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Baggage handler seniority and musculoskeletal complaints - is heavy lifting in awkward positions associated with the risk of pain?

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Title page

Baggage handler seniority and musculoskeletal complaints -Is heavy lifting in awkward positions associated with the risk of pain?

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ABSTRACT

Objectives: Heavy lifting is associated with musculoskeletal disorders but it is unclear whether it is related to acute reversible effects or to chronic effects from cumulated exposure. The aim of this study was to examine if musculoskeletal complaints in Danish airport baggage handlers were associated with their seniority as baggage handler, indicating chronic effects from cumulated work load.

Methods: We established a cohort of baggage handlers employed at Copenhagen Airport during the period 1983-2012 (n=3,092) and a reference cohort of men in other unskilled occupations with less heavy work (n=2,478). Data regarding work history, lifestyle and musculoskeletal complaints were collected using a self-administered questionnaire (response rate 70.1% among baggage handlers and 68.8% among the reference group).

Results: The odds ratios of self-reported musculoskeletal complaints during the last 12 months in the neck/upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in the reference group. These differences were explained by significant linear effects of baggage handler seniority for six anatomical regions. Adjustment for age, BMI, smoking and leisure-time physical activity did not change these results. The findings were stable over age strata and among present and former baggage handlers.

Conclusion: The risk of musculoskeletal complaints in six anatomical regions increased with increasing seniority as a baggage handler. This is consistent with the assumption that cumulated heavy lifting may cause chronic or long lasting musculoskeletal complaints. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations.

Strengths and limitations of this study:

- This study includes a the large number of baggage handlers with a large variation in seniority
- We found a high degree of comparability in characteristics of the study- and reference group
- A reference group of working men reduces the risk of healthy worker effect bias in this study
- Information on both exposure and outcome is based on self-reports
- The interpretation of results might be challenged by age which is strongly associated with both seniority and musculoskeletal complaints

INTRODUCTION

The relation between occupational lifting and musculoskeletal complaints has been examined in several studies with different designs and in different occupational groups. Heavy lifting and lifting in twisted and stooped positions have been found to be risk factors for developing musculoskeletal disorders in the lower back region,[1-9] shoulders,[10-12] hips[13, 14] and knees.[13, 15-19] However, the degree to which these associations are related to acute reversible effects or to chronic effects from cumulated exposure is not clear, and data on exposure-response associations are sparse. Causal inferences, therefore, remain uncertain.[8, 9, 20]

If cumulated heavy lifting in awkward positions causes chronic musculoskeletal complaints one would expect that seniority in occupations with the same daily exposures over years could serve as a simple proxy measure of cumulated exposure. Baggage handling is characterized by repetitions of the same relatively few work tasks throughout the whole working day. These work tasks are primarily characterized by heavy lifting in awkward positions.[21] In particular, loading and unloading luggage in compartments of narrow bodied aircrafts are performed in stooped, squatting, sitting or kneeling positions in constrained spaces[21, 22]. On average a baggage handler at Copenhagen Airport lifts 4-5 tonnes during a normal work shift. The average weight of each lift is around 15 kg and most of the lifts are performed in awkward positions. The amount of goods lifted by the individual baggage handler has been rather constant over many years. [Brauer et al. unpublished]

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A few epidemiological studies have examined the association between heavy lifting and musculoskeletal complaints among baggage handlers.[22-24] Stålhammar et al. used a questionnaire to measure occurrence of shoulder, knee and back pain in baggage handlers and found that more than half of the study population reported pain in the shoulders, knees and lower back, even though the population consisted of young men only (mean age 27 years) of whom 59% had a seniority of less than five years.[22] Additionally, Undeutsch et al. investigated transport workers in a German airport and found that 66% reported complaints in the lower back, 33% in the neck and 41% in the arms. Furthermore, they found an association between baggage handler seniority and occurrence of back symptoms.[23, 24] These previous studies were based on limited sample sizes of 78 and 366 baggage handlers, respectively, and no reference group was included in these studies.

The aim of the present study was to examine if baggage handlers have an increased risk of musculoskeletal complaints compared to a reference group of men in other unskilled occupations with less heavy work, and if seniority as a baggage handler is associated with musculoskeletal complaints.

MATERIAL AND METHODS

Study population

Using the electronic employee registers of the two leading handling companies at Copenhagen Airport and the electronic member directory from the local labour union that organizes the airport baggage handlers, we identified a group of 4,527 persons with occupational codes that indicated work as a baggage handler anytime between 1983 and 2012. We further used the electronic member directory of unskilled workers in the Greater Copenhagen area, the electronic member directory of the Union of Security Workers and the Copenhagen Airport electronic employee register of security personal in the airport to establish a similarly selected reference group consisting of 3,927 randomly selected men in unskilled occupations with less heavy work, e.g. cleaning, security and catering.

Data collection

A questionnaire was delivered to baggage handlers and persons in the reference group who met the following criteria: They were alive in 2012; had permanent residence in Denmark; had an age between 25 and 75 years; and had not previously requested not to participate in research projects (an option in Danish civil registration). These criteria were met by 3,092 baggage handlers and 2,469 in the reference group. The group of baggage handlers consisted of 1,140 currently employed and 1,952 formerly employed at Copenhagen Airport. The currently employed baggage handlers were asked to fill in the questionnaire at the airport during their working time, while the formerly employed baggage handlers and all individuals in the reference group received the questionnaire by mail. The participants who did not answer the questionnaire within 3 weeks received a phone call and were invited to answer the questionnaire by phone. In total 2,179 baggage handlers (response rate 70.1%) and 1,710 in the reference group (response rate 68.8%) answered the questionnaire.

Measurements of exposure and outcome

In the questionnaire the participants were asked about their height, weight, date of birth, musculoskeletal complaints in eight different anatomical regions and lifestyle determinants, such as physical leisure activity and smoking. The questions were all validated questions used in original or slightly modified versions.

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Additionally, the baggage handlers were asked supplementary questions about their work as a baggage handler.

In order to validate the information on occupation, participants identified as baggage handlers in the registers and member directory were asked if they had ever worked as a baggage handler. Only participants who answered in the affirmative were included as baggage handlers in the subsequent analyses, whereas participant who stated that they had never worked as baggage handlers were transferred to the reference group. In total, 352 individuals (16.2%) were transferred from the study to the reference group, so that we in the analyses ended up with 1,827 baggage handlers and 2,062 in the reference group.

Information on baggage handler seniority was measured by the question: *For how many years, all together, have you worked as a baggage handler?*

Musculoskeletal complaints were recorded for eight anatomical regions: neck and upper back, lower back, shoulders, elbows, wrists, hips, knees and ankles, and were measured by the question: *How much have you been bothered by pain or discomfort in the following body regions during the last 12 months*? This was followed by a list of the eight anatomical regions with response categories: *not at all, a little/somewhat*, *quite a lot*, and *very much*. In the analyses the degree of pain was dichotomized into the categories: *no complaints* which consisted of the categories *not at all* and *a little/somewhat* and *complaints* which consisted of the categories *quite a lot* and *very much*.

As potential confounders we included age as a continuous variable. Smoking (*never*, *former smoker*, *yes*), leisure-time physical activity (*<2 hours/week*, *2-4 hours/week*, *>4 hours/week*) and body mass index (BMI) *(<18.5*, *18.5 - <25*, *25 - <30*, *≥30*) were included as categorical variables.

Statistical analyses

Associations between baggage handler seniority and musculoskeletal complaints were analyzed using three different models. In model 1 we tested differences in regional musculoskeletal complaints between baggage handlers and the reference group only adjusted for age. In model 2 we further included baggage handler seniority, first as a categorical variable divided into quartiles (the highest quartile covered a large range of seniority and was therefore subdivided into two) (model 2.1), and then as a continuous variable with the reference group coded with 0 years of baggage handler seniority (model 2.2). We used the likelihood ratio test to estimate if seniority could be fitted as a linear effect. In all models including seniority as a continuous variable we also included the binary group variable, coded '0' for the reference group and '1' for baggage handlers. By this coding, the effect of the seniority variable only refers to baggage handler seniority, and inflation or deflation of effect estimates owing to group differences are avoided. In the final model (model 3) we further included the potential confounders mentioned above. Supplementary analyses were made by adding general health (categories: excellent or very good, good, fair or poor) to the final model (model 4). The data were analyzed using logistic regression, SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Results are presented as odds ratios (OR) with 95%-confidence intervals (95% CI).

RESULTS

Table 1 shows the characteristics of the participants. The age distribution was slightly skewed towards a larger part of older participants in the reference group compared to baggage handlers. The average

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seniority for the baggage handlers was 11 years; 2.4% had a seniority of less than one year and 24.4 % had a seniority of more than 16 years. Pearson's correlation coefficient between age and baggage handler seniority was 0.56.

Tabel 1: Paricipant characteristics and description of variables.
Values are numbers (percentages) unless stated otherwise.

	Baggage handlers	Reference group
Number of respondents	1827 (47.0)	2059 (53.0)
Age (years)		
25-34	244 (13.6)	227 (11.3)
35-44	587 (32.7)	554 (27.5)
45-54	644 (35.9)	679 (33.7)
55-64	236 (13.2)	377 (18.7)
65-75	82 (4.6)	176 (8.8)
Seniority (years)		
0	0 (0.0)	2059 (100.0)
> 0-3	499 (28.1)	0 (0.0)
4-8	404 (22.7)	0 (0.0)
9-16	442 (24.9)	0 (0.0)
17-25	266 (15.0)	0 (0.0)
≥ 26	167 (9.4)	0 (0.0)
Complaints		
Lower back	553 (32.6)	450 (23.4)
Neck/upper back	353 (21.8)	335 (17.8)
Shoulders	419 (25.4)	305 (16.3)
Elbows	174 (11.2)	123 (6.8)
Wrists	185 (11.8)	131 (7.2)
Hips	116 (7.6)	111 (6.1)
Knees	408 (24.3)	325 (17.2)
Ankles	127 (8.1)	146 (8.0)
Height (cm) (mean)	181.2	180.5
Weight (kg) (mean)	87.4	87.5
BMI		
Underweight	31 (1.7)	66 (3.2)
Normal weight	644 (35.3)	684 (33.2)
Overweight	958 (52.4)	1046 (50.8)
Obese	194 (10.6)	262 (12.7)
General health		
Excellent/very good	692 (38.3)	897 (44.0)
Good	725 (40.1)	834 (40.9)
Fair/poor	394 (21.6)	307 (15.1)
Smoking		
No	721 (39.8)	704 (34.4)
Former	590 (32.6)	724 (35.3)
Yes	501 (27.6)	621 (30.3)
Physical leisure activity		
< 2 hours/week	179 (9.9)	721 (39.8)
2-4 hours/week	618 (34.2)	590 (32.6)
> 4 hours week	1008 (55.8)	501 (27.7)

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The degree of musculoskeletal complaints were higher for the baggage handlers than for the reference group within all anatomical regions, except for the ankles, and the lower back was the site of most pain in both groups. Furthermore, the height, weight and smoking were similar in the two groups, whereas the baggage handlers reported a poorer general health and a higher level of physical leisure activity than the reference group.

Table 2 shows the results of the logistic regression analyses. We found a significantly higher odds ratio of musculoskeletal complaints in the group of baggage handlers compared with the reference group for all anatomical regions, except for the ankles (model 1). The odds of musculoskeletal complaints increased systematically with higher categories of baggage handler seniority in six of the anatomical regions: the lower back, neck and upper back, shoulders, elbows, wrists and knees (model 2.1).

The likelihood ratio test showed that the effect of baggage handler seniority could be fitted as a linear effect for all regions except for the hips, and hence baggage handler seniority was included continuously in the final model (model 3). When baggage handler seniority was included continuously in the model (model 2.2), the effect of baggage handler (yes/no) diminished and became insignificant for all regions, except for the shoulders (OR 1.37, 95% CI: 1.08 to 1.72) while the linear effect of baggage handler seniority was statistically significant in all of the anatomical regions. Thus, the higher prevalence of musculoskeletal complaints among the baggage handlers was to a large extent explained by seniority as a baggage handler.

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Tabel 2: Odds Ratio (95% CI) for musculoskeletal complaints within the last 12 months according to occupation and baggage handler seniority for baggage handlers and a reference group with less heavy work

			Lower back OR (CI 95%)	Neck/Upper back OR (CI 95%)	Shoulders OR (CI 95%)	Elbows OR (CI 95%)	Wrists OR (CI 95%)	Hips OR (CI 95%)	Knees OR (CI 95%)	Ankles OR (CI 95%)
Model 1	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		**1.64 (1.42-1.91)**	**1.34 (1.13-1.59)**	**1.82 (1.54-2.15)**	**1.84 (1.44-2.36)**	**1.82 (1.43-2.31)**	**1.45 (1.10-1.92)**	**1.68 (1.42-1.99)**	1.14 (0.89-1.47)
Model 2.1	**Seniority (years)**	n								
	0 (reference)	2059	1	1	1	1	1	1	1	1
	>0-3	499	1.09 (0.85-1.38)	0.97 (0.73-1.28)	1.21 (0.92-1.60)	0.82 (0.50-1.28)	1.26 (0.84-1.85)	1.19 (0.71-1.90)	1.20 (0.91-1.58)	0.75 (0.45-1.19)
	4-8	404	1.25 (0.96-1.61)	1.15 (0.85-1.53)	**1.57 (1.18-2.06)**	1.50 (0.98-2.23)	1.46 (0.96-2.16)	1.49 (0.90-2.37)	**1.48 (1.11-1.96)**	1.12 (0.70-1.73)
	9-16	442	**1.91 (1.52-2.39)**	**1.45 (1.11-1.88)**	**2.27 (1.77-2.91)**	**2.19 (1.53-3.09)**	**1.94 (1.35-2.74)**	0.94 (0.55-1.52)	**1.98 (1.54-2.54)**	1.06 (0.68-1.58)
	17-25	266	**2.41 (1.82-3.18)**	**1.70 (1.24-2.32)**	**2.31 (1.70-3.12)**	**3.08 (2.07-4.52)**	**2.33 (1.54-3.46)**	1.49 (0.90-2.38)	**1.81 (1.33-2.44)**	1.40 (0.88-2.16)
	>26	167	**3.02 (2.12-4.30)**	**2.26 (1.53-3.30)**	**2.31 (1.57-3.37)**	**2.93 (1.74-4.76)**	**3.15 (1.93-5.01)**	**2.78 (1.66-4.53)**	**2.83 (1.97-4.06)**	**1.76 (1.05-2.86)**
Model 2.2	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		1.10 (0.89-1.35)	0.97 (0.76-1.22)	**1.37 (1.08-1.72)**	1.06 (0.75-1.50)	1.22 (0.87-1.70)	1.03 (0.68-1.55)	1.24 (0.98-1.57)	0.81 (0.55-1.17)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1	1	1	1
	Baggage handler		**1.42 (1.26-1.61)**	**1.32 (1.16-1.52)**	**1.27 (1.12-1.45)**	**1.55 (1.29-1.85)**	**1.38 (1.16-1.64)**	**1.27 (1.03-1.56)**	**1.30 (1.14-1.48)**	**1.30 (1.07-1.57)**
Model 3	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.16 (0.94-1.44)	1.02 (0.80-1.30)	**1.40 (1.10-1.77)**	1.10 (0.77-1.56)	1.31 (0.93-1.83)		**1.35 (1.06-1.71)**	0.92 (0.62-1.34)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handler		**1.38 (1.22-1.56)**	**1.30 (1.14-1.50)**	**1.27 (1.11-1.45)**	**1.53 (1.28-1.83)**	**1.33 (1.11-1.60)**		**1.26 (1.01-1.44)**	1.21 (0.99-1.49)
	Age (per 10 years)		1.06 (0.98-1.15)	1.01 (0.92-1.11)	1.04 (0.95-1.14)	1.07 (0.93-1.23)	1.07 (0.94-1.21)		**1.17 (1.07-1.28)**	**1.36 (1.19-1.56)**
	Smoking									
	No		1	**1**	**1**	**1**	**1**		**1**	**1**
	Former smoker		1.02 (0.85-1.23)	1.16 (0.94-1.43)	**1.37 (1.11-1.69)**	1.01 (0.74-1.36)	**1.35 (1.01-1.82)**		**1.41 (1.15-1.74)**	**1.47 (1.06-2.06)**
	Yes		**1.28 (1.05-1.55)**	1.20 (0.96-1.49)	**1.53 (1.23-1.90)**	**1.29 (0.95-1.76)**	1.30 (0.96-1.77)		1.21 (0.97-1.51)	**1.76 (1.26-2.49)**
	Physical activity									
	<2 hours/week		**1**	**1**	**1**	**1**	**1**		**1**	**1**
	2-4 hours/week		0.94 (0.74-1.21)	**0.70 (0.54-0.91)**	0.89 (0.68-1.18)	1.00 (0.67-1.50)	0.96 (0.66-1.40)		**0.73 (0.57-0.95)**	0.76 (0.53-1.11)
	>4 hours/week		**0.75 (0.59-0.96)**	**0.56 (0.43-0.72)**	0.94 (0.72-1.24)	0.93 (0.63-1.39)	0.74 (0.51-1.09)		**0.52 (0.41-0.68)**	**0.64 (0.44-0.94)**
	BMI									
	Underweight		0.81 (0.41-1.50)	0.94 (0.44-1.85)	0.74 (0.33-1.68)	0.52 (0.12-1.49)	1.73 (0.76-3.56)		0.67 (0.28-1.40)	0.81 (0.24-2.10)
	Normal weight		1	1	1	1	1		1	1
	Obese		1.11 (0.94-1.32)	**1.24 (1.02-1.51)**	**1.36 (1.12-1.65)**	0.86 (0.65-1.33)	0.79 (0.61-1.04)		**1.25 (1.03-1.52)**	1.06 (0.78-1.44)
	Overweight		**1.64 (1.28-2.10)**	**1.46 (1.10-1.95)**	**1.79 (1.35-2.36)**	**1.28 (0.86-1.88)**	1.40 (0.96-2.01)		**1.99 (1.52-2.61)**	**1.98 (1.34-2.91)**
Model 4	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.11 (0.88-1.40)	0.94 (0.72-1.22)	**1.35 (1.05-1.73)**	1.05 (0.73-1.51)	1.24 (0.87-1.75)		**1.33 (1.03-1.70)**	0.86 (0.58-1.28)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handlers		**1.20 (1.05-1.38)**	1.13 (0.97-1.32)	1.12 (0.97-1.29)	**1.43 (1.18-1.72)**	1.19 (0.98-1.44)		1.13 (0.98-1.30)	1.11 (0.89-1.37)

Model 1: Baggage handler (yes/no) and age
Model 2.1: Baggage handler (Yes/no), baggage handler seniority (categorical) and age
Model 2.2: Baggage handler (yes/no), baggage handler seniority (continuous) and age
Model 3: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity
Model 4: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity, general health

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Model 3 shows that when age, BMI, smoking and physical leisure activity were added in the model, the effect estimates decreased but remained substantial and significant for all of the regions, except for the ankles. For example, for every 10 year of baggage handler seniority the odds of complaints in the lower back increased by 38% (OR 1.38, 95% CI: 1.22 to 1.56), the odds of complaints in the elbows increased by 53% (OR 1.53, 95% CI: 1.28 to 1.83) and the odds of complaints in the wrists increased by 33% (OR 1.33, 95% CI: 1.11 to 1.60). Furthermore, model 3 shows that only complaints in the knees and ankles were significantly affected by age after adjustment for seniority. In general the covariates had the same effect on musculoskeletal complaints as known from former studies: Physical leisure activity decreased the odds of pain whereas smoking[4, 5] and a high BMI[13, 16, 17, 19] increased the odds of pain.

Additional analyses for the hips showed that the risks of complaints in the first four categories of seniority (in model 2.1) were not significantly different and could be combined into one category (0-16 years) without changing the fit of the model significantly (data not shown). This indicates that the risk of hip-complaints did not significantly increase until at least 26 years of baggage handler seniority.

In all of the adjusted analyses we tested whether adjustment for height and weight instead of BMI changed the estimates. Also, we tested for interactions between height and weight. None of these variations changed the estimates substantially. Furthermore, stratified analyses on current versus former baggage handlers, showed that the effects of seniority reported in model 3 remained significant for both groups (data not shown).

Supplementary analyses

As noted in Table 1, self-reported general health of the baggage handlers was poorer than that of the reference group and further analysis revealed that this relation increased with baggage handler seniority. Furthermore, general health was associated with musculoskeletal complaints. We tried to examine if the relation between general health and baggage handler seniority disappeared if we adjusted for number of regions with complaints. In this analysis we further included age and the other covariates in the final model on regional pain and seniority (data not shown). By doing so the relation between general health and seniority still persisted indicating that seniority and thereby cumulated work factors also are related to other health effects than musculoskeletal complaints and that the linear relation between baggage handler seniority and complaints might – to some extent – be explained by general health. In order to assess the maximal potential bias, which could be related to general health, we added general health as a covariate in the final model (model 4). The linear relation between seniority and pain persisted for all regions and was still significant for lower back (OR 1.20, 95% CI: 1.05-1.38) and elbows (OR 1.43, 95% CI: 1.18-1.72), and the lower confidence limit for the other regions was only slightly below unity in most regions.

DISCUSSION

We found that the odds ratios of self-reported musculoskeletal complaints in the neck and upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in a reference group of men in other unskilled occupations with less heavy work. These differences between the groups were to a great extent attributable to length of employment as a baggage handler, indicating

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that the study- and reference groups were basically comparable in relation to reporting of musculoskeletal complaints.

Baggage handler seniority was significantly, positively associated with musculoskeletal complaints in all of the measured anatomical regions, except for the ankles, and a significant, linear relationship was found for the neck and upper back, lower back, shoulders, elbows, wrists and knees. However, the pattern for the hips was irregular and only significantly increased compared to the control group for baggage handlers with more than 26 years of seniority. These results may suggest that cumulated heavy lifting in awkward positions does not only affect the lower back, knees and shoulders, as indicated by previous studies but also other anatomical regions, such as the wrists and elbows. As we do not expect cumulated exposure to be associated with acute reversible musculoskeletal complaints, the implication is that long lasting daily exposures to heavy lifting in awkward positions may cause chronic or longer lasting adverse effects on musculoskeletal health in several body regions. This interpretation is supported by similar relations between seniority and musculoskeletal complaints among presently and previously employed baggage handlers.

Our results are in line with the study of Undeutsch et al. that found an age-adjusted association between seniority as a baggage handler and occurrence of back symptoms.[23] However, the present study is the first to show a linear relationship between baggage handler seniority and self-reported pain in a number of other anatomical regions.

In this study we found a linear association between baggage handler seniority and musculoskeletal complaints in six out of eight anatomical regions, although some of the regions are not normally assumed to be affected by heavy lifting, e.g. the wrists. This lack of regional specificity in the relation between baggage handler seniority and pain may be seen as a weakness in the causal interpretation of our findings. However, heavy lifting in awkward positions implies biomechanical loads on all body parts, and short-term exposure to baggage handling is associated with acute pain in most of the anatomical regions included in our study.[25-28] Thus, if repeated acute pain plays a role in the development of chronic pain, the lack of specificity of the relationship between regional pain and seniority may not be an important issue in the interpretation of our results. Furthermore, it is well known that the reporting of pain in one anatomical region is associated with increased pain reporting from adjacent and contralateral regions, possibly due to pain processing in the central nervous system.[29, 30]

One may also wonder about the linear effect of seniority from even low levels, as it might be expected that effects of cumulated exposure would occur only after a longer period of exposure. The higher odds ratio of pain in baggage handlers with increasing seniority could possibly be explained by the combination of recurrent episodes of acute pain from soft tissue strains and more chronic pain from degenerative changes in the joints and tendons at higher seniority. The contribution by different mechanisms might also differ between regions and could possibly explain the somewhat different findings for the hip region. However, the mechanisms leading to longer lasting or chronic musculoskeletal pain are unknown.

Limitations

It may be a limitation that information on seniority as well as musculoskeletal complaints was based on self-reports, which may involve recall bias and differential misclassification. However, we consider seniority to be factual information with an expected high level of accuracy. If our findings of a linear relationship

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between seniority and musculoskeletal complaints were attributable to misclassification of pain or seniority, baggage handlers should consistently and increasingly overestimate either their pain by increasing seniority or their seniority by increasing levels of pain. We cannot exclude such biases but consider them as unlikely explanations of our results.

Another limitation that may challenge the interpretation of our results is that general health was strongly associated with both seniority and pain. Our supplementary analyses showed that the linear relation between baggage handler seniority and pain could to some extent be explained by general health (Tabel 2, model 4). However, it is important to consider the possible pathways between baggage handler seniority, general health and regional pain. One pathway is that baggage handler seniority reflects cumulated exposure to heavy lifting, causing regional musculoskeletal pain which leads to a feeling of poorer general health. In this case the relation between seniority and musculoskeletal pain should not be adjusted for effects of general health. However an alternative pathway might also exist: The poorer general health that follows with baggage handler seniority could result from other health affecting factors than heavy lifting that cumulates with length of employment, e.g. particulate air pollution or psychosocial work conditions. This could be associated with more unspecific symptom reporting in general, including reporting of diffuse regional pain. If this is the case, the associations between baggage handler seniority and pain could be explained by a poorer general health caused by factors additional to heavy lifting. However, even if we assume the last mentioned pathway to be the dominating – and thereby our supplementary analyses to reflect the true associations – the pattern of associations between seniority and pain persisted for all regions and was still significant for lower back and elbows, while the lower confidence limit for the other regions was only slightly below unity.

Finally, we only measured associations between baggage handler seniority and current musculoskeletal complaints without considering time for onset of the complaints or the way the complaints started. We assume that the complaints are caused by cumulative hard musculoskeletal demands but it could be caused by accidents at work or in leisure time or even have occurred before the employment as a baggage handler.

The strengths of this study are the large number of currently and formerly employed baggage handlers with a large variation in seniority. Furthermore, all the covariates in the analyses had the expected influence on pain which corroborates the validity in data. Additionally, our data showed a high degree of comparability in characteristics of the study and reference group, and the inclusion of a reference group consisting of working men only reduces the influence of healthy worker effect bias.[31-33]

CONCLUSION

We conclude that baggage handlers had a significantly higher risk of musculoskeletal complaints than a reference group with less heavy work. This difference was to a large extent explained by seniority as a baggage handler. Further, we found a strong linear association between regional musculoskeletal complaints and seniority which is consistent with a long lasting or chronic effect of cumulated exposure to heavy lifting. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations. To pursue this issue further, future research should include information on onset and cause of pain, and estimates of individual differences in amount and frequency of heavy lifting.

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Data sharing

Extra data available by emailing sigurd.mikkelsen.regionh.dk

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract No
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found Yes
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Yes
Objectives	3	State specific objectives, including any prespecified hypotheses Yes
Methods		
Study design	4	Present key elements of study design early in the paper yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection yes
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls Yes *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Yes
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 Yes
Bias	9	Describe any efforts to address potential sources of bias Yes
Study size	10	Explain how the study size was arrived at Yes
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding Yes
		(*b*) Describe any methods used to examine subgroups and interactions Yes
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

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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 Yes
		(b) Give reasons for non-participation at each stage Yes
		(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 Yes
		(b) Indicate number of participants with missing data for each variable of interest yes
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures yes
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 yes
		(*b*) Report category boundaries when continuous variables were categorized yes
		(*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 yes
Discussion		
Key results	18	Summarise key results with reference to study objectives yes
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 yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence yes
Generalisability	21	Discuss the generalisability (external validity) of the study results No
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 Yes

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

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 www.strobe-statement.org.

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Baggage handler seniority and musculoskeletal complaints - is heavy lifting in awkward positions associated with the risk of pain?

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Title page

Baggage handler seniority and musculoskeletal complaints -Is heavy lifting in awkward positions associated with the risk of pain?

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ABSTRACT

Objectives: Heavy lifting is associated with musculoskeletal disorders but it is unclear whether it is related to acute reversible effects or to chronic effects from cumulated exposure. The aim of this study was to examine if musculoskeletal complaints in Danish airport baggage handlers were associated with their seniority as baggage handler, indicating chronic effects from cumulated work load.

Methods: We established a group of baggage handlers employed at Copenhagen Airport during the period 1983-2012 (n=3,092) and a reference group of men in other unskilled occupations with less heavy work (n=2,478). Data regarding work history, lifestyle and musculoskeletal complaints were collected using a self-administered questionnaire (response rate 70.1% among baggage handlers and 68.8% among the reference group).

Results: The odds ratios of self-reported musculoskeletal complaints during the last 12 months in the neck/upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in the reference group. These differences were explained by significant linear effects of baggage handler seniority for six anatomical regions. Adjustment for age, BMI, smoking and leisure-time physical activity did not change these results. The findings were stable over age strata and among present and former baggage handlers.

Conclusion: The risk of musculoskeletal complaints in six anatomical regions increased with increasing seniority as a baggage handler. This is consistent with the assumption that cumulated heavy lifting may cause chronic or long lasting musculoskeletal complaints. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations.

Strengths and limitations of this study:

- This study includes a large number of baggage handlers with a large variation in seniority
- We found a high degree of comparability in characteristics of the study- and reference group
- A reference group of working men reduces the risk of healthy worker effect bias in this study
- Information on both exposure and outcome is based on self-reports
- The interpretation of results might be challenged by general health which is strongly associated with both seniority and musculoskeletal complaints

INTRODUCTION

The relation between occupational lifting and musculoskeletal complaints has been examined in several studies with different designs and in different occupational groups. Heavy lifting and lifting in twisted and stooped positions have been found to be risk factors for developing musculoskeletal disorders in the lower back region,[1-9] shoulders,[10-12] hips[13, 14] and knees.[13, 15-19] However, the degree to which these associations are related to acute reversible effects or to chronic effects from cumulated exposure is not clear, and data on exposure-response associations are sparse. Causal inferences, therefore, remain uncertain.[8, 9, 20]

If cumulated heavy lifting in awkward positions causes chronic musculoskeletal complaints one would expect that seniority in occupations with the same daily exposures over years could serve as a simple proxy measure of cumulated exposure. Baggage handling is characterized by repetitions of the same relatively few work tasks throughout the whole working day. These work tasks are primarily characterized by heavy lifting in awkward positions.[21] In particular, loading and unloading luggage in compartments of narrow bodied aircrafts are performed in stooped, squatting, sitting or kneeling positions in constrained spaces[21, 22]. On average a baggage handler at Copenhagen Airport lifts 4-5 tonnes during a normal work shift. The average weight of each lift is around 15 kg and most of the lifts are performed in awkward positions. The amount of goods lifted by the individual baggage handler has been rather constant over many years. [Brauer et al. unpublished]

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A few epidemiological studies have examined the association between heavy lifting and musculoskeletal complaints among baggage handlers.[22-24] Stålhammar et al. used a questionnaire to measure occurrence of shoulder, knee and back pain in baggage handlers and found that more than half of the study population reported pain in the shoulders, knees and lower back, even though the population consisted of young men only (mean age 27 years) of whom 59% had a seniority of less than five years.[22] Additionally, Undeutsch et al. investigated transport workers in a German airport and found that 66% reported complaints in the lower back, 33% in the neck and 41% in the arms. Furthermore, they found an association between baggage handler seniority and occurrence of back symptoms.[23, 24] These previous studies were based on limited sample sizes of 78 and 366 baggage handlers, respectively, and no reference group was included in these studies.

The aim of the present study was to examine if baggage handlers have an increased risk of musculoskeletal complaints compared to a reference group of men in other unskilled occupations with less heavy work, and if seniority as a baggage handler is associated with musculoskeletal complaints.

MATERIAL AND METHODS

Study population

Using the electronic employee registers of the two leading handling companies at Copenhagen Airport and the electronic member directory from the local labour union that organizes the airport baggage handlers, we identified a group of 4,527 persons with occupational codes that indicated work as a baggage handler anytime between 1983 and 2012. We further used the electronic member directory of unskilled workers in the Greater Copenhagen area, the electronic member directory of the Union of Security Workers and the Copenhagen Airport electronic employee register of security personal in the airport to establish a reference group consisting of 3,927 randomly selected men in who within the same period were occupied with other unskilled jobs with less heavy work, e.g. cleaning, security and catering.

Data collection

A questionnaire was delivered to baggage handlers and persons in the reference group who met the following criteria: They were alive in 2012; had permanent residence in Denmark; had an age between 25 and 75 years; and had not previously requested not to participate in research projects (an option in Danish civil registration). These criteria were met by 3,092 baggage handlers and 2,469 in the reference group. The group of baggage handlers consisted of 1,140 currently employed and 1,952 formerly employed at Copenhagen Airport. The currently employed baggage handlers were asked to fill in the questionnaire at the airport during their working time, while the formerly employed baggage handlers and all individuals in the reference group received the questionnaire by mail. The participants who did not answer the questionnaire within 3 weeks received a phone call and were invited to answer the questionnaire by phone. In total 2,179 baggage handlers (response rate 70.1%) and 1,710 in the reference group (response rate 68.8%) answered the questionnaire.

Measurements of exposure and outcome

In the questionnaire the participants were asked about their height, weight, date of birth, musculoskeletal complaints in eight different anatomical regions and lifestyle determinants, such as physical leisure activity and smoking. The questions were all validated questions used in original or slightly modified versions.

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Additionally, the baggage handlers were asked supplementary questions about their work as a baggage handler.

In order to validate the information on occupation, participants identified as baggage handlers in the registers and member directory were asked if they had ever worked as a baggage handler. Only participants who answered in the affirmative were included as baggage handlers in the subsequent analyses, whereas participant who stated that they had never worked as baggage handlers were transferred to the reference group. In total, 352 individuals (16.2%) were transferred from the study to the reference group, so that we in the analyses ended up with 1,827 baggage handlers and 2,062 in the reference group.

Information on baggage handler seniority was measured by the question: *For how many years, all together, have you worked as a baggage handler?*

Musculoskeletal complaints were recorded for eight anatomical regions: neck and upper back, lower back, shoulders, elbows, wrists, hips, knees and ankles, and were measured by the question: *How much have you been bothered by pain or discomfort in the following body regions during the last 12 months*? This was followed by a list of the eight anatomical regions with response categories: *not at all, a little/somewhat*, *quite a lot*, and *very much*. In the analyses the degree of pain was dichotomized into the categories: *no complaints* which consisted of the categories *not at all* and *a little/somewhat* and *complaints* which consisted of the categories *quite a lot* and *very much*.

As potential confounders we included age as a continuous variable. Smoking (*never*, *former smoker*, *yes*), leisure-time physical activity (*<2 hours/week*, *2-4 hours/week*, *>4 hours/week*) and body mass index (BMI) *(<18.5*, *18.5 - <25*, *25 - <30*, *≥30*) were included as categorical variables.

Statistical analyses

Associations between baggage handler seniority and musculoskeletal complaints were analyzed using three different models. In model 1 we tested differences in regional musculoskeletal complaints between baggage handlers and the reference group only adjusted for age. In model 2 we further included baggage handler seniority, first as a categorical variable divided into quartiles (the highest quartile covered a large range of seniority and was therefore subdivided into two) (model 2.1), and then as a continuous variable with the reference group coded with 0 years of baggage handler seniority (model 2.2). We used the likelihood ratio test to estimate if seniority could be fitted as a linear effect. In all models including seniority as a continuous variable we also included the binary group variable, coded '0' for the reference group and '1' for baggage handlers. By this coding, the effect of the seniority variable only refers to baggage handler seniority, and inflation or deflation of effect estimates owing to group differences are avoided. In the final model (model 3) we further included the potential confounders mentioned above. Supplementary analyses were made by adding general health (categories: excellent or very good, good, fair or poor) to the final model (model 4). The data were analyzed using logistic regression, SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Results are presented as odds ratios (OR) with 95%-confidence intervals (95% CI).

RESULTS

Table 1 shows the characteristics of the participants. The age distribution was slightly skewed towards a larger part of older participants in the reference group compared to baggage handlers. The average

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seniority for the baggage handlers was 11 years; 2.4% had a seniority of less than one year and 24.4 % had a seniority of more than 16 years. Pearson's correlation coefficient between age and baggage handler seniority was 0.56.

Tabel 1: Paricipant characteristics and description of variables.
Values are numbers (percentages) unless stated otherwise.

	Baggage handlers	Reference group
Number of respondents	1827 (47.0)	2059 (53.0)
Age (years)		
25-34	244 (13.6)	227 (11.3)
35-44	587 (32.7)	554 (27.5)
45-54	644 (35.9)	679 (33.7)
55-64	236 (13.2)	377 (18.7)
65-75	82 (4.6)	176 (8.8)
Seniority (years)		
0	0 (0.0)	2059 (100.0)
> 0-3	499 (28.1)	0 (0.0)
4-8	404 (22.7)	0 (0.0)
9-16	442 (24.9)	0 (0.0)
17-25	266 (15.0)	0 (0.0)
≥ 26	167 (9.4)	0 (0.0)
Complaints		
Lower back	553 (32.6)	450 (23.4)
Neck/upper back	353 (21.8)	335 (17.8)
Shoulders	419 (25.4)	305 (16.3)
Elbows	174 (11.2)	123 (6.8)
Wrists	185 (11.8)	131 (7.2)
Hips	116 (7.6)	111 (6.1)
Knees	408 (24.3)	325 (17.2)
Ankles	127 (8.1)	146 (8.0)
Height (cm) (mean)	181.2	180.5
Weight (kg) (mean)	87.4	87.5
BMI		
Underweight	31 (1.7)	66 (3.2)
Normal weight	644 (35.3)	684 (33.2)
Overweight	958 (52.4)	1046 (50.8)
Obese	194 (10.6)	262 (12.7)
General health		
Excellent/very good	692 (38.3)	897 (44.0)
Good	725 (40.1)	834 (40.9)
Fair/poor	394 (21.6)	307 (15.1)
Smoking		
No	721 (39.8)	704 (34.4)
Former	590 (32.6)	724 (35.3)
Yes	501 (27.6)	621 (30.3)
Physical leisure activity		
< 2 hours/week	179 (9.9)	721 (39.8)
2-4 hours/week	618 (34.2)	590 (32.6)
> 4 hours week	1008 (55.8)	501 (27.7)

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The degree of musculoskeletal complaints were higher for the baggage handlers than for the reference group within all anatomical regions, except for the ankles, and the lower back was the site of most pain in both groups. Furthermore, the height, weight and smoking were similar in the two groups, whereas the baggage handlers reported a poorer general health and a higher level of physical leisure activity than the reference group.

Table 2 shows the results of the logistic regression analyses. We found a significantly higher odds ratio of musculoskeletal complaints in the group of baggage handlers compared with the reference group for all anatomical regions, except for the ankles (model 1). The odds of musculoskeletal complaints increased systematically with higher categories of baggage handler seniority in six of the anatomical regions: the lower back, neck and upper back, shoulders, elbows, wrists and knees (model 2.1).

The likelihood ratio test showed that the effect of baggage handler seniority could be fitted as a linear effect for all regions except for the hips, and hence baggage handler seniority was included continuously in the final model (model 3). When baggage handler seniority was included continuously in the model (model 2.2), the effect of baggage handler (yes/no) diminished and became insignificant for all regions, except for the shoulders (OR 1.37, 95% CI: 1.08 to 1.72) while the linear effect of baggage handler seniority was statistically significant in all of the anatomical regions. Thus, the higher prevalence of musculoskeletal complaints among the baggage handlers was to a large extent explained by seniority as a baggage handler.

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Tabel 2: Odds Ratio (95% CI) for musculoskeletal complaints within the last 12 months according to occupation and baggage handler seniority for baggage handlers and a reference group with less heavy work

			Lower back OR (CI 95%)	Neck/Upper back OR (CI 95%)	Shoulders OR (CI 95%)	Elbows OR (CI 95%)	Wrists OR (CI 95%)	Hips OR (CI 95%)	Knees OR (CI 95%)	Ankles OR (CI 95%)
Model 1	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		**1.64 (1.42-1.91)**	**1.34 (1.13-1.59)**	**1.82 (1.54-2.15)**	**1.84 (1.44-2.36)**	**1.82 (1.43-2.31)**	**1.45 (1.10-1.92)**	**1.68 (1.42-1.99)**	1.14 (0.89-1.47)
Model 2.1	**Seniority (years)**	n								
	0 (reference)	2059	1	1	1	1	1	1	1	1
	>0-3	499	1.09 (0.85-1.38)	0.97 (0.73-1.28)	1.21 (0.92-1.60)	0.82 (0.50-1.28)	1.26 (0.84-1.85)	1.19 (0.71-1.90)	1.20 (0.91-1.58)	0.75 (0.45-1.19)
	4-8	404	1.25 (0.96-1.61)	1.15 (0.85-1.53)	**1.57 (1.18-2.06)**	1.50 (0.98-2.23)	1.46 (0.96-2.16)	1.49 (0.90-2.37)	**1.48 (1.11-1.96)**	1.12 (0.70-1.73)
	9-16	442	**1.91 (1.52-2.39)**	**1.45 (1.11-1.88)**	**2.27 (1.77-2.91)**	**2.19 (1.53-3.09)**	**1.94 (1.35-2.74)**	0.94 (0.55-1.52)	**1.98 (1.54-2.54)**	1.06 (0.68-1.58)
	17-25	266	**2.41 (1.82-3.18)**	**1.70 (1.24-2.32)**	**2.31 (1.70-3.12)**	**3.08 (2.07-4.52)**	**2.33 (1.54-3.46)**	1.49 (0.90-2.38)	**1.81 (1.33-2.44)**	1.40 (0.88-2.16)
	>26	167	**3.02 (2.12-4.30)**	**2.26 (1.53-3.30)**	**2.31 (1.57-3.37)**	**2.93 (1.74-4.76)**	**3.15 (1.93-5.01)**	**2.78 (1.66-4.53)**	**2.83 (1.97-4.06)**	**1.76 (1.05-2.86)**
Model 2.2	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		1.10 (0.89-1.35)	0.97 (0.76-1.22)	**1.37 (1.08-1.72)**	1.06 (0.75-1.50)	1.22 (0.87-1.70)	1.03 (0.68-1.55)	1.24 (0.98-1.57)	0.81 (0.55-1.17)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1	1	1	1
	Baggage handler		**1.42 (1.26-1.61)**	**1.32 (1.16-1.52)**	**1.27 (1.12-1.45)**	**1.55 (1.29-1.85)**	**1.38 (1.16-1.64)**	**1.27 (1.03-1.56)**	**1.30 (1.14-1.48)**	**1.30 (1.07-1.57)**
Model 3	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.16 (0.94-1.44)	1.02 (0.80-1.30)	**1.40 (1.10-1.77)**	1.10 (0.77-1.56)	1.31 (0.93-1.83)		**1.35 (1.06-1.71)**	0.92 (0.62-1.34)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handler		**1.38 (1.22-1.56)**	**1.30 (1.14-1.50)**	**1.27 (1.11-1.45)**	**1.53 (1.28-1.83)**	**1.33 (1.11-1.60)**		**1.26 (1.01-1.44)**	1.21 (0.99-1.49)
	Age (per 10 years)		1.06 (0.98-1.15)	1.01 (0.92-1.11)	1.04 (0.95-1.14)	1.07 (0.93-1.23)	1.07 (0.94-1.21)		**1.17 (1.07-1.28)**	**1.36 (1.19-1.56)**
	Smoking									
	No		1	**1**	**1**	**1**	**1**		**1**	**1**
	Former smoker		1.02 (0.85-1.23)	1.16 (0.94-1.43)	**1.37 (1.11-1.69)**	1.01 (0.74-1.36)	**1.35 (1.01-1.82)**		**1.41 (1.15-1.74)**	**1.47 (1.06-2.06)**
	Yes		**1.28 (1.05-1.55)**	1.20 (0.96-1.49)	**1.53 (1.23-1.90)**	**1.29 (0.95-1.76)**	1.30 (0.96-1.77)		1.21 (0.97-1.51)	**1.76 (1.26-2.49)**
	Physical activity									
	<2 hours/week		**1**	**1**	**1**	**1**	**1**		**1**	**1**
	2-4 hours/week		0.94 (0.74-1.21)	**0.70 (0.54-0.91)**	0.89 (0.68-1.18)	1.00 (0.67-1.50)	0.96 (0.66-1.40)		**0.73 (0.57-0.95)**	0.76 (0.53-1.11)
	>4 hours/week		**0.75 (0.59-0.96)**	**0.56 (0.43-0.72)**	0.94 (0.72-1.24)	0.93 (0.63-1.39)	0.74 (0.51-1.09)		**0.52 (0.41-0.68)**	**0.64 (0.44-0.94)**
	BMI									
	Underweight		0.81 (0.41-1.50)	0.94 (0.44-1.85)	0.74 (0.33-1.68)	0.52 (0.12-1.49)	1.73 (0.76-3.56)		0.67 (0.28-1.40)	0.81 (0.24-2.10)
	Normal weight		1	1	1	1	1		1	1
	Obese		1.11 (0.94-1.32)	**1.24 (1.02-1.51)**	**1.36 (1.12-1.65)**	0.86 (0.65-1.33)	0.79 (0.61-1.04)		**1.25 (1.03-1.52)**	1.06 (0.78-1.44)
	Overweight		**1.64 (1.28-2.10)**	**1.46 (1.10-1.95)**	**1.79 (1.35-2.36)**	**1.28 (0.86-1.88)**	1.40 (0.96-2.01)		**1.99 (1.52-2.61)**	**1.98 (1.34-2.91)**
Model 4	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.11 (0.88-1.40)	0.94 (0.72-1.22)	**1.35 (1.05-1.73)**	1.05 (0.73-1.51)	1.24 (0.87-1.75)		**1.33 (1.03-1.70)**	0.86 (0.58-1.28)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handlers		**1.20 (1.05-1.38)**	1.13 (0.97-1.32)	1.12 (0.97-1.29)	**1.43 (1.18-1.72)**	1.19 (0.98-1.44)		1.13 (0.98-1.30)	1.11 (0.89-1.37)

Model 1: Baggage handler (yes/no) and age
Model 2.1: Baggage handler (Yes/no), baggage handler seniority (categorical) and age
Model 2.2: Baggage handler (yes/no), baggage handler seniority (continuous) and age
Model 3: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity
Model 4: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity, general health

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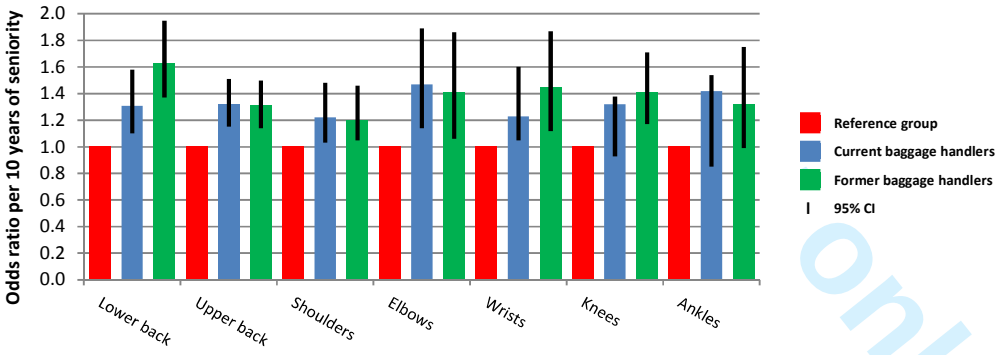
Model 3 shows that when age, BMI, smoking and physical leisure activity were added in the model, the effect estimates decreased but remained substantial and significant for all of the regions, except for the ankles. For example, for every 10 year of baggage handler seniority the odds of complaints in the lower back increased by 38% (OR 1.38, 95% CI: 1.22 to 1.56), the odds of complaints in the elbows increased by 53% (OR 1.53, 95% CI: 1.28 to 1.83) and the odds of complaints in the wrists increased by 33% (OR 1.33, 95% CI: 1.11 to 1.60). Furthermore, model 3 shows that only complaints in the knees and ankles were significantly affected by age after adjustment for seniority. In general the covariates had the same effect on musculoskeletal complaints as known from former studies: Physical leisure activity decreased the odds of pain whereas smoking[4, 5] and a high BMI[13, 16, 17, 19] increased the odds of pain.

Additional analyses for the hips showed that the risks of complaints in the first four categories of seniority (in model 2.1) were not significantly different and could be combined into one category (0-16 years) without changing the fit of the model significantly (data not shown). This indicates that the risk of hip-complaints did not significantly increase until at least 26 years of baggage handler seniority.

In all of the adjusted analyses we tested whether adjustment for height and weight instead of BMI changed the estimates. Also, we tested for interactions between height and weight. None of these variations changed the estimates substantially. Furthermore, stratified analyses on current versus former baggage handlers, showed that the effects of seniority reported in model 3 remained significant for both groups within all anatomical regions except for the knees (Figure 1).

Figure 1: Odds ratio of muscucoskeletal complaints for current and former baggage handlers compared with the reference group



Adjusted for baggage handler (Yes/no), age, height, weight, smoking and physical leisure activity

Supplementary analyses

As noted in Table 1, self-reported general health of the baggage handlers was poorer than that of the reference group and further analysis revealed that this relation increased with baggage handler seniority. Furthermore, general health was associated with musculoskeletal complaints. We tried to examine if the relation between general health and baggage handler seniority disappeared if we adjusted for number of regions with complaints. In this analysis we further included age and the other covariates in the final model on regional pain and seniority (data not shown). By doing so the relation between general health and

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seniority still persisted indicating that seniority and thereby cumulated work factors also are related to other health effects than musculoskeletal complaints and that the linear relation between baggage handler seniority and complaints might – to some extent – be explained by general health. In order to assess the maximal potential bias, which could be related to general health, we added general health as a covariate in the final model (model 4). The linear relation between seniority and pain persisted for all regions and was still significant for lower back (OR 1.20, 95% CI: 1.05-1.38) and elbows (OR 1.43, 95% CI: 1.18-1.72), and the lower confidence limit for the other regions was only slightly below unity in most regions.

DISCUSSION

We found that the odds ratios of self-reported musculoskeletal complaints in the neck and upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in a reference group of men in other unskilled occupations with less heavy work. These differences between the groups were to a great extent attributable to length of employment as a baggage handler, indicating that the study- and reference groups were basically comparable in relation to reporting of musculoskeletal complaints.

Baggage handler seniority was significantly, positively associated with musculoskeletal complaints in all of the measured anatomical regions, except for the ankles, and a significant, linear relationship was found for the neck and upper back, lower back, shoulders, elbows, wrists and knees. However, the pattern for the hips was irregular and only significantly increased compared to the control group for baggage handlers with more than 26 years of seniority. These results may suggest that cumulated heavy lifting in awkward positions does not only affect the lower back, knees and shoulders, as indicated by previous studies but also other anatomical regions, such as the wrists and elbows. As we do not expect cumulated exposure to be associated with acute reversible musculoskeletal complaints, the implication is that long lasting daily exposures to heavy lifting in awkward positions may cause chronic or longer lasting adverse effects on musculoskeletal health in several body regions. This interpretation is supported by similar relations between seniority and musculoskeletal complaints among presently and previously employed baggage handlers.

Our results are in line with the study of Undeutsch et al. that found an age-adjusted association between seniority as a baggage handler and occurrence of back symptoms.[23] However, the present study is the first to show a linear relationship between baggage handler seniority and self-reported pain in a number of other anatomical regions.

In this study we found a linear association between baggage handler seniority and musculoskeletal complaints in six out of eight anatomical regions, although some of the regions are not normally assumed to be affected by heavy lifting, e.g. the wrists. This lack of regional specificity in the relation between baggage handler seniority and pain may be seen as a weakness in the causal interpretation of our findings. However, heavy lifting in awkward positions implies biomechanical loads on all body parts, and short-term exposure to baggage handling is associated with acute pain in most of the anatomical regions included in our study.[25-28] Thus, if repeated acute pain plays a role in the development of chronic pain, the lack of specificity of the relationship between regional pain and seniority may not be an important issue in the interpretation of our results. Furthermore, it is well known that the reporting of pain in one anatomical

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region is associated with increased pain reporting from adjacent and contralateral regions, possibly due to pain processing in the central nervous system.[29, 30]

One may also wonder about the linear effect of seniority from even low levels, as it might be expected that effects of cumulated exposure would occur only after a longer period of exposure. The higher odds ratio of pain in baggage handlers with increasing seniority could possibly be explained by the combination of recurrent episodes of acute pain from soft tissue strains and more chronic pain from degenerative changes in the joints and tendons at higher seniority. The contribution by different mechanisms might also differ between regions and could possibly explain the somewhat different findings for the hip region. However, the mechanisms leading to longer lasting or chronic musculoskeletal pain are unknown.

Limitations

It may be a limitation that information on seniority as well as musculoskeletal complaints was based on self-reports, which may involve recall bias and differential misclassification. However, we consider seniority to be factual information with an expected high level of accuracy. If our findings of a linear relationship between seniority and musculoskeletal complaints were attributable to misclassification of pain or seniority, baggage handlers should consistently and increasingly overestimate either their pain by increasing seniority or their seniority by increasing levels of pain. We cannot exclude such biases but consider them as unlikely explanations of our results.

Another limitation that may challenge the interpretation of our results is that general health was strongly associated with both seniority and pain. Our supplementary analyses showed that the linear relation between baggage handler seniority and pain could to some extent be explained by general health (Tabel 2, model 4). However, it is important to consider the possible pathways between baggage handler seniority, general health and regional pain. One pathway is that baggage handler seniority reflects cumulated exposure to heavy lifting, causing regional musculoskeletal pain which leads to a feeling of poorer general health. In this case the relation between seniority and musculoskeletal pain should not be adjusted for effects of general health. However an alternative pathway might also exist: The poorer general health that follows with baggage handler seniority could result from other health affecting factors than heavy lifting that cumulates with length of employment, e.g. particulate air pollution or psychosocial work conditions. This could be associated with more unspecific symptom reporting in general, including reporting of diffuse regional pain. If this is the case, the associations between baggage handler seniority and pain could be explained by a poorer general health caused by factors additional to heavy lifting. However, even if we assume the last mentioned pathway to be the dominating – and thereby our supplementary analyses to reflect the true associations – the pattern of associations between seniority and pain persisted for all regions and was still significant for lower back and elbows, while the lower confidence limit for the other regions was only slightly below unity.

Further, we only measured associations between baggage handler seniority and current musculoskeletal complaints without considering time for onset of the complaints or the way the complaints started. We assume that the complaints are caused by cumulative hard musculoskeletal demands but it could be caused by accidents at work or in leisure time or even have occurred before the employment as a baggage handler. Finally, in our analyses we assume that exposure to heavy lifting has been constant over the years, without considering changes in external factors that might have affected the risk of musculoskeletal disorders, such as air traffic, work schedules and the introduction of assistive equipment to reduce the

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manual work load. However, data on flights, goods and baggage handlers from Copenhagen Airport show that even when considering these factors, the average of goods lifted by the individual baggage handler seems rather constant during the study period (Brauer et al. unpublished).

The strengths of this study are the large number of currently and formerly employed baggage handlers with a large variation in seniority. Furthermore, all the covariates in the analyses had the expected influence on pain which corroborates the validity in data. Additionally, our data showed a high degree of comparability in characteristics of the study and reference group, and the inclusion of a reference group consisting of working men only reduces the influence of healthy worker effect bias.[31-33] However, the observed associations could not be explained by healthy worker selection; if musculoskeletal complaints led some baggage handlers to leave their jobs, the exposure-response relationship with seniority would only be weakened. Similarly, if some of the references had also at some times held heavy manual jobs, the effect would have been to reduce the strength of associations.

CONCLUSION

We conclude that baggage handlers had a significantly higher risk of musculoskeletal complaints than a reference group with less heavy work. This difference was to a large extent explained by seniority as a baggage handler. Further, we found a strong linear association between regional musculoskeletal complaints and seniority which is consistent with a long lasting or chronic effect of cumulated exposure to heavy lifting. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations. To pursue this issue further, future research should include information on onset and cause of pain, and estimates of individual differences in amount and frequency of heavy lifting.

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Author contributions: SHB drafted the article and all authors revised it critically for important intellectual content, and all authors approved the final version to be published.
Study conception and design: SHB, HK, CB, LCT, EBS, TA, JPB, SM.
Acquisition of data: SHB, KLM, HK
Interpretation of data: SHB, SM, CB, LCT, JPB
Statistical analyses: SHB, SM

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Ethical approval: The study was notified to the Scientific Ethical Committee, County of Copenhagen (journal no: H-4-2011-125) but returned without review because Danish law does not require that questionnaire studies are approved be an ethical committee.

Data sharing: There are no additional data available.

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Title page

Baggage handler seniority and musculoskeletal complaints -Is heavy lifting in awkward positions associated with the risk of pain?

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ABSTRACT

Objectives: Heavy lifting is associated with musculoskeletal disorders but it is unclear whether it is related to acute reversible effects or to chronic effects from cumulated exposure. The aim of this study was to examine if musculoskeletal complaints in Danish airport baggage handlers were associated with their seniority as baggage handler, indicating chronic effects from cumulated work load.

Methods: We established a group~~cohort~~ of baggage handlers employed at Copenhagen Airport during the period 1983-2012 (n=3,092) and a reference ~~cohort~~group of men in other unskilled occupations with less heavy work (n=2,478). Data regarding work history, lifestyle and musculoskeletal complaints were collected using a self-administered questionnaire (response rate 70.1% among baggage handlers and 68.8% among the reference group).

Results: The odds ratios of self-reported musculoskeletal complaints during the last 12 months in the neck/upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in the reference group. These differences were explained by significant linear effects of baggage handler seniority for six anatomical regions. Adjustment for age, BMI, smoking and leisure-time physical activity did not change these results. The findings were stable over age strata and among present and former baggage handlers.

Conclusion: The risk of musculoskeletal complaints in six anatomical regions increased with increasing seniority as a baggage handler. This is consistent with the assumption that cumulated heavy lifting may cause chronic or long lasting musculoskeletal complaints. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations.

Strengths and limitations of this study:

- This study includes a large number of baggage handlers with a large variation in seniority
- We found a high degree of comparability in characteristics of the study- and reference group
- A reference group of working men reduces the risk of healthy worker effect bias in this study
- Information on both exposure and outcome is based on self-reports
- The interpretation of results might be challenged by general health which is strongly associated with both seniority and musculoskeletal complaints

INTRODUCTION

The relation between occupational lifting and musculoskeletal complaints has been examined in several studies with different designs and in different occupational groups. Heavy lifting and lifting in twisted and stooped positions have been found to be risk factors for developing musculoskeletal disorders in the lower back region,[1-9] shoulders,[10-12] hips[13, 14] and knees.[13, 15-19] However, the degree to which these associations are related to acute reversible effects or to chronic effects from cumulated exposure is not clear, and data on exposure-response associations are sparse. Causal inferences, therefore, remain uncertain.[8, 9, 20]

If cumulated heavy lifting in awkward positions causes chronic musculoskeletal complaints one would expect that seniority in occupations with the same daily exposures over years could serve as a simple proxy measure of cumulated exposure. Baggage handling is characterized by repetitions of the same relatively few work tasks throughout the whole working day. These work tasks are primarily characterized by heavy lifting in awkward positions.[21] In particular, loading and unloading luggage in compartments of narrow bodied aircrafts are performed in stooped, squatting, sitting or kneeling positions in constrained spaces[21, 22]. On average a baggage handler at Copenhagen Airport lifts 4-5 tonnes during a normal work shift. The average weight of each lift is around 15 kg and most of the lifts are performed in awkward positions. The amount of goods lifted by the individual baggage handler has been rather constant over many years. [Brauer et al. unpublished]

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A few epidemiological studies have examined the association between heavy lifting and musculoskeletal complaints among baggage handlers.[22-24] Stålhammar et al. used a questionnaire to measure occurrence of shoulder, knee and back pain in baggage handlers and found that more than half of the study population reported pain in the shoulders, knees and lower back, even though the population consisted of young men only (mean age 27 years) of whom 59% had a seniority of less than five years.[22] Additionally, Undeutsch et al. investigated transport workers in a German airport and found that 66% reported complaints in the lower back, 33% in the neck and 41% in the arms. Furthermore, they found an association between baggage handler seniority and occurrence of back symptoms.[23, 24] These previous studies were based on limited sample sizes of 78 and 366 baggage handlers, respectively, and no reference group was included in these studies.

The aim of the present study was to examine if baggage handlers have an increased risk of musculoskeletal complaints compared to a reference group of men in other unskilled occupations with less heavy work, and if seniority as a baggage handler is associated with musculoskeletal complaints.

MATERIAL AND METHODS

Study population

Using the electronic employee registers of the two leading handling companies at Copenhagen Airport and the electronic member directory from the local labour union that organizes the airport baggage handlers, we identified a group of 4,527 persons with occupational codes that indicated work as a baggage handler anytime between 1983 and 2012. We further used the electronic member directory of unskilled workers in the Greater Copenhagen area, the electronic member directory of the Union of Security Workers and the Copenhagen Airport electronic employee register of security personal in the airport to establish a ~~similarly selected~~ reference group consisting of 3,927 randomly selected men in who within the same period were occupied with other unskilled ~~occupations~~ jobs with less heavy work, e.g. cleaning, security and catering.

Data collection

A questionnaire was delivered to baggage handlers and persons in the reference group who met the following criteria: They were alive in 2012; had permanent residence in Denmark; had an age between 25 and 75 years; and had not previously requested not to participate in research projects (an option in Danish civil registration). These criteria were met by 3,092 baggage handlers and 2,469 in the reference group. The group of baggage handlers consisted of 1,140 currently employed and 1,952 formerly employed at Copenhagen Airport. The currently employed baggage handlers were asked to fill in the questionnaire at the airport during their working time, while the formerly employed baggage handlers and all individuals in the reference group received the questionnaire by mail. The participants who did not answer the questionnaire within 3 weeks received a phone call and were invited to answer the questionnaire by phone. In total 2,179 baggage handlers (response rate 70.1%) and 1,710 in the reference group (response rate 68.8%) answered the questionnaire.

Measurements of exposure and outcome

In the questionnaire the participants were asked about their height, weight, date of birth, musculoskeletal complaints in eight different anatomical regions and lifestyle determinants, such as physical leisure activity and smoking. The questions were all validated questions used in original or slightly modified versions.

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Additionally, the baggage handlers were asked supplementary questions about their work as a baggage handler.

In order to validate the information on occupation, participants identified as baggage handlers in the registers and member directory were asked if they had ever worked as a baggage handler. Only participants who answered in the affirmative were included as baggage handlers in the subsequent analyses, whereas participant who stated that they had never worked as baggage handlers were transferred to the reference group. In total, 352 individuals (16.2%) were transferred from the study to the reference group, so that we in the analyses ended up with 1,827 baggage handlers and 2,062 in the reference group.

Information on baggage handler seniority was measured by the question: *For how many years, all together, have you worked as a baggage handler?*

Musculoskeletal complaints were recorded for eight anatomical regions: neck and upper back, lower back, shoulders, elbows, wrists, hips, knees and ankles, and were measured by the question: *How much have you been bothered by pain or discomfort in the following body regions during the last 12 months*? This was followed by a list of the eight anatomical regions with response categories: *not at all, a little/somewhat*, *quite a lot*, and *very much*. In the analyses the degree of pain was dichotomized into the categories: *no complaints* which consisted of the categories *not at all* and *a little/somewhat* and *complaints* which consisted of the categories *quite a lot* and *very much*.

As potential confounders we included age as a continuous variable. Smoking (*never*, *former smoker*, *yes*), leisure-time physical activity (*<2 hours/week*, *2-4 hours/week*, *>4 hours/week*) and body mass index (BMI) *(<18.5*, *18.5 - <25*, *25 - <30*, *≥30*) were included as categorical variables.

Statistical analyses

Associations between baggage handler seniority and musculoskeletal complaints were analyzed using three different models. In model 1 we tested differences in regional musculoskeletal complaints between baggage handlers and the reference group only adjusted for age. In model 2 we further included baggage handler seniority, first as a categorical variable divided into quartiles (the highest quartile covered a large range of seniority and was therefore subdivided into two) (model 2.1), and then as a continuous variable with the reference group coded with 0 years of baggage handler seniority (model 2.2). We used the likelihood ratio test to estimate if seniority could be fitted as a linear effect. In all models including seniority as a continuous variable we also included the binary group variable, coded '0' for the reference group and '1' for baggage handlers. By this coding, the effect of the seniority variable only refers to baggage handler seniority, and inflation or deflation of effect estimates owing to group differences are avoided. In the final model (model 3) we further included the potential confounders mentioned above. Supplementary analyses were made by adding general health (categories: excellent or very good, good, fair or poor) to the final model (model 4). The data were analyzed using logistic regression, SAS 9.2 (SAS Institute Inc., Cary, NC, USA). Results are presented as odds ratios (OR) with 95%-confidence intervals (95% CI).

RESULTS

Table 1 shows the characteristics of the participants. The age distribution was slightly skewed towards a larger part of older participants in the reference group compared to baggage handlers. The average

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seniority for the baggage handlers was 11 years; 2.4% had a seniority of less than one year and 24.4 % had a seniority of more than 16 years. Pearson's correlation coefficient between age and baggage handler seniority was 0.56.

Tabel 1: Paricipant characteristics and description of variables.
Values are numbers (percentages) unless stated otherwise.

	Baggage handlers	Reference group
Number of respondents	1827 (47.0)	2059 (53.0)
Age (years)		
25-34	244 (13.6)	227 (11.3)
35-44	587 (32.7)	554 (27.5)
45-54	644 (35.9)	679 (33.7)
55-64	236 (13.2)	377 (18.7)
65-75	82 (4.6)	176 (8.8)
Seniority (years)		
0	0 (0.0)	2059 (100.0)
> 0-3	499 (28.1)	0 (0.0)
4-8	404 (22.7)	0 (0.0)
9-16	442 (24.9)	0 (0.0)
17-25	266 (15.0)	0 (0.0)
≥ 26	167 (9.4)	0 (0.0)
Complaints		
Lower back	553 (32.6)	450 (23.4)
Neck/upper back	353 (21.8)	335 (17.8)
Shoulders	419 (25.4)	305 (16.3)
Elbows	174 (11.2)	123 (6.8)
Wrists	185 (11.8)	131 (7.2)
Hips	116 (7.6)	111 (6.1)
Knees	408 (24.3)	325 (17.2)
Ankles	127 (8.1)	146 (8.0)
Height (cm) (mean)	181.2	180.5
Weight (kg) (mean)	87.4	87.5
BMI		
Underweight	31 (1.7)	66 (3.2)
Normal weight	644 (35.3)	684 (33.2)
Overweight	958 (52.4)	1046 (50.8)
Obese	194 (10.6)	262 (12.7)
General health		
Excellent/very good	692 (38.3)	897 (44.0)
Good	725 (40.1)	834 (40.9)
Fair/poor	394 (21.6)	307 (15.1)
Smoking		
No	721 (39.8)	704 (34.4)
Former	590 (32.6)	724 (35.3)
Yes	501 (27.6)	621 (30.3)
Physical leisure activity		
< 2 hours/week	179 (9.9)	721 (39.8)
2-4 hours/week	618 (34.2)	590 (32.6)
> 4 hours week	1008 (55.8)	501 (27.7)

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The degree of musculoskeletal complaints were higher for the baggage handlers than for the reference group within all anatomical regions, except for the ankles, and the lower back was the site of most pain in both groups. Furthermore, the height, weight and smoking were similar in the two groups, whereas the baggage handlers reported a poorer general health and a higher level of physical leisure activity than the reference group.

Table 2 shows the results of the logistic regression analyses. We found a significantly higher odds ratio of musculoskeletal complaints in the group of baggage handlers compared with the reference group for all anatomical regions, except for the ankles (model 1). The odds of musculoskeletal complaints increased systematically with higher categories of baggage handler seniority in six of the anatomical regions: the lower back, neck and upper back, shoulders, elbows, wrists and knees (model 2.1).

The likelihood ratio test showed that the effect of baggage handler seniority could be fitted as a linear effect for all regions except for the hips, and hence baggage handler seniority was included continuously in the final model (model 3). When baggage handler seniority was included continuously in the model (model 2.2), the effect of baggage handler (yes/no) diminished and became insignificant for all regions, except for the shoulders (OR 1.37, 95% CI: 1.08 to 1.72) while the linear effect of baggage handler seniority was statistically significant in all of the anatomical regions. Thus, the higher prevalence of musculoskeletal complaints among the baggage handlers was to a large extent explained by seniority as a baggage handler.

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Tabel 2: Odds Ratio (95% CI) for musculoskeletal complaints within the last 12 months according to occupation and baggage handler seniority for baggage handlers and a reference group with less heavy work

			Lower back OR (CI 95%)	Neck/Upper back OR (CI 95%)	Shoulders OR (CI 95%)	Elbows OR (CI 95%)	Wrists OR (CI 95%)	Hips OR (CI 95%)	Knees OR (CI 95%)	Ankles OR (CI 95%)
Model 1	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		**1.64 (1.42-1.91)**	**1.34 (1.13-1.59)**	**1.82 (1.54-2.15)**	**1.84 (1.44-2.36)**	**1.82 (1.43-2.31)**	**1.45 (1.10-1.92)**	**1.68 (1.42-1.99)**	1.14 (0.89-1.47)
Model 2.1	**Seniority (years)**	n								
	0 (reference)	2059	1	1	1	1	1	1	1	1
	>0-3	499	1.09 (0.85-1.38)	0.97 (0.73-1.28)	1.21 (0.92-1.60)	0.82 (0.50-1.28)	1.26 (0.84-1.85)	1.19 (0.71-1.90)	1.20 (0.91-1.58)	0.75 (0.45-1.19)
	4-8	404	1.25 (0.96-1.61)	1.15 (0.85-1.53)	**1.57 (1.18-2.06)**	1.50 (0.98-2.23)	1.46 (0.96-2.16)	1.49 (0.90-2.37)	**1.48 (1.11-1.96)**	1.12 (0.70-1.73)
	9-16	442	**1.91 (1.52-2.39)**	**1.45 (1.11-1.88)**	**2.27 (1.77-2.91)**	**2.19 (1.53-3.09)**	**1.94 (1.35-2.74)**	0.94 (0.55-1.52)	**1.98 (1.54-2.54)**	1.06 (0.68-1.58)
	17-25	266	**2.41 (1.82-3.18)**	**1.70 (1.24-2.32)**	**2.31 (1.70-3.12)**	**3.08 (2.07-4.52)**	**2.33 (1.54-3.46)**	1.49 (0.90-2.38)	**1.81 (1.33-2.44)**	1.40 (0.88-2.16)
	>26	167	**3.02 (2.12-4.30)**	**2.26 (1.53-3.30)**	**2.31 (1.57-3.37)**	**2.93 (1.74-4.76)**	**3.15 (1.93-5.01)**	**2.78 (1.66-4.53)**	**2.83 (1.97-4.06)**	**1.76 (1.05-2.86)**
Model 2.2	**Baggage handler**									
	No		1	1	1	1	1	1	1	1
	Yes		1.10 (0.89-1.35)	0.97 (0.76-1.22)	**1.37 (1.08-1.72)**	1.06 (0.75-1.50)	1.22 (0.87-1.70)	1.03 (0.68-1.55)	1.24 (0.98-1.57)	0.81 (0.55-1.17)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1	1	1	1
	Baggage handler		**1.42 (1.26-1.61)**	**1.32 (1.16-1.52)**	**1.27 (1.12-1.45)**	**1.55 (1.29-1.85)**	**1.38 (1.16-1.64)**	**1.27 (1.03-1.56)**	**1.30 (1.14-1.48)**	**1.30 (1.07-1.57)**
Model 3	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.16 (0.94-1.44)	1.02 (0.80-1.30)	**1.40 (1.10-1.77)**	1.10 (0.77-1.56)	1.31 (0.93-1.83)		**1.35 (1.06-1.71)**	0.92 (0.62-1.34)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handler		**1.38 (1.22-1.56)**	**1.30 (1.14-1.50)**	**1.27 (1.11-1.45)**	**1.53 (1.28-1.83)**	**1.33 (1.11-1.60)**		**1.26 (1.01-1.44)**	1.21 (0.99-1.49)
	Age (per 10 years)		1.06 (0.98-1.15)	1.01 (0.92-1.11)	1.04 (0.95-1.14)	1.07 (0.93-1.23)	1.07 (0.94-1.21)		**1.17 (1.07-1.28)**	**1.36 (1.19-1.56)**
	Smoking									
	No		1	**1**	**1**	**1**	**1**		**1**	**1**
	Former smoker		1.02 (0.85-1.23)	1.16 (0.94-1.43)	**1.37 (1.11-1.69)**	1.01 (0.74-1.36)	**1.35 (1.01-1.82)**		**1.41 (1.15-1.74)**	**1.47 (1.06-2.06)**
	Yes		**1.28 (1.05-1.55)**	1.20 (0.96-1.49)	**1.53 (1.23-1.90)**	**1.29 (0.95-1.76)**	1.30 (0.96-1.77)		1.21 (0.97-1.51)	**1.76 (1.26-2.49)**
	Physical activity									
	<2 hours/week		**1**	**1**	**1**	**1**	**1**		**1**	**1**
	2-4 hours/week		0.94 (0.74-1.21)	**0.70 (0.54-0.91)**	0.89 (0.68-1.18)	1.00 (0.67-1.50)	0.96 (0.66-1.40)		**0.73 (0.57-0.95)**	0.76 (0.53-1.11)
	>4 hours/week		**0.75 (0.59-0.96)**	**0.56 (0.43-0.72)**	0.94 (0.72-1.24)	0.93 (0.63-1.39)	0.74 (0.51-1.09)		**0.52 (0.41-0.68)**	**0.64 (0.44-0.94)**
	BMI									
	Underweight		0.81 (0.41-1.50)	0.94 (0.44-1.85)	0.74 (0.33-1.68)	0.52 (0.12-1.49)	1.73 (0.76-3.56)		0.67 (0.28-1.40)	0.81 (0.24-2.10)
	Normal weight		1	1	1	1	1		1	1
	Obese		1.11 (0.94-1.32)	**1.24 (1.02-1.51)**	**1.36 (1.12-1.65)**	0.86 (0.65-1.33)	0.79 (0.61-1.04)		**1.25 (1.03-1.52)**	1.06 (0.78-1.44)
	Overweight		**1.64 (1.28-2.10)**	**1.46 (1.10-1.95)**	**1.79 (1.35-2.36)**	**1.28 (0.86-1.88)**	1.40 (0.96-2.01)		**1.99 (1.52-2.61)**	**1.98 (1.34-2.91)**
Model 4	**Baggage handler**									
	No		1	1	1	1	1		1	1
	Yes		1.11 (0.88-1.40)	0.94 (0.72-1.22)	**1.35 (1.05-1.73)**	1.05 (0.73-1.51)	1.24 (0.87-1.75)		**1.33 (1.03-1.70)**	0.86 (0.58-1.28)
	Seniority (per 10 years)									
	Reference		1	1	1	1	1		1	1
	Baggage handlers		**1.20 (1.05-1.38)**	1.13 (0.97-1.32)	1.12 (0.97-1.29)	**1.43 (1.18-1.72)**	1.19 (0.98-1.44)		1.13 (0.98-1.30)	1.11 (0.89-1.37)

Model 1: Baggage handler (yes/no) and age
Model 2.1: Baggage handler (Yes/no), baggage handler seniority (categorical) and age
Model 2.2: Baggage handler (yes/no), baggage handler seniority (continuous) and age
Model 3: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity
Model 4: Baggage handler (yes/no), baggage handler seniority (continuous), age, height, weight, smoking, physical leisure activity, general health

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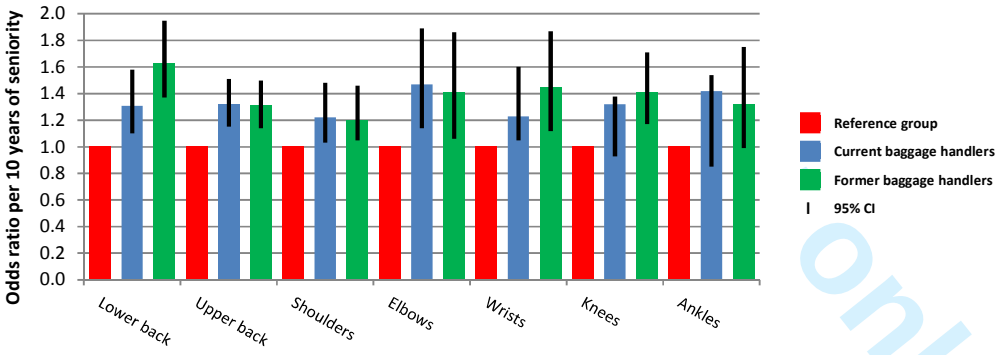
Model 3 shows that when age, BMI, smoking and physical leisure activity were added in the model, the effect estimates decreased but remained substantial and significant for all of the regions, except for the ankles. For example, for every 10 year of baggage handler seniority the odds of complaints in the lower back increased by 38% (OR 1.38, 95% CI: 1.22 to 1.56), the odds of complaints in the elbows increased by 53% (OR 1.53, 95% CI: 1.28 to 1.83) and the odds of complaints in the wrists increased by 33% (OR 1.33, 95% CI: 1.11 to 1.60). Furthermore, model 3 shows that only complaints in the knees and ankles were significantly affected by age after adjustment for seniority. In general the covariates had the same effect on musculoskeletal complaints as known from former studies: Physical leisure activity decreased the odds of pain whereas smoking[4, 5] and a high BMI[13, 16, 17, 19] increased the odds of pain.

Additional analyses for the hips showed that the risks of complaints in the first four categories of seniority (in model 2.1) were not significantly different and could be combined into one category (0-16 years) without changing the fit of the model significantly (data not shown). This indicates that the risk of hip-complaints did not significantly increase until at least 26 years of baggage handler seniority.

In all of the adjusted analyses we tested whether adjustment for height and weight instead of BMI changed the estimates. Also, we tested for interactions between height and weight. None of these variations changed the estimates substantially. Furthermore, stratified analyses on current versus former baggage handlers, showed that the effects of seniority reported in model 3 remained significant for both groups within all anatomical regions except for the knees (Figure 1) ~~(data not shown)~~.

Figure 1: Odds ratio of muscucoskeletal complaints for current and former baggage handlers compared with the reference group



Adjusted for baggage handler (Yes/no), age, height, weight, smoking and physical leisure activity

Supplementary analyses

As noted in Table 1, self-reported general health of the baggage handlers was poorer than that of the reference group and further analysis revealed that this relation increased with baggage handler seniority. Furthermore, general health was associated with musculoskeletal complaints. We tried to examine if the relation between general health and baggage handler seniority disappeared if we adjusted for number of regions with complaints. In this analysis we further included age and the other covariates in the final model on regional pain and seniority (data not shown). By doing so the relation between general health and

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seniority still persisted indicating that seniority and thereby cumulated work factors also are related to other health effects than musculoskeletal complaints and that the linear relation between baggage handler seniority and complaints might – to some extent – be explained by general health. In order to assess the maximal potential bias, which could be related to general health, we added general health as a covariate in the final model (model 4). The linear relation between seniority and pain persisted for all regions and was still significant for lower back (OR 1.20, 95% CI: 1.05-1.38) and elbows (OR 1.43, 95% CI: 1.18-1.72), and the lower confidence limit for the other regions was only slightly below unity in most regions.

DISCUSSION

We found that the odds ratios of self-reported musculoskeletal complaints in the neck and upper back, lower back, shoulders, elbows, wrists, hips and knees were significantly higher in baggage handlers than in a reference group of men in other unskilled occupations with less heavy work. These differences between the groups were to a great extent attributable to length of employment as a baggage handler, indicating that the study- and reference groups were basically comparable in relation to reporting of musculoskeletal complaints.

Baggage handler seniority was significantly, positively associated with musculoskeletal complaints in all of the measured anatomical regions, except for the ankles, and a significant, linear relationship was found for the neck and upper back, lower back, shoulders, elbows, wrists and knees. However, the pattern for the hips was irregular and only significantly increased compared to the control group for baggage handlers with more than 26 years of seniority. These results may suggest that cumulated heavy lifting in awkward positions does not only affect the lower back, knees and shoulders, as indicated by previous studies but also other anatomical regions, such as the wrists and elbows. As we do not expect cumulated exposure to be associated with acute reversible musculoskeletal complaints, the implication is that long lasting daily exposures to heavy lifting in awkward positions may cause chronic or longer lasting adverse effects on musculoskeletal health in several body regions. This interpretation is supported by similar relations between seniority and musculoskeletal complaints among presently and previously employed baggage handlers.

Our results are in line with the study of Undeutsch et al. that found an age-adjusted association between seniority as a baggage handler and occurrence of back symptoms.[23] However, the present study is the first to show a linear relationship between baggage handler seniority and self-reported pain in a number of other anatomical regions.

In this study we found a linear association between baggage handler seniority and musculoskeletal complaints in six out of eight anatomical regions, although some of the regions are not normally assumed to be affected by heavy lifting, e.g. the wrists. This lack of regional specificity in the relation between baggage handler seniority and pain may be seen as a weakness in the causal interpretation of our findings. However, heavy lifting in awkward positions implies biomechanical loads on all body parts, and short-term exposure to baggage handling is associated with acute pain in most of the anatomical regions included in our study.[25-28] Thus, if repeated acute pain plays a role in the development of chronic pain, the lack of specificity of the relationship between regional pain and seniority may not be an important issue in the interpretation of our results. Furthermore, it is well known that the reporting of pain in one anatomical

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region is associated with increased pain reporting from adjacent and contralateral regions, possibly due to pain processing in the central nervous system.[29, 30]

One may also wonder about the linear effect of seniority from even low levels, as it might be expected that effects of cumulated exposure would occur only after a longer period of exposure. The higher odds ratio of pain in baggage handlers with increasing seniority could possibly be explained by the combination of recurrent episodes of acute pain from soft tissue strains and more chronic pain from degenerative changes in the joints and tendons at higher seniority. The contribution by different mechanisms might also differ between regions and could possibly explain the somewhat different findings for the hip region. However, the mechanisms leading to longer lasting or chronic musculoskeletal pain are unknown.

Limitations

It may be a limitation that information on seniority as well as musculoskeletal complaints was based on self-reports, which may involve recall bias and differential misclassification. However, we consider seniority to be factual information with an expected high level of accuracy. If our findings of a linear relationship between seniority and musculoskeletal complaints were attributable to misclassification of pain or seniority, baggage handlers should consistently and increasingly overestimate either their pain by increasing seniority or their seniority by increasing levels of pain. We cannot exclude such biases but consider them as unlikely explanations of our results.

Another limitation that may challenge the interpretation of our results is that general health was strongly associated with both seniority and pain. Our supplementary analyses showed that the linear relation between baggage handler seniority and pain could to some extent be explained by general health (Tabel 2, model 4). However, it is important to consider the possible pathways between baggage handler seniority, general health and regional pain. One pathway is that baggage handler seniority reflects cumulated exposure to heavy lifting, causing regional musculoskeletal pain which leads to a feeling of poorer general health. In this case the relation between seniority and musculoskeletal pain should not be adjusted for effects of general health. However an alternative pathway might also exist: The poorer general health that follows with baggage handler seniority could result from other health affecting factors than heavy lifting that cumulates with length of employment, e.g. particulate air pollution or psychosocial work conditions. This could be associated with more unspecific symptom reporting in general, including reporting of diffuse regional pain. If this is the case, the associations between baggage handler seniority and pain could be explained by a poorer general health caused by factors additional to heavy lifting. However, even if we assume the last mentioned pathway to be the dominating – and thereby our supplementary analyses to reflect the true associations – the pattern of associations between seniority and pain persisted for all regions and was still significant for lower back and elbows, while the lower confidence limit for the other regions was only slightly below unity.

~~Finally~~ Further, we only measured associations between baggage handler seniority and current musculoskeletal complaints without considering time for onset of the complaints or the way the complaints started. We assume that the complaints are caused by cumulative hard musculoskeletal demands but it could be caused by accidents at work or in leisure time or even have occurred before the employment as a baggage handler. Finally, in our analyses we assume that exposure to heavy lifting has been constant over the years, without considering changes in external factors that might have affected the risk of musculoskeletal disorders, such as air traffic, work schedules and the introduction of assistive equipment to

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reduce the manual work load. However, data on flights, goods and baggage handlers from Copenhagen Airport show that even when considering these factors, the average of goods lifted by the individual baggage handler seems rather constant during the study period (Brauer et al. unpublished).

The strengths of this study are the large number of currently and formerly employed baggage handlers with a large variation in seniority. Furthermore, all the covariates in the analyses had the expected influence on pain which corroborates the validity in data. Additionally, our data showed a high degree of comparability in characteristics of the study and reference group, and the inclusion of a reference group consisting of working men only reduces the influence of healthy worker effect bias.[31-33] However, the observed associations could not be explained by healthy worker selection; if musculoskeletal complaints led some baggage handlers to leave their jobs, the exposure-response relationship with seniority would only be weakened. Similarly, if some of the references had also at some times held heavy manual jobs, the effect would have been to reduce the strength of associations.

CONCLUSION

We conclude that baggage handlers had a significantly higher risk of musculoskeletal complaints than a reference group with less heavy work. This difference was to a large extent explained by seniority as a baggage handler. Further, we found a strong linear association between regional musculoskeletal complaints and seniority which is consistent with a long lasting or chronic effect of cumulated exposure to heavy lifting. However, we cannot exclude that other factors related to baggage handler seniority may explain some of the associations. To pursue this issue further, future research should include information on onset and cause of pain, and estimates of individual differences in amount and frequency of heavy lifting.

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Data sharing: There are no additional data available.

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