (#92-198). All participation in the study was voluntary and with informed consent from the respondents. The record linkages of baseline data with the National Patient Register and the Cause of Death Register was approved by the Regional Ethical Review board in Stockholm (#2006/257-31).

RESULTS

In total, 9,961 people, 6,849 men and 3,112 women, without history of myocardial infarction, were followed during a mean follow-up time of 13.1 years (47 days – 16.9 years). During the follow-up time 249 cases, both fatal and nonfatal, of myocardial infarction was registered, 223 cases among men and 26 cases among women. Table 1 shows baseline characteristics of the study subjects in total, and divided by the three levels of occupational physical activity. Most of the participants in the study belonged to OPA 1 (n=4,997). The other two groups, OPA 2 (n=2,568) and OPA 3 (n=2,396), were quite similar regarding number of participants. The mean age at baseline was 42.7 (range 19 – 70) years. A clear difference was seen in the distribution of men and women in the different levels of OPA, with the lowest proportion of women in OPA 3. As expected, there was also a clear difference in socioeconomic status between the three levels of OPA. Almost 90% of the participants in OPA 3 were manual workers and only 0.9% were professionals. In contrast, only 19% in OPA 1 were manual workers. Some differences in lifestyles factors in the three levels of occupational physical activity were seen at baseline. For example, the highest proportion of current smokers was observed in OPA 3, while the highest proportion of leisure time physical activity were found in OPA 1. An alternative categorization of occupational physical activity is presented in supplementary tables 1 and 2, where the group with sedentary jobs in combination with lifting/carrying was treated as a separate category.

Table 1. Baseline characteristics of study subjects by occupational physical activity.

	Total n = 9,961	OPA 1* n = 4,997	OPA 2** n = 2,568	OPA 3*** n = 2,396	P value#
Age					
Mean (SD)	42.7 (10.7)	43.2 (10.1)	43.0 (10.9)	41.5 (11.4)	<0.001
< 45 years, n (%)	5,306 (53.3)	2,602 (52.1)	1,322 (51.5)	1,382 (57.7)	
45-54 years, n (%)	3,164 (31.8)	1,701 (34.0)	820 (31.9)	643 (26.8)	<0.001
≥ 55 years, n (%)	1,491 (15.0)	694 (13.9)	426 (16.6)	371 (15.5)	
Sex					
Men, n (%)	6,849 (68.8)	3,075 (61.5)	1,751 (68.2)	2,023 (84.4)	<0.001
Women, n (%)	3,112 (31.2)	1,922 (38.5)	817 (31.8)	373 (15.6)	
Myocardial infarction during follow- up, n (%)	249 (2,5)	116 (2.3)	74 (2.9)	59 (2.5)	0.33
Socioeconomic status					
Manual workers, n (%)	4,372 (43.9)	965 (19.3)	1,257 (49.0)	2,150 (89.8)	
Low and intermediate non-manual workers, n (%)	4,334 (43.5)	3,008 (60.3)	1,102 (42.2)	224 (9.4)	<0.001
Professionals, n (%)	1,246 (12.5)	1,017 (20.4)	208 (8.1)	21 (0.9)	
Smoking					
Never smoked, n (%)	4,647 (47.8)	2,435 (49.6)	1,209 (48.1)	1,003 (43.5)	
Former smoker, n (%)	2,872 (29.5)	1,500 (30.6)	728 (29.0)	644 (27.9)	<0.001
Current smoker, n (%)	2,207 (22.7)	972 (19.8)	575 (22.9)	660 (28.6)	
Leisure time physical activity					
Never or seldom, n (%)	2,479 (24.9)	1,181 (23.7)	609 (23.7)	689 (28.9)	
Sometimes, n (%)	3,823 (38.4)	1,787 (35.8)	1,019 (39.7)	1,017 (42.6)	<0.001
Regularly, n (%)	3,645 (36.6)	2,025 (40.6)	938 (36.6)	682 (28.6)	
Consumption of fruit					
One piece or more per day, n (%)	6,160 (63.1)	3,130 (63.5)	1,618 (64.2)	1,412 (60.8)	0.03
Consumption of vegetables					
One portion or more per day, (%)	3,250 (34.1)	1,895 (39.1)	792 (32.3)	563 (25.3)	<0.001
Consumption of alcohol					
Non-drinker, n (%)	490 (5.0)	185 (3.8)	147 (5.8)	158 (6.8)	
Moderate, n (%)	8,554 (87.7)	4,408 (89.5)	2,231 (88.7)	1,915 (83.0)	<0.001
Intermediate, n (%)	312 (3.2)	158 (3.2)	64 (2.5)	90 (3.9)	
Heavy, n (%)	394 (4.0)	176 (3.6)	73 (2.9)	145 (6.3)	

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying. **OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying. ***OPA 3 = Lifting or carrying regardless of seated or standing/walking.
#Chi^2 -tests for comparison of proportions, ANOVA for comparisons of continuous variable.

The results of the Cox proportional hazard regressions with occupational physical activity as exposure and myocardial infarction as outcome, are shown in table 2. In model 1, adjusted for age, the HR for OPA 2 was 1.29 (95% CI, 0.96-1.72), the corresponding HR for OPA 3 was 1.20 (95% CI, 0.87-1.64), with OPA 1 as the reference category. Adjusting for age, sex and socioeconomic status (model 3) resulted in HR 1.13 (95% CI, 0.83-1.54) for OPA 2 and HR 0.86 (95 % CI, 0.59-1.24) for OPA 3 compared with OPA 1. Adjustment for lifestyle factors (model 4) didn't alter the HRs in any major way. It might be argued that socioeconomic status should not be adjusted for since it may lead to over-adjustment, model 5 is therefore without adjustment for socioeconomic status. Table 2 also contains analyses restricted to those working 35 hours per week or more (n=9,058). In general, the results from these analyses were very similar to the results based on the total sample. A significant increased HR was seen for OPA 2 compared to OPA 1 in model 1, HR 1.36 (95% CI. 1.00-1.86), but after adjusting for age, sex and socioeconomic status (model 3), the HR for OPA 2, was attenuated to 1.18 (95% CI. 0.85-1.63).

Table 2. The association between occupational physical activity and risk of myocardial infarction (MI). Analysis made for the total sample and restricted to those working 35 hours per week or more. Hazard ratios (HR) with 95 % confidence intervals (95% CI).

		Model 1[§]	Model 2[§§]	Model 3[+]	Model 4[++]	Model 5[¤]
		HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
OPA (Total)	MI cases during follow up	n=9,961	n=9,961	n=9,952	n=9,048	n=9,056
1[*]	n=116	1	1	1	1	1
2[**]	n=74	1.29 (0.96-1.72)	1.21 (0.90-1.62)	1.13 (0.83-1.54)	1.12 (0.80-1.56)	1.15 (0.84-1.58)
3[***]	n=59	1.20 (0.87-1.64)	0.98 (0.71-1.34)	0.86 (0.59-1.24)	0.86 (0.57-1.29)	0.90 (0.64-1.28)
OPA (>35h/ week)		n=9,058	n=9,058	n=9,049	n=8,247	n=8,255
1[*]	n=101	1	1	1	1	1
2[**]	n=67	1.36 (1.00-1.86)	1.27 (0.94-1.75)	1.18 (0.85-1.63)	1.14 (0.80-1.61)	1.20 (0.86-1.69)
3[***]	n=55	1.26 (0.91-1.75)	1.04 (0.75-1.45)	0.87 (0.59-1.27)	0.87 (0.57-1.32)	0.98 (0.68-1.41)

[*]OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.

[**]OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.

[***]OPA 3 = Lifting or carrying regardless of seated or standing/walking.

[§]Model 1, adjusted for age.

[§§]Model 2, adjusted for age and sex.

[+]Model 3, adjusted for age, sex and socioeconomic status.

[++]Model 4, adjusted for age, sex, socioeconomic status and lifestyle factors (smoking, leisure time physical activity, alcohol, fruit and vegetable consumption.

[¤]Model 5, adjusted for age, sex and lifestyle factors.

Results from stratified analyses, adjusted age, sex and socioeconomic status where applicable, are shown in table 3. The HRs for the different levels of occupational physical activity in relation to myocardial infarction indicates no major differences between men and women. However, the confidence intervals for women compared to men are wider, indicating greater uncertainty due to few cases. Stratified analysis for different socioeconomic groups shows a tendency to a decreased risk for professionals in OPA 2, compared with manual workers and low and intermediate manual workers in OPA 2. However, these analyses are based on subgroups with few participants, which must be considered. Stratifying for different levels of leisure time physical activity showed a tendency towards a reduced risk for participants who are physically active both during work and leisure time, but the result was not statistically significant. When stratifying for age, a reduced risk for myocardial infarction was observed for young participants, aged < 45, in OPA 3 (HR 0.37, 95% CI, 0.17-0.84). A joint effect analysis between occupational physical activity and leisure time physical activity, and the association with myocardial infarction, was made as a supplementary analysis (supplementary table 3). The result showed a significant increased risk for myocardial infarction for people with a lot of standing and walking at work, and never or seldom were physical active during leisure time.

Table 3. The association between occupational physical activity and risk of myocardial infarction. Analyses stratified for age, sex, socioeconomic status and leisure time physical activity. Hazard ratios (HR) with 95 % confidence intervals (95% CI), adjusted for age, sex and socio-economic status, where applicable.

	Age					
	19 – 44 years n=5,306		45 – 54 years n=3,164		55 –70 years n=1,491	
OPA	n		n		n	
1*	2,602	1	1,701	1	694	1
2**	1,322	1.09 (0.56-2.09)	820	1.50 (0.95-2.35)	426	0.77 (0.45-1.32)
3***	1,382	0.37 (0.17-0.84)	643	1.51 (0.86-2.67)	371	0.72 (0.40-1.32)
	Sex					
	Men n=6,849		Women n=3,112			
OPA	n		n			
1*	3,075	1	1,922	1		
2**	1,751	1.11 (0.80-1.54)	817	1.26 (0.52-3.03)		
3***	2,023	0.85 (0.58-1.25)	373	0.92 (0.22-3.73)		
	Socioeconomic status					
	Manual workers n=4,372		Low and intermediate non-manual workers n=4,334		Professionals n=1,246	
OPA	n		n		n	
1*	965	1	3,008	1	1,017	1
2**	1,257	1.28 (0.79-2.06)	1,102	1.14 (0.73-1.77)	208	0.54 (0.16-1.82)
3***	2,150	0.90 (0.57-1.43)	224	1.06 (0.46-2.44)	21	-
	Leisure time physical activity					
	Never/Seldom n=2,479		Sometimes n=3,823		Regularly n=3,645	
OPA	n		n		n	
1*	1,181	1	1,787	1	2,025	1
2**	609	1.42 (0.82-2.45)	1,019	1.35 (0.84-2.16)	938	0.67 (0.36-1.26)
3***	689	0.83 (0.43-1.59)	1,017	1.07 (0.61-1.86)	682	0.67 (0.30-1.48)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.

**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.

***OPA 3 = Lifting or carrying regardless of seated or standing/walking.

DISCUSSION

In this study, we found no significant associations between occupational physical activity and myocardial infarction, neither when looking at participants with substantial standing and walking at work, nor when looking at participants with lifting or carrying at work, compared with participants who were seated most of their working day. Based on the results from this study, occupational physical activity doesn't seem to have the same association with myocardial infarction which is seen for leisure time physical activity. The hypothesis that occupational physical activity has a protective effect against myocardial infarction could not be confirmed in this study. Neither do the results from this study support the theory that high levels of occupational physical activity would increase the risk of myocardial infarction.

A restriction to full-time workers was made in order to see if the association between occupational physical activity and myocardial infarction would be stronger in this group. The results from the analyses adjusted for age, showed significant increased risk of myocardial infarction for the participants with substantial standing and walking at work. However this association was attenuated and no longer statistically significant after adjusting for other traditional risk factors as sex, socioeconomic status and lifestyle factors. In general, the results from the restricted analyses were similar as the results based on the total sample.

Other studies of occupational physical activity and myocardial infarction have showed diverse results. A significant increased risk of myocardial infarction for men with moderate levels of occupational physical activity, was for example observed in the study by Holtermann et al. in the Copenhagen City Heart Study[15]. Unlike the present study, they used a combination of baseline and follow up measures after five years in their categorization of occupational physical activity. Furthermore, in a study by Allesoe et al an increased risk was noted for women with high levels of physical activity at work[14]. In contrast to the present study where a variety of occupations are included, they were only studying nurses.

A significantly reduced risk for myocardial infarction was noted for both men and women with moderate to high levels of occupational physical activity in a Finnish study[16]. They were using quite similar categorization as in the present study. A difference though, is that they started their data collection 20 years earlier than in our study. The two studies differ with regard to number of subjects in the highest level of occupational physical activity, the Finnish study having higher numbers in this category. The differences in results seen between the two studies may reflect changes over time regarding both occupational physical activity and physical activity in general.

Guidelines about physical activity in general, emphasis the importance of a non-sedentary life-style, in order to protect diseases[18]. However, in a recent study by Moller et al[21], no differences were seen between employees with sedentary and non-sedentary work regarding the risk of ischemic heart disease. It has been proposed that leisure time physical activity and occupational physical activity might have different effect on the cardiovascular system, with leisure time physical activity leading to a training effect on the heart and occupational physical activity leading to an overload on the cardiovascular system[22].

A factor that might affect the risk of myocardial infarction is the participants' level of physical fitness. It has previously been shown that high levels of occupational physical activity don't seem to improve physical fitness[23, 24]. This could be understood from the idea that occupational physical activity in most cases doesn't increase heart rate enough to improve fitness level, and therefore doesn't have positive effect on the cardiovascular system. Research where combination of high levels of occupational physical activity and moderate to high levels of leisure time physical activity have been studied has resulted both in increased[25] and decreased[26] risk of ischemic heart disease. When looking at the baseline characteristics for participants in this study, there is a larger proportion taking part in leisure time physical activity in OPA 1, this proportion decreases in OPA 2 and is at its smallest in OPA 3. Explanations for this may involve that high levels of occupational physical activity leads to fatigue in leisure time, with little energy left to take part in exercise. Other possible explanations may involve socioeconomic differences between the groups and thereby differences in health behavior.

Stratifying for different age groups resulted in a significantly reduced risk for participants younger than 45 years old, with work including lifting or carrying. One possible explanation for these findings might be the, in general, higher fitness level seen for younger people, which may allow for a higher level of occupational physical activity. For the middle-aged, 45 to 54 years old, no statistically significant results were seen. Compared to the younger participants the results for this group rather showed a tendency towards an increased risk of myocardial infarction for work including substantial standing and walking. This might has to do with declining functional reserve capacity with older ages[27]. In contrast to the results from the middle-aged group, the results from the group of the oldest participants don't show the same tendency towards increased risk, as seen for the middle-aged. Here, theories about "the healthy worker"[28] might be part of the explanation. In general, all the results from the stratified analyses must be interpreted with caution, due to the few participants in some of the analyzed subgroups, leading to low precision in estimates and wide confidence intervals, and hence low power to detect a true association.

A strength with the present study is the high response rate, together with the distribution between different socioeconomic groups, which increases the validity in this study and also the ability to generalize the results from this study to the Swedish population as well as to other populations with similarities in working conditions. Data on myocardial infarction was obtained from the National Patient Register and the Cause of Death Register in Sweden. The proportion of cases of myocardial infarction identified by the registers has been found to be between 77 and 91.5 percent, which implies high validity and little loss of follow-up for this data[29]. In this study only cases of myocardial infarction were used, extension to other diagnosis of ischemic heart diseases would probably have led to more cases and higher power. However, we wanted to use the specific and well-defined outcome of myocardial infarction in this analysis.

One limitation in the study is that only data from the baseline is used regarding the participants' levels of occupational physical activity. Participants may have changed exposure category during the time of follow-up. Given that a true association exist between occupational physical activity and myocardial infarction, change of exposure category might have attenuated the association in the present study. A follow up of the participants' level of occupational physical activity would therefore further have increased the validity of this study. Another limitation is that the data regarding occupational physical activity is self-reported from the participants and the questions may be considered rather unspecific. Other ways of assessing occupational physical activity are for example used by Krause et al.[13]. They interviewed the study subjects about their physical activity at work and how many minutes they spent in different activity. Out of these interviews, energy expenditure were calculated. A more objective measurement is tested by Skotte et al.[30] using triaxial accelerometers for detection of physical activity. An objective assessment of occupational physical activity would have been preferable, but is often not feasible to include in large scale epidemiological studies, as this would require extensive resources. These limitations regarding assessment of occupational physical activity, also largely applies to the assessment of leisure time physical activity in the WOLF study.

Conclusion

No significant associations between occupational physical activity and the risk of myocardial infarction was observed in this prospective cohort study of 9,961 employees in the total study population. A significant reduced risk were seen for participants younger than 45 years old with work including lifting and carrying, but this result must be interpreted with caution, due to the few

participants in the stratified analyses. Based on the results from this study, occupational physical activity in general does not seem to be enough for reducing the risk of myocardial infarction, which is an important message to people with high levels of occupational physical activity.

Contributorship statement

LA, AK and PJMW were responsible for the baseline data collection, AMJ and EIF were responsible for the conception and the design of the present study. AMJ drafted the first version of the manuscript. All authors interpreted the data and revised the manuscript critically for important intellectual content. All authors read and approved the final version of the manuscript.

Competing interests

There are no competing interests for this publication.

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Data sharing statement

No additional unpublished data from the study is available.

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Supplementary material

Supplementary table 1. Baseline characteristics of study subjects by occupational physical activity.

	Total n = 9,836	OPA 1* n = 4,997	OPA 2** n = 2,568	OPA 3*** n = 1,922	OPA 4**** n = 349
Age					
Mean (SD)	42.7 (10.7)	43.2 (10.1)	43.0 (10.9)	41.5 (11.4)	40.9 (11.2)
< 45 years, n (%)	5,247 (53.3)	2,602 (52.1)	1,322 (51.5)	1,111 (57.8)	212 (60.1)
45-54 years, n (%)	3,121 (31.7)	1,701 (34.0)	820 (31.9)	512 (26.6)	88 (25.2)
≥ 55 years, n (%)	1,468 (14.9)	694 (13.9)	426 (16.6)	299 (15.6)	49 (14.0)
Sex					
Men, n (%)	6,739 (68.5)	3,075 (61.5)	1,751 (68.2)	1,621 (84.3)	292 (83.7)
Women, n (%)	3,097 (31.5)	1,922 (38.5)	817 (31.8)	301 (15.7)	57 (16.3)
Myocardial infarction during follow- up, n (%)	243 (2,5)	116 (2.3)	74 (2.9)	46 (2.4)	7 (2.0)
Socioeconomic status					
Manual workers, n (%)	4,258 (43.3)	965 (19.3)	1,257 (49.0)	1,749 (91.0)	287 (82.2)
Low and intermediate non-manual workers, n (%)	4,323 (44.0)	3,008 (60.3)	1,102 (42.2)	162 (8.4)	51 (14.6)
Professionals, n (%)	1,246 (12.7)	1,017 (20.4)	208 (8.1)	10 (0.5)	11 (3.2)
Smoking					
Never smoked, n (%)	4,602 (47.9)	2,435 (49.6)	1,209 (48.1)	810 (43.8)	148 (43.7)
Former smoker, n (%)	2,839 (29.6)	1,500 (30.6)	728 (29.0)	512 (27.7)	99 (29.2)
Current smoker, n (%)	2,166 (22.5)	972 (19.8)	575 (22.9)	527 (28.5)	92 (27.1)
Leisure time physical activity					
Never or seldom, n (%)	2,440 (24.8)	1,181 (23.7)	609 (23.7)	544 (28.4)	106 (30.5)
Sometimes, n (%)	3,773 (38.4)	1,787 (35.8)	1,019 (39.7)	811 (42.3)	156 (44.8)
Regularly, n (%)	3,611 (36.8)	2,025 (40.6)	938 (36.6)	562 (29.3)	86 (24.7)
Consumption of fruit					
One piece or more per day, n (%)	6,094 (63.1)	3,130 (63.5)	1,618 (64.2)	1,159 (62.1)	187 (55.2)
Consumption of vegetables					
One portion or more per day, (%)	3,220 (34.2)	1,895 (39.1)	792 (32.3)	440 (24.6)	93 (28.7)
Consumption of alcohol					
Non-drinker, n (%)	480 (5.0)	185 (3.8)	147 (5.8)	130 (7.0)	18 (5.3)
Moderate, n (%)	8,465 (87.9)	4,408 (89.5)	2,231 (88.7)	1,538 (83.1)	288 (85.0)

Intermediate, n (%)	300 (3.1)	158 (3.2)	64 (2.5)	65 (3.5)	13 (3.8)
Heavy, n (%)	387 (4.0)	176 (3.6)	73 (2.9)	118 (6.4)	20 (5.9)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Standing or walking for more than 50 % of working day and lifting or carrying.
****OPA 4 = Seated for more than 50 % of working day and lifting and carrying.

Supplementary table 2. The association between occupational physical activity and risk of myocardial infarction. Analysis made for the total sample and restricted to those working 35 hours per week or more. Hazard ratios (HR) with 95 % confidence intervals (95% CI).

	Model 1§	Model 2§§	Model 3+	Model 4++	Model 5¤
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
OPA (Total)	n=9,836	n=9,836	n=9,827	n=8,948	n=8,956
1*	1	1	1	1	1
2**	1.29 (0.96-1.73)	1.21 (0.91-1.63)	1.13 (0.83-1.54)	1.12 (0.80-1.56)	1.16 (0.84-1.59)
3***	1.17 (0.83-1.65)	0.96 (0.68-1.35)	0.83 (0.56-1.24)	0.79 (0.51-1.23)	0.85 (0.58-1.25)
4****	0.99 (0.46-2.12)	0.82 (0.38-1.76)	0.73 (0.33-1.59)	0.88 (0.40-1.94)	0.93 (0.43-2.01)
OPA (>35h/week)	n=8,948	n=8,948	n=8,939	n=8,159	n=8,167
1*	1	1	1	1	1
2**	1.37 (1.00-1.86)	1.29 (0.95-1.76)	1.18 (0.85-1.63)	1.13 (0.80-1.61)	1.21 (0.86-1.70)
3***	1.22 (0.85-1.74)	1.00 (0.70-1.44)	0.82 (0.54-1.25)	0.78 (0.50-1.24)	0.90 (0.60-1.35)
4****	1.06 (0.49-2.28)	0.91 (0.42-1.95)	0.76 (0.35-1.67)	0.91 (0.41-2.03)	1.04 (0.48-2.25)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Standing or walking for more than 50 % of working day and lifting or carrying.
****OPA 4 = Seated for more than 50 % of working day and lifting and carrying.
§Model 1, adjusted for age.
§§Model 2, adjusted for age and sex. Model 3+, adjusted for age, sex and socioeconomic status.
++Model 4, adjusted for age, sex, socioeconomic status and lifestyle factors (smoking, leisure time physical activity, alcohol, fruit and vegetable consumption.
¤Model 5, adjusted for age, sex and lifestyle factors.

Supplementary table 3: The association between the combination of occupational physical activity and leisure time physical activity, and risk of myocardial infarction. Hazard ratios (HR) with 95 % confidence intervals (95% CI) adjusted for age, sex and socio-economic status.

	Leisure time physical activity					
	Never or seldom		Sometimes		Regularly	
	n	HR (95% CI)	n	HR (95% CI)	n	HR (95% CI)
OPA 1*	1,181	1.25 (0.79-2.00)	1,787	1.07 (0.69-1.66)	2,025	1
OPA 2**	609	1.83 (1.09-3.09)	1,019	1.39 (0.87-2.24)	938	0.71 (0.38-1.32)
OPA 3***	689	1.06 (0.58-1.91)	1,017	1.06 (0.63-1.79)	682	0.71 (0.34-1.46)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Lifting or carrying regardless of seated or standing/walking.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4, 7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5, 6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	?
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	10, 11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, 8
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13 5, 6
		(*b*) Report category boundaries when continuous variables were categorized	5, 6, 13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15, 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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The association between occupational physical activity and myocardial infarction – a prospective cohort study

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The association between occupational physical activity and myocardial infarction – a prospective cohort study

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Key terms: myocardial infarction, physical activity, prospective study, work

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ABSTRACT

Objective: Recommendations regarding physical activity typically include both leisure time and occupational physical activity. However, the results from previous studies on occupational physical activity and the association to myocardial infarction have been inconsistent. The aim of this study was to investigate if occupational physical activity is associated with the risk of myocardial infarction.

Design: Prospective cohort study.

Participants: Data from the Swedish WOLF study was used, comprising 9,961 employees (6,849 men, 3,112 women, mean age 42.7 years) having no history of myocardial infarction. The participants were categorized into three groups according to their level of occupational physical activity.

Outcome: Data regarding incident myocardial infarction was obtained from the Swedish National Patient Register and the Cause of Death Register. Hazard ratios (HR) were estimated using Cox proportional hazard regression for different levels of occupational physical activity in relation to the risk of myocardial infarction.

Results: During a mean follow-up of 13.1 years, 249 cases of incident myocardial infarction were identified. In analyses adjusted for age, sex and socio-economic status, participants standing and walking more than 50% of their working day had an HR of 1.13 (95% CI, 0.83-1.54), compared to participants seated more than 50% of their working day. The corresponding HR for participants whose work included lifting or carrying was 0.86 (95% CI, 0.59-1.24). Further adjustment did not alter the results. Stratified analyses resulted in a significantly decreased risk for young people whose work included lifting or carrying, HR 0.37 (95% CI, 0.17-0.84), compared with younger persons who sat most of their working day.

Conclusion: No significant association between occupational physical activity and the risk of myocardial infarction was observed in the total group of employees in this study. Based on the results from this study, occupational physical activity in general does not seem to be enough for reducing the risk of myocardial infarction.

Strengths and limitations of this study

- This is a large prospective cohort study.
- The study includes working men and women from a variety of occupations.
- The outcome myocardial infarction, is ascertained through nation-wide registers with high coverage.
- The high response rate, together with the distribution between different socioeconomic groups, increases the validity in this study.
- A limitation is that the exposure occupational physical activity, only is measured at baseline.

INTRODUCTION

Ischemic heart disease is the leading cause of global mortality and burden of disease. In 2010, more than 13% of all deaths were due to ischemic heart disease[1, 2]. Physical activity is, known as a preventive factor for ischemic heart disease[3-6]. However, the term physical activity is general and may involve leisure time physical activity, occupational physical activity, commuting and household chores[7]. In more recent research a distinction is often made between leisure time physical activity and occupational physical activity. The findings regarding leisure time physical activity are quite consistent that high levels of physical activity decrease the risk of cardiovascular disease (CVD)[8-12]. In contrast, studies of occupational physical activity and CVD show more inconsistent results, where some studies have shown that high occupational physical activity increases the risk of CVD[11, 13-15], while other results point toward a protective effect of moderate to high occupational physical activity[10, 16, 17]. In the recommendations from WHO regarding physical activity, both leisure time physical activity and occupational physical activity are included, without distinction in the recommendations regarding these different domains of physical activity[18].

The aim of this study was to investigate if occupational physical activity in terms of standing/walking and lifting/carrying at work, is associated with the risk of myocardial infarction and if the association is modified by age, sex, socio-economic status and leisure time physical activity. In line with the recommendations from WHO regarding physical activity in general, the hypothesis in this study was that occupational physical activity has a protective effect against myocardial infarction.

METHODS

Data used for this study was obtained from the Swedish Work, Lipids and Fibrinogen (WOLF) study[19]. Participants were included for the baseline data collection 1992-1995 in the Stockholm County and 1996-1997 in the counties of Jämtland and Västernorrland. Occupational health service units were invited to participate in the study, 33 out of 36 accepted the invitation. These units served employees from around 60 different companies in several different branches and occupations. The employees who were willing to participate filled in a questionnaire including questions regarding their occupation and work environment, socioeconomic factors, life-style factors, hereditary factors and disease history. In addition, the employees went through a clinical examination including measurements of blood pressure, height, weight, waist and hip circumference. In total, 10,416

employees both responded to the questionnaire and went through the clinical examination. The response rate was 82 % for the total sample, with higher response rates in Jämtland and Västernorrland, compared to the Stockholm area.

Occupational physical activity

The participants were asked about their occupational physical activity by three questions in the questionnaire: (1) Whether or not they were seated for more than half of their total working hours; (2) If they were lifting or carrying more than 5 kg for at least two hours of their working day; and (3) for women, if they were lifting or carrying more than 20 kg at least five times per working day. For men, the corresponding question was if they were lifting or carrying more than 30 kg at least five times per working day.

Out of these three questions, the participants were categorized into three groups: seated for more than half of their working day and no lifting or carrying (OPA 1); standing or walking for more than half of their working day but with no lifting or carrying (OPA 2); lifting or carrying either 5 kg for at least two hours of their working day, or heavy lifting (20 kg for women and 30 kg for men) at least five times per working day, regardless of if they were seated or standing/walking most of their working day (few were lifting/carrying and were seated most of their working day) (OPA 3).

Myocardial infarction

Data regarding incident myocardial infarction was obtained from the National Patient Register and the Cause of Death Register, using the diagnosis “acute myocardial infarction”, I21 (ICD-10) or 410 (ICD-9).

Potential confounders

As several factors, such as age, sex, socioeconomic status, smoking, leisure time physical activity, alcohol and consumption of fruit and vegetables, might be associated with both occupational physical activity and the risk of myocardial infarction, these were taken into account in the analyses. Age was used as a continuous variable in all analyses except when stratifying the analysis by age, where the participants were categorized into three different groups: (1) younger than 45 years old; (2) 45 – 54 years old; (3) 55 years or older. Socioeconomic status was defined from Swedish

socioeconomic classification[20], according to the participants' occupation and education. From this classification the participants were categorized into three different socioeconomic groups: (1) manual workers; (2) low and intermediate non-manual workers; (3) professionals. The participants were categorized into three groups regarding their smoking habits at baseline: never smoked, former smokers or current smokers. The participants were asked about their leisure time physical activity by the question "How often do you exercise?" The response options were "never", "very seldom", "sometimes" and "regularly". In the analyses the participants were categorized into three groups where the two least active answers were combined into one group: (1) never or seldom; (2) sometimes; (3) regularly. The participants were categorized into two groups regarding their consumption of fruit and vegetables: whether or not they were eating at least one piece of fruit every day, and whether or not they were eating one portion of vegetables every day. The participants were asked about their average alcohol consumption during the last 12 months. Out of this question the participants were classified into four categories: (1) non-drinking; (2) moderate drinking; (3) intermediate drinking; (4) heavy drinking. Moderate drinking was defined as drinking 1 – 21 units of alcohol per week (men), or 1 – 14 units per week (women). Intermediate drinking was defined as drinking 22 -27 units per week (men), or 15 – 20 units per week (women). Heavy drinking was defined as drinking 28 units alcohol or more per week (men), or 21 units or more per week (women). One unit of alcohol is approximately equivalent to 10 grams of ethanol.

Statistical analysis

In this prospective cohort study, participants without any history of myocardial infarction at baseline were followed from inclusion date (the day of their clinical examination) until their first myocardial infarction event, migration out of Sweden, death, or end of follow up (December 31, 2008), whichever came first. Data on incidence of myocardial infarction before baseline was obtained from the respondent's disease history in the questionnaire, or from data in the National Patient Register. Data on migration was obtained from the Swedish Tax Agency.

In the present study, 93 participants with a history of myocardial infarction prior to the inclusion date were excluded. Students (n=113), and one participant that emigrated from Sweden before inclusion date (n=1), were also excluded. Participants with missing answers in one or more of the questions regarding physical activity at work (n=248), could not with certainty be categorized in the correct level of occupational physical activity and were therefore excluded. In total, this yielded an analytical sample for this study of n=9,961.

Hazard ratios (HR) were estimated with 95% confidence intervals (95% CI), using Cox proportional hazard regression, for different levels of occupational physical activity in relation to the risk of myocardial infarction. Multivariable regression models included adjustment for age, sex, socioeconomic status, smoking, leisure time physical activity, consumption of fruit and vegetables, and consumption of alcohol. Stratified analyses were made for different age groups, for men and women, for different socioeconomic groups, and for different engagement in leisure time physical activity. All analyses were conducted using the statistical program IBM SPSS Statistics version 21.

Ethical considerations

The baseline study of WOLF was approved by the Ethics Committee at Karolinska Institutet, Stockholm (#92-198). All participation in the study was voluntary and with informed consent from the respondents. The record linkages of baseline data with the National Patient Register and the Cause of Death Register was approved by the Regional Ethical Review board in Stockholm (#2006/257-31).

RESULTS

In total, 9,961 people, 6,849 men and 3,112 women, without history of myocardial infarction, were followed during a mean follow-up time of 13.1 years (47 days – 16.9 years). During the follow-up time 249 cases, both fatal and nonfatal, of myocardial infarction was registered, 223 cases among men and 26 cases among women. Table 1 shows baseline characteristics of the study subjects in total, and divided by the three levels of occupational physical activity. Most of the participants in the study belonged to OPA 1 (n=4,997). The other two groups, OPA 2 (n=2,568) and OPA 3 (n=2,396), were quite similar regarding number of participants. The mean age at baseline was 42.7 (range 19 – 70) years. A clear difference was seen in the distribution of men and women in the different levels of OPA, with the lowest proportion of women in OPA 3. As expected, there was also a clear difference in socioeconomic status between the three levels of OPA. Almost 90% of the participants in OPA 3 were manual workers and only 0.9% were professionals. In contrast, only 19% in OPA 1 were manual workers. Some differences in lifestyles factors in the three levels of occupational physical activity were seen at baseline. For example, the highest proportion of current smokers was observed in OPA 3, while the highest proportion of leisure time physical activity were found in OPA 1. An alternative categorization of occupational physical activity is presented in supplementary tables 1 and 2, where the group with sedentary jobs in combination with lifting/carrying was treated as a separate category.

Table 1. Baseline characteristics of study subjects by occupational physical activity.

	Total n = 9,961	OPA 1* n = 4,997	OPA 2** n = 2,568	OPA 3*** n = 2,396	P value#
Age					
Mean (SD)	42.7 (10.7)	43.2 (10.1)	43.0 (10.9)	41.5 (11.4)	<0.001
< 45 years, n (%)	5,306 (53.3)	2,602 (52.1)	1,322 (51.5)	1,382 (57.7)	
45-54 years, n (%)	3,164 (31.8)	1,701 (34.0)	820 (31.9)	643 (26.8)	<0.001
≥ 55 years, n (%)	1,491 (15.0)	694 (13.9)	426 (16.6)	371 (15.5)	
Sex					
Men, n (%)	6,849 (68.8)	3,075 (61.5)	1,751 (68.2)	2,023 (84.4)	<0.001
Women, n (%)	3,112 (31.2)	1,922 (38.5)	817 (31.8)	373 (15.6)	
Myocardial infarction during follow- up, n (%)	249 (2,5)	116 (2.3)	74 (2.9)	59 (2.5)	0.33
Socioeconomic status					
Manual workers, n (%)	4,372 (43.9)	965 (19.3)	1,257 (49.0)	2,150 (89.8)	
Low and intermediate non-manual workers, n (%)	4,334 (43.5)	3,008 (60.3)	1,102 (42.2)	224 (9.4)	<0.001
Professionals, n (%)	1,246 (12.5)	1,017 (20.4)	208 (8.1)	21 (0.9)	
Smoking					
Never smoked, n (%)	4,647 (47.8)	2,435 (49.6)	1,209 (48.1)	1,003 (43.5)	
Former smoker, n (%)	2,872 (29.5)	1,500 (30.6)	728 (29.0)	644 (27.9)	<0.001
Current smoker, n (%)	2,207 (22.7)	972 (19.8)	575 (22.9)	660 (28.6)	
Leisure time physical activity					
Never or seldom, n (%)	2,479 (24.9)	1,181 (23.7)	609 (23.7)	689 (28.9)	
Sometimes, n (%)	3,823 (38.4)	1,787 (35.8)	1,019 (39.7)	1,017 (42.6)	<0.001
Regularly, n (%)	3,645 (36.6)	2,025 (40.6)	938 (36.6)	682 (28.6)	
Consumption of fruit					
One piece or more per day, n (%)	6,160 (63.1)	3,130 (63.5)	1,618 (64.2)	1,412 (60.8)	0.03
Consumption of vegetables					
One portion or more per day, (%)	3,250 (34.1)	1,895 (39.1)	792 (32.3)	563 (25.3)	<0.001
Consumption of alcohol					
Non-drinker, n (%)	490 (5.0)	185 (3.8)	147 (5.8)	158 (6.8)	
Moderate, n (%)	8,554 (87.7)	4,408 (89.5)	2,231 (88.7)	1,915 (83.0)	<0.001
Intermediate, n (%)	312 (3.2)	158 (3.2)	64 (2.5)	90 (3.9)	
Heavy, n (%)	394 (4.0)	176 (3.6)	73 (2.9)	145 (6.3)	

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying. **OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying. ***OPA 3 = Lifting or carrying regardless of seated or standing/walking.
#Chi^2 -tests for comparison of proportions, ANOVA for comparisons of continuous variable.

The results of the Cox proportional hazard regressions with occupational physical activity as exposure and myocardial infarction as outcome, are shown in table 2. In model 1, adjusted for age, the HR for OPA 2 was 1.29 (95% CI, 0.96-1.72), the corresponding HR for OPA 3 was 1.20 (95% CI, 0.87-1.64), with OPA 1 as the reference category. Adjusting for age, sex and socioeconomic status (model 3) resulted in HR 1.13 (95% CI, 0.83-1.54) for OPA 2 and HR 0.86 (95 % CI, 0.59-1.24) for OPA 3 compared with OPA 1. Adjustment for lifestyle factors (model 4) didn't alter the HRs in any major way. It might be argued that socioeconomic status should not be adjusted for since it may lead to over-adjustment, model 5 is therefore without adjustment for socioeconomic status. Table 2 also contains analyses restricted to those working 35 hours per week or more (n=9,058). In general, the results from these analyses were very similar to the results based on the total sample. A significant increased HR was seen for OPA 2 compared to OPA 1 in model 1, HR 1.36 (95% CI. 1.00-1.86), but after adjusting for age, sex and socioeconomic status (model 3), the HR for OPA 2, was attenuated to 1.18 (95% CI. 0.85-1.63).

Table 2. The association between occupational physical activity and risk of myocardial infarction (MI). Analysis made for the total sample and restricted to those working 35 hours per week or more. Hazard ratios (HR) with 95 % confidence intervals (95% CI).

		Model 1[§]	Model 2[§§]	Model 3[+]	Model 4[++]	Model 5[¤]
		HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
OPA (Total)	MI cases during follow up	n=9,961	n=9,961	n=9,952	n=9,048	n=9,056
1[*]	n=116	1	1	1	1	1
2[**]	n=74	1.29 (0.96-1.72)	1.21 (0.90-1.62)	1.13 (0.83-1.54)	1.12 (0.80-1.56)	1.15 (0.84-1.58)
3[***]	n=59	1.20 (0.87-1.64)	0.98 (0.71-1.34)	0.86 (0.59-1.24)	0.86 (0.57-1.29)	0.90 (0.64-1.28)
OPA (>35h/ week)		n=9,058	n=9,058	n=9,049	n=8,247	n=8,255
1[*]	n=101	1	1	1	1	1
2[**]	n=67	1.36 (1.00-1.86)	1.27 (0.94-1.75)	1.18 (0.85-1.63)	1.14 (0.80-1.61)	1.20 (0.86-1.69)
3[***]	n=55	1.26 (0.91-1.75)	1.04 (0.75-1.45)	0.87 (0.59-1.27)	0.87 (0.57-1.32)	0.98 (0.68-1.41)

[*]OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.

[**]OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.

[***]OPA 3 = Lifting or carrying regardless of seated or standing/walking.

[§]Model 1, adjusted for age.

[§§]Model 2, adjusted for age and sex.

[+]Model 3, adjusted for age, sex and socioeconomic status.

[++]Model 4, adjusted for age, sex, socioeconomic status and lifestyle factors (smoking, leisure time physical activity, alcohol, fruit and vegetable consumption.

[¤]Model 5, adjusted for age, sex and lifestyle factors.

Results from stratified analyses, adjusted age, sex and socioeconomic status where applicable, are shown in table 3. The HRs for the different levels of occupational physical activity in relation to myocardial infarction indicates no major differences between men and women. However, the confidence intervals for women compared to men are wider, indicating greater uncertainty due to few cases. Stratified analysis for different socioeconomic groups shows a tendency to a decreased risk for professionals in OPA 2, compared with manual workers and low and intermediate manual workers in OPA 2. However, these analyses are based on subgroups with few participants, which must be considered. Stratifying for different levels of leisure time physical activity showed a tendency towards a reduced risk for participants who are physically active both during work and leisure time, but the result was not statistically significant. When stratifying for age, a reduced risk for myocardial infarction was observed for young participants, aged < 45, in OPA 3 (HR 0.37, 95% CI, 0.17-0.84). A joint effect analysis between occupational physical activity and leisure time physical activity, and the association with myocardial infarction, was made as a supplementary analysis (supplementary table 3). The result showed a significant increased risk for myocardial infarction for people with a lot of standing and walking at work, and never or seldom were physical active during leisure time.

Table 3. The association between occupational physical activity and risk of myocardial infarction. Analyses stratified for age, sex, socioeconomic status and leisure time physical activity. Hazard ratios (HR) with 95 % confidence intervals (95% CI), adjusted for age, sex and socio-economic status, where applicable.

	Age					
	19 – 44 years n=5,306		45 – 54 years n=3,164		55 –70 years n=1,491	
OPA	n		n		n	
1*	2,602	1	1,701	1	694	1
2**	1,322	1.09 (0.56-2.09)	820	1.50 (0.95-2.35)	426	0.77 (0.45-1.32)
3***	1,382	0.37 (0.17-0.84)	643	1.51 (0.86-2.67)	371	0.72 (0.40-1.32)
	Sex					
	Men n=6,849		Women n=3,112			
OPA	n		n			
1*	3,075	1	1,922	1		
2**	1,751	1.11 (0.80-1.54)	817	1.26 (0.52-3.03)		
3***	2,023	0.85 (0.58-1.25)	373	0.92 (0.22-3.73)		
	Socioeconomic status					
	Manual workers n=4,372		Low and intermediate non-manual workers n=4,334		Professionals n=1,246	
OPA	n		n		n	
1*	965	1	3,008	1	1,017	1
2**	1,257	1.28 (0.79-2.06)	1,102	1.14 (0.73-1.77)	208	0.54 (0.16-1.82)
3***	2,150	0.90 (0.57-1.43)	224	1.06 (0.46-2.44)	21	-
	Leisure time physical activity					
	Never/Seldom n=2,479		Sometimes n=3,823		Regularly n=3,645	
OPA	n		n		n	
1*	1,181	1	1,787	1	2,025	1
2**	609	1.42 (0.82-2.45)	1,019	1.35 (0.84-2.16)	938	0.67 (0.36-1.26)
3***	689	0.83 (0.43-1.59)	1,017	1.07 (0.61-1.86)	682	0.67 (0.30-1.48)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.

**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.

***OPA 3 = Lifting or carrying regardless of seated or standing/walking.

DISCUSSION

In this study, we found no significant associations between occupational physical activity and myocardial infarction, neither when looking at participants with substantial standing and walking at work, nor when looking at participants with lifting or carrying at work, compared with participants who were seated most of their working day. Based on the results from this study, occupational physical activity doesn't seem to have the same association with myocardial infarction which is seen for leisure time physical activity. The hypothesis that occupational physical activity has a protective effect against myocardial infarction could not be confirmed in this study. Neither do the results from this study support the theory that high levels of occupational physical activity would increase the risk of myocardial infarction.

A restriction to full-time workers was made in order to see if the association between occupational physical activity and myocardial infarction would be stronger in this group. The results from the analyses adjusted for age, showed significant increased risk of myocardial infarction for the participants with substantial standing and walking at work. However this association was attenuated and no longer statistically significant after adjusting for other traditional risk factors as sex, socioeconomic status and lifestyle factors. In general, the results from the restricted analyses were similar as the results based on the total sample.

Other studies of occupational physical activity and myocardial infarction have showed diverse results. A significant increased risk of myocardial infarction for men with moderate levels of occupational physical activity, was for example observed in the study by Holtermann et al. in the Copenhagen City Heart Study[15]. Unlike the present study, they used a combination of baseline and follow up measures after five years in their categorization of occupational physical activity. Furthermore, in a study by Allesoe et al an increased risk was noted for women with high levels of physical activity at work[14]. In contrast to the present study where a variety of occupations are included, they were only studying nurses.

A significantly reduced risk for myocardial infarction was noted for both men and women with moderate to high levels of occupational physical activity in a Finnish study[16]. They were using quite similar categorization as in the present study. A difference though, is that they started their data collection 20 years earlier than in our study. The two studies differ with regard to number of subjects in the highest level of occupational physical activity, the Finnish study having higher numbers in this category. The differences in results seen between the two studies may reflect changes over time regarding both occupational physical activity and physical activity in general.

Guidelines about physical activity in general, emphasis the importance of a non-sedentary life-style, in order to protect diseases[18]. However, in a recent study by Moller et al[21], no differences were seen between employees with sedentary and non-sedentary work regarding the risk of ischemic heart disease. It has been proposed that leisure time physical activity and occupational physical activity might have different effect on the cardiovascular system, with leisure time physical activity leading to a training effect on the heart and occupational physical activity leading to an overload on the cardiovascular system[22].

A factor that might affect the risk of myocardial infarction is the participants' level of physical fitness. It has previously been shown that high levels of occupational physical activity don't seem to improve physical fitness[23, 24]. This could be understood from the idea that occupational physical activity in most cases doesn't increase heart rate enough to improve fitness level, and therefore doesn't have positive effect on the cardiovascular system. Research where combination of high levels of occupational physical activity and moderate to high levels of leisure time physical activity have been studied has resulted both in increased[25] and decreased[26] risk of ischemic heart disease. When looking at the baseline characteristics for participants in this study, there is a larger proportion taking part in leisure time physical activity in OPA 1, this proportion decreases in OPA 2 and is at its smallest in OPA 3. Explanations for this may involve that high levels of occupational physical activity leads to fatigue in leisure time, with little energy left to take part in exercise. Other possible explanations may involve socioeconomic differences between the groups and thereby differences in health behavior.

Stratifying for different age groups resulted in a significantly reduced risk for participants younger than 45 years old, with work including lifting or carrying. One possible explanation for these findings might be the, in general, higher fitness level seen for younger people, which may allow for a higher level of occupational physical activity. For the middle-aged, 45 to 54 years old, no statistically significant results were seen. Compared to the younger participants the results for this group rather showed a tendency towards an increased risk of myocardial infarction for work including substantial standing and walking. This might has to do with declining functional reserve capacity with older ages[27]. In contrast to the results from the middle-aged group, the results from the group of the oldest participants don't show the same tendency towards increased risk, as seen for the middle-aged. Here, theories about "the healthy worker"[28] might be part of the explanation. In general, all the results from the stratified analyses must be interpreted with caution, due to the few participants in some of the analyzed subgroups, leading to low precision in estimates and wide confidence intervals, and hence low power to detect a true association.

A strength with the present study is the high response rate, together with the distribution between different socioeconomic groups, which increases the validity in this study and also the ability to generalize the results from this study to the Swedish population as well as to other populations with similarities in working conditions. Data on myocardial infarction was obtained from the National Patient Register and the Cause of Death Register in Sweden. The proportion of cases of myocardial infarction identified by the registers has been found to be between 77 and 91.5 percent, which implies high validity and little loss of follow-up for this data[29]. In this study only cases of myocardial infarction were used, extension to other diagnosis of ischemic heart diseases would probably have led to more cases and higher power. However, we wanted to use the specific and well-defined outcome of myocardial infarction in this analysis.

One limitation in the study is that only data from the baseline is used regarding the participants' levels of occupational physical activity. Participants may have changed exposure category during the time of follow-up. Given that a true association exist between occupational physical activity and myocardial infarction, change of exposure category might have attenuated the association in the present study. A follow up of the participants' level of occupational physical activity would therefore further have increased the validity of this study. Another limitation is that the data regarding occupational physical activity is self-reported from the participants and the questions may be considered rather unspecific. For example, the predefined cut-off for sitting or standing more or less than 50 % of the working day was used in our study. This may not necessarily be the best way of defining being sedentary versus physically active at work. Other ways of assessing occupational physical activity are for example used by Krause et al.[13]. They interviewed the study subjects about their physical activity at work and how many minutes they spent in different activity. Out of these interviews, energy expenditure were calculated. A more objective measurement is tested by Skotte et al.[30] using triaxial accelerometers for detection of physical activity. An objective assessment of occupational physical activity would have been preferable, but is often not feasible to include in large scale epidemiological studies, as this would require extensive resources. These limitations regarding assessment of occupational physical activity, also largely applies to the assessment of leisure time physical activity in the WOLF study.

Conclusion

No significant associations between occupational physical activity and the risk of myocardial infarction was observed in this prospective cohort study of 9,961 employees in the total study

population. A significant reduced risk were seen for participants younger than 45 years old with work including lifting and carrying, but this result must be interpreted with caution, due to the few participants in the stratified analyses. Based on the results from this study, occupational physical activity in general does not seem to be enough for reducing the risk of myocardial infarction, which is an important message to people with high levels of occupational physical activity.

Contributorship statement

LA, AK and PJMW were responsible for the baseline data collection, AMJ and EIF were responsible for the conception and the design of the present study. AMJ drafted the first version of the manuscript. All authors interpreted the data and revised the manuscript critically for important intellectual content. All authors read and approved the final version of the manuscript.

Competing interests

There are no competing interests for this publication.

Funding

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Data sharing statement

No additional unpublished data from the study is available.

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Supplementary material

Supplementary table 1. Baseline characteristics of study subjects by occupational physical activity.

	Total n = 9,836	OPA 1* n = 4,997	OPA 2** n = 2,568	OPA 3*** n = 1,922	OPA 4**** n = 349
Age					
Mean (SD)	42.7 (10.7)	43.2 (10.1)	43.0 (10.9)	41.5 (11.4)	40.9 (11.2)
< 45 years, n (%)	5,247 (53.3)	2,602 (52.1)	1,322 (51.5)	1,111 (57.8)	212 (60.1)
45-54 years, n (%)	3,121 (31.7)	1,701 (34.0)	820 (31.9)	512 (26.6)	88 (25.2)
≥ 55 years, n (%)	1,468 (14.9)	694 (13.9)	426 (16.6)	299 (15.6)	49 (14.0)
Sex					
Men, n (%)	6,739 (68.5)	3,075 (61.5)	1,751 (68.2)	1,621 (84.3)	292 (83.7)
Women, n (%)	3,097 (31.5)	1,922 (38.5)	817 (31.8)	301 (15.7)	57 (16.3)
Myocardial infarction during follow- up, n (%)	243 (2,5)	116 (2.3)	74 (2.9)	46 (2.4)	7 (2.0)
Socioeconomic status					
Manual workers, n (%)	4,258 (43.3)	965 (19.3)	1,257 (49.0)	1,749 (91.0)	287 (82.2)
Low and intermediate non-manual workers, n (%)	4,323 (44.0)	3,008 (60.3)	1,102 (42.2)	162 (8.4)	51 (14.6)
Professionals, n (%)	1,246 (12.7)	1,017 (20.4)	208 (8.1)	10 (0.5)	11 (3.2)
Smoking					
Never smoked, n (%)	4,602 (47.9)	2,435 (49.6)	1,209 (48.1)	810 (43.8)	148 (43.7)
Former smoker, n (%)	2,839 (29.6)	1,500 (30.6)	728 (29.0)	512 (27.7)	99 (29.2)
Current smoker, n (%)	2,166 (22.5)	972 (19.8)	575 (22.9)	527 (28.5)	92 (27.1)
Leisure time physical activity					
Never or seldom, n (%)	2,440 (24.8)	1,181 (23.7)	609 (23.7)	544 (28.4)	106 (30.5)
Sometimes, n (%)	3,773 (38.4)	1,787 (35.8)	1,019 (39.7)	811 (42.3)	156 (44.8)
Regularly, n (%)	3,611 (36.8)	2,025 (40.6)	938 (36.6)	562 (29.3)	86 (24.7)
Consumption of fruit					
One piece or more per day, n (%)	6,094 (63.1)	3,130 (63.5)	1,618 (64.2)	1,159 (62.1)	187 (55.2)
Consumption of vegetables					
One portion or more per day, (%)	3,220 (34.2)	1,895 (39.1)	792 (32.3)	440 (24.6)	93 (28.7)
Consumption of alcohol					
Non-drinker, n (%)	480 (5.0)	185 (3.8)	147 (5.8)	130 (7.0)	18 (5.3)
Moderate, n (%)	8,465 (87.9)	4,408 (89.5)	2,231 (88.7)	1,538 (83.1)	288 (85.0)

Intermediate, n (%)	300 (3.1)	158 (3.2)	64 (2.5)	65 (3.5)	13 (3.8)
Heavy, n (%)	387 (4.0)	176 (3.6)	73 (2.9)	118 (6.4)	20 (5.9)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Standing or walking for more than 50 % of working day and lifting or carrying.
****OPA 4 = Seated for more than 50 % of working day and lifting and carrying.

Supplementary table 2. The association between occupational physical activity and risk of myocardial infarction. Analysis made for the total sample and restricted to those working 35 hours per week or more. Hazard ratios (HR) with 95 % confidence intervals (95% CI).

	Model 1§	Model 2§§	Model 3+	Model 4++	Model 5¤
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
OPA (Total)	n=9,836	n=9,836	n=9,827	n=8,948	n=8,956
1*	1	1	1	1	1
2**	1.29 (0.96-1.73)	1.21 (0.91-1.63)	1.13 (0.83-1.54)	1.12 (0.80-1.56)	1.16 (0.84-1.59)
3***	1.17 (0.83-1.65)	0.96 (0.68-1.35)	0.83 (0.56-1.24)	0.79 (0.51-1.23)	0.85 (0.58-1.25)
4****	0.99 (0.46-2.12)	0.82 (0.38-1.76)	0.73 (0.33-1.59)	0.88 (0.40-1.94)	0.93 (0.43-2.01)
OPA (>35h/week)	n=8,948	n=8,948	n=8,939	n=8,159	n=8,167
1*	1	1	1	1	1
2**	1.37 (1.00-1.86)	1.29 (0.95-1.76)	1.18 (0.85-1.63)	1.13 (0.80-1.61)	1.21 (0.86-1.70)
3***	1.22 (0.85-1.74)	1.00 (0.70-1.44)	0.82 (0.54-1.25)	0.78 (0.50-1.24)	0.90 (0.60-1.35)
4****	1.06 (0.49-2.28)	0.91 (0.42-1.95)	0.76 (0.35-1.67)	0.91 (0.41-2.03)	1.04 (0.48-2.25)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Standing or walking for more than 50 % of working day and lifting or carrying.
****OPA 4 = Seated for more than 50 % of working day and lifting and carrying.
§Model 1, adjusted for age.
§§Model 2, adjusted for age and sex. Model 3+, adjusted for age, sex and socioeconomic status.
++Model 4, adjusted for age, sex, socioeconomic status and lifestyle factors (smoking, leisure time physical activity, alcohol, fruit and vegetable consumption.
¤Model 5, adjusted for age, sex and lifestyle factors.

Supplementary table 3: The association between the combination of occupational physical activity and leisure time physical activity, and risk of myocardial infarction. Hazard ratios (HR) with 95 % confidence intervals (95% CI) adjusted for age, sex and socio-economic status.

	Leisure time physical activity					
	Never or seldom		Sometimes		Regularly	
	n	HR (95% CI)	n	HR (95% CI)	n	HR (95% CI)
OPA 1*	1,181	1.25 (0.79-2.00)	1,787	1.07 (0.69-1.66)	2,025	1
OPA 2**	609	1.83 (1.09-3.09)	1,019	1.39 (0.87-2.24)	938	0.71 (0.38-1.32)
OPA 3***	689	1.06 (0.58-1.91)	1,017	1.06 (0.63-1.79)	682	0.71 (0.34-1.46)

*OPA 1 = Seated for more than 50 % of working day, no lifting or carrying.
**OPA 2 = Standing or walking for more than 50 % of working day, no lifting or carrying.
***OPA 3 = Lifting or carrying regardless of seated or standing/walking.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4, 7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4, 5
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	Not applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5, 6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5, 6
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	?
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	10, 11
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, 8
		(b) Give reasons for non-participation at each stage	7
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 9
		(b) Indicate number of participants with missing data for each variable of interest	9
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	8

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-13 5, 6
		(*b*) Report category boundaries when continuous variables were categorized	5, 6, 13
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15, 16
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.