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ISCHAEMIC HEART DISEASE AMONG WORKERS IN OCCUPATIONS ASSOCIATED WITH HEAVY LIFTING

HARALD HANNERZ and ANDREAS HOLTERMANN

National Research Centre for the Working Environment, Copenhagen, Denmark
Department of Occupational Health

Abstract
Objectives: To investigate a hypothesized positive association between employment in occupations where heavy lifting is likely to occur, and the risk of ischaemic heart disease (IHD). **Material and Methods:** Male blue-collar workers from Denmark (N = 516 180) were monitored with respect to hospital treatment or death due to IHD, through national registers over the years 2001–2010. Poisson regression was used to estimate relative rates of IHD between "workers in occupations which, according to an expert opinion, are likely to involve heavy lifting" and "other blue-collar workers." Prevalent cases were excluded from the analysis. **Results:** The rate ratio was estimated at 0.97 (95% confidence interval (CI): 0.94–1.00) for deaths or hospitalizations due to IHD and 1.07 (95% CI: 0.94–1.21) for deaths due to IHD. **Conclusions:** The results do not support the hypothesis that occupational heavy lifting is an important risk factor for IHD.

Key words:
Occupational epidemiology, Cohort studies, Heavy lifting, Cardiovascular disease, Hospital treatment, Mortality

INTRODUCTION

Ischaemic heart disease (IHD) is a worldwide leading cause of years of lost life due to premature mortality [1], a significant proportion of which can be attributed to occupational exposures. Estimates of the work-related attributable fraction for IHD mortality, among people of working age, ranges from 8% in Korea [2] to 17% in Denmark [3] and Finland [4].

It is recognized that a person's risk of IHD may be increased by work-related psychosocial factors e.g., low decision authority [5], job insecurity [6] and job strain [7]. It has also been established that the risk may be increased by the physical work environment, e.g., through exposures to loud noise [2] and environmental tobacco smoke [2], as well as by work time arrangements, e.g., shift work [8] and long working hours [9].

Ergonomic work factors, such as a strenuous physical activity, sedentary work, heavy lifting, awkward work postures and repetitive movements, may also play a role in the etiology of IHD, but, as far as we know, the evidence for any such an association is insufficient. Several studies have been performed but the results have either been inconsistent or insufficiently reproduced [10].

One of the ergonomic work factors, for which the results are insufficiently reproduced, is frequent heavy lifting, which is believed to increase the risk of IHD. It has been shown that heavy lifting increases blood pressure momentarily to quite extreme levels. MacDougal et al. have recorded blood pressure response to heavy-weight lifting exercise in 5 body builders, and have found a mean value for peak pressure to be 320/250 mm Hg for double leg press and 255/190 mm Hg

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Corresponding author: H. Hannerz, National Research Centre for the Working Environment, Lersø Parkalle 105, 2100 Copenhagen Ø, Denmark (e-mail: hha@nrcwe.dk).

for single arm curl exercises [11]. Moreover, it has been suggested that a high frequency of occupational heavy lifting may lead to elevated blood pressure levels that remain increased quite some time after the activity has ended [12]; and it is known that a chronically elevated blood pressure is a risk factor for IHD [13].

The notion that occupational heavy lifting is an important risk factor for IHD is supported by the statistically significant results from 2 Scandinavian population-based studies [14,15]. Exposure data in those studies were, however, self-reported, which indicates that the results may have been influenced by reporting bias – a worker with poor cardiovascular health may have a higher propensity to perceive his/her work environment as heavy.

The aim of the present study was to test the association between occupational heavy lifting and subsequent IHD with a research design that is free from reporting bias. We could accomplish this goal by comparing the rate of IHD in blue-collar occupations in which frequent heavy lifting is likely to occur with that among other blue-collar occupations. We hypothesized that the rate of hospital treatments or deaths due to IHD and the rate of death due to IHD were higher in the occupations where frequent heavy lifting is likely to occur in comparison with other blue-collar occupations.

In keeping with good epidemiological practice, the hypotheses and statistical methods were completely defined, peer-reviewed and published [16] before the statistical analyses were commenced.

MATERIAL AND METHODS

The study utilised a database obtained through a record-linkage between 4 national registers – the central person register [17], the hospital patient register [18], the cause of death register [19] and the employment classification module [20]. The central person register contains information on gender, addresses and dates of birth, death and migrations for every person who is or has been an inhabitant of Denmark sometime between 1968 and present time. A person's occupation and industry have been registered, since 1975, annually in the employment classification module. Since 1994, the occupations have been encoded according to the Danish International Standard Classification of Occupations – DISCO-88 [21], which is a national version of the International Standard Classification of Occupations – ISCO-88. The national hospital register has existed since 1977 and contains data from all public hospitals in Denmark (more than 99% of all admissions). From 1977 to 1994, the register included only inpatients but from 1995 it has also covered outpatients and emergency ward visits. Since 1994, the diagnoses have been encoded according to the International Classification of Diseases (tenth revision) ICD-10 [22].

The DISCO-88 divides a total of 372 occupations into 10 major groups:

- group 0 – armed forces occupations,
- group 1 – managers,
- group 2 – professionals,
- group 3 – technicians and associate professionals,
- group 4 – clerical support workers,
- group 5 – service and sales workers,
- group 6 – skilled agricultural, forestry and fishery workers,
- group 7 – craft and related trades workers,
- group 8 – plant and machine operators, and assemblers,
- group 9 – elementary occupations.

The present study concerns workers from the groups 6–9 which we, for the sake of brevity, will call blue-collar workers in thereof text. An expert opinion and a subsequent validation [16] allowed us to select the following DISCO-88 categories to represent blue-collar occupations in which heavy lifting is likely to occur:

- 712 – building frame and related trades workers,
- 921 – agricultural, forestry and fishery labourers,
- 931 – construction labourers,
- 933 – transport and storage labourers.

Ethics

The usage of the data was approved by the Statistics Denmark and the Danish Data Protection Agency (file No. 2001-54-0180). The study complies with the Act on Processing Personal Data (Act No. 429) [23], which implements the European Union Directive 95/46/EC on protection of individuals.

Primary statistical analysis

All male blue-collar workers in Denmark, who were between 21 and 59 years of age at baseline (1 January 2001), were followed in our national registers, from January 1, 2001 to December 31, 2010. The main occupation in the calendar year 2000 was used as a proxy for occupation at baseline.

The following clinical endpoints were considered:

- hospital treatment or death due to IHD (ischaemic heart disease) as principal diagnosis/cause of death. Case definition includes the following ICD-10 codes: I20 angina pectoris, I21 acute myocardial infarction, I22 subsequent myocardial infarction, I23 certain current complications following acute myocardial infarction, I24 other acute ischaemic heart diseases, I25 chronic ischaemic heart disease;
- death with IHD as a principal cause of death.

Only those who were free from IHD related hospital visits, throughout the calendar year preceding the baseline, were included in the analysis. For each of the 2 endpoints, each of the included individuals was followed until any of the following events occurred: the subject reached the clinical endpoint of the follow-up, he emigrated, he died or the study period ended. Person years at risk (PYRS) were calculated for each individual.

Poisson regression was used to estimate rate ratios (RR) with 95% confidence intervals (CI) between "the workers in occupations where heavy lifting is likely to occur" and "all the other blue-collar workers," while adjusting for age (10-year age groups). The analysis was implemented in the genmod procedure of the Statistical Analysis System (SAS) version 9.3.

Sensitivity analyses

We performed 2 sensitivity analyses with hospital treatment or death due to IHD as an endpoint.

The 1st one used the same inclusion criteria and statistical method as the primary analysis, but differed in that the observations were censored whenever a person reached the age of 60, which is the age at which, according to a public insurance policy, it was possible for most of the workers to opt for early retirement. The 2nd sensitivity analysis used the same statistical method and censoring criteria as the primary analysis, but differed in that it only included the workers who remained in the same occupational category and were free from IHD related hospital contacts throughout a 3-year period prior to the baseline.

RESULTS

The inclusion criteria for the primary analysis and sensitivity analysis 1 were fulfilled by 516 180 persons. The mean age (± standard deviation) at baseline was 39.84 (±10.81) years among the workers associated with heavy lifting and 39.63 (±10.79) years among the other blue-collar workers. The inclusion criteria for the 2nd sensitivity analysis were fulfilled by 368 271 persons.

In the primary analysis, the rate ratio among the workers in occupations associated with heavy lifting versus the other blue-collar workers was 0.97 (95% CI: 0.94–1.00) for death or hospitalization due to IHD and 1.07 (95% CI: 0.94–1.21) for death due to IHD.

In sensitivity analysis 1, which censored observations whenever a person reached the age of 60, the rate ratio for death or hospitalization due to IHD was 0.98 (95% CI: 0.94–1.02).

In sensitivity analysis 2, which only included the workers who remained in the same occupational category and were free from IHD related hospital contacts throughout

Table 1. Rate ratio for ischaemic heart disease (IHD) among male workers in the occupations associated with heavy lifting, Denmark

Analysis*	Study group (total) [n]	Time at risk [person years]	Participants treated for and/or who died due to IHD [n]	RR	95% CI
Primary analysis (deaths or hospitalizations)					
1	120 397	1 148 200	4 955	0.97	0.94–1.00
2	395 783	3 790 983	16 529	1.00	–
Primary analysis (deaths only)					
1	120 397	1 170 279	320	1.07	0.94–1.21
2	395 783	3 865 001	971	1.00	–
Sensitivity analysis 1 (deaths or hospitalizations)					
1	120 397	1 042 525	3805	0.98	0.94–1.02
2	395 783	3 441 941	12 523	1.00	–
Sensitivity analysis 2 (deaths or hospitalizations)					
1	72 318	692 026	2 980	0.96	0.92–0.99
2	295 953	2 841 015	12 536	1.00	–

* Occupational category: 1 – occupations associated with heavy lifting; 2 – other blue-collar occupations.
RR – rate ratio; CI – confidence interval.

a 3-year pre-baseline period, the rate ratio for death or hospitalization due to IHD was 0.96 (95% CI: 0.92–0.99). The number of persons, cases and person years at risk for the various analyses are presented in Table 1. A flow-chart describing inclusions and exclusions is shown in Figure 1.

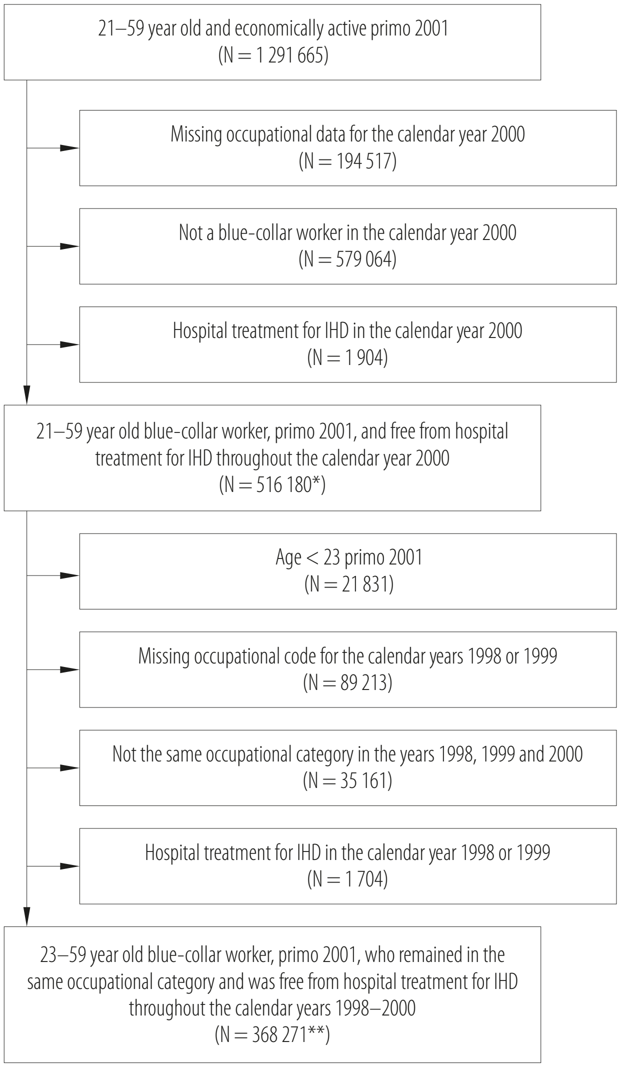
DISCUSSION

The present study targeted blue-collar workers in the general population of Denmark. We hypothesized that employment in occupations where heavy lifting is likely to occur will be associated with an increased risk for hospitalizations and death due to IHD. Our research hypotheses were not confirmed.

Methodological considerations

Bias from missing follow-up data was eliminated, since the dates of deaths, emigrations and the clinical endpoints of the study were determined through the national registers covering all residents of Denmark. By including the total target population in the analyses, we eliminated volunteer bias, and by using job codes as a proxy for occupational exposure, we eliminated reporting bias. We also eliminated hindsight bias through the publication of our study protocol [16], in which all hypotheses and statistical models were specified carefully before we looked at any relation between the exposure and response variables in our data material. The large number of participants gave us an extraordinary high statistical power, and the prospective design ascertained that the exposure took place before the outcome.

Since IHD is associated with a long latency period [24], we kept the participants in their baseline exposure categories throughout the follow-up period regardless of whether or not they shifted to another job or retired during the study period. All of the workers were eligible for an old age pension at the age of 65, and most of them had the possibility



IHD – ischaemic heart disease.
* Included in the primary analyses and sensitivity analysis 1.
** Included in sensitivity analysis 2.

Fig. 1. Flow-chart for the inclusion and exclusion criteria of the study

to opt for early retirement at the age of 60. It was, therefore, possible that the results of the primary analysis could be influenced by differential use of an early retirement option. We explored this possibility with a sensitivity analysis, which censored observations whenever a participant reached the age of 60. The result of the sensitivity analysis was for all practical purposes equal to that of the primary analysis. Thus, we can rule out the possibility that the null-finding was due to differential rates of early retirement.

All the workers who were hospital treated for IHD sometime during a 1-year period preceding the baseline were excluded in the primary analysis. This action ascertained that any case of hospital treatment during the follow-up period was a new episode rather than a revisit in a course of treatment, which had started already before the baseline. However, we cannot tell if the 1st instance of IHD during the follow-up was the 1st instance ever. Some workers might have changed from a job requiring heavy lifting to a lighter job, due to IHD, a few years prior to the baseline. Such a process would move vulnerable people from the exposed group to the comparison group and thereby, bias the analysis in the opposite direction of the hypothesis. We addressed this issue with a sensitivity analysis, which included only the workers who were free from IHD-related hospital contacts and remained in the same occupational category throughout a 3 year period preceding the baseline. The result of the sensitivity analysis was very close to the one obtained in the primary analysis. It is, therefore, unlikely that the null-finding was due to a too short pre-baseline assessment period.

There are, however, some drawbacks and limitations of the design that need to be considered. An ideal data set would be one in which each of the individual workers could be classified according to:
– how often he lifts and carry items,
– how much the lifted items typically weigh,
– what work postures and movements the lifting activities typically involve.

It would, moreover, contain individual based data on known IHD predictors, such as age [25], smoking [26], body mass index [27], physical fitness [28], cholesterol [29], blood pressure [29], work time arrangements [8,9] and other significant occupational factors.

Occupational code constituted the only exposure data that was available to the present study, and age was the only risk factor we could control for in the analysis. Therefore, we cannot rule out the possibility that a significant effect from heavy lifting has been missed (offset) by the factors which we could not control for.

We know, however, from collateral data [16] that the null-finding is unlikely to be explained by differences in BMI and smoking habits. We can also rule out confounding from socio-economic status, since in the study we only included blue-collar workers.

Previous research

A positive association between occupational heavy lifting and acute myocardial infarction has been found in a Swedish retrospective case-control study [14], which classified workers as exposed if they lifted or carried more than 20 kg (women) or 30 kg (men) at least 5 times per working day. The odds ratio was estimated at 1.30 (95% CI: 1.02–1.66) among men and 1.83 (95% CI: 1.05–3.18) among women. A later study from the same research group [30] has indicated, however, that IHD cases, compared with their controls, had a higher tendency to mistakenly recall their past work environment as heavy. In other words, we cannot rule out the possibility that the finding was due to recall bias.

Previous prospective studies on the relationship between occupational physical activity (OPA) and IHD have typically classified workers into having high (or medium) vs. low physical demands, without regard to whether the demands primarily concern high energy expenditure, dynamic aerobic workload, heavy and static loads or a combination of these [31,32].

To our knowledge, only 1 previous prospective study has specifically targeted heavy lifting as a potential risk factor for IHD [15]. The workers in that study were randomly sampled from the general population of Denmark and classified as exposed or non-exposed in accordance to their reply to the question: "Are you exposed to lifting or carrying heavy burdens (min. 10 kg) at work more than 2 days a week?"

Among men, the hazard ratio for heavy lifting with control for general OPA level (high vs. low) was estimated at 1.52 (95% CI: 1.15–2.02), while the hazard ratio for general OPA level with control for heavy lifting was estimated at 0.50 (95% CI: 0.37–0.68). These results suggest that high levels of dynamic-aerobic work activities tend to be beneficial, while high levels of heavy dynamic resistance-anaerobic work activities tend to be detrimental to cardiovascular health, and emphasize the need to differentiate between the 2 types of activity. The reliability of the results is, however, questionable since the hazard ratios among women in the same study pointed in the opposite direction.

Among women, the hazard ratio for heavy lifting was 0.81 (95% CI: 0.5–1.56), while the ratio for general OPA level was 1.55 (95% CI: 0.98–2.44).

Generalisability

In the present study, employment in occupations in which heavy lifting is likely to occur was not associated with an increased risk of IHD. The finding pertains to the general working population of Denmark – a country with generous sick leave benefits, relatively strong work environment legislations, free medical care, 5 weeks paid vacation and a full-time workweek of 37 hours. It might not correspond to the nations with longer working hours and less opportunity for recovery between work shifts. Moreover, non-increased rates among workers in the general population do not necessarily mean that the working conditions are safe for all workers. In particular, they do not tell us whether or not patients treated for hypertension should be advised against taking up or continuing employment in jobs that require heavy lifting.

CONCLUSIONS

As this is not a randomised study it can neither confirm nor reject etiologic hypotheses. It managed, however, to either confirm or reject a research hypothesis which stated that employment in occupations that, according to an expert opinion, are associated with heavy lifting is an important predictor for IHD. A confirmation of the research hypothesis would have lent support to the underlying hypothesis, which states that occupational heavy lifting is an important risk factor for IHD. However, the research hypothesis was not confirmed. Hence, the results of the present study do not support the hypothesis that occupational heavy lifting is an important risk factor for IHD.

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