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Original Articles

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Evaluation of a Training Program to Reduce Stressful Trunk Postures in the Nursing Professions: A Pilot Study

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Abstract

Objectives: The aim of this pilot study was to evaluate metrologically the effectiveness of a training program on the reduction of stressful trunk postures in geriatric nursing professions.
Methods: A training program, consisting of instruction on body postures in nursing, practical ergonomic work methods at the bedside or in the bathroom, reorganization of work equipment, and physical exercises, was conducted in 12 wards of 6 nursing homes in Germany. The Computer-Assisted Recording and Long-Term Analysis of Musculoskeletal Loads (CUELA) measurement system was used to evaluate all movements and trunk postures adopted during work before and 6 months after the training program. In total, 23 shifts were measured. All measurements were supported by video recordings. A specific software program (WIDAAN 2.75) was used to synchronize the measurement data and video footage.
Results: The median proportion of time spent in sagittal inclinations at an angle of >20° was significantly reduced (by 29%) 6 months after the intervention [from 35.4% interquartile range (27.6–43.1) to 25.3% (20.7–34.1); $P < 0.001$]. Very pronounced inclinations exceeding 60° [2.5% (1.1–4.6) to 1.0% (0.8–1.7); $P = 0.002$] and static inclinations of over 20° for >4 s [4.4% (3.0–6.7) to 3.6% (2.5–4.5); $P < 0.001$] were significantly reduced, by 60% and 22%, respectively. Video analysis showed that in 49% of care situations, ergonomic measures were implemented properly, either at the bedside or in the bathroom.
Conclusions: Stressful trunk postures could be significantly reduced by raising awareness of the physical strains that frequently occur during a shift, by changes in work practices and by redesigning the work environment. Workplace interventions aimed at preventing or reducing low back pain

in nursing personnel would probably benefit from sensitizing employees to their postures during work.

Keywords: bending; ergonomics; geriatric nurses; metrological evaluation; musculoskeletal disorders; stressful trunk posture; training program

Introduction

Although low back pain (LBP) is common among the working-age population and the causes are multifactorial (Balague *et al.*, 2012), nursing personnel are more likely to suffer from LBP than the general population. A recent review found that the 12-month mean prevalence of LBP in nursing personnel is 55% (Davis and Kotowski, 2015). A review of the global prevalence of LBP in the general population reported a lower mean prevalence of 38% (Hoy *et al.*, 2012). The development of LBP is attributed to the frequency of transfers (Engkvist *et al.*, 2000; Holtermann *et al.*, 2013), as well as the repositioning and handling of patients (Smedley *et al.*, 1995; Eriksen *et al.*, 2004). A recent review of the work relatedness of LBP in nursing personnel found convincing evidence of a causal relationship between the mechanical stress caused by patient-handling activities and LBP. However, other patient care tasks—such as bathing, dressing, or feeding—are also associated with an elevated risk and confound the dose–response assessment of patient lifting alone (Yassi and Lockhart, 2013).

Interventions to reduce or prevent physical workload and LBP in nursing have been studied for many years and mainly focus on training in manual patient handling (Videman *et al.*, 1989; Best, 1997), exercise training (Dehlin *et al.*, 1981; Gundewall *et al.*, 1993), stress reduction training (Horneij *et al.*, 2001), or multidimensional strategies (Garg and Owen, 1992; Alexandre *et al.*, 2001). Four systematic reviews have evaluated the effect of interventions on prevention or reduction of LBP and injuries in health professions and demonstrate moderate level of evidence for multidimensional intervention strategies (e.g. education and training combined with an ergonomic intervention). However, they found high evidence that interventions based solely on training in patient handling had no effect on LBP (Hignett, 2003; Bos *et al.*, 2006; Dawson *et al.*, 2007; Tullar *et al.*, 2010). Since training in manual handling alone—which has been the principle focus of workplace interventions—is unlikely to be successful in reducing musculoskeletal disorders (MSD), other work-related aspects need to be taken into account.

Although lifting and transferring patients impose high strains on the spine, nurses spend only a short time on these tasks during the course of a working day. Hodder *et al.* (2010) found that patient care tasks (e.g. bathing, dressing, and feeding) and miscellaneous tasks (e.g. making beds) account for almost 50% of shift duration, while lifting accounted for only 4%. Similarly, Freitag *et al.* (2007) found that, on average, 2 min per shift were spent transferring patients. To perform patient and non-patient care activities, nurses frequently had to bend forward or work for extended periods in a static trunk inclination. Repeated bending and awkward trunk postures are under consideration as additional risk factors for the development of LBP, as they increase the exertion and muscle power required to complete a task (Occupational Safety and Health Administration, 2009). To our knowledge, only a few intervention studies have focussed on postural alignment (Engels *et al.*, 1998; Pohjonen *et al.*, 1998; Fanello *et al.*, 1999; Nussbaum and Torres, 2001). Compared to controls, they found a significant increase in upright/safe postures and fewer errors after ergonomic educational training.

In a prior study in geriatric wards, we found that sagittal inclinations exceeding an angle of 60° were most often triggered by bed making (22%), clearing up/cleaning (16%), and basic care activities (16%) (Freitag *et al.*, 2007). In a subsequent experimental study, we examined the influence of different bed heights (knee, thigh, and hip) and work methods in the bathroom (standing, kneeling, and sitting) on forward-bending postures. The proportion of time spent in an upright position increased significantly, by almost 20%, when the bed was raised from thigh to hip height. Similarly, working in a sitting, rather than a standing, position in the bathroom resulted in a significant increase (26%) in the time spent in an upright position (Freitag *et al.*, 2014).

Taking the preliminary findings into account, the objective of the present study was to conduct and evaluate the effectiveness of a training program aimed at reducing stressful trunk postures in geriatric nurses, by raising their awareness of frequent bending occurring during specific care tasks and procedures. Moreover, the training program also included instructions in practical ergonomic work at the bedside and in the bathroom, as well as ergonomic reorganization of working materials and redesign of residents' room.

Methods

Study procedure and population

A convenience sample of six facilities, each with two wards, took part. Two voluntary participants were recruited from each participating ward. They were measured using the personal Computer-assisted Recording and Long-term Analysis of Musculoskeletal Loads (CUELA) measuring system throughout an early shift, before and after the intervention. The first measurement was conducted 2 weeks before the start of the intervention, and the same subjects were measured again 6 months later. In order to minimize disruption of the regular ward routine during measurement, only one measuring system per ward and early shift was used. Two measuring systems were used in parallel in the two wards of the respective facility. The measurements were taken on two consecutive days.

There were several conditions for inclusion in the study. During the study phase, the institutions had to have exclusively height-adjustable beds, and they were not to be planning any alterations, certifications, mergers, or other research projects during this period. Participants who wore the CUELA measuring system had to be prepared to take part in the training activities. They had to be female, without a senior management position, and not trainees. Moreover, the participants had to be available for at least three-quarters of a year (i.e. they had no intention to resign or change jobs and were not pregnant or planning any lengthy in-service training or leave of absence). Participants had no back problems that might have inhibited their performance of specific care tasks. Furthermore, all employees and managers of the participating wards had to attend the basic seminar.

A total of 23 early shifts (T_0) were measured and recorded. During the second measurement, we identified measurement uncertainties attributable to the CUELA system in three participants. Measurement of another participant had to be terminated prematurely for personal reasons. We therefore obtained complete measurement data (T_1) for 19 participants.

In the participating facilities, all participating employees, residents, and their relatives were given detailed information about the study goals and programs (e.g. measuring system, video filming) in advance, and consent forms were obtained for participation and for videos and photos to be taken. This study was approved by the Ethics Committee of the Hamburg Medical Association (Ärztekammer Hamburg, Germany).

Contents of the intervention program

To reduce stressful trunk postures, we designed a 2-day basic seminar and two follow-up training sessions. In each facility, intervention began with a basic seminar in which not only the test participants but also all employees of the two participating wards were involved. In order to maintain regular operations in the wards, the seminar was held twice in each facility, with half the employees from each of the two wards participating on each occasion. The basic seminar focused on the theory of body postures in the care professions, on body awareness training and physical exercises, on setting/equipment modifications, and on practical ergonomic work methods at the bedside and in the bathroom. In a participatory ergonomic intervention, we began by describing and discussing the occupational risks of musculoskeletal MSD in the care profession. Pictorial material was then used to sensitize participants to the body postures that they frequently adopted during a work shift. The corresponding work situations were then analysed interactively, and alternative ergonomic solutions were discussed. The aforementioned laboratory study not only showed that raising the bed height and using a stool in the bathroom led to a reduction in unfavourable body postures but also that when participants adhered to these ergonomic principles they felt that their work was less stressful (Freitag *et al.*, 2014). These findings were taken into account in practical implementation of ergonomic ways of working at the residents' bedsides and in the bathroom (Table 1).

Eight weeks after the basic seminar, we held a half-day follow-up training session, followed by another 12 weeks later. These follow-up training sessions were offered only to test participants and took the form of advice and support during an early shift. Two weeks after the basic seminar, we conducted a telephone interview with the participants. This was followed by a second telephone interview 2 weeks after the first follow-up training session. Respondents were asked to report the extent to which they were implementing the seminar contents in their daily work. Those who had difficulties with implementation were asked about the underlying reasons. For this purpose, we used a standardized interview guide with 18 closed or open questions. Open questions were analysed by frequency of citation (see Supplementary Table 1 is available at *Annals of Work Exposures and Health* online).

Questionnaire

A questionnaire was used to establish the following variables for participants: age, weight, height, professional experience (in years), type of training (geriatric nurse, hospital nurse, or geriatric or nursing care assistant), occupational status (no leading position, deputy ward manager, ward manager), scope of employment (full time or part-time), general state of health (five-point Likert scale), work ability (five-point Likert scale), and whether they had any illness or injury that impeded their

Table 1. Contents of the intervention program.

Knowledge transfer on body postures in nursing professions
Information on physical strains in nursing care and the associated risks to the musculoskeletal system, with the focus on the spine
Ergonomic findings from previous studies in nursing care
Body awareness training and physical exercises
Body postures at work (e.g. to sensitize participants to the body postures adopted while working, photographs of actual care situations were shown, and body postures in the corresponding work situation were discussed)
Body strength and coordination training (e.g. to raise participants' awareness of their own body tension and posture, various exercises were taught on coordination and body tension)
Physical exercises (e.g. to strengthen and relax the spine muscles, exercises that can be carried out during routine work were demonstrated)
Ergonomic practical instructions
Basic care activities were carried out at a typical resident's bedside and in the bathroom. The aim was for participants to draw a direct comparison and sense for themselves just how much working with a raised bed or sitting on a stool relieves strain
Every participant was asked to perform activities twice in succession: (i) first at a low bed (thigh height) and then with the bed at the optimal (hip) height, (ii) first in a standing or kneeling position and then sitting on a stool in the resident's bathroom
Reorganization and redesign
Reorganization of working materials and ergonomic redesign of the resident's room (e.g. frequently used utensils or clothing were re-sorted and placed at an ergonomic height)
Use of a care basket for stowing care utensils in daily use. This is intended to prevent repeated bending forward to the bedside cupboard
Use of a laundry basket to reduce repeated bending to pick up dirty laundry from the floor

work performance. We subsequently calculated body mass index from the weight and height variables.

While the measurements were being taken, the ward managers of the 12 participating wards were questioned about the following aspects: number of (height-adjustable) beds and current occupancy, number of qualified and non-qualified care workers on the early shift, and availability of aids (e.g. lifters, sliding mats, transfer boards). A nurse-to-resident staffing ratio was calculated by dividing the number of occupied beds per ward by the number of nurses on the early shift.

Measurement system and video recordings

The CUELA measurement system and video analyses were used to evaluate this intervention. CUELA has been demonstrated to have good validity and reliability in laboratory investigations and field studies (Berufsgenossenschaftliches Institut für Arbeitsschutz, 1998; Ellegast *et al.*, 2009). Figure 1 shows the measuring system in use on a geriatric care ward. Sensors on the thoracic and lumbar spine recorded data on locational and angular positions at a frequency of 50 Hz. This permits accurate kinematic reconstruction of the subject's movements. The participants were able to move freely without restrictions since they were not connected to any external components. They were instructed to carry out their work as usual. The measuring system was only switched off during breaks, documentation, or handover interviews, since these work tasks are normally performed while sitting. For each measurement, participants were filmed throughout the shift. Specially developed software (WIDAAN 2.79) was used to synchronize the measurement data and video footage. Thus, it allowed precise allocation of the measurement data to each work task performed by the nurse during the shift. For accurate synchronization of real-work situations, an animated computer figure represented the corresponding measured values (Freitag *et al.*, 2007, 2012).

Care intensity score

The intensity of care for individual residents and thus the basic care required (e.g. bed making, washing, or dressing) varies considerably. In order to take this into account, in a preliminary study, we developed a basic care intensity score (Freitag *et al.*, 2012). This score was assessed for both time points, in order to examine whether intensity of care differed or remained constant over time. The number of residents a nurse had to care for while measurements were being taken was ascertained by video analyses. Each resident was allocated a number of points corresponding to the effort expended (1 = nurse only made the bed; 2 = nurse made the bed and <50% of basic care activities; 3 = nurse made the bed and >50% of basic care activities). This figure was added to the total points for the particular shift. The higher the total score per nurse, the higher the intensity of care provided to residents (Freitag *et al.*, 2012).

Figure 1. A nurse is wearing the CUELA measurement system while working. Sensors on the thoracic and lumbar spine deliver three-dimensional data on trunk movements.

Trunk postures and video analysis

According to ISO 11226 (ISO, 2000) and DIN EN 1005-4 (DIN, 2005), sagittal inclinations between 0° and 20° are within the acceptable range and are designated as upright postures. Pressure on the spinal disk is lowest in this position. It increases in line with increasing sagittal inclination (Wilke *et al.*, 1999). Sagittal inclinations between 20° und 60° are classified as conditionally acceptable and of >60° as unacceptable (ISO, 2000; DIN, 2005). According to DIN EN 1005-1 standard (DIN, 2002), trunk postures that were maintained for >4 s at a constant or slightly changing force were defined as static postures. We calculated the frequency and the proportion of the work shift spent in those postures. The functioning of the measuring system and the ergonomic evaluation of body postures in a care setting have been described in detail in earlier publications (Freitag *et al.*, 2007, 2012).

The video recordings made during the follow-up measurements were evaluated by a skilled observer, who began by identifying the number of care situations for each participant at the bedside and in the bathroom. The observer then assessed whether the participant implemented the proper measures at the bedside (raising the bed to hip height) and in the bathroom (using a stool). If the bed was raised to thigh height only, the observer rated the measure as having been partially implemented. However, in few basic care situations, the residents requested us to switch off the camera for privacy reasons.

Statistical analyses

The metric variables were expressed as a mean with standard deviations or median with interquartile range; categorical data were presented as counts (percentages). Differences between two measurements were assessed by using a paired-samples *t*-test and, as a non-parametric alternative, a Wilcoxon matched pair signed-rank test. Hodges–Lehman estimates for the differences between two samples with a 95% confidence interval were presented. In addition, we calculated the relative change between the two measurements $[(T_1 - T_0)/T_0] \times 100$. *P*-values of <0.05, two-tailed, were considered statistically significant. Analyses were performed with IBM SPSS Version 22.0.

Results

Measurement data were available from 23 participants at baseline and from 19 participants at a 6-month follow-up. After a short adjustment period, participants became accustomed to the system while performing daily tasks; no restrictions on functionality and performance were reported. The mean measurement time per shift was similar at baseline and follow-up (326 and 315 min, respectively). All 12 wards were almost fully occupied and equipped with ergonomic aids and height-adjustable beds. A nurse-to-resident ratio of 1:8 showed that on average one nurse cared for eight residents per shift. The mean basic care intensity score was nearly identical for the two time points (21 points), though more residents were in need of intensive care (Stage 3) (Table 2). The participants had worked an average of 17 (± 8.7) years in the care sector. Almost two-thirds worked part-time, were registered nurses, or held no leading position. The majority rated their health as good or very good. Impairment due to disease or injury was reported by five participants (22%), but only one person had some restrictions during work. Twenty-two percent rated their work ability as fair. Further participant characteristics are shown in Table 3.

After the intervention, the median proportion of time spent in sagittal inclinations exceeding 20° was significantly reduced, by 29% ($P < 0.001$), from 1772 to 1708 median trunk movements per shift. The proportion of very pronounced inclinations exceeding 60° was reduced by 60% ($P = 0.002$), from 288 to 135 inclinations per shift. A significant reduction in static inclinations was also detected (22%; $P < 0.001$), from 462 to 329 inclinations per shift (numbers of inclinations not in the table). The median time spent in sagittal inclinations exceeding 20° was reduced by 27 min per shift (Table 4).

Results of the video analyses at the second measurement show that in total 217 basic care activities at the bedside were observed. As recommended by the seminar instructor, the bed was raised to hip height in 44.7% of all care situations. However, in 44.2% of situations, the bed was partially raised, and in 11.1%, the bed was not raised at all. In total, 52 care situations in the bathroom were observed. A stool was used in 67.3% of these situations to perform basic care in the sitting position; in 32.7% of the situations, the stool was not used by the nurses (Table 5).

Supplementary Table 1 available at *Annals of Work Exposures and Health* online shows the main results of the first telephone interviews 2 weeks after the seminar. Participation rate in the first interview was 96% ($N = 22$) and in the second interview 57% ($N = 13$). Since there were no relevant differences in responses between the first and second interviews, we analysed information gained from the first telephone interview on account of the high participant rate. All participants reported that they were more conscious of adopting awkward postures during work. The majority (96%) paid more attention to raising beds to an ergonomic height. However, 50% admitted to not having adjusted the bed properly in some stressful working situations. The majority (91%) reported that they had performed some bedside tasks differently (e.g. using ergonomic mobilization techniques) or had reorganized residents' wardrobes or drawers (e.g. placing frequently used laundry or equipment at an ergonomic

Table 2. Ward- and care-related factors.

Ward-related factors (N = 12 wards)	**Proportions (95% CI)**
Residents per nurse and per shift (n)	8.1 (7.2–9.0)
Occupancy rate	96% (93%–97.4%)
Rate of height-adjustable beds	100% (72%–100%)
Rate of wards equipped with ergonomic aids[a]	92% (63%–100%)
Rate of registered geriatric nurses per shift	50% (35%–65%)
Care-related factors (N_{T0} = 23 participants)	**Mean (± SD)**
Basic care intensity score (points)	T_0 21.0 (± 4.8); T_1 21.6 (± 6.4)[b]
Number of patients provided with basic care—Stage 1[c]	T_0 1.1 (± 1.1); T_1 1.3 (± 1.4)[b]
Number of patients provided with basic care—Stage 2[d]	T_0 0.6 (± 0.8); T_1 0.5 (± 0.8)[b]
Number of patients provided with basic care—Stage 3[e]	T_0 6.2 (± 1.5); T_1 6.5 (± 2.0)[b]

CI, confidence interval; SD, standard deviation.
[a]Gliding boards, lifters.
[b]Statistically not significant.
[c]Stage 1—making beds; no other basic care tasks.
[d]Stage 2—making beds and <50% of other basic care tasks.
[e]Stage 3—making beds and >50% of other basic care tasks.

Table 3. Characteristics of the participants (N_{T0} = 22[a]).

Demographic and work-related factors	N (%) or mean (± SD)
Age (years)	
≤39	4 (17.3)
≤49	11 (47.8)
≤59	7 (39.1)
Height (cm)	167 (± 7.6)
BMI	23.4 (± 3.1)
Professional experience (years)	17 (± 8.7)
Part-time employment	14 (60.9)
Educational background	
Registered (geriatric) nurse	14 (60.9)
Nursing assistant	8 (34.8)
Managerial position	
No leading position	15 (65.2)
Group or deputy ward manager	7 (30.3)
Health-related factors	
Health status	
Excellent or very good	8 (34.8)
Good	11 (47.8)
Less well	2 (8.7)
Impairment due to disease or injury	
No impairment	16 (69.6)
Complaints but no restrictions during work	4 (17.4)
Complaints and some restrictions during work	1 (4.3)
Work ability (regarding physical strain)	
Excellent	6 (26.1)
Quite or very good	10 (43.5)
Fair	5 (21.7)

BMI, body mass index; SD, standard deviation.
[a]Complete information for one case was missing; information on health-related factors was missing for another case.

height). To avoid frequent bending, they also used a care basket for daily care utensils (100%), a laundry basket (64%), and a stool during care activities in the bathroom (64%). Only a few participants (14%) encountered some problems when implementing these measures. The main reasons were time pressure due to understaffing, other priorities, or residents requesting otherwise.

Discussion

In this metrological evaluation, we found that frequent bending by geriatric nursing staff could be significantly reduced by means of participatory ergonomics, body and posture awareness training, and physical training. The time spent in sagittal inclinations of >20° was significantly reduced, from ~2 to 1.5 h per shift, 6 months after training. Video analyses showed that in 49% of the care situations, ergonomic measures were implemented as recommended, either at the bedside or in the bathroom. These observations suggest that there is considerable additional potential to further reduce frequent bending. Overall, the participating nurses judged the scope and content of the training as helpful and appropriate. One should bear in mind, however, that our training program was not aimed primarily at reducing LBP but at increasing overall awareness of body postures and physical strains that nursing staff hardly notice during their work.

In line with our previous findings, at baseline, the geriatric nurses spent 36% of the measured time in a forward-bending position (Freitag *et al.*, 2012). However, results of continuous posture monitoring studies in geriatric nurses showed that less time was spent in flexed postures (Jansen *et al.*, 2001; Hodder *et al.*, 2010; Ribeiro *et al.*, 2011). By using an inclinometer, Jansen *et al.* (2001) showed that geriatric nurses spent ~21% of their working time at an angle of >20°, and in the study by Hodder *et al.* (2010), the participants spent 25% of their time at an angle of >30°. Using the Spineangle accelerometer, Ribeiro *et al.* (2011) showed that 5% of work time was spent in flexed postures at an angle of >30°. These substantial differences were mainly the result of the different devices used and the location in which they were attached to the body. While we measured the mean inclination of the entire trunk, Jansen *et al.* (2001) and Ribeiro *et al.* (2011) measured the inclination of the lumbar spine and Hodder *et al.* (2010) measured the inclination of the thoracic spine.

When monitoring trunk postures during work, it should be noted that 19% of all non-neutral inclinations are coupled with lateral and/or torsional movement of the trunk (Freitag *et al.*, 2007). However, we evaluated the sagittal inclinations of the trunk, as these movements are associated with increased intradiscal pressure, resulting in greater spine loads than twisting or lateral bending (Nachemson, 1975). As in our previous study, we detected a large number of static postures per shift (Freitag *et al.*, 2012). After training, these were significantly reduced by 22%. Nurses themselves reported static postures as one of the main physical stressors at work (Engels *et al.*, 1996). In a study involving a course in ergonomic education, a decreasing trend in awkward postures and errors while performing nursing tasks was observed in the group receiving this intervention (Engels *et al.*, 1998).

After being made aware of the repeated bending during a shift and the actual time needed to raise a bed, the majority of participants in the present study

Table 4. Time spent in different trunk postures before and after the intervention.

Inclinations	$Mdn_{baseline}$ (IQR)	$Mdn_{follow-up}$ (IQR)	Hodges–Lehman estimates (95% CI)	RC (%)	*P* value
Proportion of SI ≥ 20° (%)	35.4 (27.6–43.1)	25.3 (20.7–34.1)	−7.7 (−11.1 to −4.3)	−29	<0.001
Proportion of SI ≥ 60° (%)	2.5 (1.1–4.6)	1.0 (0.8–1.7)	−1.3 (−3.2 to −0.5)	−60	0.002
Proportion of static SI ≥ 20° for >4 s (%)	4.4 (3.0–6.7)	3.6 (2.5–4.5)	−1.4 (−2.3 to −0.6)	−22	<0.001
Duration of SI ≥ 20° (min)	104 (90–134)	77 (66–103)	−27.3 (−40.5 to −15.5)	−26	<0.001

CI, confidence interval; IQR, interquartile range; Mdn, median; RC, relative change $[(T_1 - T_0)/T_0] \times 100$; SI, sagittal inclinations.

Table 5. Implementation rates of work methods at the bedside and in the bathroom.

Location	Care situations per shift and nurse	Measure implemented correctly	Measure partly implemented	Measure not implemented
	N	*n* (%)	*n* (%)	*n* (%)
At the bedside	217	97 (44.7)	96 (44.2)	24 (11.1)
In the bathroom	52	35 (67.3)	—	17 (32.7)
Total	269	132 (49)	137 (51)	

reported that they paid more attention to raising beds to an ergonomic height. However, one-half also reported situations where they did not raise a bed appropriately. They frequently explained this with stress or time pressure (Supplementary Table 1 is available at *Annals of Work Exposures and Health* online). This coincides with the video analyses, in which we found that in 55% of bedside care situations, nurses only partially raised the bed, if at all. Although proper adjustment of the resident's bed resulted in better working postures and less strain on the body (Freitag *et al.*, 2014), nurses argued that this procedure was time consuming (Petzäll *et al.*, 2001). However, it takes an average of 53–59 s to raise a bed from knee to hip height (Freitag *et al.*, 2014). One further reason why nurses often failed to adjust beds to hip height could be a lack of awareness of how often they bend their trunk forward during a shift (Freitag *et al.*, 2007, 2012). As regards the use of stools during personal care, we found that more than two-thirds of nurses performed basic care in the sitting position. This was confirmed by the interviews (64%). Although we did not ask for impediments, we assume that a lack of space for manoeuvre in residents' bathrooms might be one reason. Another possible explanation is that nurses are not accustomed to perform basic care in a sitting position.

Several studies have shown that nurses spend a high proportion of time in non-patient-handling tasks during a shift (Engels *et al.*, 1994; Freitag *et al.*, 2007; Hodder *et al.*, 2010; Holmes *et al.*, 2010). Merely focusing on patient-handling tasks such as lifting or repositioning may therefore lead to an underestimation of the overall strain in nursing. As regards the relationship between occupational postural exposure such as frequent or sustained flexion and the development of LBP, conflicting evidence has been reported (Bakker *et al.*, 2009; Ribeiro *et al.*, 2012). Systematic reviews using Bradford–Hill criteria for causality conclude that occupational bending/twisting and awkward postures are not independently causative of LBP (Roffey *et al.*, 2010; Wai *et al.*, 2010). Body posture may lead to excessive biomechanical stress on the musculoskeletal system, although epidemiological studies suggest that the role of body posture on the development of LBP is debatable (Solomonow *et al.*, 2003; Olson *et al.*, 2004; Solomonow, 2004). Wai *et al.* (2010) suggested that differences in the outcome and postural measurement approaches may lead to inconsistent results for this relationship. Nonetheless, several studies on nursing professions reported a positive association between postural exposure and LBP (Josephson *et al.*, 1998; Jansen *et al.*, 2004; Yip, 2004). According to Holtermann *et al.* (2013), frequent lifting and carrying of a low load mass with the back bent forward doubled the risk of chronic LBP in female nursing staff, whereas lifting and carrying any load mass with an upright back did not increase the risk.

The advantage of our study was the use of the CUELA measurement system coupled with video recordings to evaluate the effectiveness of the training program. As no external connection to system components was required and the weight of the equipment was reasonable (2.7 kg), the nurses could move freely and without limitation in performing their daily care routine. The WIDAAN specially developed software synchronized the measurement data and video recordings, so that each trunk posture could be assigned to the corresponding work situation.

Several limitations should be pointed out. When we set out to implement and evaluate the training program in body postures in geriatric care facilities, we faced some acquisition problems. Facilities refused to participate in this study—mainly because their daily routine had to be filmed while measurements were taken. There may therefore be a selection bias that might affect the generalizability of the study results. Although residents had given their consent to video recordings, in few basic care situations, we were asked to switch off the camera for privacy reasons. Thus, the proportion of the care activities might have been underestimated. As the video footage might not display the complete working tasks, the evaluation of the effectiveness could show some inaccuracies.

Another drawback arises from the observation bias, also known as the Hawthorne effect. As the participants had to wear the measurement system and were filmed while working, it is likely that they automatically changed their behaviour to fit the expected results. Hence, our results may considerably underestimate the frequency and duration of sagittal inclination. In the previous CUELA study, the nurses also reported that patients made an unusual effort to cooperate with them during the course of measurement (Freitag *et al.*, 2012).

Implementation of the CUELA system made high logistical demands on participating facilities and the research team. Therefore, only two voluntary participants from the two wards in each facility were measured and videotaped during work. As a result, the sample size was rather small. In addition, the focus in this work-site intervention was on relatively short-term training effects rather than on potential prevention or reduction of LBP injury. The sustainability of such ergonomic training is therefore doubtful and has to be explored in further studies investigating health-related outcomes with frequent refresher units and at least a 1-year follow-up.

Furthermore, results from pre-experimental designs (without a control group) should be interpreted with caution, since they pose a threat to the internal validity. To examine the significance of the behavioural change due to the training program, a randomly selected control group should be considered to reduce the effect of known or expected sources of variability, and thus to improve the precision of our results, to exclude alternative explanations, and to establish a causal relationship. However, the study presented here pursues an exploratory approach to establish whether the observed effect is worthy of further investigation. The effectiveness of this training concept should be investigated by a randomized controlled trial with extended follow-up periods. On the basis of the results of this study, we estimated that with a power of 90%, 12 wards with three individuals per ward would be sufficient for a proper cluster randomized controlled trial to validate the effects.

In this evaluation, we did not quantify the effects of force on the spine. Future studies should consider continuous posture monitoring to evaluate low back loads. Holmes *et al.* (2010) used an inclinometer to evaluate peak and cumulative lumbar spine loads in long-term care nurses. Eighty percent of cumulative compression originated from activities such as personal care, unloaded standing, walking, or other activities, whereas 10% resulted from lifting and transferring patients. Although transfers and lifts contributed to high peak loads, little time was spent on those tasks (Holmes *et al.*, 2010). Focusing on patient handling to determine the load on the musculoskeletal system would therefore lead to an underestimate of nurses' total working posture load. Vieira and Kumar (2006) argue that a reduction in peak load may not reduce the risk of lower back injury when the cumulative load increases.

Conclusion

This study showed a significant improvement in body postures after implementation of a training concept consisting of instruction on frequent body postures in nursing, physical exercises, instructions in practical ergonomic work at the bedside and in the bathroom, and reorganization of work environment. As nurses spend a large proportion of time on basic care tasks and these tasks may have the greatest effect on cumulative load, future investigations on prevention and reduction of LBP in nurses may profit by including elements on postural alignment in addition to patient-handling techniques.

Supplementary Data

Supplementary data are available at *Annals of Work Exposures and Health* online.

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