International Journal of Nursing Studies 99 (2019) 103389

Contents lists available at ScienceDirect

International Journal of Nursing Studies

journal homepage: www.elsevier.com/ijns

Evaluation of the effectiveness of the sliding sheet in repositioning care in terms of working time and subjective fatigue: A comparative study with an experimental design

Yuka Omura[a,*], Yuki Yamagami[a,b], Yutaka Hirota[a], Eiji Nakatani[a,c,d], Tomomi Tsujimoto[a], Tomoko Inoue[a]

[a] *Division of Health Sciences, Osaka University Graduate School of Medicine, Japan*
[b] *Department of Epidemiology, Nara Medical University School of Medicine, Japan*
[c] *Division of Medical Statistics, Translational Research Center for Medical Innovation, Foundation for Biomedical Research and Innovation at Kobe, Hyogo, Japan*
[d] *Division of Statistical Analysis, Research Support Center, Shizuoka General Hospital, Shizuoka, Japan*

ARTICLE INFO

Article history:
Received 29 January 2019
Received in revised form 21 June 2019
Accepted 27 July 2019

Keywords:
Assistive device
Caregiver burden
Experimental design
Low back pain
Nursing
Patient transfer
Repositioning
Subjective fatigue
Working time

ABSTRACT

Background: Manual patient handling is a major cause of low back pain among healthcare staff. The sliding sheet is an assistive device designed to aid healthcare staff performing patient repositioning in bed. The use of sliding sheets in healthcare facilities is currently relatively rare because of the perceived additional time required compared with non-assisted handling. However, the details of the time difference between techniques and the barriers to the use of sliding sheets have not been examined in depth.
Objectives: We sought to evaluate differences in working time and subjective fatigue between the use of sliding sheets and non-assisted handling techniques for patient repositioning, in order to understand the factors preventing the use of sliding sheets among nurses.
Design: We conducted a comparative study with an experimental design.
Settings: The study was conducted in the nursing practice room at a university in Japan.
Participants: We recruited 30 pairs of nurses and care receivers. All nurses were under 60 years old, with experience in lateral turning and repositioning in the process of changing diapers in clinical settings. Those with a previous or current medical history of low back pain were excluded. Care receivers were older adults (65–80 years old). We excluded adults with bedsores, body mass index values >30, or restricted joint motion due to femoral trochanteric fracture or compression fracture. Thus, 27 pairs were included in the final analysis.
Methods: The care receivers were instructed to behave as if they were bedridden patients with no limb movement, and as if they had contracture and difficulty communicating. Nurses repositioned the patient using three techniques assigned as interventions in random order: repositioning by one person using a sliding sheet (*Sheet*), repositioning by two people without a sliding sheet (*Double*), and repositioning by one person without a sliding sheet (*Single*). Working time was the primary endpoint for comparative analysis among the three technique conditions.
Results: The results revealed that the *Sheet* technique required significantly more time than the non-assisted techniques. However, when total staff time was taken into consideration, the *Sheet* technique outperformed the *Double* technique. Moreover, the *Sheet* technique was associated with significantly lower levels of subjective fatigue, compared with the *Double* technique.
Conclusions: The use of a sliding sheet can substantially reduce caregiver burden when performing patient repositioning, and requires less staff time than manual techniques involving more than one caregiver.

* Corresponding author at: Division of Health Sciences, Osaka University Graduate School of Medicine, 1-7 Yamadaoka Suita, Osaka 565-0871, Japan.
E-mail address: y-omura@sahs.med.osaka-u.ac.jp (Y. Omura).

http://dx.doi.org/10.1016/j.ijnurstu.2019.103389

What is already known about the topic?

- Lateral transfers, particularly repositioning, are frequently performed in clinical settings, and are reported to involve substantial exertion by caregivers.
- Although sliding sheets can reduce caregiver burden, they are rarely used in clinical settings because of the perceived additional time required.
- Patient handling with assistive devices (such as transferring from bed to chair, or bed to bed) takes longer than manual patient handling.

What this paper adds

- Repositioning with a sliding sheet takes longer than without one, but is more effective in terms of total personnel time and subjective evaluations of fatigue.
- To remove the time-related barriers of use, the current findings indicate that it may be valuable to provide nurses with opportunities to actively use the sliding sheet and become accustomed to its use.

1. Introduction

The rate of musculoskeletal injuries related to overexertion in healthcare-related occupations is among the highest of all industries in the United States (U.S. Department of Labor, Bureau of Labor Statistics, 2014). Manual patient handling is the single greatest risk factor for overexertion injuries among healthcare workers, including manual lifting, moving and repositioning of patients (National Institute of Occupational Safety and Health (NIOSH), 2018). Previous studies reported that over 50% of Japanese clinical nurses experienced low back pain (Fujimura et al., 2012; Harada et al., 2015), and the prevalence of low back pain among nurses in the past month was 30%, substantially higher than the prevalence among office workers (22%) and sales/marketing personnel (19%) (Matsudaira et al., 2011). Moreover, the Japanese Survey of Employment-related Disease 2017 regarding workers' compensation claims indicate that the healthcare industry was responsible for 31.5% of all occupational injuries (Ministry of Health, Labour and Welfare, 2017a). In addition, the rate of back injury in the healthcare industry (31.5%) is twice that in the manufacturing industries (15.0%; Ministry of Health, Labour and Welfare, 2017a).

Patient handling involves various types of lifts and transfers, putting caregivers at risk of low back pain due to awkward postures, often requiring bending forward with twisting of the torso. The frequency of repositioning of patients in bed in clinical settings is reported to account for 47.6% of total transfers (McCoskey, 2007). Patient lifts and transfers, such as moving a patient from bed to a chair, were found to account for less than 4% of shifts in patient care (Hodder et al., 2010). One reason for the higher frequency of repositioning compared with other patient handling tasks is that repositioning of patients in bed is required at least once every 2 h, alternating the body position to prevent pressure ulcers and other adverse events associated with immobility by rolling patients from side to side (Waters et al., 2007). Moreover, several studies have revealed that staff members rate repositioning tasks as requiring substantial exertion (Fujimura et al., 2012; Marras et al., 1999; McCoskey, 2007; Waters et al., 2007; Weiner et al., 2015), and frequent manual repositioning is associated with increased risk of low back pain for caregivers (Yip, 2001).

The Guidelines for Nursing Homes developed by the Occupational Safety and Health Administration (OSHA) (OSHA, 2009) require caregivers to use fully-body sling lifts or friction-reducing devices, with two or more caregivers, when repositioning a patient who cannot move without assistance in bed. However, it is difficult to determine whether this policy is followed in clinical settings around the world. In Denmark, the rate of transferring or similar activities by one caregiver was reported to exceed 30% (Andersen et al., 2014). In Japan, one study reported that the rate of repositioning by one caregiver was 74.4% (Harada et al., 2015), although Japanese workplace lumbago prevention guidelines, which are similar to the OSHA guidelines, have been recommended (Ministry of Health, Labour and Welfare, 2013). The sliding sheet is a friction-reducing device designed for repositioning patients in bed. However, one study reported that the sliding sheet was used in only 14% of situations requiring patient repositioning in bed (Koppelaar et al., 2012). Moreover, a study in Japan reported that the rate of sliding sheet use during patient repositioning was only 2.5% (Takahashi et al., 2016).

In a systematic review Koppelaar et al. (2009) reported 16 individual and 45 environmental barriers and facilitators for the implementation of primary preventive interventions in patient handling in healthcare. The most important environmental category was "convenience and easy accessibility" (Koppelaar et al., 2009). Evanoff et al. (2003) interviewed healthcare workers, while Engst et al. (2005) conducted a questionnaire with care staff. Both studies reported that the reasons for not using assistive devices included a lack of availability of mechanical aids, and the extra time required compared with a manual transfer (Engst et al., 2005; Evanoff et al., 2003).

Several previous studies have evaluated the time required for patient handling with assistive devices (Zhuang et al., 2000; Pellino et al., 2006). Zhuang et al. (2000) compared the transfer time from bed to wheelchair using 12 different kinds of lifts, a sliding board, and other aid tools, while Pellino et al. (2006) compared the transfer time from bed to bed with or without assistive devices. Both studies focused on the time required for patient handling using mechanical devices for lifting. However, the time required for repositioning in bed with a sliding sheet has been poorly documented.

The aim of the current study was to investigate and evaluate the effectiveness of sliding sheets in terms of working time, in order to understand the barriers to the use of sliding sheets. We compared the working time required for patient repositioning using three techniques: one person using a sliding sheet, two people without a sliding sheet, and one person without a sliding sheet.

2. Methods

2.1. Design and participants

This study was a comparative study with an experimental design. Participants were randomly assigned to a sequence of three interventions involving different repositioning procedures.

Nurses aged <60 years old with previous experience in lateral turning and repositioning in the process of changing diapers in clinical settings were included as caregivers in this study. Exclusion criteria were used to exclude nurses with previous or current medical history of low back pain. We recruited nurses to the study via flyers distributed at the university at which the authors are based, as well as via introductions from acquaintances, between March and June, 2018.

Older adults aged 65 to 80 years were included as care receivers. Older adults with bedsores, body mass index (BMI) values >30, or restricted joint motion due to femoral trochanteric fracture or compression fracture were excluded. Older people were recruited to the study via flyers and introduction from a talent agency for older people between March and June, 2018. The older people were generally healthy, but were instructed to play the role of care receivers, behaving as if they were completely bedridden with no limb movement, and as if they had contracture and difficulty communicating.

2.2. Intervention

The patient repositioning in bed task was performed using three different techniques: *Sheet*, *Double*, *Single*. Repositioning by one person using a sliding sheet was called the "*Sheet*" technique. The sliding sheet device (Rakurakkusu mini, Amano Inc., Japan) is a nylon sheet, which is placed under a bedridden patient and pulled to reduce friction, enabling caregivers to easily move the body of a bedridden patient. Second, repositioning by two people without a sliding sheet was called the "*Double*" technique. The two people were a nurse and one of four research assistants, who were all women in their twenties with no clinical experience. Assistants were trained to move only according to the instructions of the nurse. Third, repositioning by one person without a sliding sheet was called the "*Single*" technique.

2.3. Randomization and washout time

There were six patterns (Sequences 1–6) for performing the three interventions (*Sheet*, *Double*, and *Single*; Fig. 1). We constructed an experiment schedule beforehand. Based on the schedule, we organized nurses who were able to participate at the appropriate times, and asked the talent agency to send older people according to the schedule. On each day of the experiment, we paired one nurse with one care receiver, according to the order they arrived at the nursing practice room. The pairs were allocated to sequence 1–6 using a randomized allocation table generated by an independent researcher, which was sealed and kept in a locked drawer. In addition, we used a 7-minute interval as a washout time between the three different interventions. In the intervals, the nurses rested in a chair, and the older people rested in a chair or lay on the bed.

2.4. Repositioning procedures

The task used in this study was for a nurse to laterally turn a care receiver lying in bed, from the right lateral decubitus position to the left lateral decubitus position, to simulate the process of changing a patient's diaper. The five steps, in order, were: (1) right lateral decubitus, (2) simulation of changing a diaper, (3) repositioning on the bed from one side to the other side, in the supine position, (4) turning, and (5) left lateral decubitus (Fig. 2).

After obtaining consent, researchers provided instructions regarding the repositioning procedures to nurses and care receivers separately. Specifically, because some nurses had never used the sliding sheet, researchers provided nurses with instructions about how to use the sliding sheet, using an illustration and a mannequin. Nurses then practiced the method for approximately 5 min before the start of the first intervention.

2.5. Settings

The tasks were conducted in the university nursing practice room at the authors' institution between March and June 2018. The bed used in the study was equipped with an electric switch that raised the patient's upper body and feet, and the left and right bed fences could be unlocked by grasping them in one piece. The height of the bed at the starting time was 50 cm from the floor to the mattress surface: the head was 73 cm above the floor (23 cm raised), the foot was 53 cm above the floor (3 cm raised), and the bed fence at the start was raised on both sides. The nurse could freely change the height of the bed and remove the bed fence. When a task finished, the researcher reset the bed to these settings.

2.6. Endpoints

Working time was the primary endpoint, defined as the time (in seconds) from the beginning until the end of the repositioning procedure. The secondary endpoint was defined as changes in the caregiver's level of fatigue before and after the intervention, measured using a 100 mm visual analog scale (VAS). In the VAS for fatigue, one end of the line indicated "no fatigue", corresponding to a score of 0 points, while the other end indicated "unbearable fatigue (the worst feeling involving exhaustion)", corresponding to a score of 100 points.

2.7. Questionnaire

We administered a questionnaire regarding participants' characteristics. For nurses, we also asked about the number of years of nursing experience, and the frequency of using sliding sheets.

2.8. Statistical analysis

Based on a pilot study of three caregivers, the mean ± standard deviation (SD) for working time was 256 ± 17 for the *Sheet* technique, 179 ± 31 for the *Double* technique, and 238 ± 41 in the *Single* technique. When we set the correlation to 0.4, and the power

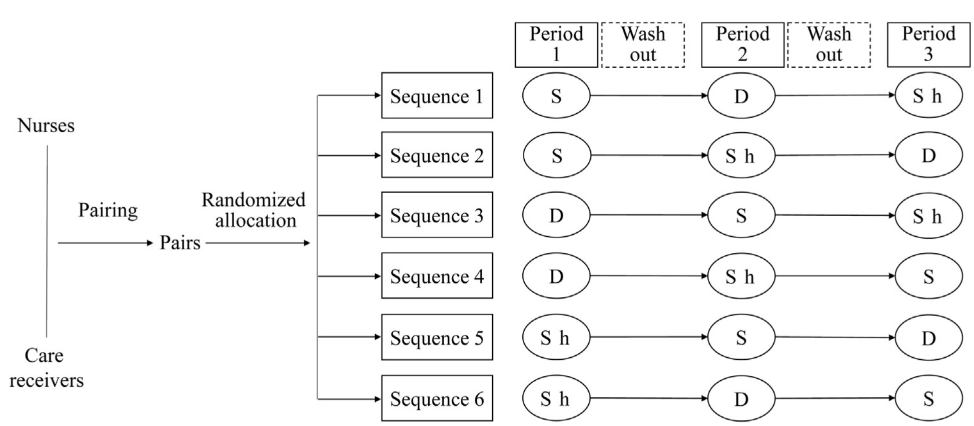

Fig. 1. Pairing, randomized allocation and data collection timeline: after screening, a pair of nurses and care receivers was allocated to the sequence of interventions. S: Single, D: Double, Sh: Sheet.

Fig. 2. Repositioning procedures: photographs used as examples of the *Single* technique.

and type 1 error in a two-sided test fulfilled the conditions >0.7 and <0.05, respectively, using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), the minimum sample sizes for comparison between the *Sheet* and *Double* techniques, and between the *Sheet* and *Single* techniques, were calculated as four and 29 pairs, respectively. Accordingly, the sample size in this study was determined to be 30 pairs, in consideration of potential dropouts.

We tested hypotheses regarding the primary and secondary endpoints. This study was based on a randomized crossover design in which the same subject performed three different interventions in three periods, respectively. We analyzed continuous variables with mixed effects models with compound-symmetry covariances for repeated measures within a participant. We included the following pre-specified baseline factors as fixed effects: intervention allocation, period, and the intervention-by-period interaction. Participant ID was treated as a random effect. The least squares mean (LSM) was calculated from a model adjusted for period and carryover effects. Intention to treat analysis excluded participants with no data for all three interventions, with incorrect allocation, or with omissions in the questionnaire about each participant's characteristics. Categorical and continuous data are presented as number of participants (percentage) and mean (standard deviation), respectively. Analyses were performed using R version 3.5.0 (R Foundation, Vienna, Austria) with the mixed effects model (nlme) library.

3. Results

3.1. Number of analysis targets

We recruited 30 pairs of nurses as caregivers and older people as care receivers (Fig. 3). A total of 27 pairs were included in the final analysis, after excluding one pair in which the task could not be performed three times due to the time constraints of participants, one pair in which an error was found in the demographic characteristics questionnaire responses, and one pair in which the intervention failed to be allocated. Adverse events were not observed in the implementation of this study.

3.2. Characteristics of nurses and care receivers

As shown in Table 1, the nurses' mean (SD) age was 32.4 (6.8) years, with a mean of 8.6 (6.0) years of nursing experience. The mean age in the care receiver group was 72.2 (3.9) years, with a mean BMI value of 21.7 (2.5). Eight nurses had clinical experience in surgical wards, seven had experience in internal medical wards, and six had experience in care units. In response to the questionnaire, 29.6% of the nurses reported that repositioning of a patient in a bed by two people was usual in their wards, and 59.3% of the nurses reported that they were using a sliding sheet for the first time.

3.3. Working time

The crude mean working time was 348.22 s for the *Sheet* technique, 252.00 s for the *Double* technique, and 289.48 s for the *Single* technique. The adjusted LSM was 379.40 s for the *Sheet* technique, 252.61 s for the *Double* technique, and 299.56 s for the *Single* technique (Fig. 4). Thus, the *Double* technique had a working time that was 126.79 s shorter than that of the *Sheet* technique (95%CI: −164.12, −89.46), and the *Single* technique had a working time that was 79.84 s shorter than that of the *Sheet* technique (95% CI: −117.18, −42.51).

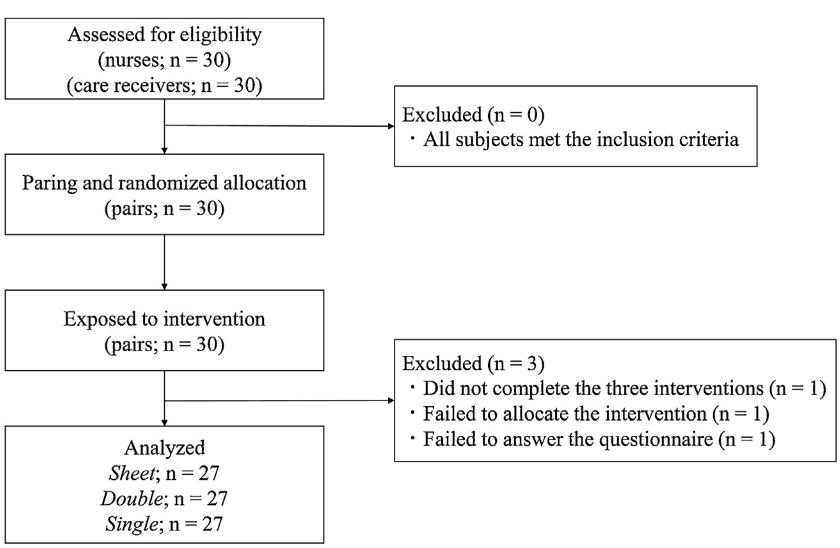

Fig. 3. Study enrollment and flow.

Table 1
Characteristics of nurses and care receivers.

Variable	Category	Statistic
Nurse as caregiver (n = 27)		
Age (years)		32.4 (6.8, 23–49)
Sex (women: men)		22: 5
Height (cm)		162.0 (8.8, 151–185)
Nurse-experienced years		8.6 (6.0, 1–25)
Primary ward type	Surgical ward	8 (29.6)
	Medical ward	7 (25.9)
	ICU, CCU, SCU	6 (22.2)
	Others	6 (22.2)
Rate of repositioning by two people in the ward	Less than 10%	4 (14.8)
	10–20%	6 (22.2)
	20–50%	3 (11.1)
	50–80%	6 (22.2)
	More than 80%	8 (29.6)
Frequency of using sliding sheets	Never	16 (59.3)
	Less than 10 times (in a life time)	5 (18.5)
	Usually	6 (22.2)
Care receivers (n = 27)		
Age (years)		72.2 (3.9, 66–79)
Sex (women: men)		8: 19
Height (cm)		161.7 (7.7, 147–175)
BMI (kg/ m^2)		21.7 (2.5, 16.7–26.0)

ICU: intensive care unit, CCU: coronary care unit, SCU: stroke care unit, BMI: body mass index. A summary of age, height, and BMI, mean (standard deviation, range) are presented.

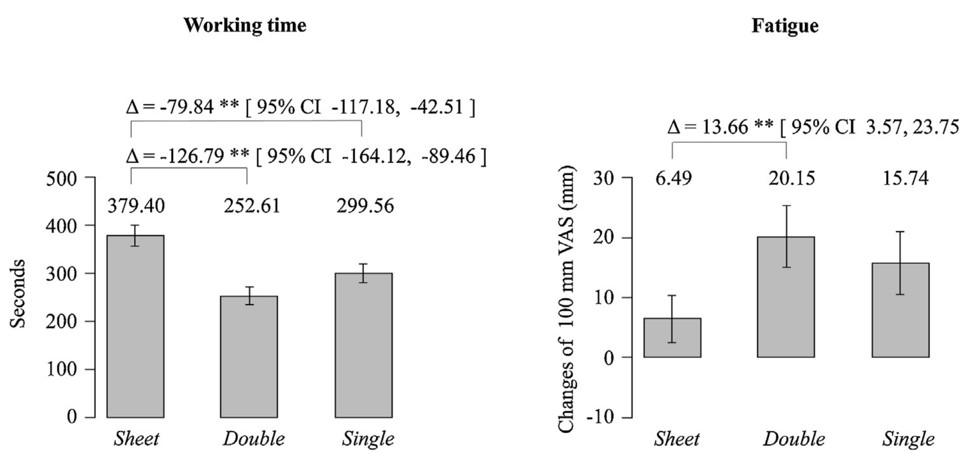

Fig. 4. Working time and subjective fatigue associated with each intervention. Data are presented as LSM ± SE. The error bars show the SE. VAS: visual analog scale, **: $p < .01$, *: $p < .05$.

3.4. Changes in VAS for fatigue

The crude mean change in VAS score for fatigue was 9.37 for *Sheet*, 10.57 for the *Double* technique, and 12.96 for the *Single* technique. The adjusted LSM values were 6.49 for the *Sheet* technique, 20.15 for the *Double* technique, and 15.74 for the *Single* technique (Fig. 4). Thus, the *Double* technique was associated with a VAS score indicating significantly more fatigue than the *Sheet* technique (a VAS score difference of 13.66; 95%CI: 3.57, 23.75).

The average subjective fatigue value of 27 nurses was 14.09 before the first intervention, and 21.02 after three interventions. These results indicated that the level of subjective fatigue was low.

4. Discussion

In the current study, we examined working time and subjective fatigue during a patient repositioning task simulating diaper changing. In this task, nurses were required to move a passive patient toward the side of the bed using three different techniques: one person using a sliding sheet (*Sheet*), two people without a sliding sheet (*Double*), or one person without a sliding sheet (*Single*). The mean number of years of nursing experience was 8.6 (6.0) years, and the mean of age of nurses was 32.4 (6.8) years. Thus, the nurses in this study were younger than the overall population of nurses in Japan (Japanese Nursing Association, 2018). The nurses' primary work wards varied, and included the intensive care unit (ICU), stroke care unit (SCU), coronary care unit (CCU), surgical ward, and medical ward. Thus, it is conceivable that there were differences in the proficiency of care, strength, and method of repositioning. However, these interindividual fluctuations would not be expected to influence the results, because of the mixed model used for the analysis. The mean age of the care receivers in the current study was similar to the mean age of care receivers in Japan (Ministry of Health Labour and Welfare, 2017b).

The results of this study revealed several new findings regarding working time and subjective burden. First, a comparison between the *Sheet* and *Double* techniques revealed that working time in the *Sheet* condition was 126.79 s longer than that in the *Double* condition. Thus, the *Double* condition was associated with better performance in terms of working time. However, the *Double* technique required twice as many personnel as the other techniques. In the current study, the time required for the *Double* technique was not less than half of the time required for the one-person techniques (*Sheet* and *Single*). Thus, when total staff time was taken into account, repositioning with two caregivers required more working time than the other techniques. Based on this finding, if nursing personnel are abundant, the *Double* technique appears to be the optimal technique. However, because severe nursing shortages are a widespread problem internationally (Marc et al., 2019; WHO, 2013), it is unrealistic to recommend that patient handling should be undertaken by two caregivers to reduce working time. Indeed, less than 30% of respondents in the current study reported that the rate of repositioning by two caregivers exceeded 80%. Similar findings were reported in a previous study using a questionnaire about the association between low back pain and nursing tasks, revealing that nurses usually moved patients on a bed using a technique involving a single caregiver (Harada et al., 2015).

The mean subjective fatigue score of the *Sheet* technique was 13.66 points lower than that of the *Double* technique when compared using a 100-point VAS. According to previous studies that determined the amount of change in pain severity using a VAS, the magnitude of difference we observed would be considered to constitute a minimum clinically significant difference (Todd and Funk, 1996; Todd et al., 1996; Wells et al., 1993). Thus, we considered the change of 13.66 points to indicate clinical significance. Similar findings have been observed in other studies. Lundberg and Wiwatjesadawout (1998) investigated and compared caregiver load using a questionnaire about the feeling of fatigue and musculoskeletal fatigue and pain when repositioning patients upward with and without the aid of a sliding sheet. The results revealed that repositioning using a sliding sheet involved less load for caregivers (Lundberg and Wiwatjesadawout, 1998). The current VAS score findings revealed that using a sliding sheet, even with only one person, involved less subjective fatigue for a caregiver than two people without a sliding sheet. Therefore, from the perspective of working time and the evaluation of subjective fatigue, the current findings revealed that the use of the sliding sheet during repositioning was more effective than a method involving two people without a sliding sheet.

Second, a comparison between the *Sheet* and *Single* techniques revealed that working time using the *Sheet* technique was 79.84 s longer than that for the *Single* technique. Thus, the *Single* technique was slightly better in terms of working time. However, a previous study reported that the one-person technique for repositioning a patient was associated with the highest risk of low back pain and spinal load, exceeding the tolerance limits for compressive loads of 3,400 N (Marras et al., 1999; Skotte and Fallentin, 2008). Other studies using electromyography of the caregiver's lumbar or shoulder region during patient handling revealed the positive effects of using a sliding sheet by reducing the physical burden for the caregiver (Drew et al., 2015; Theou et al., 2011). Despite the fact that repositioning using a sliding sheet reduces the burden on the lumbar region, the frequency of use of the sliding sheet is reported to be only 2.5%–14.0% (Koppelaar et al., 2012; Takahashi et al., 2016). Previous studies have reported that the main barrier to the use of assistive devices is the time required (Evanoff et al., 2003), or the time constraints involved (Noble and Sweeney, 2018). Fragala and Fragala (2014) reported that even when the effect of the sliding sheet is known, additional actions, such as the necessity to spread and remove the sheet, prevent caregivers from using the device.

We calculated the additional time required for using a sliding sheet in the current study, revealing a difference of 79.8 s between the *Sheet* and *Single* techniques. Healthcare workers in aged care facilities are typically required to change diapers for passive patients 6.8 ± 1.3 times per day (Tomioka et al., 2006). Considering the number of workers, one study reported that a nursing staff member typically performed this action over 20 times in a day shift, and over 50 times in a night shift (Seo, 2001). Based on the current data, we can calculate the time loss due to the use of a sliding sheet as follows: 79.8 s (the difference of working time) $\times$ 20 (the number of diaper changes) = 26.6 min for a day shift and 79.8 s $\times$ 50 = 66.5 min for a night shift.

The usage rate of assistive devices is currently low, and many nurses have rarely used them. Thus, nursing staff may believe that assistive devices require more time than is actually necessary. The current findings clarified how much additional time is required for the use of sliding sheets. Increased time can have an important impact on care efficiency for caregivers. However, the results of the current study indicate that the actual increase in the time required for using sliding sheets was approximately 30 min for a day shift. Thus, adjusting the time of other work based on this consideration may be an important step. In addition, efforts to reduce the extra time required for using assistive devices are also necessary. Recent initiatives for the prevention of low back pain in healthcare have focused on training in the proper use of patient handling devices (Nelson and Baptiste, 2004). Thus, it may be valuable for nurses to have more opportunities to familiarize themselves with the use of sliding sheets. The current findings suggest the possibility that providing nurses with experience actively using assistive devices and becoming accustomed to handling them could reduce the working time required. Importantly, 59.3% of nurses in the current study had never used sliding sheets. Thus, training for caregivers in the handling of sliding sheets could substantially reduce the working time.

Although it has been reported that the use of sliding sheet reduces the physical and perceived demands associated with a lateral patient-handling task in a laboratory setting (Drew, 2015, Theou et al., 2011), the use of small aids was not found to be associated with a decreased occurrence of musculoskeletal complaints and diseases (Freiberg et al., 2016). Importantly, the risk of low back disorder remains, even with proper use of a sliding sheet. Marras (1999) reported that repositioning by two people using the draw sheet technique still involved a relatively high spinal load and risk of low back disorder. At present, reducing the burden on the low back could be helped by familiarizing nurses with the use of the sliding sheet, which could help to promote the use of the device by shortening the amount of time required. In future, the development of new types of assistive devices should aim to eliminate the risk of low back pain among caregivers and minimize the extra time required for using assistive devices.

5. Strengths and limitations

The current study is the first to evaluate aspects of performance, such as the working time and subjective fatigue associated with using sliding sheets, in patient handling. The current study is unique in that it was carried out in an experimental setting with randomization of interventions, and analyzed using a mixed model that enabled comparisons within participants.

Despite these strengths, the current study involved five limitations that should be considered. First, the primary ward of nurses in the current study was biased towards the acute care ward. In our sample, more than half of the participants worked in acute care facilities, with 22.2% of nurses working in units such as ICU, and 29.6% working in surgical wards. Previous studies have reported that the content and frequency of patient handling differ between acute care facilities and aged care medical facilities (Callison and Nussbaum, 2012; Evanoff et al., 2003). In addition, previous studies have suggested that working time may differ between care facilities as a result of differences in the content and frequency of repositioning, which may have affected the current results. Second, the research was conducted in an experimental environment, restricting its external validity. Nurses, as well as care receivers, may not have been representative of those in other nursing settings in terms of their height and weight, which could have potentially affected working time and subjective fatigue. Third, the *Double* technique was carried out only by one nurse and another person who was inexperienced in patient handling, which differed from a typical real-world hospital situation. This could have potentially affected working time and subjective fatigue for nurses. Fourth, most nurses in the current study had never used sliding sheets, which might have influenced the results. Finally, because of the experimental design, the study was not blinded, and the nurses as well as care receivers were selected by convenience sampling.

Future studies should examine the working time required for repositioning using assistive devices via more extensive and detailed research, such as consecutive sampling of nurses and care receivers to avoid selection bias, sufficiently long follow-ups for the association of the frequency of sliding sheets and the level of low back pain, or investigating musculoskeletal outcomes like low back pain with validated instruments. Furthermore, the current study focused solely on the sliding sheet, which is one type of friction-reducing device, during side to side repositioning. However, other types of assistive devices are also used in hospital settings. In future studies, it will be important to verify the effects of a range of devices in terms of the burden on the caregiver, the comfort of the care receiver, and cost effectiveness.

6. Conclusion

Repositioning with a sliding sheet takes longer than repositioning without one. However, when total personnel time and subjective evaluation of fatigue are taken into consideration, the use of a sliding sheet is more effective than other techniques. Recognizing and managing the additional working time required for the use of sliding sheets and providing nurses with opportunities to become accustomed to using the device could be important steps for removing the time-related barriers to using sliding sheets.

Ethical considerations

The study was approved by the Institutional Review Board of the university-affiliated hospital. Informed consent was obtained from nurses and older people.

Registration number and name of trial registry

The study was registered with the University Hospital Medical Information Network (registration number: UMIN000031752).

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author declaration

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We further confirm that any aspect of the work has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

We understand that the Corresponding Author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs.

Declaration of Competing Interest

The authors have no conflict of interest to declare.

Acknowledgements

The authors would like to thank all participants for their cooperation in this study.

References

Andersen, L.L., Burdorf, A., Fallentin, N., Persson, R., Jakobsen, M.D., Mortensen, O.S., Clausen, T., Holtermann, A., 2014. Patient transfers and assistive devices: prospective cohort study on the risk for occupational back injury among healthcare workers. Scand. J. Work Environ. Health 40 (1), 74–81.
Callison, M.C., Nussbaum, M.A., 2012. Identification of physically demanding patient-handling tasks in an acute care hospital. Int. J. Ind. Ergon. 42 (3), 261–267.
Drew, K.E., Kozey, J.W., Moreside, J.M., 2015. Biomechanical evaluation and perceived exertion of a lateral patient-handling task. Occup. Ergon. 12 (4), 151–163.
Engst, C., Chhokar, R., Miller, A., Tate, R.B., Yassi, A., 2005. Effectiveness of overhead lifting devices in reducing the risk of injury to care staff in extended care facilities. Ergonomics 48 (2), 187–199.
Evanoff, B., Wolf, L., Aton, E., Canos, J., Collins, J., 2003. Reduction in injury rates in nursing personnel through introduction of mechanical lifts in the workplace. Am. J. Ind. Med. 44 (5), 451–457.
Fragala, G., Fragala, M., 2014. Improving the safety of patient turning and repositioning tasks for caregivers. Workplace Health Saf. 62 (7), 268–273.
Freiberg, A., Euler, U., Girbig, M., Nienhaus, A., Freitag, S., Seidler, A., 2016. Does the use of small aids during patient handling activities lead to a decreased occurrence of musculoskeletal complaints and diseases? A systematic review. Int. Arch. Occup. Environ. Health 89 (4), 547–559.
Fujimura, T., Takeda, M., Asada, F., Kawase, M., Takano, K., Sawada, S., Hiroshige, K., 2012. The investigation of low back pain among hospital nurses. Jpn. J. Occup. Med. Traumatol. 60 (2), 91–96.
Harada, K., Nishida, N., Kitahara, T., 2015. A questionnaire study on the presence of lower back pain in nurses associated with nursing tasks. Jpn. J. Nurs. Art Sci. 14 (2), 164–173.
Hodder, J.N., Holmes, M.W.R., Keir, P.J., 2010. Continuous assessment of work activities and posture in long-term care nurses. Ergonomics 53 (9), 1097–1107.
Japanese Nursing Association, 2018. Nursing Staff Survey 2017. Research Report No.92, 3-7. . (Accessed on 16 May 2019 https://www.nurse.or.jp/home/document/view.php?f=research/92.pdf.
Koppelaar, E., Knibbe, J.J., Miedema, H.S., Burdorf, A., 2009. Determinants of implementation of primary preventive interventions on patient handling in healthcare: a systematic review. Occup. Environ. Med. 66 (6), 353–360.
Koppelaar, E., Knibbe, H.J.J., Miedema, H.S., Burdorf, A., 2012. The influence of ergonomic devices on mechanical load during patient handling activities in nursing homes. Ann. Occup. Hyg. 56 (6), 708–718.
Lundberg, P.C., Wiwatjesadawout, P., 1998. Lifting patients in bed with and without a drawsheet: a comparative ergonomics study. J. Hum. Ergol. 27 (1-2), 55–61.
Marc, M., Bartosiewicz, A., Burzynska, J., Chmiel, Z., Januszewicz, P., 2019. A nursing shortage - a prospect of global and local policies. Int. Nurs. Rev. 66 (1), 9–16.
Marras, W.S., Davis, K.G., Kirking, B.C., Bertsche, P.K., 1999. A comprehensive analysis of low-back disorder risk and spinal loading during the transferring and repositioning of patients using different techniques. Ergonomics 42 (7), 904–926.
Matsudaira, K., Palmer, K.T., Reading, I., Hirai, M., Yoshimura, N., Coggon, D., 2011. Prevalence and correlates of regional pain and associated disability in Japanese workers. Occup. Environ. Med. 68 (3), 191–196.
McCoskey, K.L., 2007. Ergonomics and patient handling. AAOHN J. 55 (11), 454–462.
Ministry of Health, Labour and Welfare, 2013. Lumbago Prevention Guidelines in a Workplace. . (Accessed on 15 December 2018) https://www.mhlw.go.jp/stf/houdou/youtsuushishin.html.

Ministry of Health, Labour and Welfare, 2017a. Survey of Employment-related Disease. . (Accessed on 15 December 2018) https://www.mhlw.go.jp/bunya/roudoukijun/anzeneisei11/h29.html.
Ministry of Health, Labour and Welfare, 2017b. Patient Survey. . (Accessed on 16 May 2019 https://www.mhlw.go.jp/toukei/saikin/hw/kanja/17/dl/01.pdf.
National Institute of Occupational Safety and Health (NIOSH), 2018. Safe Patient Handling and Mobility (SPHM). . (Accessed on 15 December 2018 https://www.cdc.gov/niosh/topics/safepatient.
Nelson, A., Baptiste, A.S., 2004. Evidence-based practices for safe patient handling and movement. Online J. Issues Nurs. 9 (3), 4.
Noble, N.L., Sweeney, N.L., 2018. Barriers to the use of assistive devices in patient handling. Workplace Health Saf. 66 (1), 41–48.
Occupational Safety and Health Administration (OSHA), 2009. Guidelines for Nursing Homes Ergonomics for Prevention of Musculoskeletal Disorders. U.S. Department of labor, Occupational Safety and Health Administration.
Pellino, T.A., Owen, B., Knapp, L., Noack, J., 2006. The evaluation of mechanical devices for lateral transfers on perceived exertion and patient comfort. Orthop. Nurs. 25 (1), 4–10.
Seo, A., 2001. Workload of care workers at the care facilities for the aged. Hokuriku J. Public Health 27 (2), 67–75.
Skotte, J., Fallentin, N., 2008. Low back injury risk during repositioning of patients in bed: the influence of handling technique, patient weight and disability. Ergonomics 51 (7), 1042–1052.
Takahashi, I., Misao, H., Takeda, Y., 2016. Relationship between the occurrence of low back pain and the frequency of mobility assistance or the proper use of mobility aids among nurses who assist patients with mobility. J. Jpn. Acad. Nurs. Sci. 36, 130–137.
Theou, O., Soon, Z., Filek, S., Brims, M., Leach-MacLeod, K., Binsted, G., Jakobi, J., 2011. Changing the sheets a new system to reduce strain during patient repositioning. Nurs. Res. 60 (5), 302–308.
Todd, K.H., Funk, J.P., 1996. The minimum clinically important difference in physician-assigned visual analog pain scores. Acad. Emerg. Med. 3 (2), 142–146.
Todd, K.H., Funk, K.G., Funk, J.P., Bonacci, R., 1996. Clinical significance of reported changes in pain severity. Ann. Emerg. Med. 27 (4), 485–489.
Tomioka, K., Kumagai, S., Kosaka, H., Yoshida, J., Tabuchi, T., Kosaka, J., Arai, Y., 2006. Equipment at the Special Nursing Homes for the elderly: a workplace survey of new nursing homes in Osaka Prefecture. J. Occup. Health 48 (2), 49–55.
U.S. Department of Labor, Bureau of Labor Statistics, 2014. Incidence Rates for Nonfatal Occupational Injuries and Illnesses Involving Days Away From Work Per 10,000 Full-time Workers by Industry and Selected Events or Exposures Leading to Injury or Illness, Private Industry, 2014. . (Accessed on 15 December 2018 https://www.bls.gov/iif/oshwc/osh/case/ostb4374.pdf.
Waters, T.R., Nelson, A., Proctor, C., 2007. Patient handling tasks with high risk for musculoskeletal disorders in critical care. Crit. Care Nurs. Clin. North Am. 19 (2), 131–143.
Weiner, C., Alperovitch-Najenson, D., Ribak, J., Kalichman, L., 2015. Prevention of nurses' work-related musculoskeletal disorders resulting from repositioning patients in bed comprehensive narrative review. Workplace Health Saf. 63 (5), 226–232.
Wells, G.A., Tugwell, P., Kraag, G.R., Baker, P.R.A., Groh, J., Redelmeier, D.A., 1993. Minimum important difference between patients with rheumatoid-arthritis - The patients perspective. J. Rheumatol. 20 (3), 557–560.
World Health Organization, 2013. A Universal Truth: No Health without a Workforce. . (Accessed on 10 May 2019 https://www.who.int/workforcealliance/knowledge/resources/hrhreport_summary_En_web.pdf?ua=1.
Yip, Y.B., 2001. A study of work stress, patient handling activities and the risk of low back pain among nurses in Hong Kong. J. Adv. Nurs. 36 (6), 794–804.
Zhuang, Z.Q., Stobbe, T.J., Collins, J.W., Hsiao, H.W., Hobbs, G.R., 2000. Psychophysical assessment of assistive devices for transferring patients/residents. Appl. Ergon. 31 (1), 35–44.