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CARDIOVASCULAR DISEASE

# The association between leisure time physical activity and coronary heart disease among men with different physical work demands: a prospective cohort study

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**Abstract** The interplay of occupational and leisure time physical activity (LTPA) in affecting cardiovascular health is subject to debate. This study aimed to examine the independent and interacting associations of leisure time and occupational physical activity (OPA) with the incidence of coronary events within the BELSTRESS cohort. The study included 14,337 middle-aged men free from coronary heart disease at baseline. Standardized questionnaires and clinical examinations were used to assess socio-demographic factors, level of physical activity, job strain and classical coronary risk factors. The incidence of clinical coronary events was monitored during a mean follow-up time of 3.15 years. Results demonstrated overall a beneficial relation of LTPA and an adverse relation of physical work demands with cardiovascular health. However, an interaction effect between both physical activity types was observed, showing that men with high physical job demands who also engaged in physical activity during leisure time had an almost four times increased incidence of coronary events after adjusting for socio-demographic and classical coronary risk factors (HR 3.82; 95 % CI 1.41–10.36). Stratified analyses revealed that moderate to high physical activity during leisure time was associated with a 60 % reduced incidence rate of coronary events in men with low OPA (age adjusted HR 0.40; 95 % CI 0.21–0.76), while this protective association was not observed in workers being exposed to high physical work demands (age adjusted HR 1.67; 95 % CI 0.63–4.48). These findings suggest that recommendations regarding LTPA should be tailored according to the level of occupational physical activity.

**Keywords** Physical activity · Coronary heart disease · Occupational · Leisure

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## Introduction

The relation between leisure time physical activity (LTPA) and health has been widely established in literature. A large body of evidence shows that people who regularly engage in physical activity of moderate or vigorous intensity have a reduced risk of cardiovascular disease and mortality [1]. In contrast to this, the association between occupational physical activity (OPA) and cardiovascular disease has been examined to a much lesser extent. Several prospective cohort studies have showed that heavy physical job demands have detrimental effects for cardiovascular disease [2–4], although findings in literature are rather inconsistent [5]. Hence, more research is needed to disentangle the roles of LTPA and OPA on cardiovascular health [5, 6]. In recommendations on physical activity and health by expert committees, no distinction is made between physical activity performed during work or leisure time [7, 8]. It is therefore important to know the impact on cardiovascular health of different types and settings of physical activity.

Another issue for scientific debate is whether workers with high OPA should be recommended to relax or to be physically active during leisure time [9]. Engaging in high levels of LTPA when the body is already fatigued from multiple hours of OPA could introduce an overloading rather than a training effect on the cardiovascular system through prolonged intravascular turbulence and increased wall shear stress [4, 5]. Because of the specific physiological mechanisms embedded in LTPA versus OPA, additional aerobic exercise during leisure time may cause more exhaustion without having beneficial impact in workers who already exceed safe limits for energy expenditure at work due to exposure to heavy static work on the job [4, 5]. Only very few scientific studies have investigated the effects of LTPA on cardiovascular health among workers with different levels of OPA, with contrasting results [9–12].

Data from the BELSTRESS cohort have been revisited in order to examine the independent and interacting associations of LTPA and OPA with the incidence of coronary heart disease (CHD). In line with findings from literature, we hypothesized a beneficial relation of LTPA and an adverse relation of OPA with CHD. In addition, we expected an interaction between OPA and LTPA in the sense that high levels of LTPA among workers with high OPA are associated with an increased incidence rate of CHD.

## Methods

### Study population

BELSTRESS is a large epidemiological cohort study on job stress, cardiovascular and other health issues and sickness absence [13]; it was part of the Job stress, Absenteeism and Coronary heart disease European cooperative (JACE) study [14]. Baseline data were collected between 1994 and 1998 in a sample of 21,419 respondents (24 % women) from 25 companies or public administrations across Belgium. The participating organizations included 13 large industrial plants, six bank and insurance companies, four public administrations, and two hospitals. Within the participating companies, all workers aged 35–59 years were personally invited to participate in the study; a participation rate of 48 % was reached. All participants gave their informed consent before inclusion in the study. Data were collected through self-administered questionnaires and bio-clinical examinations. The questionnaires contained information on socio-demographic variables, work-related characteristics, lifestyle factors, medical history and health perception. In collaboration with the occupational health services of the participating companies, trained observers conducted the medical examinations which aimed mainly at measuring classical coronary risk factors. The ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels approved the BELSTRESS study.

### Questionnaire data

Participants reported their age, educational level and job title. Primary school was classified as low education level, secondary school as medium education level, and high school or university as high education level. Occupations were defined according to the International Standard Classification of Occupations (ISCO) and grouped into executive, white-collar and blue-collar [15]. Participants were asked about their smoking status and usual consumption of alcoholic drinks during week and weekend days. Current smokers were defined as those who regularly smoke cigarettes, cigars or pipes. The average total number of alcohol units per week was calculated. People were classified as having diabetes if they had answered positively to the question if a physician had ever told them that they had diabetes. Stress at work was measured by items from the Job Content Questionnaire, based on the Job-Demand-Control model [16, 17]. The psychological job demand scale was composed of the sum score of five items, while the job control scale included nine items. Job strain was defined as the ratio of job demands over job control.

#### *Physical activity measures*

The usual level of OPA was measured with a scale including five items from the Job Content Questionnaire [17]. The scale is composed of three items assessing physical exertion (high physical effort, lifting heavy loads, rapid physical activity) and two items assessing isometric loads (awkward body positions, awkward positions of head or arms), and has been shown an internationally validated tool to measure physical job demands [17]. The items were scored on a four-point Likert scale from 'totally disagree' to 'totally agree'. A summary scale of OPA was composed of the sum score of the five items and ranged from 5 to 20. This variable was highly skewed to the right and was therefore categorized. A minimum score of 13 was classified as a high level of overall OPA which generally corresponds to an exposure to three up to five of the individual OPA items.

Participants were asked to indicate their usual level of LTPA on a set of four response possibilities: no weekly activity; only light physical activity during most weeks; heavy physical activity (i.e. resulting in sweating and elevated pulse rate) during 20 min or more once or twice per

week; heavy physical activity during 20 min or more three times or more per week. Moderate to high physical activity was attributed to persons who engage in heavy physical activity during 20 min or more, at least once a week, corresponding to the upper two categories.

### Clinical examination

Participants were medically examined by trained members of the research team, using standardized methods. The examinations were done during working hours at the workplace. Blood pressure was calculated as the average of two successive readings with a 5 min interval obtained by sphygmomanometry in a sitting position. A nonfasting blood sample was taken and shipped to a central laboratory for determination of serum total and high density lipoprotein (HDL) cholesterol. Body mass index (BMI) was calculated as body weight (in kg) divided by the square of the height (in m). In line with international standards defined by the World Health Organization, overweight was defined as a BMI of 25 or higher; those with a BMI of 30 or higher were classified as obese.

### Follow-up of coronary heart disease

Females were not included in the prospective follow-up given the low number of events expected among women. The male population was followed up until December 31, 1999 for clinical manifest coronary events, defined as the occurrence of an acute myocardial infarction, unstable angina, and hospitalization for coronary artery bypass grafting or percutaneous transluminal coronary angioplasty [18]. Because of organizational reasons, follow-up information was not gathered in seven of the smaller companies, resulting in 14,859 male employees included in the prospective follow-up study. The mean follow-up time was 3.15 years, with a total of 45,210 person-years of observation. The incidence of CHD was carefully monitored in collaboration with the occupational health service according to a standardized procedure; details have been described previously [18]. At the analysis stage, 522 men with existing CHD at baseline were excluded, resulting in a cohort of 14,337 men free of CHD at the start with complete follow-up information.

### Statistical analyses

Descriptive statistics were obtained through proportions and mean values. Cox proportional hazard regression modeling was used to assess the relation between physical activity exposures and CHD in a predictive model for time-to-event data. Parameter estimation was conducted by the maximum likelihood method; Exp(B) with the corresponding 95 % confidence interval was produced as the estimated hazard ratio. A visual inspection of the log minus log plots was performed in order to check whether the proportional hazards assumption was met. Adjustment for confounders was done stepwise. Age adjusted hazard ratios were generated in the first model while in the second model adjustments were done for age, educational level, occupational class, job strain, body mass index, smoking, alcohol consumption, diabetes, systolic blood pressure, total cholesterol and HDL cholesterol.

In order to examine the interplay of both types of physical activity in relation to CHD, a Cox proportional hazard regression model was tested in which the multiplicative interaction term of OPA*LTPA was added in addition to both main effects of OPA and LTPA as well as all confounding variables (age, educational level, occupational class, job strain, body mass index, smoking, alcohol consumption, diabetes, systolic blood pressure, total cholesterol and HDL cholesterol).

A $p$ value at $<0.05$ level was considered statistically significant. All analyses were conducted with IBM SPSS Statistics version 19.

## Results

Baseline characteristics of the cohort including 14,337 middle-aged men free from existing CHD are shown in Table 1. Within this cohort, 87 new coronary events, including 20 fatal attacks, were registered during a mean follow-up of 3.15 years. These events included 44 cases of acute myocardial infarction, 28 cases of unstable angina, nine cases of percutaneous transluminal coronary angioplasty and six coronary artery bypass grafting surgical procedures. Almost 44 % of the sample had a low educational level; the majority of participants were white-collar (43 %) or blue-collar (39 %) workers. About 15 % of the cohort was exposed to high levels of OPA, while 39 % was considered to be moderately to highly physically active during leisure time. In general, the coronary risk profile of the sample was in line with expectation for a male Belgian working population of that age range in the nineties, with 30 % current smokers, 3 % individuals with diabetes, and 14 % being obese.

Table 2 displays the crude and adjusted relations between physical activity levels and incidence of CHD. Workers with high OPA had a 72 % increased incidence rate of CHD, while those being moderately to highly physically active during leisure time had a 49 % reduced incidence rate. Based on the age and mutually adjusted model, the relation of LTPA was independently significant while this was not the case for OPA. Both associations were not statistically significant after adjusting for age,

**Table 1** Description of baseline socio-demographic factors, cardiovascular risk factors and physical activity levels in 14,337 men

| Characteristics | % (N) or mean (SD) |
|---|---|
| Age in years: mean (SD) | 45.8 (6.0) |
| Educational level: % (N) | |
| Low | 43.5 (6,188) |
| Medium | 28.8 (4,098) |
| High | 27.7 (3,950) |
| Occupational class: % (N) | |
| Executive | 17.8 (2,486) |
| White-collar | 42.9 (5,988) |
| Blue-collar | 39.2 (5,471) |
| Current smoker: % (N) | 29.5 (4,192) |
| Weekly alcohol consumption in units: mean (SD) | 14.8 (16.1) |
| Diabetes: % (N) | 2.8 (392) |
| Body mass index (kg/m$^2$): mean (SD) | 26.4 (3.6) |
| Weight group: % (N) | |
| Normal weight (BMI $<$ 25 kg/m$^2$) | 36.6 (5,241) |
| Overweight (25 kg/m$^2$ $\leq$ BMI $<$ 30 kg/m$^2$) | 49.5 (7,081) |
| Obesity (BMI $\geq$ 30 kg/m$^2$) | 13.9 (1,992) |
| Systolic blood pressure (mmHg): mean (SD) | 132.9 (15.3) |
| Diastolic blood pressure (mmHg): mean (SD) | 84.5 (10.2) |
| Total cholesterol (mg/dl): mean (SD) | 225.4 (39.8) |
| HDL cholesterol (mg/dl): mean (SD) | 49.0 (13.3) |
| Occupational physical activity: % (N) | |
| Low | 85.4 (12,035) |
| High | 14.6 (2,052) |
| Leisure time physical activity: % (N) | |
| Low | 60.8 (8,447) |
| Moderate to high | 39.2 (5,450) |

*SD* standard deviation, *BMI* body mass index

educational level, occupational class, job strain, body mass index, smoking, alcohol consumption, diabetes, systolic blood pressure, total cholesterol and HDL cholesterol.

A significant multiplicative interaction was found between LTPA and OPA in relation to incidence of coronary events in a model adjusting for both main effects and all confounding variables: HR for the OPA*LTPA interaction term was 5.01 with 95 % CI 1.43–17.53. Based on this result, the interplay between both physical activity types was examined in a model including the combined exposure to OPA and LTPA. Four separate groups were created according to the combination of low versus high OPA and low versus moderate to high LTPA; results are shown in Table 2. After adjusting for socio-demographic and classical coronary risk factors, men who combined high physical work demands with moderate to high levels of physical activity during leisure time showed an almost four times significantly higher incidence rate of coronary events compared to the lowest risk group with low OPA and moderate to high LTPA. The combined analysis showed that low LTPA was related with an increased coronary event incidence, although the fully adjusted association was no longer significant when combined with high OPA while it became borderline significant in combination with low physical job demands. In order to further explore the nature of this interactive association, stratified analyses were performed for men with different levels of OPA (Table 3). In men with low OPA there was a significantly independent protective relation of moderate to high LTPA with CHD, with a 60 % incidence reduction in the age adjusted model. This relation turned borderline significant after adjusting for all confounders. However, no beneficial association of LTPA was observed in workers exposed to high OPA.

## Discussion

A convincing plea has been made to make a distinction between the impact of LTPA and OPA on cardiovascular health [5, 6]. In the present study the independent associations of both LTPA and OPA on the short-term incidence of coronary events was examined in a cohort of 14,337 middle-aged men. Only a minority of existing studies have simultaneously examined the differentiating effects of both LTPA and OPA, often with conflicting results [5, 19–21]. Overall, the study hypotheses were confirmed by our results. High physical demands on the job were related with an increased rate of coronary events, but the relation was no longer significant after adjusting for LTPA, socio-demographic variables, job strain and classical coronary risk factors. This modest relation is in line with literature showing adverse effects of OPA for cardiovascular health [2–4]. Likewise, our results confirmed the beneficial relation of physical activity during leisure time with cardiovascular health [1].

We further hypothesized that workers engaged in both high OPA and LTPA would have an excessive load on the cardiovascular system [4, 5], and therefore be at increased risk of CHD. This assumption was supported by our findings. A significant interaction effect between LTPA and OPA on incidence of coronary events was observed. Workers who combined high physical job demands with moderate to high levels of physical activity during leisure time showed an almost four times increased incidence of coronary events after adjusting for socio-demographic variables and classical coronary risk factors. Stratified analyses showed that in workers who were not exposed to high levels of physical demands on the job, moderate to high physical activity during leisure time was associated

**Table 2** Crude and adjusted relations between occupational and leisure time physical activity and coronary heart disease, results from Cox proportional hazards regression analyses in 14,337 men

| | % | No of events (total no. of subjects) | Crude | | Model 1[a] | | Model 2[b] | |
|---|---|---|---|---|---|---|---|---|
| | | | HR | 95 % CI | HR | 95 % CI | HR | 95 % CI |
| Occupational physical activity (OPA) | | | | | | | | |
| Low | 0.5 | 66 (12,035) | 1 | | 1 | | 1 | |
| High | 0.9 | 19 (2,052) | **1.72** | 1.03–2.87 | 1.67 | 0.96–2.91 | 1.28 | 0.68–2.44 |
| Leisure time physical activity (LTPA) | | | | | | | | |
| Low | 0.7 | 58 (8,447) | 1 | | 1 | | 1 | |
| Moderate to high | 0.3 | 19 (5,450) | **0.51** | 0.31–0.86 | **0.58** | 0.35–0.98 | 0.76 | 0.43–1.32 |
| Combined groups | | | | | | | | |
| Low OPA and moderate to high LTPA | 0.2 | 11 (4,605) | 1 | | 1 | | 1 | |
| Low OPA and low LTPA | 0.7 | 49 (7,117) | **2.83** | 1.47–5.44 | **2.55** | 1.30–4.92 | 1.98 | 0.99–3.96 |
| High OPA and low LTPA | 0.7 | 8 (1,196) | **2.82** | 1.14–7.02 | **2.62** | 1.05–6.51 | 1.51 | 0.54–4.19 |
| High OPA and moderate to high LTPA | 1.1 | 8 (759) | **4.38** | 1.76–10.90 | **4.58** | 1.84–11.39 | **3.82** | 1.41–10.36 |

*HR* hazard ratio, *CI* confidence interval, significant associations at the 0.05 level are in bold

[a] Adjusted for age and for leisure time/occupational physical activity, respectively (except for the model including the combined groups)

[b] Additionally adjusted for educational level, occupational class, job strain, body mass index, smoking, alcohol consumption, diabetes, systolic blood pressure, total cholesterol and HDL cholesterol

**Table 3** Crude and adjusted relations between leisure time physical activity and coronary heart disease, results from stratified Cox proportional hazards regression analyses in 14,337 men with different levels of occupational physical activity

| | % | No of events (total no. of subjects) | Crude | | Model 1[a] | | Model 2[b] | |
|---|---|---|---|---|---|---|---|---|
| | | | HR | 95 % CI | HR | 95 % CI | HR | 95 % CI |
| Low occupational physical activity | | | | | | | | |
| Leisure time physical activity | | | | | | | | |
| Low | 0.7 | 49 (7,117) | 1 | | 1 | | 1 | |
| Moderate to high | 0.2 | 11 (4,605) | **0.36** | 0.19–0.68 | **0.40** | 0.21–0.76 | 0.52 | 0.26–1.04 |
| High occupational physical activity | | | | | | | | |
| Leisure time physical activity | | | | | | | | |
| Low | 0.7 | 8 (1,196) | 1 | | 1 | | 1 | |
| Moderate to high | 1.1 | 8 (759) | 1.56 | 0.58–4.15 | 1.67 | 0.63–4.48 | 2.30 | 0.75–7.09 |

*HR* hazard ratio, *CI* confidence interval, significant associations at the 0.05 level are in bold

[a] Adjusted for age

[b] Additionally adjusted for educational level, occupational class, job strain, body mass index, smoking, alcohol consumption, diabetes, systolic blood pressure, total cholesterol and HDL cholesterol

with about 50 % reduced incidence rate of coronary events after adjusting for covariates, but this protective relation of LTPA was not observed in those being exposed to high levels of OPA. Therefore, the findings of this study support the assumption based on the hemodynamic theory of atherosclerosis [22], that engaging in both heavy physical activity at work and during leisure time generates an overloading of the cardiovascular system by excessive time per day spent with increased heart rate, causing prolonged intravascular turbulence and wall shear stress, resulting in inflammation of the arterial walls and finally leading to atherosclerosis [4, 5]. This hypothesis of differing physiological mechanisms of both types of physical activity is based on the assumption that performing aerobic exercise during leisure time induces a training effect in contrast to heavy physical demands on the job which usually include more static or anaerobic physical activities [4, 5].

Even in modern service economies, a considerable proportion of the working population is exposed to heavy physical demands [4, 23, 24]. Our findings suggest that people working in these physically demanding jobs that require a lot of static or anaerobic movements should not be recommended to engage in LTPA because this could

have detrimental effects on their cardiovascular health. From a public health perspective, a lot of attention is given to the health promoting role of physical activity. According to the global recommendations formulated by the World Health Organization, adults aged 18–64 years should engage in at least 150 min of moderate-intensity (or at least 75 min of vigorous-intensity) aerobic physical activity throughout the week, in order to achieve beneficial health effects [8]. This guideline does not make a distinction between activity levels during occupational or leisure time. It was recently shown that adverse responses in cardiometabolic risk factors to regular exercise are not uncommon, and that predictors should be identified [25]. Based on the results presented here, it is recommended to tailor LTPA guidelines according to the level of OPA.

To the best of our knowledge, only three other cohort studies have investigated the specific interplay of OPA and LTPA in relation to CHD. In all three studies OPA and LTPA interacted with each other in affecting CHD risk, but the nature of the interaction effect differed [9, 11, 12]. Our findings are in line with a large prospective Finnish study showing a protective effect of LTPA on CHD only in men with low levels of OPA [12]. However, the opposite was observed in the long-term prospective Copenhagen Male Study where LTPA reduced the ischaemic heart disease mortality risk only in men with moderate and high OPA [9, 10]. Our results are also in contrast to findings from the Copenhagen City Heart Study in which high OPA was associated with an increased risk of cardiovascular mortality among men with low and moderate LTPA, but not among men with high LTPA [11]. Comparing our results with these other findings in literature is not straightforward because of some important differences in the methodologies that were used. The follow-up time in the present study was relatively short compared to the other long-term cohort studies, and the definitions of the outcome events were not completely identical.

The most important disparity however, that could probably account for the conflicting findings is the different operationalization of OPA levels. In the present study the assessment of physical job demands was based on a standardized scale covering five detailed items (high physical effort, lifting heavy loads, rapid physical activity, awkward body positions and awkward positions of head or arms) [17]. In all three studies mentioned above, the assessment of OPA was mainly based on a single item resulting in a more unspecified measure [9, 11, 12]. For instance, the description of an elevated level of physical job demands includes both walking and lifting as example activities, while these activities are likely to produce diverse physiological mechanisms. Additional research is definitely needed to bring more clarity in this matter. It is of particular importance to obtain data based on objective measurements of physical activity which allow detailed assessments of the beneficial and detrimental levels of specific types of OPA.

This study offers an important contribution to literature as the unknown interrelationships between OPA and LTPA have been identified as the most obvious research gap regarding physical activity and cardiovascular disease [5]. The major strengths of this study are the use of an objective clinical outcome of CHD within a prospective cohort design. In addition, thorough control of confounding was conducted by taking major risk factors for coronary events into account including age, educational level, occupational class, job strain and classical coronary risk factors. Moreover, additional subgroup analyses (results not shown) revealed similar patterns of the interplay between LTPA and OPA in relation to CHD incidence in white-collar versus blue-collar workers, which demonstrates the independency of the results from socio-economic status.

This study also faces some notable limitations. As mentioned above, the main limitation concerns the assessment of physical activity, which was based on self-reports and did not include objective monitoring data. Only a single measurement of OPA and LTPA was available, which also increases the risk of misclassification. Moreover, due to the short follow-up time and hence small number of events, it was not feasible to use more detailed categorizations of physical activity to examine dose–response relations. For measuring the exposure to LTPA, people engaging in both moderate and high levels were grouped together because only 5 events were observed in the highly physically active group. Nonetheless, additional results (not shown) revealed comparable effect estimates when applying this alternative categorization, although the results did not reach statistical significance. Concerning the categorization of OPA, the cut-off of 13 on a scale ranging from 5 to 20 was based on logical grounds (high OPA corresponds to an exposure to three up to five of the individual OPA items). However, since this categorization still is somewhat arbitrary, sensitivity analyses were performed with an alternative categorization using cut-off 12 (corresponding to an exposure to two up to five of the individual OPA items, reported by 20 % of the sample), which revealed highly similar results. Although thorough adjustments were made for personal, socio-economic and classical coronary risk factors, it remains possible that the observed findings are due to residual confounding. It could be for instance that workers with varying physical job demands have a different understanding of what high physical activity during leisure time means. Again, this warrants for future research to test these study hypotheses with detailed objective measures of OPA and LTPA. Another shortcoming is the lack of physical fitness data in this study, because evidence suggests that the level of fitness may be a confounder in the interplay between LTPA and OPA on

CHD [2]. Finally, the findings presented here have limited generalizability since no women were included in the study.

In conclusion, the associations of both LTPA and OPA with the short-term incidence of coronary events was examined in a cohort of 14,337 middle-aged men. Results confirmed the beneficial relation of LTPA and adverse relation of OPA with cardiovascular health. An interaction effect between both physical activity types was observed, showing that men with both high physical job demands and moderate to high levels of physical activity during leisure time showed an almost four times increased incidence of coronary events. Moderate to high LTPA was associated with a reduced incidence of coronary events within workers having low OPA, while this protective relation was not shown within the subgroup being exposed to high physical work demands. These findings suggest that LTPA guidelines should be tailored according to the level of OPA. Further research with objective measures is needed to confirm these conclusions.

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**Conflict of interest** The authors declare that they have no conflict of interest.

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