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Original Article

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Daily Shoulder Pain Among Flight Baggage Handlers and its Association With Work Tasks and Upper Arm Postures on the Same Day

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Abstract

Objectives: This study of flight baggage handlers aimed at examining the extent to which shoulder pain developed during single work shifts, and whether a possible development was associated with biomechanical exposures and psychosocial factors during the same shift.
Methods: Data were collected during, in total, 82 work shifts in 44 workers. Right and left shoulder pain intensity was rated just before and just after the shift (VAS scale 0–100 mm). Objective data on 'time in extreme' and 'time in neutral' upper arm postures were obtained for the full shift using accelerometers, and the baggage handlers registered the number of 'aircrafts handled' in a diary. During half of the shift, workers were recorded on video for subsequent task analysis of baggage handling. 'Influence' at work and 'support' from colleagues were measured by use of Copenhagen Psychosocial Questionnaire (COPSOQ). Associations between exposures and the increase in pain intensity during the shift ('daily pain') were analysed for the right and left shoulder separately using Generalized Estimating Equations (GEE).
Results: 'Daily pain' was observed in approximately one third of all shifts. It was significantly associated with the number of 'aircrafts handled' for both the right and left shoulder. In multivariate models including both biomechanical exposures and the psychosocial factors 'influence' at work and 'support' from colleagues, 'aircrafts handled' was still significantly associated with 'daily pain' in both shoulders, and so was 'influence' and 'support', however in opposite directions.
Conclusions: 'Daily pain' was, in general, associated with biomechanical exposures during the same shift and with general 'influence' and 'support' in the job. In an effort to reduce pain among flight baggage handlers, it may therefore be justified to consider a reduction of biomechanical exposures during handling of aircrafts, combined with due attention to psychosocial factors at work.

Keywords: biomechanical exposure; ergonomics; manual handling; musculoskeletal disorder

Introduction

Musculoskeletal disorders (MSDs) are common among workers performing manual material handling (da Costa and Vieira 2010; van Rijn *et al.*, 2010). While pain is difficult to quantify unambiguously, it is commonly used in epidemiological studies of work-related MSDs (Descatha *et al.*, 2007). Associations between biomechanical exposures at work and pain have been extensively studied in cross-sectional as well as longitudinal studies, identifying high forces (van der Windt *et al.*, 2000; Harkness *et al.*, 2003), repetitive movements (van der Windt *et al.*, 2000; Andersen *et al.*, 2003), and work with elevated upper arms or above shoulder level (van der Windt *et al.*, 2000; Harkness *et al.*, 2003; Bodin *et al.*, 2012) to be risk factors for developing pain. Psychosocial factors at work, such as demands, control, social support, and influence, have also shown to be associated with shoulder pain as reported in several reviews (Bongers *et al.*, 2002; Hauke *et al.*, 2011).

In most longitudinal studies, the period between exposure recordings and registration of the outcome is in the order of months or years. This hampers interpretations of possible associations, since the induction period of pain may be shorter (Fredriksson *et al.*, 2002), and since pain is known to fluctuate between weeks, and even from day to day (Axén *et al.*, 2014; Hallman *et al.*, 2016; Andersen *et al.*, 2017). Also, exposures are known to vary on a short time scale (Wahlström *et al.*, 2010; Wahlström *et al.*, 2016; Andersen *et al.*, 2017).

Fluctuations of exposures and pain with time feed the need to understand the latency of effects of exposure on pain, including work-related and individual factors associated with fluctuations. This, in turn, requires studies operating with different time lags between exposure and pain, down to the point of addressing whether exposure during a work shift influence pain during that particular shift (Andersen *et al.*, 2017).

If occupational exposures have short-term, 'acute' pain effects on the same day, it appears justified to assume even a cumulated effect on pain of exposures experienced for prolonged periods of time. This notion was pursued recently by Andersen *et al.*, (2017), showing a cumulative effect of lifting on low-back pain across days among workers in supermarkets. Besides being helpful in understanding risk factors for pain, possible short-term effects of exposure on pain would be relevant in the context of workplace ergonomics interventions aiming at reducing occupational MSDs.

In order to gain more knowledge into the short-term acute pain effect of occupational exposures, the present study will explore within-shift associations between occupational exposures and pain was performed among flight baggage handlers. These workers are exposed to manual work in awkward postures, including heavy lifting (Dell 2007; Splittstoesser *et al.*, 2007; Wahlström *et al.*, 2016), and the 1 year prevalence of MSDs is similar to that in other occupations with considerable biomechanical exposures, especially for low-back and shoulders (Bern *et al.*, 2013; Bergsten *et al.*, 2015). A few previous studies have addressed risk factors associated with baggage handling, such as bag weights, working techniques (Korkmaz *et al.*, 2006; Splittstoesser *et al.*, 2007), postures (Wahlström *et al.*, 2016), seniority (Bern *et al.*, 2013), and cumulative employment (Thygesen *et al.*, 2016). Bag weight and increased destination height when stowing bags have been shown in experimental studies to increase spinal loading while the worker is kneeling (Splittstoesser *et al.*, 2007), and weight information on bags and an altered stowing method has been demonstrated to lead to reduced cumulative spinal loading and trunk muscle activity (Korkmaz *et al.*, 2006). Also, the introduction of technical devices to support handling on the ramp has been shown in a large cohort study to reduce the incidence of subacromial shoulder disorders (Thygesen *et al.*, 2016). Seniority as a baggage handler has been reported to be associated with an increased risk of MSDs in six body regions (Bern *et al.*, 2013), and more cumulative employment years have been shown to correlate with an increased incidence of subacromial shoulder disorders (Thygesen *et al.*, 2016). Work-related psychosocial factors have been shown to be cross-sectionally associated with the 1-year prevalence of shoulder pain among baggage handlers, with lack of support from colleagues showing a strong relationship with pain interfering with work (Bergsten *et al.*, 2015). None of these cited studies addressed the development of pain during a shift.

During 2015, 37.6 million passengers travelled to and from the 10 largest airports in Sweden and 480 000 take offs and landing took place (https://www.swedavia.se/flygmarknad/Frakt-och-passagerarflyg/). In these large airports, baggage handlers typically work either in baggage sorting or at the ramp, i.e. the area around the aircraft. Ramp baggage handlers' main task is to load and unload aircrafts, typically for about 30 minutes per aircraft. In addition to literally handling baggage at the aircraft, the handlers are engaged in directing and towing aircrafts to and from the gates, attaching auxiliary power cables, and putting brake bumpers and stairs to the aircraft into place (Wahlström *et al.*, 2016). The number of aircrafts handled during a work shift depends on several factors, including traffic intensity, the number of baggage handlers available, and whether specific competences are needed for loading/unloading some of the aircrafts. In smaller airports, baggage handlers have generally more varied tasks, including e.g. maintenance work in the garage, fueling, and snow ploughing. The variable nature of the baggage handling job between days at different types of airports makes this occupation well-suited for studying whether the development of daily pain intensity is associated with exposures during that same day.

The aims of the present study were to examine the extent to which self-reported shoulder pain develops during single work shifts among flight baggage handlers and, as a second aim, to determine the extent to which exposures during the shift can explain the development of pain. Our hypothesis is that the daily increase in shoulder pain is associated with the number of aircrafts handled, biomechanical exposures (time in extreme shoulder postures, time in neutral shoulder postures), and certain psychosocial factors (influence at work and support from colleagues).

Methods

Study design

The study was part of a larger project organized 2010–2012 by the Vocational Training and Working Environment Council (Transport Trades), a council formed by employers and unions in the Swedish transport sector. The purpose of the large project was to reduce work environment hazards and injuries among flight baggage handlers. Documentation of biomechanical (Wahlström *et al.*, 2016) and psychosocial (Bergsten *et al.*, 2015) exposures, as well as the pain prevalence was part of this main project. The present study focusses on selected biomechanical and psychosocial exposure variables, likely to be associated with shoulder pain according to previous literature and reasonable assumptions; i.e. work with extreme arm postures (van Rijn *et al.*, 2010), time with neutral arm postures, the number of handled aircrafts (as a proxy for strenuous work), influence at work, and support from colleagues (Larsson *et al.*, 2007).

Participants and procedure

Forty-four randomly selected baggage handlers working at six Swedish airports at either morning, afternoon, or night shifts agreed to participate (Table 1). Data were collected January to March and August to September 2011. At the largest airport, i.e. #1 in Table 1, data were collected from 16 workers at the ramp, with five, four, three, and two days of measurement obtained from three, two, nine, and two workers, respectively. At the smaller airports (#2–#6 in Table 1), data were collected for 1 day from each worker; giving a total of 82 measured shifts distributed among 44 workers (Table 1). All workers signed an informed consent prior to participation approved by the Regional Ethical Review Board in Uppsala, Sweden.

Data collection

Working postures

Upper arm elevation with respect to the line of gravity was assessed using VitaMove tri-axial accelerometers as inclinometers (INC; 2 M Engineering, Veldhoven, The Netherlands). Data were collected by five researchers trained in using the equipment and protocols for INC measurements. INCs were attached to the left and right upper arms over the deltoid muscle, aligned with the humerus. The instrumentation was set up prior to the work shift and data were collected throughout the shift using procedures described in detail in previous papers (Wahlström *et al.*, 2016). In order to identify vertical, i.e. 0° of elevation, a reference recording was obtained when workers were seated and leaning to the side with the relaxed arm hanging down while holding a 1-kg dumbbell in the hand. Based on the full-shift continuous recordings of upper arm elevation obtained from the accelerometers, 'time in extreme', i.e. percentage time with arms elevated >60° and 'time in neutral', i.e. percentage time with arm elevation <20° and arm movement velocity <5° s^{-1} were determined, following previous recommendations (Wahlström *et al.*, 2016).

Aircrafts handled

The baggage handlers carried a paper-and-pencil diary during the measured shifts, in which they registered loadings and unloadings of aircrafts performed during the shift. The total number of loadings and unloadings during a shift were summarized in the variable 'aircrafts handled'.

Table 1. Number of workers, *n*(*s*), and shifts, *n*(*d*), assessed using inclinometers (INC) and video recordings in the six participating airports.

	INC, *n*(*s*)	INC, *n*(*d*)	Video, *n*(*s*)
Airport 1	16	54	5
Airport 2	6	6	6
Airport 3	5	5	5
Airport 4	6	6	4
Airport 5	6	6	5
Airport 6	5	5	4
Total	44	82	29

Task analysis

In order to further understand the contents of the variable aircrafts handled, workers participating in the INC measurements were recorded on video continuously for the first or second half of their work shift. One of the authors (E.L.B.) observed all these recordings using a customized computer video analysis tool, ATM 3.0. (Forsman *et al.*, 2002). Prior to observation, about 30 activities performed in two different areas were identified, i.e. 'ramp inside'; e.g. getting dressed for going outside, checking assigned aircraft to load/unload, register work done, and 'ramp outside'; e.g. loading and unloading on the ground or inside compartment, pushing/pulling baggage carts, directing traffic, towing aircrafts, and vehicle maintenance in the garage. The observer pressed a button whenever an activity ended. A box on the screen was available for the researcher to note special events. Thus, the observation resulted in an annotated time-line of start and stop times for each period of a specified activity. In a further procedure, durations of all observed activities were classified into eight main activities, each of them belonging to either the 'ramp inside' or the 'ramp outside' category. After this compilation, 'ramp inside' included three activities; i.e. on their way out/waiting (walking around waiting for colleagues, getting dressed); recovery (eating, drinking coffee, socialising, watching TV, playing cards), and administration, while 'ramp outside' included five activities; i.e. driving vehicles, manually push/pull baggage carts, arrival/departure (directing aircrafts, placing auxiliary power cables, brake bumpers, and stairs into place), loading/unloading (loading/unloading aircrafts on the ground or inside the aircraft compartment), and garage work (in smaller airports). The characteristics and temporal structure of 'ramp outside' activities were used to describe the contents of the variable aircrafts handled.

Psychosocial factors

In a previous study in a larger population of Swedish baggage handlers, influence at work was rated by the workers as the most dissatisfying psychosocial factor, and lack of social support from colleagues was the psychosocial factor most strongly associated with the 1-year prevalence of pain interfering with work (Bergsten *et al.*, 2015). The importance of these two factors for the development of pain was examined in the present study. General ratings of the psychosocial factors 'influence' at work and 'support' from colleagues were obtained from all participants using the latest edition of the medium-length Copenhagen Psychosocial Questionnaire, COPSOQ II (Pejtersen *et al.*, 2010), which was administered during the same time period as the INC measurements. Four questions measure 'influence'; i.e. 'Do you have a large degree of influence concerning your work? Do you have a say in choosing who you work with? Can you influence the amount of work assigned to you? Do you have any influence on what you do at work?' Three questions addressed social 'support' from colleagues; i.e. 'How often do you get help and support from your colleagues? How often are your colleagues willing to listen to your problems at work? How often do your colleagues talk with you about how well you carry out your work?' The questions were answered on a five-step response scale ranging from 'always' to 'never/hardly ever'. For all scales, the five possible answers to each question were transformed to numbers for reasons of comparability; i.e. 0, 25, 50, 75, 100. The overall scores for 'influence' and 'support' were then computed as the mean score across questions in the corresponding scale, a higher score indicating more positive psychosocial factors.

Demographics

In the questionnaire used to obtain information about psychosocial factors, demographic data on age, years of work experience (<1 year, 1–5 years, 6–10 years, and >10 years), weight (kg), and height (cm) were also collected. Body mass index was calculated from this data (weight·height^{-2}).

Pain ratings

Just before and immediately after the work shift, workers rated their shoulder pain, for the right and left shoulder separately, on a 0 to 100 mm VAS scale from 'no pain' to 'worst pain imaginable'. The change in pain rating from before to after work was used as the outcome variable 'daily pain'.

Statistical analyses

Descriptive data on workers, exposures, and pain ratings are presented as mean and standard deviation across shifts. Associations between the outcome variable 'daily pain' and the exposure variables 'aircrafts handled', 'time in extreme' shoulder postures, 'time in neutral' shoulder postures, 'influence', and 'support' were analysed using linear regression. Since the data included repeated measurements from some of the workers, Generalized Estimating Equations (GEE) were used to account for within-subject correlations. First, univariate associations were determined for the right and left shoulders independently between 'daily pain' and each of the variables age, shoulder pain before the shift, 'aircrafts handled', 'time in extreme', 'time in neutral', 'influence', and 'support'. Data for right and left upper arm postures were used in the analyses of right and left shoulder pain, respectively. Seniority was strongly correlated with age and was therefore not analysed. Second, we determined the association between 'daily pain' and the biomechanical exposures shown to be significant in the univariate analyses, i.e. 'aircrafts handled' and 'time in extreme' (model 1). Both models also included age and shoulder pain before the shift as potential confounders. In a final GEE model, we included all variables assumed to be associated with 'daily pain' to assess the joint effects of both biomechanical and psychosocial factors, adjusted for confounding (model 2). All analyses were performed with SPSS v. 22 (SPSS Inc, Chicago, IL, USA).

Results

Participants

The studied population of baggage handlers was, on average, 36.6 years of age, and 72% had a work experience of >6 years (Table 2). Quality control of the inclinometer recordings showed that 12 shifts had to be excluded due to intractable noise or too much missing data, leaving 70 shifts for further analyses.

Pain

A considerable proportion of the baggage handlers reported to have no pain both before and after the work shift (37% and 39% for the right and left arm, respectively; Table 3). In another, 5–6% of the shifts workers reported identical non-zero pain values before and after the shift. Thus, the total proportion of shifts showing no change in pain was 42% and 45% for the right and left shoulder, respectively (Table 3). Pain increased in approximately one third of the shifts (Table 3).

Associations between exposures and daily pain

Descriptive data on biomechanical and psychosocial exposures are reported in Table 2. The variables 'aircrafts handled' and 'time in extreme' showed weak negative correlations for both the right and left shoulder (Pearson's correlation coefficients −0.18 (P = 0.13) and −0.23 (P = 0.05), respectively; data not shown in Table 2). In the univariate analyses, 'aircrafts handled' and 'time in extreme' were the only biomechanical exposure variables showing a significant association with 'daily pain' (Table 4). Thus, for each aircraft handled, pain increased by 1.29 mm (95% confidence interval = 0.11–2.47) and 1.60 mm (0.44–2.76) for the right and left shoulder, respectively (Table 4). The psychosocial variables 'influence' and 'support' were not associated with 'daily pain' in the univariate analysis (Table 4).

In the multivariate analyses, the association between 'aircrafts handled' and 'daily pain' persisted, and it was even stronger after adjustment for covariates in both model 1 and 2.

Description of ramp work

Twenty-nine video recordings (in total 119 hours of work) were analysed. Handling aircrafts, as described above, made up 48% of the ramp work and included arrival/departure (26.5%), loading/unloading baggage outside and inside the aircraft compartment (10%), driving vehicles (9.4%), and pushing/pulling baggage carts (2.1%). The mean duration of one 'aircrafts handled' operation was 28 minutes, with a range of 7 to 52 minutes. Other tasks identified for workers on the ramp were administration (2.3% of the total work time), waiting inside or on the way out on the ramp (6.1%), breaks (32.8%), and non-ramp tasks, such as garage work in smaller airports

Table 2. Descriptives of workers, exposures, and pain ratings.

	n(*s*)	m (SD)
Age (yrs)	42	36.6 (10.9)
Height (cm)	36	180.1 (6.4)
Weight (kg)	35	84.8 (11.6)
BMI (kg·m^{-2})	33	26.4 (4.1)
Work experience	36	% of workers
< 1 year	1	3
1–5 years	9	25
6–10 years	8	22
>10 years	18	50
Psychosocial factors	*n*(*s*)	m (SD)
'Influence' at work	36	39 (15.9)
'Support' from colleagues	37	62 (17.1)
Work task	*n*(*d*)	
Aircrafts handled	82	6.4 (range 2–12)
Upper arm elevation	*n*(*d*)	m (SD)
'Time in extreme', right arm, %	70	7.1 (7.6)
'Time in extreme', left arm, %	70	7.7 (7.4)
'Time in neutral', right arm, %	70	7.1 (4.7)
'Time in neutral', left arm, %	70	8.8 (5.3)
Pain	*n*(*d*)	m (SD)
Right shoulder before shift (mm)	82	8.7 (13.3)
Right shoulder after shift (mm)	82	11.0 (14.9)
Left shoulder before shift (mm)	82	7.7 (11.4)
Left shoulder after shift (mm)	82	10.3 (14.9)

BMI, body mass index; *n*(*s*), number of participants; *n*(*d*), number of shifts; m, mean; SD, standard deviation.

Table 3. Number (percentage) of shifts ($n(d)$ = 82 in total) with no pain at all, no change in pain, increased pain, or decreased pain in the right and left shoulder.

Right shoulder				Left shoulder			
No pain before and after shift, $n(d)$ (%)	No change in pain, $n(d)$ (%)	Increased pain, $n(d)$ (%)	Decreased pain, $n(d)$ (%)	No pain before and after, $n(d)$ (%)	No change in pain, $n(d)$ (%)	No change in pain, $n(d)$ (%)	Decreased pain, $n(d)$ (%)
30 (37)	34 (42)	29 (35)	19 (23)	32 (39)	37 (45)	26 (32)	19 (23)

$n(d)$, number of shifts.

Table 4. Univariate and multivariate associations between biomechanical and psychosocial factors and 'daily pain' for the right and left shoulders.

			Right shoulder			Left shoulder
Univariate	$n(s)$	$n(d)$	B (95% CI)	$n(s)$	$n(d)$	B (95% CI)
Age	42	80	−0.02 (−3.33 to 10.30)	42	80	−0.05 (−0.31 to 0.21)
Shoulder pain before	44	82	**−0.24 (−0.38 to −0.10)**	44	82	**−0.37 (−0.61 to −0.12)**
'Aircrafts handled'	44	82	**1.29 (0.11 to 2.47)**	44	82	**1.60 (0.44 to 2.76)**
'Time in extreme'	40	70	**−0.22 (−0.42 to −0.03)**	40	70	**−0.28 (0.56 to 0.00)**
'Time in neutral'	40	70	−0.25 (−0.75 to 0.25)	40	70	−0.14 (−0.76 to 0.48)
'Influence'	36	72	−0.20 (−0.45 to 0.04)	36	72	−0.20 (−0.47 to 0.07)
'Support'	37	72	0.14 (0.08 to 0.36)	37	72	0.20 (−0.05 to 0.44)
Model 1						
Age	38	68	**0.21 (0.01 to 0.41)**	38	68	0.00 (−0.20 −0.20)
Shoulder pain before	38	68	**−0.32 (−0.48 to −0.16)**	38	68	**−0.45 (−0.64 to −0.27)**
'Aircrafts handled'	38	68	**1.85 (0.44 to 3.25)**	38	68	**1.76 (0.50 to 3.03)**
'Time in extreme'	38	68	−0.77 (−0.28 to 0.13)	38	68	0.09 (−0.17 to 0.35)
Model 2						
Age	32	62	0.11 (−0.21 to 0.44)	32	62	−0.01 (−0.38 to 0.36)
Shoulder pain before	32	62	**−0.24 (−0.40 to −0.08)**	32	62	**−0.44 (−0.64 to −0.23)**
'Aircrafts handled'	32	62	**1.74 (0.41 to 3.07)**	32	62	**1.50 (0.40 to 2.60)**
'Time in extreme'	32	62	−0.29 (−0.63 to 0.05)	32	62	−0.03 (−0.37 to 0.32)
'Time in neutral'	32	62	−0.43 (−0.94 to 0.09)	32	62	−0.11 (−0.74 to 0.52)
'Influence'	32	62	**−0.45 (−0.83 to −0.06)**	32	62	**−0.46 (−0.82 to −0.10)**
'Support'	32	62	**0.33 (0.01 to 0.66)**	32	62	**0.38 (0.03 to 0.72)**

CI, confidence interval; $n(s)$, number of workers; $n(d)$, number of shifts; coefficients significantly differing from 0 ($P < 0.05$) are marked in bold.

(4.4%). Work in larger airports differed from that in small airport in the sense that the baggage handlers in larger airports did not perform any other job tasks in-between handling aircrafts, while at smaller airports they would for instance, perform maintenance work in the garage.

Discussion

In this study, we aimed at examining the development of shoulder pain during a single work shift among flight baggage handlers, and at determining to which extent selected biomechanical exposures and psychosocial factors could explain this development. An increase in pain intensity was observed in 35% and 32% of the shifts for the right and left shoulder, respectively, while shoulder pain present in the morning did not change during about 5% of the shifts. The number of 'aircrafts handled' was associated with the increase in shoulder pain intensity. One 'aircrafts handled' operation lasted between 7 and 52 minutes, and between 2 and 12 aircrafts were handled during one shift.

We found an average increase in pain intensity during the work day of 2.3 mm and 2.6 mm for the right and left shoulder, respectively, while also noting that in many shifts no change occurred, often because pain intensity was zero both in the morning and in the afternoon. Some workers even reported less pain in the afternoon than in the morning, which may be explained by a 'warm-up' or training effect during the day if the exposure was not too extreme (Waling *et al.*, 2000).

Our findings indicate that these short-term increases in shoulder pain were associated with biomechanical exposures on the same day. For 63% of the shifts, workers had pain when arriving in the morning. This may indicate a cumulative increase in pain across consecutive workdays, and thus, a transition between effects of exposure on a very short time scale, and effects appearing after a more prolonged period of time.

We were not able to find other studies reporting daily increases in shoulder pain in comparable populations, let alone studies of associations between such changes and daily exposures. One study by Andersen and co-workers (2017), however, compared low-back pain in the morning after a workday among workers at supermarkets to that in the morning after a non-workday, and reported the pain to be larger by 0.55 units (0–10 scale) after workdays. The study even found a cumulative effect on pain of consecutive workdays with high loads. Thus, while that study addresses low-back pain in a different population than flight baggage handlers and found more pronounced effects than we did, we believe our results to point in the same direction.

Our findings add to results in a long-term study reporting heavy lifting, work above shoulder level, carrying, pushing, and pulling, to be associated with the onset of shoulder pain in a 2-year period (Harkness *et al.*, 2003). In that study, new cases of shoulder pain were identified in different occupational settings, and associations were observed for similar work task exposures as in baggage handling work, while over a longer latency time.

In contrast to conclusions in a review by Larsson *et al.*, (2007), low 'influence' and lack of 'support' from colleagues in our study were not independently associated with increased shoulder pain, while they did show up to be significant when analyzed in interaction with additional mechanical exposure variables (model 2). More 'influence' among workers was associated with a decrease in 'daily pain' while more 'support' was associated with increased 'daily pain' (model 2). One tentative explanation for this somewhat unexpected result may be that good support from colleagues leads to a greater acceptance of experiencing and reporting pain.

In our study, more 'time in extreme' arm postures was associated with decreased 'daily pain'. This unexpected result may be explained by workers prone to develop pain during the shift developing a coping strategy where they lift less, work in less awkward postures, and use work devices to a larger extent.

Methodological discussion

The biomechanical exposure data in the present study have a good internal validity since they were collected by means of objective measurements and diaries addressing familiar work tasks taking place on the same day. All workers reported the measured work shifts to be typical for the job. Furthermore, meticulous observations were available to understand the structure and characteristics of the job when handling aircrafts, while other studies often describe work only through job titles. This will obviously give a less differentiated idea of tasks involved in the job, how often they occur, and how long time they are performed. Current pain intensity was measured just before and just after the addressed shift, which eliminates the risk of recall bias. However, information on previous injuries or diagnoses that may have influenced pain ratings, and even ratings of psychosocial factors, was not available and could therefore not be included as covariates in the analysis.

'Aircrafts handled' proved to be associated with 'daily pain'. Our study did not allow a stratified analysis by airport, because measurements were few for all airports but one. Thus, our analyses assume that exposures associated with 'aircrafts handled' are similar across airports, even if we may suspect that they may differ, for instance because different types of aircrafts traffic smaller and larger airports, loading devices are available to different extents, and the amount of checked in baggage will differ.

The present study addressed the extent to which pain development during a shift was associated with extreme and neutral arm postures during the same shift. In previous studies of shoulder pain, upper arm velocity has been suggested to be an important factor of concern (Nordander *et al.*, 2016). However, a previous thorough documentation of biomechanical exposures in the present population (Wahlström *et al.*, 2016) showed that upper arm velocity was moderate compared to that in occupations with an increased occurrence of shoulder disorders. We therefore decided not to include velocity in the present study. The reason that arm velocities are quite low among flight baggage handlers may be that the handled bags are heavy compared to burdens in many other manual handling jobs, which would likely decrease movement velocity. This, however, draws attention to the limitation of the present study that information was not available on the extent to which heavy loads were handled in extreme or neutral postures. We encourage future studies of flight baggage handling to attempt biomechanical modeling of loads, based on combined information on postures and weights of handled bags; or, as an alternative, to measure muscle activity in shoulder muscles using electromyography (Hägg *et al.*, 2000).

Conclusion

We found shoulder pain intensity to increase during approximately one third of the measured shifts. Increased pain intensity during the shift was associated with extreme upper arm postures and the number of aircrafts handled, but these effects were modified by the psychosocial factors influence at work and support from colleagues. Thus, in an effort to decrease and prevent shoulder pain among flight baggage handlers it appears justified to consider a reduction of biomechanical exposures, combined with due attention to psychosocial factors at work.

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Conflict of Interests

The authors declare no conflict of interest with regards to the source of funding for the research or any other support that would have biased the research.

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