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Physical Exposure during Patient Transfer and Risk of Back Injury & Low-back Pain: Prospective Cohort Study

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Abstract

Background

Work-related musculoskeletal disorders (MSDs) are more common among healthcare workers compared with most other professions. Because frequent patient transfer has been associated with increased risk of MSDs, we aim to quantify the physical load associated with commonly used assistive devices and to investigate associations between accumulated physical exposure during patient transfer and risk of MSDs.

Methods

By applying an exposure matrix based on measure¬ments of electromyography and trunk flexion on a large (n=1285) prospective cohort, intensity of low-back pain (LBP) and risk of back injury at 1-year follow-up were modelled using a linear model and logistic regressions, respectively. The cohort was divided into groups based on physical exposure; i.e. low (1st quartile), moderate (2nd and 3rd quartiles) and high (4th quartile) exposure.

Results

Exposure profiles are provided for 9 groups of assistive devices, with ceiling lifts and intelligent beds eliciting the lowest physical exposure. In the fully-adjusted model, we report differences in LBP intensity at follow-up between the low and moderate exposure groups (p=0.0085). No differ-ence was found between the moderate and high exposure groups (p=0.2967). Likewise, we find no associations between physical exposure and risk of back injury at 1-year follow-up, with a prevalence of 11%, 13% and 11% for the three groups, respectively.

Conclusions

Low physical exposure during patient transfer was prospectively associated with lower intensity of LBP. Consistent use of assistive devices associ¬ated with low physical exposure, namely ceiling-lifts and intelligent beds, may play a role in reducing the prevalence of MSDs among healthcare workers.

Background

Work-related musculoskeletal disorders (MSDs) are more frequently reported among healthcare workers compared with other professions [1–4], and 37% of Danish healthcare workers report being

hindered in their profession due to pain [5]. Low-back pain (LBP) is the most commonly-cited musculoskeletal complaint among this subgroup of the working population, with a 1-year prevalence ranging between 28% − 96% [1, 6, 7]. In addition to the individual burden of LBP [8], the socioeconomic costs – e.g. sickness absence and loss of productivity – are likewise alarmingly high [9–11], making the current situation in the healthcare industry a societal issue with far-reaching implications. The severity of the situation is furthermore highlighted by the current global shortage of nurses; estimated to increase by 2030 [12–15]. Thus, identifying risk factors with the goal of improving the local working environment is vital for the profession.

The need for identification of potential risk factors and preventative interventions is furthermore reflected in the fact that the afore-mentioned high prevalence of work-related MSDs among healthcare personnel goes back several decades [16–18]. Likewise, the notion that a high frequency of manual patient transfers is associated with increased risk of low back injury cannot be considered a new finding [19, 20].

Because individualized and/or multimodal approaches are inherently difficult to apply to large populations of the workforce, most interventions to date have focused on identifying possible risk factors that apply to the healthcare profession as a whole [21]. Several of these interventions have focused on the negative consequences of high physical loads throughout the workday [22–24]. For example, a recent prospective cohort study reported that an accumulated high number of physical workloads was associated with an increased risk of overall poor health [22]. Following this, some of the most promising interventions aiming to reduce the physical load among healthcare workers seem to be the ones focusing on decreasing the frequency and/or intensity of manual lifting [25–29]. This is often and most successfully done by increasing the use of assistive devices during patient transfers, as previous studies have reported associations between frequent use and lower risk of back injury and MSDs [30–32]. However, it is currently unknown whether this effect is mainly due to single/specific assistive devices or if it is related to the consistent use of a combination of assistive devices. Following this, in-depth information based on detailed biomechanical measurements regarding the specific risk factors associated with patient transfer and the accompanying benefits of

utilizing specific assistive devices when appropriate, is lacking. Thus, quantifying the biomechanical exposure associated with the use of different assistive devices would be highly relevant when investigating the risk of back injury and LBP in this population.

Therefore, by combining technical measurements of muscle activity and trunk inclination during patient transfers with a prospective questionnaire design, we sought to create an exposure-matrix to identify associations between biomechanical load during patient transfer and the risk of back injury and LBP among healthcare workers.

Methods

In relation to this project we have previously published a protocol describing the technical measurements in detail (Vinstrup et al., 2017). Therefore, the present article refers to this publication and primarily directs its focus on the methods related to the development of exposure profiles.

Study design and participants

This study utilizes the combination of technical measurements and a prospective questionnaire design. Measurements of bilateral erector spinae electromyographic activity (EMG) and trunk forward- & lateral flexion (actigraphy) during patient transfers throughout an entire work day were acquired from 52 female healthcare workers, using wireless equipment (TeleMyo DTS Telemetry, Noraxon, AZ, USA). EMG values consisted of normalized (% of max), 95th percentile ranks from the merged value of the erector spinae muscles.

The results from the technical measurements were used to create an exposure profile for each individual assistive device, comprised of averages from EMG- and accelerometer data.

“No assistive device” was used as reference and given the value “1”. All other assistive devices were assigned exposure profiles relative to this value, based on their combined values from EMG- and accelerometer data in the following manner: The normalized values were divided by the reference to achieve a fraction (e.g. nRMS ceiling-lift/”no assistive device”; 24.0/27.9 = 0.86), and the average of the EMG- and accelerometer values was calculated. In order to weigh the contribution from EMG and kinematics more equally and hereby emphasize the former [34], the average of the two kinetic values was used to calculate the exposure profile; i.e. the average of forward- and lateral flexion represented

one flexion value which was then used to calculate the average of the combined EMG and flexion values. The normalized EMG- and accelerometer values utilized in creating the exposure matrix are found in the descriptive article related to this project, in which descriptions of the included assistive devices as well as demographics of the participants who partook in the field measurements, also are found (Vinstrup 2020, in review). Table 2 shows the exposure profiles of each assistive device based on these measurements.

The survey used in the present study was partially based on the 2018 round of the Danish Work Environment Cohort Study (DWECS) - from which we have previously reported associations between pain, stress and sleep [35, 36] - and included questions concerning lifestyle- and work environment factors among the working population. The baseline questionnaire was sent out to 3329 healthcare workers during the summer of 2017 with a 1-year follow-up. For the purpose of this analysis, a total of 1285 was included as they fulfilled the criteria corresponding to the population from which the technical measurements were collected: Females working as nurses, nurses´ aides and assistants, physio- or occupational therapists, radiographer or porter, engaging in daily patient transfers including patients who were not completely self-reliant and having experienced no back injury within the previous year and with LBP intensity < 6 (0–10). From this cohort, 710 (55%) responded to the follow-up questionnaire and were included in the analysis. Because the presence and intensity of LBP are strong predictors of future LBP [37], we included only healthcare workers with low pain levels and who were injury-free in order to determine if low biomechanical load would elicit a preventative effect against LBP.

By using the exposure profile of each assistive device (technical measurements) and the quantification of frequency of use (survey information), each participant was assigned individual exposure values. Therefore, the individual exposure values were created by initially identifying the relative EMG, forward- and lateral flexion values (i.e. exposure value) inherent to each assistive device, multiplied with the frequency of use for each participant. That is, the more frequent the participant used an assistive device with a certain profile, the closer the participant´s exposure value would be to that of the specific assistive device. The participants were then grouped into quartiles

based on their exposure value, and the two middle quartiles (25–75%) were grouped to represent the norm. Following this, we tested associations between low exposure (1st quartile; n = 175), moderate (2nd and 3rd quartiles, n = 349) and high (4th quartile, n = 186) and the following outcomes:

Outcome variables

Low-back injury and LBP at follow-up were assessed by the following survey questions:

1)
Rate your average pain for the low back within the previous 4 weeks (0–10).
2)
Have you injured your back during patient transfer within the previous 12 months?(yes/no) (Recall if the accident happened suddenly and unexpected)

Control variables

We include 9 groupings of assistive devices (Table 2), all of which was found in the questionnaire: The quantitative use of each individual assistive device was assessed with the following question, with five possible response options ranging from 0/4 (almost never) to 4/4 (every time):

How often do you use this assistive device during patient transfer?

Frequency of patient transfers was evaluated with the question: “How many patients do you transfer per day?” with possible responses ranging from 1) none, 2) less than one per day (e.g. 2–3 per week), 3) 1–2 per day, 4) 3–4 per day, 5) 5–6 per day, 6) 7–8 per day. 7) 9–10 per day to 8) more than 10 per day.

Frequency of patient transfers performed together with one or more colleagues was evaluated with the question “How often are you more than one care worker to do the transfer?” with five possible response options ranging from 0/4 (almost never) to 4/4 (every time).

Finally, self-reliance of the patients was evaluated by asking “How many of your patients are so self-reliant that it is not necessary to use assistive devices during transfers?“; again with five response options again ranging from 0/4 (virtually none) to 4/4 (all patients).

Covariates

In the results section we report fully-adjusted associations between individual exposure values and the outcomes of back injury and low-back pain (table 3 and 4, respectively). The analyses control for the following possible confounders relating to the individual, psychosocial- and working environment as well as the patient transfer scenario itself:

Age, sex, body mass index, smoking, education, physical activity during leisure time, pain intensity < 6 and no back injury within the previous 12 months at baseline, seniority, working hours, overall mental health as well as work-related attitudes towards justice, teamwork, influence, emotional demands, clarity of tasks as well as management recognition and support. Furthermore, we also adjusted for frequency and number of personnel participating in the patient transfer as well as patient self-reliance.

Statistics

All associations were modelled using the General Linear Mixed Model of SAS version 9.4, which can be used for both logistic regression and linear models. Back injury was modelled as a binary outcome (yes/no) during 1-year follow-up, i.e. logistic regression. Back pain intensity was modelled as a continuous outcome at 1-year follow-up, i.e. a linear model. Both analyses were controlled for the covariates mentioned previously, and results are reported as odds ratio (OR) and least square mean differences, respectively, for the lower and upper quartiles in relation to the two middle quartiles (reference). All estimates are provided with 95% confidence intervals and corresponding P-values, with the significance level set to $P < 0.05$.

Table 1

– Demographics, work-, health- and lifestyle variables

	Mean	SD	%
N	710		
Female			100
Age (y)	46.8	11.3	
BMI	24.9	4.6	
Smokers (yes)			9
Years in profession	17.8	11.9	
Working hours/week	34.7	3.4	
Back pain within the previous 4 weeks (0–10)	1.5	1.6	
Back injuries within the previous 12 months	0		
Frequency of patient transfers with more than 1 healthcare worker, ranging from “never” to “always”:			
0/4			3.5
1/4			19.4
2/4			30.8
3/4			26.4
4/4			19.9
Frequency of patient transfers with patients being so self-reliant			
that no assistive device is necessary:			
0/4			17.5
1/4			31.3
2/4			30.9
3/4			20.3
4/4			0.0
Level of leisure-time physical activity within the previous 12 months:			
Sedentary			5.1
Light exercise > 3/week			63.4
Moderate exercise > 3/week			28.3
Vigorous exercise several times per week			3.2

Results

We report exposure profiles for 9 groups of assistive devices, and show that ceiling lifts, intelligent beds, standing aids, masterturners and hospital beds - in ascending order - all elicit low exposure values relative to “no assistive device”. Contrastingly, assistive devices characterized by a more manual approach (e.g. bed sheet, sliding sheet and sliding board) are associated with higher physical exposure (Table 2). Additionally, the incidence of back injuries at follow-up were similar between groups; i.e. 11%, 13% and 11%, for the low, moderate and high exposure groups, respectively.

The risk of back injury at follow-up between groups is shown in table 3, presented as odds ratios (OR) and based on the fully-adjusted model. With the moderate exposure group as reference, we find no significant differences in OR when comparing to low- and high exposure groups ($p > 0.05$). In contrast, when adjusting for the covariates described in the fully-adjusted model, we report a significant

difference in low-back pain at follow-up between the low and moderate exposure groups (-0.50, p = 0.0085). No difference was found between the moderate and high exposure groups (-0.19, p = 0.2967) (table 3).

Table 2
– Exposure profiles for assistive devices

Assistive device	Index	EMG	Forward flexion	Lateral flexion
No assistive device (comparator)	1	1	1	1
Hospital bed	0,8600	0,9211	0,5492	1,0486
Intelligent bed	0,8246	0,8566	0,6792	0,9060
Bed sheet	1,0289	1,0968	1,0065	0,9155
Walking aids	1,0200	0,9892	1,0440	1,0573
Masterturner	0,8582	0,9606	0,7903	0,7215
Sliding sheet	1,0109	1,0860	1,0455	0,8259
Ceiling-lift	0,7762	0,8602	0,6123	0,7721
Sliding board	1,0264	1,2007	1,0788	0,6253
Standing aids	0,8517	0,9283	0,8372	0,7130

Exposure profiles based on the weighted contribution of EMG, forward- and lateral flexion values obtained during full-day field measurements of patient transfers performed in hospitals.

Table 3 – Physical exposure and risk of back injury & intensity of LBP at follow-up.

Values are based on the fully-adjusted model and presented as odds ratios (OR) and differences between least square means (LSM), respectively. CI; confidence intervals.

	Back Injury				LBP	
Exposure	OR (95% CI)	p-value			LSM (95% CI)	p-value
2nd & 3rd quartiles (comparator)	1				1.81	
1st quartile	1.14 (0.52–2.51)	0.7367			-0.50 (-0.89 - (-0.13))	0.0085
4rd quartile	1.36 (0.63–2.92)	0.4309			-0.19 (-0.57–0.18)	0.2967

Adjusted for age, sex, body mass index, smoking, education, physical activity, LBP, back injury, frequency of patient transfer and number of participating personnel, patient self-reliance, seniority, working hours, overall mental health and work-related attitudes towards justice, teamwork, influence, emotional demands, clarity of tasks as well as management recognition and support.

Discussion

The main finding of this study is that low levels of physical exposure during patient transfers are associated with decreased LBP intensity at 1-year follow-up, whereas no associations were found between exposure and the outcome of low back injury.

Additionally, we provide exposure profiles for the most commonly utilized assistive devices and show

that use of the more comprehensive systems, e.g. ceiling-lifts and intelligent beds, generally result in low biomechanical load during patient transfers.

Risk of back injury and LBP

In relation to the risk of back injury, our results are in contrast to a number of studies showing decreased injury rates with the implementation of various lifting policies designed to limit manual handling [25, 27, 28, 38–41]. Several of these studies investigate and credit the ceiling-lift [25, 27, 42–44], which we presently show to elicit the lowest biomechanical load among the included assistive devices. However, these results somewhat contrast the findings of systematic reviews, showing that manual handling training by itself does not lower the risk of musculoskeletal injuries [21, 45]. Therefore, assuming that (increased) use of appropriate assistive devices constitutes the main implementation of manual handling training, it is unlikely that any effect of increasing the use of assistive devices is due solely to a decrease in physical workload. This notion is further supported by the finding that the high exposure group did not experience increased risk of adverse outcomes at follow-up. Although somewhat counter-intuitive when viewed through a biomechanical lens, this finding gives thought to the hypothesis that individuals with a relatively high physical capacity - through experience - share a less catastrophizing view on manual lifting and may indeed benefit from a progressively increasing workload [46, 47].

In the case of LBP, our finding that low biomechanical exposure during patient transfers is associated with a decrease in pain intensity, is adding to an already confused body of research: As is the case with the outcome of back injury, there is presently no convincing evidence of efficacy for any single intervention preventing LBP in workers [21, 48, 49]. Despite this conundrum, appropriate use of assistive devices during patient transfers has been associated with decreased risk of MSDs [26, 31]. However, several distinct work-related factors, including but not limited to work pace, night shifts, standing work, sitting work, static postures, emotional demands, social relations at work, frequent low mood, job strain- and dissatisfaction etc., have also been shown to influence the risk of MSDs [11, 31, 50–53]. In fact, nurses themselves attribute more than 50% of their work-related injuries to inadequate instruction and staffing [54], which serves to illustrate the prevailing attitudes and beliefs

among healthcare workers.

Based on the apparent controversy which likely partially originates from low-quality studies aiming to identify one intervention to rule them all, it has become evident that multiple factors contribute to the high prevalence of MSDs in this population [31, 50, 51, 55]. With the present analyses we add to the literature by showing that - even when accounting for several known confounders - consistent and appropriate use of technologically-advanced assistive devices may contribute to a protective effect against LBP in healthcare workers. Within the complex model of the biopsychosocial approach to health and its growing role within healthcare [56, 57], it is therefore not unlikely that the “bio”-aspect can be improved upon by diminishing the accumulative physical load throughout a day, month and career [22–24].

Perspectives

We have previously reported that healthcare workers in Danish hospitals utilize assistive devices during less than half of patient transfers (Vinstrup 2020, in review). It may seem counter-intuitive of a working population, characterized by experiencing a high prevalence of MSDs and end-of-day fatigue, to perform the majority of patient transfers without the use of assistive devices. However, because the most commonly-reported barriers for appropriate use of assistive devices include time-restraints and equipment availability [58–60][58, 59][58, 59][58, 59], it is likely that these factors modulate and indeed questions which assistive device, if any, is actually appropriate in the multi-faceted situation that constitutes the patient transfer scenario. Following this, a recent prospective study by Kucera and colleagues investigated multiple factors associated with appropriate use of assistive devices, and found that – in addition to the frequently reported importance and lack of staff- and equipment availability [61] – patient characteristics such as medical condition, mobility level and the presence of physical or mental impairments were associated with the use of assistive devices [59]. Likewise, a 2019- Cochrane Review indicates that patients influence the healthcare personnel´s practice and performance in numerous ways [62], and several studies illustrate how a myriad of work-related factors (e.g. self-efficacy, organizational safety climate, adequate guidance, job strain – and dissatisfaction, time-restraints, easiness of use, equipment location and compatibility, patient

preference etc.) influence whether or not healthcare workers engage in the use of appropriate assistive devices [51, 54, 59, 60, 63].

Collectively, the overall message is therefore that a broad array of situational-specific factors contributes to the decisions taken by healthcare workers during patient transfer scenarios. As indicated by the ever-increasing number of largely ineffective single-mode interventions, it seems evident that the multi-factorial issue at hand is hardly solved by one type of intervention alone [48, 63–66].

Strengths and limitations

Limitations of this study include the inherent recall-bias that accompanies prospective questionnaire designs, as well as the uncertainty attached to correctly reporting subjective outcomes such as injury and pain intensity. The potential issue regarding generalizing physical exposure associated with specific assistive devices based on technical measurements on 52 healthcare workers as well as the inherent limitations of using EMG- and kinematic measurements as indicators of biomechanical exposure have been discussed previously (Vinstrup 2020, in review).

Strengths of this study include the combination of technical measurements with a prospective design, which allows for applying objectively measured indicators of biomechanical load to a large cohort of healthcare workers. Furthermore, the exposure matrix presented for commonly-used assistive devices is believed to prove highly useful in everyday practical settings, as it provides a level of detail that is novel to the field.

Conclusion

Low physical exposure during patient transfer was prospectively associated with lower intensity of LBP at 1-year follow-up. Consistent use of assistive devices associated with lower exposure, e.g. ceiling-lifts and intelligent beds, is important for reducing the high prevalence of MSDs among healthcare workers. Hospitals aiming to improve the working environment could therefore benefit from implementing these assistive devices.

Declarations

Ethical approval and consent to participate

In line with the Helsinki Declaration, all participants were informed about the content of the study

protocol before providing written informed consent. For the technical measurements, the information was given both written and verbally before commencement of data collection.

The study was approved by the Danish National Committee on Biomedical Research Ethics (The local ethical committee of Frederiksberg and Copenhagen; H-3-2010-062) and the Danish Data Protection Agency (j.nr. 2015-41-4232). All data was de-identified and analyzed anonymously.

Consent for publication

(N/A)

Availability of data and materials

Researchers interested in the data should contact the project leader Lars L. Andersen.

Competing interests

There are no conflicts of interest.

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Authors´ contributions

Conceptualization: LLA. Data collection: JV. Data analysis: JV, MDJ, LLA, PM. Draft: JV. Review and editing: MDJ, LLA, PM.

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