

Occupational lifting and risk of hypertension, stratified by use of anti-hypertensives and age - a cross-sectional and prospective cohort study

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Abstract

Background

Heavy occupational lifting is prevalent in the general working population and is sparsely reported to associate with hypertension, especially among older and hypertensive workers. We investigated if heavy occupational lifting is associated with hypertension and blood pressure (BP) in both cross-sectional and prospective study designs in the Copenhagen General Population Study, stratified by age, and use of anti-hypertensives.

Methods

Participation was conducted following the declaration of Helsinki and approved by the ethical committee (H-KF-01-144/01). BY multivariable logistic and linear regression models we investigated the association between heavy occupational lifting and hypertension in a cross-sectional design (n=67,363, using anti-hypertensives or BP $\geq 140/\geq 90$ mmHg as outcome) and in a prospective design (n=7,020), with an above-median change in systolic BP (SBP) from baseline to follow-up and/or a shift from no use to use of anti-hypertensives as outcome), with and without stratification by age and use of anti-hypertensives.

Results

The odds ratio for hypertension was estimated at 0.97 (99% CI: 0.93 – 1.00) in the cross-sectional analysis, and at 1.08 (99% CI: 0.98 – 1.19) in the prospective analysis. The difference in SBP among workers with versus without heavy occupational lifting was estimated at -0.29 mmHg (99% CI -0.82 – 0.25) in the cross-sectional and at 1.02 mmHg (99% CI -0.41 – 2.45) in the prospective analysis. No significant interaction between heavy occupational lifting and age, nor the use of anti-hypertensives were shown.

Conclusions

Only the prospective analysis indicated heavy occupational lifting to increase the risk of hypertension. Further research on the association between occupational lifting and hypertension is needed.

Background

Hypertension increase risk for cardiovascular disease [1, 2]. Prevalence of hypertension vary across occupations and may be affected by the working environment, such as heavy lifting [3, 4]. Lifting heavy burdens acutely increases the blood pressure (BP) [5], and several hours of lifting can induce future increases in BP [6]. Only a few studies have investigated the associations of occupational lifting and blood pressure [6-8] and thus more knowledge regarding this association is warranted. Previously, one epidemiological study reported weak positive associations between occupational lifting and BP have been shown, especially among users of anti-hypertensives [7]. Additionally, did a cross-sectional study show increases in ambulatory blood pressure, both during work, leisure, and sleep time, by exposure to

occupational lifting [6]. Leisure-time physical activity (LTPA) and cardiorespiratory fitness, are known to affect the prevalence of hypertension [9-11]. Among occupational groups exposed to occupational lifting and high levels of occupational physical activity (OPA), a high level of cardiorespiratory fitness is suggested to lower the risk for cardiovascular mortality [12] by reducing the strain on the cardiovascular system [13]. Likewise, differences in ambulatory BP across sub-groups based on combinations of the level of OPA and LTPA have been reported [6], a possibility explained by the physical activity health paradox [14]. Thus, investigations of associations between occupational lifting and BP in subgroups on levels of LTPA and the use of anti-hypertensives would be of interest to future guidelines for rehabilitation and preventive initiatives. Furthermore, will rising age and hypertension stiffen the arteries contributing to endothelial damage, which may increase the total peripheral resistance and thereby also BP [15, 16]. Thus, these two factors potentially increase vulnerability to hazardous effects on BP from exposure to occupational lifting. Hence, to verify previous results, and to additionally investigate the moderating effect from LTPA, we proposed this study aiming to explore associations between heavy occupational lifting and hypertension, stratified on the use of anti-hypertensives, LTPA, and age.

Methods

Data from the Copenhagen General Population Study was analyzed to replicate the previous results based on the Copenhagen City Heart Study [7], as previously described [17]. Baseline data were collected from 2003 to 2015 and holds information on health as well as a large variety of biological, environmental, and lifestyle-related factors from approximately 110,000 study participants aged 20 to 98 years. Additionally, data from the on-going follow-up data collection, started in 2015 and planned to terminate in 2025, were included. The Copenhagen General Population Study was approved by the local ethical committee (H-KF-01-144/01), participation was conducted following the declaration of Helsinki and all study participants signed informed consent to participate.

The null-hypothesis was no association between heavy occupational lifting and the prevalence of hypertension. Secondary, interactions between age, and heavy occupational lifting, as well as between the use of anti-hypertensives, and heavy occupational lifting were planned [17].

Inclusion criteria

For the cross-sectional analysis, study participants were included by having data on BP, level of OPA (including heavy lifting), use of anti-hypertensives, and being aged ≤ 70 years old. For the prospective analysis, study participants were included by being normotensive at baseline, having data on the level of OPA at baseline, and data on BP and the use of anti-hypertensives at baseline and follow-up.

Assessment of exposure

Level of OPA was obtained by use of the question: "Please describe your level of OPA within the past year" with the following response categories: "1) predominantly sedentary; 2) sitting or standing, some walking; 3) walking, some handling of material; 4) heavy manual work". By answering 3 or 4, an

additional question regarding heavy occupational lifting; “Do you lift heavy burdens?” with the response categories: “1) yes; 2) no”, was applied. Study participants were classified as exposed to heavy occupational lifting by answering “yes” to this question, by answering “no” study participants were assigned to the reference group. The stability of exposure was evaluated by Cohen’s kappa by baseline cross-tabulated with follow-up, showing moderate agreement (0.48).

Assessment of outcome

Primary outcomes were hypertension and SBP (mmHg). Hypertension was classified as using anti-hypertensives and/or SBP \geq 140 mmHg or DBP \geq 90 mmHg at baseline examination. For the prospective analysis hypertension was classified as the shift from normotensive not using anti-hypertensives to use of anti-hypertensives or above median delta value of SBP (follow-up – baseline). Moreover, secondary analyses were conducted to evaluate associations between heavy occupational lifting on pulse pressure (SBP – DBP) and mean arterial pressure (MAP) $(2*DBP + SBP)/3$. BP was measured on one arm while sitting, after 5 minutes of rest, using an automated apparatus (BPA3plus, Microlife, Switzerland). The technicians were specially trained and the instruction was the same at both data collection time points.

Assessment of covariates

Various factors are shown to relate to both occupational workload (including lifting) and BP. Thus, those factors were included in the analyses. The following factors were included as effect modifiers by use of interaction terms: age (categories of <50 ; ≥ 50 years) [18]; the level of LTPA (categories of *mainly sedentary* “you spend most of your leisure-time performing sedentary tasks”; *light physical activity* “you go for a walk, use your bicycle a little or perform an activity for at least 4 hours per week”; *moderate physical activity* “you are an active athlete, for at least 3 hours/week; *strenuous physical activity* “you take part in competitive sports or perform moderate to vigorous activity (MVPA) more than 4 hours/week”) [19]; and use prescription medication for hypertension (anti-hypertensives) (categories of no use of anti-hypertensives; and use of anti-hypertensives). The following factors were included as confounders: sex (male/female) [20]; age (categories of <40 ; 40-49; 50-59; 60-70 years) [18]; body mass index (BMI) (categories of <18.5 ; 18.5 – 24.9; 25.0 – 29.9; ≥ 30 kg/m²) [21]; smoking (categories of nonsmoking; currently smoking) [22]; the level of LTPA (categories of *mainly sedentary* “you spend most of your leisure-time performing sedentary tasks”; *light physical activity* “you go for a walk, use your bicycle a little or perform an activity for at least 4 hours per week”; *moderate physical activity* “you are an active athlete, for at least 3 hours/week; *strenuous physical activity* “you take part in competitive sports or perform moderate to vigorous activity (MVPA) more than 4 hours/week”) [19], mental stress (“are you often feeling nervous or stressed?” yes/no) [23], and length of school education in total years [24].

Criteria for statistical significance

The overall level of statistical significance, for the cross-sectional and prospective analyses, was set at 0.05. We tested five hypotheses regarding cross-sectional associations and five hypotheses regarding prospective hypotheses. To adjust for multiple comparisons, a Bonferroni correction was applied, thus

each of the primary hypotheses was tested at a significance level of 0.01. All secondary analyses were evaluated by the 99% confidence interval (CI) and not statistical significance level, as they were considered exploratory.

Statistical analyses

All statistical analyses were performed in the statistical software SAS, version 9.4 (SAS Institute, Cary, NC, USA). In the cross-sectional analysis the odds ratio (OR) for being hypertensive, and in the prospective analysis, the odds of becoming a SBP case (defined as a shift from no use to use of anti-hypertensives and/or an above above-median change in systolic BP (baseline to follow-up)), as a function of heavy occupational lifting, were estimated by use of logistic regression in a generalized estimating equation (GEE) model. Observations from the same person were treated as repeated measurements. A first-order autoregressive correlation structure was assumed. The cross-sectional analysis was controlled for sex, age, BMI, smoking, LTPA, mental stress, school education. No exposure for heavy occupational lifting was the reference. Additionally, the prospective analysis was adjusted for BP at baseline.

Furthermore, the differences in resting SBP across study participants exposed and non-exposed to heavy occupational lifting were analyzed by cross-sectional and prospective (change in mmHg from baseline to follow-up) linear regressions adjusted for sex, age, BMI, smoking, LTPA, mental stress, and school education, and additional BP at baseline in the prospective analysis. To investigate whether age and use of anti-hypertensives moderated the association between heavy occupational lifting and SBP an interaction term was included for each of these variables (exposure*moderating factor). By significant interactions, the linear regressions were applied to groups stratified by age, and the use of anti-hypertensives.

The secondary explorative analyses investigated the effect of heavy occupational lifting on DBP, but not SBP, as previously reported [17]. Also, the linear regressions were repeated for the outcomes of MAP, and PP. Additionally, to investigate the sensitivity of the comparison group, the adjusted primary analyses were repeated in models with a comparison group split by the self-reported categories of OPA, resulting in four instead of two categories. Moreover, to investigate the sensitivity of the definition of hypertension, used in the primary analyses, two alternative definitions of hypertension were applied (SBP \geq 160 mmHg or DBP \geq 100 mmHg [25]; SBP \geq 130 mmHg or DBP \geq 80 mmHg [26]). To investigate whether the BP differs between sub-groups defined by levels of OPA, exposure to heavy occupational lifting, LTPA, and use of anti-hypertensives, mean levels of BP across these sub-groups were compared in a generalized linear model adjusted for sex, age, BMI, smoking, mental stress, and school education. Additionally, the odds for being classified as hypertensive, or becoming a SBP case, were investigated in sub-groups defined by the level of LTPA, by use of maximum likelihood and logistic regression, adjusted for sex, age, BMI, smoking, mental stress, school education, and with no exposure for heavy occupational lifting as reference.

Results

From the ongoing follow-up data collection, we had access to responses from 17,216 study participants. Based on the inclusion criteria, the final population for the cross-sectional analysis included 67,363 study participants and 75,890 observations, and the prospective analysis included 7,020 observations and study participants (figure 1).

Descriptive information of the included population

Descriptive information on the included observations is presented in table 1. The included observations in the cross-sectional analysis differed from the excluded observations by being 17.7 years younger (included 51.9, excluded 69.6), having an 11.8 mmHg lower SBP (included 133.2, excluded 145.0), 19 percentage points (pp) fewer study participants using anti-hypertensives (included 12%, excluded 33%), 9 pp more are exposed to occupational heavy lifting (included 33%, excluded 24%), 9 pp more are feeling stressed (included 27%, excluding 18%), and having 1.5 years more school education (included 11.3, excluded 9.8). In the prospective analysis, the included observations differed from the excluded observations by being 9.2 years younger (included 49.2, excluding 58.4), having a 26.0 mmHg lower SBP (included 122.2, excluding 148.2), 23 percentage points (pp) fewer study participants using anti-hypertensives (included 0%, excluding 23%), 4 pp more are exposed to occupational heavy lifting (included 14%, excluded 10%), 6 pp more are feeling stressed (included 30%, excluding 24%), and having 1.0 years more school education (included 11.2, excluding 10.2).

Some of these differences between included and excluded observations in the cross-sectional analysis might be explained by the inclusion criteria of answering the question regarding exposure to OPA and heavy occupational lifting and being aged < 70 years old at the time of data collection combined with the fact that 80% of the excluded study participants were unemployed or retired. Additionally, some of the differences may be explained by the inclusion criteria of being normotensive at baseline combined with the fact that 52% of the study participants at follow-up were hypertensive and 32% of the excluded study participants were unemployed or retired at baseline.

The adjusted cross-sectional analysis showed that those exposed to heavy occupational lifting had 3% lower odds of hypertension than the non-exposed (table 2). The adjusted prospective analysis showed an 8% higher risk for being a SBP case by exposure to heavy occupational lifting (table 2). Likewise showed the secondary analysis among those exposed to heavy occupational lifting a 2% higher odds of becoming a DBP case (table 2). Linear regressions were performed to investigate the differences in SBP, and secondary DBP, PP, and MAP, between study participants exposed and non-exposed to heavy occupational lifting. No associations were seen in either the cross-sectional analysis or prospective analysis neither in the fully adjusted or crude models (table 3 and table S1, S2, and S3). In the cross-sectional analysis, significant interactions ($p < 0.0001$) were found between heavy occupational lifting and age, and the use of anti-hypertensives, thus stratified analyses were performed. The age-stratified analysis showed insignificant odds for becoming a SBP or DBP case by exposure to heavy occupational lifting, being somewhat higher for the older than the younger study participants (table 2). Yet, the age-stratified linear regression did not show any associations between heavy occupational lifting and

difference in SBP at baseline or delta SBP at follow-up (table 3). The linear regressions stratified by use of anti-hypertensives did not show any associations neither in the cross-sectional nor the prospective analysis, except for a minimally higher pulse pressure (0.54 mmHg, 99% CI 0.13 – 0.94) and MAP (0.49 mmHg, 99% CI 0.12 – 0.86) among study participants not using anti-hypertensives (table 3).

The study participants were stratified by their self-reported level of OPA to test the sensitivity to the choice of the comparison group. The cross-sectional analysis showed exposure to OPA primarily including sitting or standing and some walking to associate to minimally higher SBP compared to predominantly sedentary work. The prospective model showed positive associations between the level of OPA and SBP, pointing towards exposure for heavy occupational lifting to give the greatest rise in SBP compared to the reference group performing predominantly sedentary work (Table S4).

Additionally, the sensitivity to cut-point for the definition of hypertension was tested by the OR for being hypertensive at both lower (SBP \geq 130 mmHg/DBP \geq 80 mmHg) and higher (SBP \geq 160 mmHg/DBP \geq 100 mmHg) cut-points, than those applied in the primary analysis (SBP \geq 140 mmHg/DBP \geq 90 mmHg). Significantly decreased prevalence of hypertension (4% and 3%) by exposure to heavy occupational lifting was seen in the adjusted models for the two highest cut-points (table S5).

The interaction between level of LTPA and heavy occupational lifting was significant and thus logistic and linear regressions stratified by level of LTPA were performed. The logistic regression showed no associations, except a reduced odds for hypertension by exposure to heavy occupational lifting among those performing light physical activity 2-4 hours/week (table S8). The linear regression showed no associations except among those being inactive or performing light physical activity during leisure time where exposure to heavy occupational lifting was associated with a decrease in SBP (-5.92 mmHg, 99% CI -11.59 - -0.25 mmHg) (table S9).

The supplementary analysis of differences in mean baseline BP across groups stratified by level of OPA and LTPA showed that the higher the level of LTPA the lower the SBP (p value <0.05) across all levels of OPA (TableS6). Differences in mean baseline BP across sub-populations stratified by level of OPA, LTPA, and use of anti-hypertensives showed an overall trend (p value ≤ 0.03 , except for those stating their OPA to be “Moderate and strenuous - with occupational lifting” and not using anti-hypertensives) of the higher the level of LTPA the lower mean BP across all levels of OPA, among those not using anti-hypertensives. However, the level of LTPA did not seem to affect BP among users of anti-hypertensives (table S6). The differences in follow-up mean SBP and DBP, stratified by level of OPA and LTPA, showed that the higher the level of LTPA the lower the mean SBP and DBP were among study participants reporting exposure to light OPA (predominantly sitting or standing, including some walking) (p value ≤ 0.03) (Table S7). No differences in SBP and DBP were seen across the remaining OPA and LTPA groups. Differences in mean BP at follow-up, across subpopulations stratified by level of OPA, LTPA, and use of anti-hypertensives, showed no differences in BP, except among study participants reporting to be exposed to light OPA (predominantly sitting or standing, including some walking) and not using anti-hypertensives, where a higher level of LTPA related to a lower mean SBP and DBP across all levels of OPA (p value ≤ 0.03) (table

S7).

Discussion

This study contributes to the knowledge on risk for hypertension from heavy occupational lifting by its aim to verify previous findings [7] and to perform further analysis accounting for the moderating effects of LTPA. Thus, this study explored associations between heavy occupational lifting and hypertension in the Copenhagen General Population Study. The adjusted cross-sectional analysis indicated a 3% lower risk of hypertension by exposure to heavy occupational lifting (table 2), which was supported by the adjusted linear associations between heavy occupational lifting and SBP (mmHg) indicating a negative association (-0.29 mmHg, 99% CI -0.82 – 0.25 mmHg, table 3). These associations could be explained by the cross-sectional design of this analysis, meaning that this result may be owed to either i) exposure to heavy occupational lifting to lower the risk for hypertension or ii) those exposed to heavy occupational lifting being less frequently hypertensive than those not. Within occupational medicine studies, results are assumed to be prone to healthy worker selection bias, implicating less healthy workers migration into occupational groups less exposed to heavy occupational lifting or other strenuous activities [27]. Thus, one could speculate that the acute peaks in BP, while performing lifting tasks [5], may give rise to angina [28], among the workers with poor cardiovascular health. Hence, workers experiencing angina or such would be more likely to migrate into less strenuous occupational groups.

On the contrary, the adjusted prospective analysis indicated an 8% higher risk for being a SBP case by exposure to heavy occupational lifting (table 2), while the linear regressions showed the greatest increase in SBP among those exposed to heavy occupational lifting (table S4). Opposite to the BP effects from resistance training during LTPA [29, 30], these results indicate heavy occupational lifting to have hazardous effects on BP, as previously indicated [7]. The background for increased risk for hypertension by exposure to heavy occupational lifting, may lie within the repeated acute peaks in BP during lifting tasks [5], occurring due to the occlusion of the vessels induced by static muscle activity leading to increases in total peripheral resistance [15]. During heavy occupational lifting, these BP peaks are repeated, both during the 7-9 hour workday, as well as during the 5-day work-week. Thereby the recovery between BP peaks may be insufficient [14, 31], and could give rise to the increased BP both during working hours as well as across the 24h BP [6]. However, this higher risk of being a SBP case by exposure to heavy occupational lifting is not reflected in the linear regressions, showing no associations between heavy occupational lifting and SBP, DBP, PP, and MAP (table 3 and table S1, S2, and S3). Thus, these findings ought to be interpreted with care.

The age-stratified prospective analysis showed exposure to heavy occupational lifting to increase the risk for being a SBP case; 11% higher risk among workers aged ≥ 50 years and 5% higher risk among workers aged < 50 years (table 2), similar to a previous study [7]. Older workers are likely to have been occupationally active throughout a longer time than younger workers, and therefore the effect of the occupational exposures might be more pronounced. Furthermore, a higher strain from heavy

occupational lifting will be expected among older than younger workers, due to the combination of age-related declines in aerobic capacity [13] and arterial compliance [15, 16], giving rise to a greater increase in BP and thus a potentially higher risk of hypertension [6].

The adjusted OR for being hypertensive by exposure to heavy occupational lifting stratified by level of LTPA showed a minimal numerical tendency of increasing risk for hypertension and for being a SBP case, by an increased level of LTPA (Table S8). These OR indicate positive associations between heavy occupational lifting and BP and higher levels of LTPA than seen among those with lower levels of LTPA. However, these rather weak associations do not support the common assumption of a beneficial effect of a decrease in risk of hypertension by increased levels of LTPA, as presented in general physical activity recommendations and previous literature [19, 25, 26, 32]. Thus, it could be assumed that the volume of physical activity by a combination of leisure-time MVPA with heavy occupational lifting, results in overstrain, and cardiovascular damage, rather than optimized cardiovascular health. This notion is supported by previous findings among both veteran athletes [33], and workers having both high OPA and high LTPA [34, 35]. However, the lack of a beneficial effect from LTPA on BP was not reflected in the baseline mean BP, showing higher levels of LTPA to relate to a lower BP, regardless of OPA level (table S6). Nevertheless, the mean BP, at follow-up, did not show any effect by the level of LTPA, independently of the level of OPA, except for those reporting a light level of OPA and not using anti-hypertensives (table S7). Thus, these tendencies of effect from the level of LTPA and OPA on BP, only seen in the cross-sectional analysis, could be explained by the fact that in the prospective analysis, the stratification on level of LTPA and OPA are made at baseline values, and thus the effect from the level of LTPA and OPA at baseline seems to have vanished in the 10-year follow-up BP. Conclusively, as causal effects cannot be drawn from the cross-sectional analysis, these presented results do not indicate the level of LTPA to affect BP across OPA strata.

The analysis stratified by the use of anti-hypertensives did not show results indicating users of anti-hypertensives to be especially vulnerable to rises in BP when exposed to heavy occupational lifting, as previously shown [7]. Yet, users of anti-hypertensives did not seem to have beneficial lowering effects on BP by increasing the level of LTPA, in the cross-sectional analysis (table S6). Previously, greater or similar beneficial effects on BP from LTPA have been seen among hypertensives compared to normotensives [19, 36]. However, these previous studies did not take OPA or heavy occupational lifting into consideration. Thus, future investigations on the effects of LTPA on BP among working-age adults should account for the level of OPA. Hence, to develop recommendations for the prevention of hypertension more knowledge is needed, especially targeted to vulnerable groups of older workers. Also, further investigations are needed to uncover the potential for prevention of progression of hypertension among users of anti-hypertensives, as the level of LTPA does not seem to have the assumed BP-lowering effect [19, 36].

Methodological considerations

The population included in the cross-sectional analysis were younger, less hypertensive, better educated, and more frequently exposed to heavy occupational lifting than those excluded from the analysis. For the prospective analysis, the differences between those in- and excluded from analysis were similar to the cross-sectional analysis. Besides the inclusion criteria of answering the question regarding exposure to OPA and heavy occupational lifting and being aged < 70 years at baseline, these differences may be explained by the frequency of excluded study participants being retired or unemployed (80% in the cross-sectional data and 32% in the prospective data). Moreover, the inclusion criteria for the prospective analysis of being normotensive excluded 52% of the study participants at follow-up. Taken together, these differences between in- and excluded study participants indicate that the population analyzed was overall healthier, but also more frequently exposed to heavy occupational lifting, and thus the results may reflect associations being more conservative than if based on the entire sample of study participants. Also, as the complete follow-up sample is currently being collected, these associations should be repeated for verification in the complete sample.

A limitation of the study is the self-reported exposure measure of occupational lifting, as self-reports of ergonomic work exposures have been found imprecise and at risk of recall [37, 38], and social desirability bias, compared to exposures collected by worn devices as accelerometers [39]. The self-reported exposure to occupational lifting is therefore inadequate for a more detailed description of the frequency and duration of lifting tasks and weight of the lifted burden. Due to the dichotomized response category of the exposure to heavy occupational lifting question (yes/no) the responses might be biased of the individual worker's perception of what heavy occupational lifting are, as no categories of the weight of the lifted burdens are given as an example. Thus, the evaluated exposure to heavy occupational lifting is a quite crude indication of exposure to occupational lifting or not, and a further investigation by use of more detailed and accurate measures of exposure to occupational lifting is warranted. Another limitation is the single measurement of a casual BP, shown to have a lower prognostic value than ambulatory BP, or BP monitored during sleep [40, 41].

The main strengths of this study include the limited risk of false-negative classification of hypertension due to the determination of hypertension based on both use of anti-hypertensives and the casual BP, in mmHg, and the high number of randomly selected study participants in the study population.

Perspectives of the proposed findings

The Eurofound survey states that 33% of the European workforce is exposed to occupational lifting (6th survey in Eurofound). Knowledge of the impact on cardiovascular health from occupational lifting is sparse, and to be able to develop preventive initiatives and clinical guidelines, investigations of the effect of heavy occupational lifting on precursors of cardiovascular disease should be encouraged. In this paper, the associations indicated workers aged ≥ 50 years to have an increased risk for hypertension (OR 1.11, 99% CI 0.95 – 1.29), when exposed to heavy occupational lifting. Thus this group holds the potential for prevention of hypertension by minimizing exposure to heavy occupational lifting, e.g. by automatization of manual work tasks or use of assistive devices.

Furthermore, future preventive initiatives and clinical guidelines should strive to modify the exposure to heavy occupational lifting, as well as stay informed on the growing knowledge of the effects on BP from the combined LTPA and OPA levels to avoid the risk of cardiovascular overstrain. However, for this development, it is essential to keep in mind the lower effect of LTPA on BP among users of anti-hypertensives. Thus, to develop preventive initiatives and clinical guidelines for heavy occupational lifting in relation to risk for hypertension more knowledge is needed.

Conclusion

No clear associations between heavy occupational lifting and BP nor hypertension were found in the cross-sectional analysis. The prospective analysis shows a trend of exposure to heavy occupational lifting to increase the risk of hypertension, especially among workers aged ≥ 50 years or reporting light to moderate levels of LTPA.

List Of Abbreviations

OPA – occupational physical activity

LTPA – Leisure-time physical activity

BMI – Body mass index

BP – Blood pressure

SBP – Systolic blood pressure

DBP – Diastolic blood pressure

pp – percentage points

GEE – generalized estimation equation

OR – Odds ratio

CI – Confidence interval

MVPA – Moderate to vigorous physical activity

Declarations

[Ethics approval and consent to participate](#)

The data are collected after signed informed consent by the study participants following the Helsinki declaration.

Consent to publish

All of the authors have read and approved the submission of the manuscript.

Availability of data and materials

Requests of data and other materials should be by correspondence to Mette Korshøj, Ph.D., Senior Researcher, Department of Occupational- and Social Medicine, Holbæk Hospital, Gl. Ringstedvej 4B, 4300 Holbæk, Denmark, email melars@regionsjaelland.dk.

Competing interests

The authors state to have no conflicts to declare.

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Author contributions

MK, AH, and HH conceived the initial idea for the study. MK, AH, HH, and EC drafted the protocol for analysis and raised funding for the performance of the study. MK analyzed the data and drafted the paper. RFS, JLM, and PS participated in the building of the cohort, RFS was managing the data and JLM supervised the statistical analysis. All authors discussed the protocol for analysis and the interpretation of the results, as well as commented on the manuscript.

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Authors' Information

Not applicable.

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Tables

Table 1. Baseline characteristics of the included 75,890 observations in the cross-sectional analysis and the 7,020 study participants in the prospective analysis.

	Cross-sectional analysis			Prospective analysis				
	Mean	SD	n (%)	Range	Mean	SD	n (%)	Range
Age (years)	51.9	9.5		20.1 - 69.9	49.2	8.4		20.6 - 69.8
Sex (%female)			41,843 (55.1)				4,550 (64.8)	
BMI (kg/m ²)	25.9	4.3		14.3 - 91.8	24.5	3.4		15.4 - 46.9
Smoking (%current smokers)			12,666 (16.7)				1,366 (19.5)	
Systolic blood pressure (mmHg)	133.2	19.5		70.0 - 240.0	122.2	10.0		71.0 - 139.0
Diastolic blood pressure (mmHg)	79.4	11.5		22.0 - 190.0	75.9	7.4		30.0 - 89.0
Blood pressure $\geq 90/ \geq 140$ mmHg			29,261 (38.6)				-	
Using anti-hypertensives			8,961 (11.8)				-	
Being hypertensive (using anti-hypertensives and/or SBP ≥ 140 mmHg or DBP ≥ 90 mmHg at baseline examination)			32,503 (42.8)				-	
Being hypertensive (using anti-hypertensives and/or SBP ≥ 130 mmHg or DBP ≥ 80 mmHg at baseline examination)			50,967 (67.2)				3,801 (54.1)	
Being hypertensive			16,137 (21.3)				-	

(using anti-hypertensives and/or SBP \geq 160 mmHg or DBP \geq 100 mmHg at baseline examination)

School education (years)	11.3	1.7	0.0 - 14.0	11.2	1.6	1.0 - 14.0
Occupational physical activity						
Predominantly sedentary		33,397 (44.0)				2,884 (41.1)
Sitting or standing, some walking		24,877 (32.8)				2,284 (32.5)
Walking, some handling of material		14,961 (19.7)				1,635 (23.3)
Heavy manual work		2,655 (3.5)				217 (3.1)
Occupational heavy lifting (%yes)		9,652 (33.0)				990 (14.1)
Leisure-time physical activity						
Inactive/light physical active < 2 hours/week		4,836 (6.4)				401 (5.7)
Light physical active 2-4 hours/week		30,531 (40.2)				2,936 (41.8)
Light physical active > 4 hours/week OR MVPA 2-4 hours/week		34,537 (45.5)				3,244 (46.2)
MVPA > 4 hours/week		5,701 (7.5)				416 (5.9)
Mental stress (%often		20,473(27.1)				2,112

Table 2. Adjusted odds ratios of being hypertensive (in the cross-sectional model) and for becoming a SBP or DBP case, defined as an above-median delta value of BP at follow-up - BP at baseline and/or a shift from no use to use of anti-hypertensives (in the prospective model) as a function of self-rated exposure to heavy occupational lifting, with and without stratification on age at baseline (\geq vs. $<$ 50 years) and level of leisure-time physical activity. No exposure to heavy occupational lifting was the reference category. [OR=Odds ratio; CI=Confidence interval]. Significant OR are highlighted in bold.

	Occupational lifting	Cross-sectional model			Prospective model				
		n	OR'	99% CI	Systolic blood pressure case			Diastolic blood pressure case	
					n	OR	99% CI	OR	99% CI
All*	Yes	9,591	0.97	0.93 - 1.00	990	1.08	0.98 - 1.19	1.02	0.93 - 1.12
	No	65,596	1.00	-	6,030	1.00	-	1.00	-
Age < 50 years*	Yes	4,048	0.96	0.91 - 1.02	566	1.05	0.93 - 1.19	1.01	0.89 - 1.14
	No	26,391	1.00	-	3,251	1.00	-	1.00	-
Age \geq 50 years*	Yes	5,540	0.97	0.93 - 1.01	424	1.11	0.95 - 1.29	1.04	0.90 - 1.21
	No	39,184	1.00	-	2,777	1.00	-	1.00	-

* adjusted for sex, age, BMI, smoking, LTPA, mental stress, and school education, and additionally SBP at baseline in the prospective analysis.

Table 3. Adjusted linear regressions on systolic blood pressure (SBP) as a function of heavy occupational lifting without and with stratification by age, level of leisure-time physical activity, and use of anti-hypertensives. Significant associations are highlighted in bold.

	Occupational lifting	Cross-sectional model Difference in systolic blood pressure			Prospective model Difference in delta systolic blood pressure		
		n	B* (mmHg)	99% CI	n	B* (mmHg)	99% CI
All*	Yes	9,591	-0.29	-0.82 - 0.25	990	1.02	-0.41 - 2.45
	No	65,596	0.00	-	6,030	0.00	-
Age < 50 years*	Yes	4,048	-0.12	-0.86 - 0.62	566	1.40	-0.47 - 3.26
	No	26,391	0.00	-	3,251	0.00	-
Age ≥ 50 years*	Yes	5,540	-0.23	-0.98 - 0.52	424	0.45	-1.75 - 2.66
	No	39,184	0.00	-	2,777	0.00	-
NOT using anti-hypertensives*	Yes	8,442	-0.21	-0.77 - 0.35	930	1.20	-0.27 - 2.67
	No	57,826	0.00	-	5,769	0.00	-
USING anti-hypertensives*	Yes	1,149	-0.55	-2.17 - 1.06	60	-2.01	-7.77 - 3.75
	No	7,770	0.00	-	261	0.00	-

* adjusted for sex, age, BMI, smoking, LTPA, mental stress, and school education, and additionally SBP at baseline in the prospective analysis.

Figures

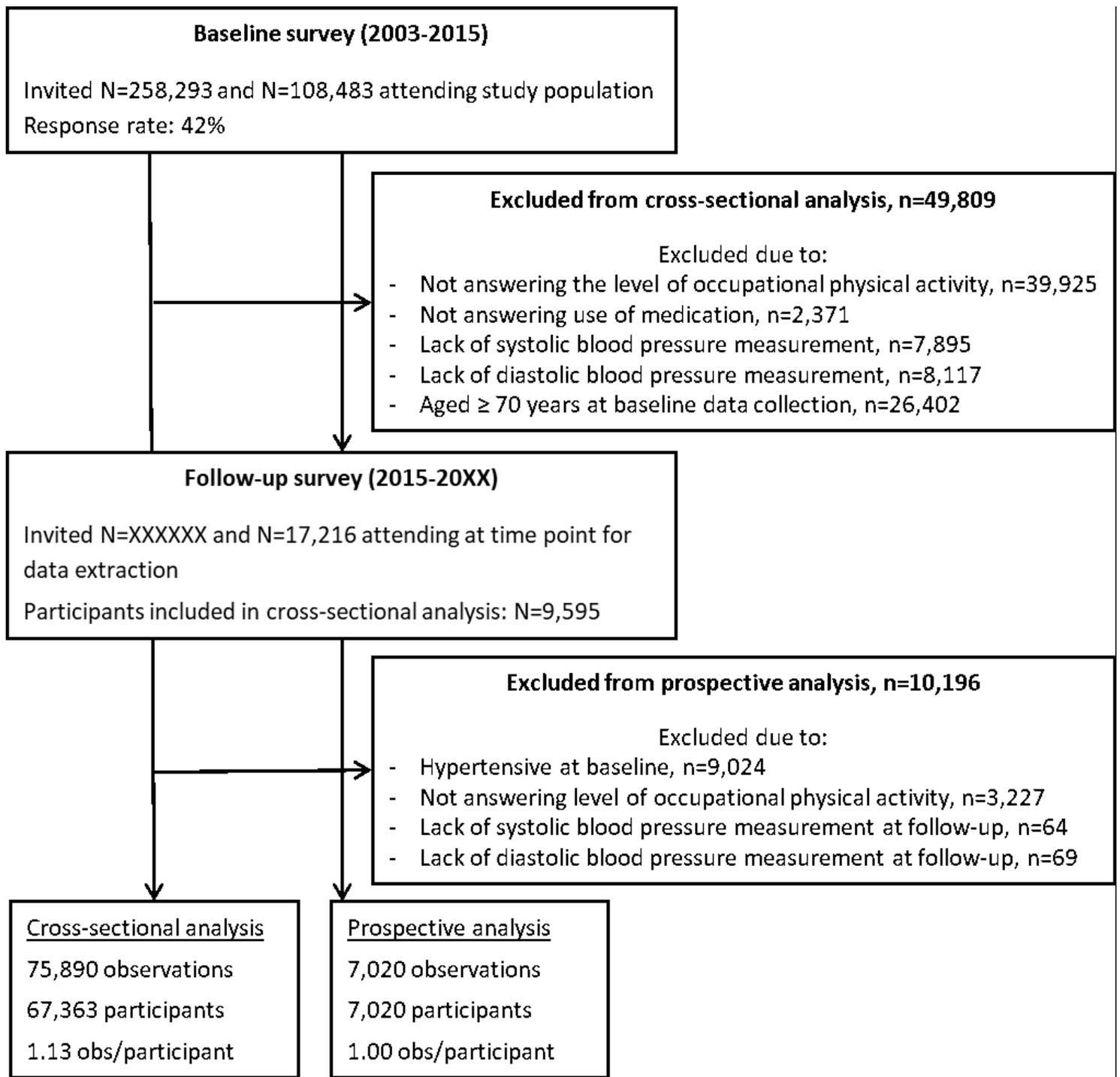


Figure 1

The flow of the observations and study participants in the examination of the Copenhagen General Population Study.

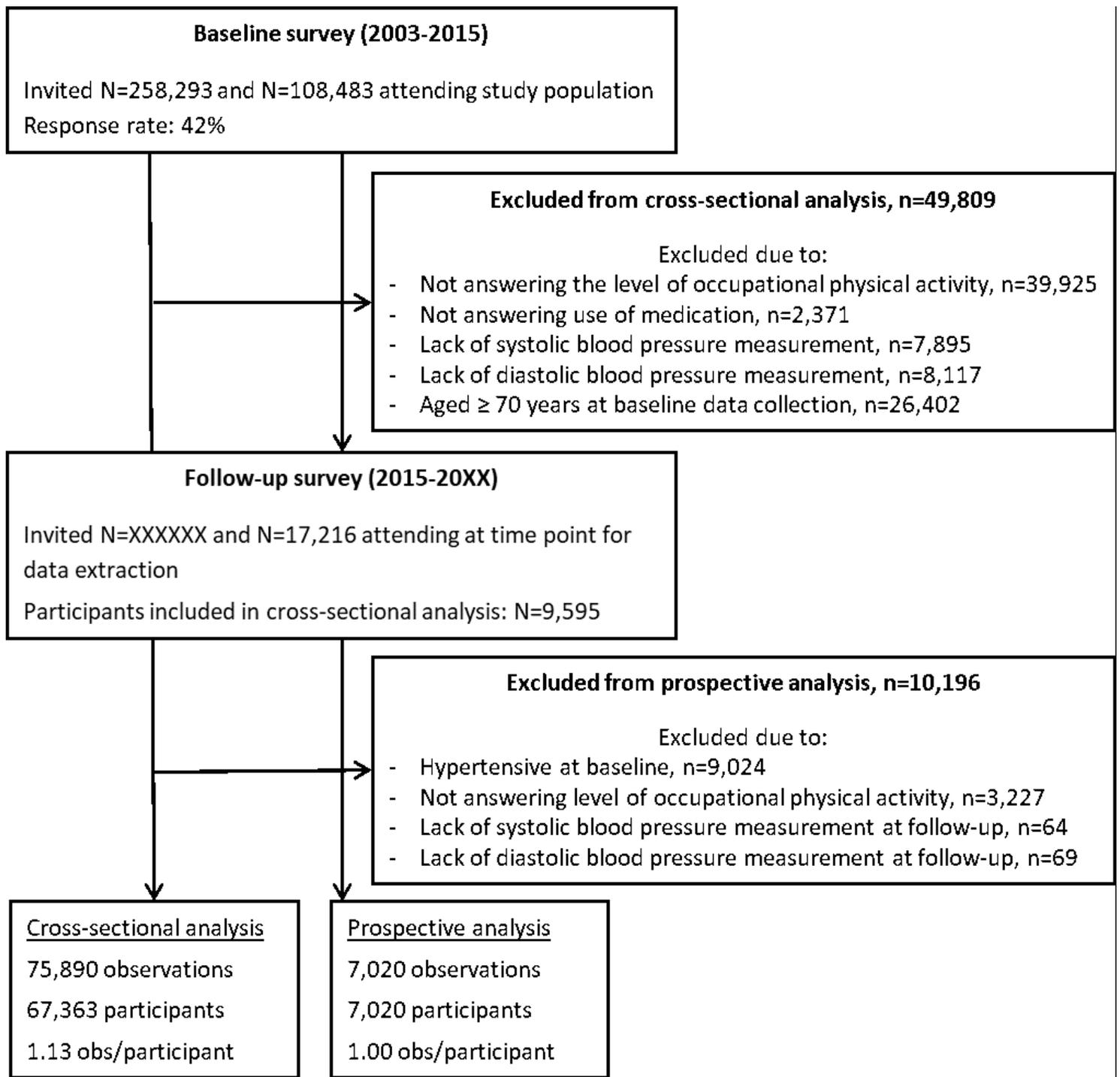


Figure 1

The flow of the observations and study participants in the examination of the Copenhagen General Population Study.

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