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# Frequent Bending—An Underestimated Burden in Nursing Professions

**SONJA FREITAG[1]*, ISABELL FINCKE-JUNOD[1], RACHIDA SEDDOUKI[2], MADELEINE DULON[1], INGO HERMANNS[3], JAN FELIX KERSTEN[4], TORE J. LARSSON[5] and ALBERT NIENHAUS[2]**

*[1]Institution for Statutory Accident Insurance and Prevention in the Health and Welfare Services, (BGW), Department for the Principle of Prevention and Rehabilitation, Pappelallee 33/35/37, 22089 Hamburg, Germany; [2]Institute for Health Services Research in Dermatology and Nursing, UKE—University Medical Centre Hamburg-Eppendorf, Martinistraße 52, 20246 Hamburg, Germany; [3]Institute for Occupational Safety and Health of the German Social Accident Insurance (IFA), Department 4: Physical Effects of Work Organisation, Alte Heerstraße 111, 53757 Sankt Augustin, Germany; [4]Department of Medical Biometry and Epidemiology, UKE—University Medical Centre Hamburg-Eppendorf, Martinistraße 52, 20246 Hamburg, Germany; [5]Centre for Health and Building, KTH—Royal Institute of Technology, Marinens väg 30, 136 40 Haninge, Sweden*

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**Objectives: The aim of the present study was to quantify the total duration per shift in which nurses work in a forward bending position over 20°. Furthermore, the influence of several factors on the occurrence of sagittal trunk inclinations in nurses was investigated.**

**Methods: Trunk postures were recorded for nine nursing home nurses from four German nursing homes and 18 hospital nurses from seven hospitals using the CUELA measurement system. A total of 79 shifts, 27 in nursing homes and 52 in hospitals, were analysed. All measurements were supported by video recordings. Specially developed software (WIDAAN 2.75) was used to synchronize the measurement data and video footage.**

**Results: The total duration of inclinations per shift was significantly affected by the working area (nursing home or hospital) with an increase of 25.3 min in nursing homes (95% confidence interval 2.4–48.2; $P = 0.032$). Another factor was the extent of personal basic care tasks performed by the nurses ($P < 0.001$). Nursing home nurses worked about twice as long per shift in a forward bending position compared with hospital nurses (112 versus 63 min; $P < 0.001$) and they assumed almost one-third more inclinations per shift (1541 versus 1170; $P = 0.005$).**

**Conclusions: Nursing staff perform a large number of inclinations. The amount of time spent by nurses working in a forward bending position was highly dependent on the working area and the extent to which patients were in need of help. It is very likely that future preventive measures, focussing on reducing the huge amount of inclination, would reduce the physical stress in everyday nursing work substantially.**

*Keywords:* bending; musculoskeletal disorders; nurses; trunk posture

## INTRODUCTION

Despite the extensive research work conducted on the subject of musculoskeletal disorders (MSDs) in nursing professions, nursing staff still suffer from an above-average frequency of back complaints compared to workers in other professions (Nelson *et al.*, 2003; Bejia *et al.*, 2005; Yassi *et al.*, 2005; Smith *et al.*, 2006; Podniece, 2007). In the past, studies on back injuries in nursing have concentrated on manual patient handling, which was thought to be the main

*Author to whom correspondence should be addressed.
Tel: +49-4020-207-3233; fax: +49-4020-207-3298;
e-mail: sonja.freitag@bgw-online.de

cause of musculoskeletal complaints of the lower back. Therefore, interventional measures have been focused on the use of lifting aids or the mastering of patient transfer techniques. Unfortunately, several reviews concluded that these approaches alone do not sufficiently reduce back problems (Lagerström *et al.*, 1998; Hignett, 2003; Nelson and Baptiste, 2004; Martimo *et al.*, 2007).

Other risk factors for MSD discussed in the literature have included repeated bending and the high proportion of static postures of the trunk (Lee and Chiou, 1995; Marras *et al.*, 1995; Knibbe and Friele, 1996; NIOSH, 1997; Jansen *et al.*, 2001; Yip, 2004). These risk factors were thought to be independent predictors for the occurrence of new back complaint symptoms. The United States Department of Labor announced that working in awkward postures increases the exertion and muscle force that an employee must apply to complete a task, and it also compresses tendons, nerves, and blood vessels; in general, the more extreme the posture, the more force is required to complete the task (OSHA, 2011). Engels *et al.* (1996) showed that nurses regard patient handling, working in awkward trunk postures and frequent bending as being stressful. Wilke *et al.* (1999) performed intra-disc pressure measurements and showed that the compression force acting on the vertebral disc L4/L5 is partly dependent on the trunk posture. The pressure was particularly low when the subject was standing upright and increased when the subject bent forward.

In the scientific literature, only a few field studies have investigated trunk postures in nursing (Lee and Chiou, 1995; Hignett, 1996; Morlock *et al.*, 2000; Jansen *et al.*, 2001; Hodder *et al.*, 2010). Previously, there was no method of long-term measurement that allowed trunk postures in nurses to be recorded objectively, continuously and in all three planes of movement under practical conditions without hindering the nurse during his or her work. In a preliminary study (Freitag *et al.*, 2007), a new measurement system called CUELA (German abbreviation for 'computer-assisted recording and long-term analysis of musculoskeletal loads') for recording body posture was tested by our group (Fig. 1). It was shown that the new measurement system is well suited for use in field studies. The investigations revealed that nurses in general assume a high proportion of inclinations and work bent forward for a mean of up to 2 h per shift. In contrast, manual patient-handling exposure accounted for only a few minutes per shift. It was also shown that the frequency and duration for which the nurses assume a bent-forward position depend on the specialization of the ward in which they work. For example, the number of inclinations was highest in the geriatric ward. This suggests that the patient population exercises an influence on the number of inclinations and that this number increases as the patients' need for care increases. Additionally, the results provided initial indications that personal basic care tasks, such as washing the patient or bed preparation, may lead to more frequent inclinations. However, the results of the preliminary study could only provide initial evidence of this increased prevalence of inclinations, as the number of nurses was small. Therefore, a new series of measurements in hospitals and nursing homes was undertaken with a larger group of nurses.

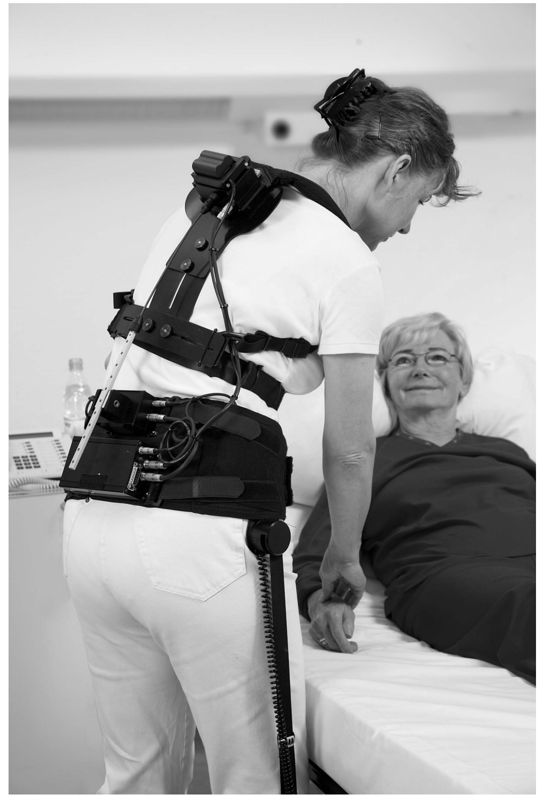

**Fig. 1.** The CUELA measurement system use in a hospital. Sensors attached at the thoracic and lumbar spine deliver 3-dimensional information about the position of the trunk.

The aim of the present study was to quantify the total duration per shift nurses work in a forward bending position over 20°. Furthermore, the influence of nurse-, ward- and care-related characteristics on the occurrence of sagittal inclinations in nurses was investigated.

## METHODS

### *Study population*

A convenience sample of 27 nurses from 4 nursing homes (9 nurses) and 7 hospitals (18 nurses) in Germany participated in this study (Fig. 2). The CUELA measurement system and a video camera were used to capture all trunk movements and activities. The nurses wore the system for three consecutive shifts. Two nurses only wore the system for two shifts. Thus, a total of 79 shifts were monitored; 27 in nursing homes and 52 in hospitals. The hospital measurements included 23 shifts in the surgical wards, 14 shifts in the internal medicine wards, 9 shifts in the geriatric wards, and 6 shifts in the gynaecological wards.

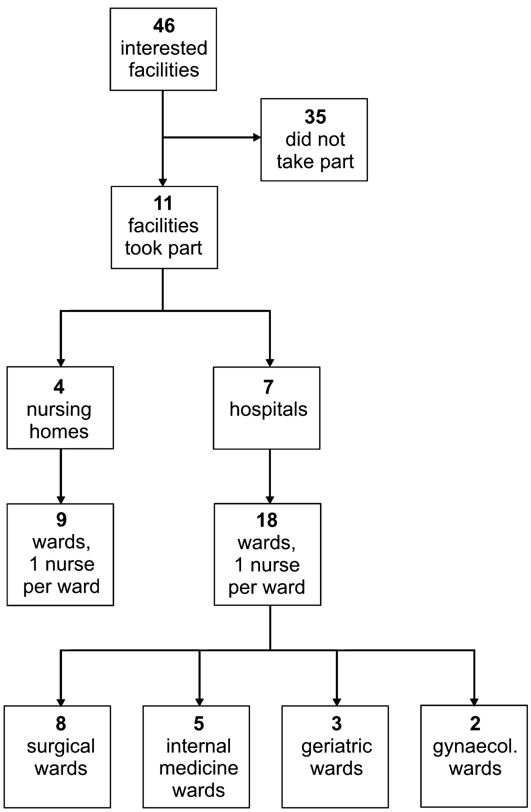


**Fig. 2.** Recruitment of facilities, wards, and nurses.

### *Plan of measurements*

Immediately after the handover from the night shift to the morning shift, the measurement system was attached to the nurses and the first period of measurement was initiated (Table 1). The nurses then started their work, and all movements and activities were recorded using the measurement system and a video camera. All nurses were instructed to work normally on the measurement days and not increase or decrease the frequency of any activity because of the study. The readings were only interrupted for the morning break. The second period of measurement was stopped as soon as the nurses had finished taking care of the patients and only documentation work towards the end of the shift and the subsequent handover to the midday shift was left. We excluded handover and documentation work because this is normally performed seated and the trunk is usually supported by the arms when leaning forward. Documentation work captured during the measurement periods was removed using the WIDAAN 2.75 software after the measurements had been taken.

### *The CUELA measurement system*

The mean trunk inclination in the sagittal direction (hereafter referred to as 'inclination') was measured using the CUELA system (Ellegast and Kupfer, 2000). The inclination is calculated by dividing the sum of the thoracic inclination and the lumbar inclination by two. Additionally, the postures of the legs in the sagittal direction were measured and the vertical floor reaction forces were measured by special pressure-sensitive insoles. The floor reaction forces were mainly used in this study to obtain a more precise automatic recognition of body postures and movements, such as walking, sitting, standing, or crouching. As the sampling rate of the sensors is

Table 1. Typical morning shift in participating hospitals and nursing homes and corresponding time flow of the measurements.

| Time | Section | Included in measurement | |
|---|---|---|---|
| | | No | Yes |
| 06:00–06:30 a.m. | Handover from the night shift to the morning shift | X | |
| 06:30–07:00 a.m. | Attaching the measurement system to the nurse | X | |
| 07:00–10:00 a.m. | 1st measurement period | | X |
| 10:00–10:30 a.m. | Morning break | X | |
| 10:30–01:00 p.m. | 2nd measurement period | | X |
| 01:00–01:30 p.m. | Handover from the morning shift to the midday shift | X | |

50 Hz, we were able to capture a realistic record of the nurses' movements. All necessary system components (weighing a total of 2.7 kg) were attached to the body over the nurses' working clothes and elastic belts were used to ensure that the measurement system fit the body shape of the nurse. No connection to external components was necessary, and the nurses were able to move freely while performing their work. In addition, the nurses were filmed with a video camera throughout the measurement period. After completion of the measurements, the specially developed WIDAAN 2.75 software was used to synchronize the data recorded with the CUELA system and the video camera. In this way, the nurses' specific situation was shown for each trunk posture selected in the angle time diagram (Fig. 3).

*Selection of the facilities and nurses*

Because of the measurement system and the required video recordings, it was very difficult to find facilities that would give their consent to such a study project. Apart from the patients and the residents (hereafter referred to as 'patients'), the nursing staff and people responsible for the facilities, such as ward managers, medical and nursing directors, and staff representatives, etc. also had to give their consent. We therefore used a convenience sample of facilities and nurses. An appeal was made on the Internet to recruit facilities for the study project. A detailed information event was held at each interested facility to give interested nurses and others an opportunity to try out the measurement system. This was done to help people decide whether they would like to participate in the study. Of the initial 46 facilities that were interested, seven hospitals and four nursing homes decided to take part. All nurses who wanted to participate in the study had to be predominantly free of back pain. That means they had to be capable of performing their work as usual. Nurses who were not able to carry out certain tasks due to acute back pain were not allowed to participate in the study. Additionally, the nurses had to be involved in care activities; thus, the managerial staff members who wanted to take part in the study had to perform the same work as a nurse who does not hold a managerial position. In Germany, it is usual for managerial staff such as group managers, deputy ward managers, or ward managers to be involved in the daily routine of care activities. However, the amount of care activities they perform is lower than that of staff members

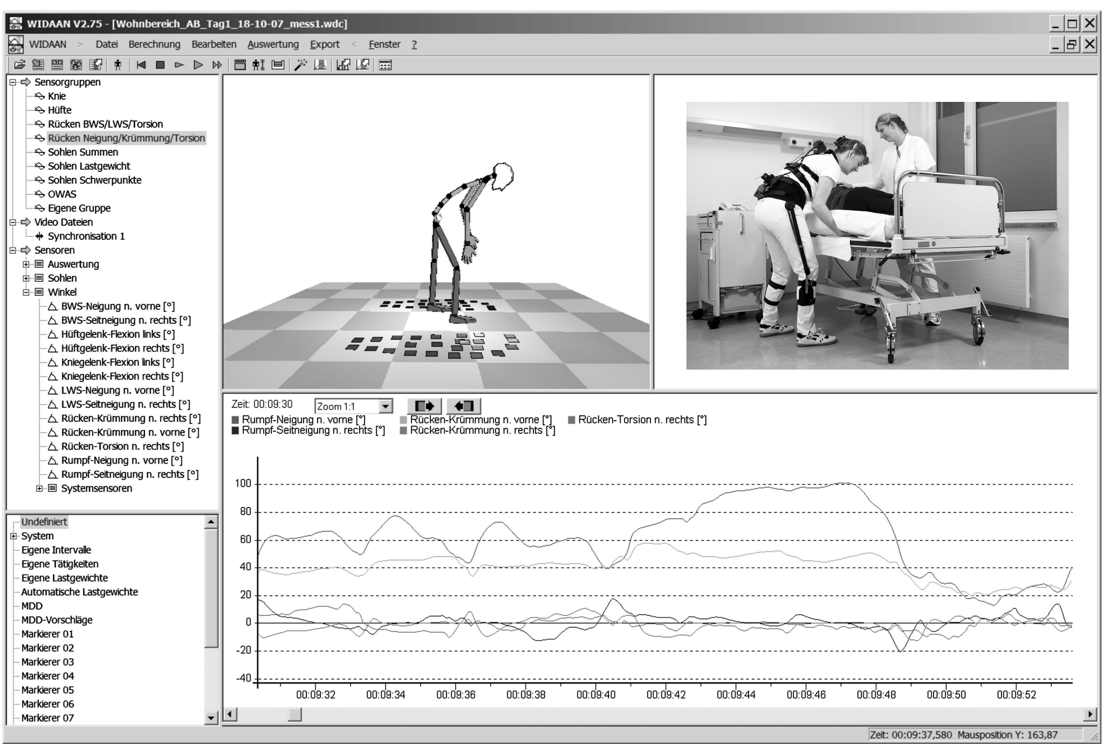


**Fig. 3.** The user interface of the software (WIDAAN 2.75) that was used to evaluate the measured data, with an animated computer figure and synchronized video sequence.

who do not hold a managerial position due to the additional administrative work they have. Therefore, for managerial staff members taking part in the study administrative work was only to be performed after the measurements had been taken.

*Posture evaluation*

According to the ISO 11226 (ISO, 2000) and DIN EN 1005-4 (DIN, 2005) standards, inclinations between 0° and 20° are defined as acceptable and correspond to an upright trunk position. Inclinations of over 20° are only acceptable under the following conditions: the trunk is supported, the movement is symmetrical (i.e. not combined with a lateral movement or torsion) and the movement is performed less than twice per minute during a shift. In this study, all inclinations over 20° were counted for each nurse during each morning shift. Here, an inclination was defined as first reaching and then exceeding the 20° limit (Fig. 4).

To determine the proportion of time in each shift that the nurses spent leaning forward, all inclinations of over 20° were added up. Additionally, all static inclinations over 20° were counted. According to the DIN EN1005-1 (DIN, 2002) standards, trunk postures were classified as static postures if they were maintained for >4 s under a constant or slightly changing force.

*Description of the nurse- and ward-related variables*

The following factors were assessed for nurses (Table 2): age, gender, height, body mass index (BMI), work experience, part-time employment, education, and managerial position. Education was divided in registered nurse (state-registered nurse or state-registered geriatric nurse) and non-registered nurse. Managerial positions included ward managers, deputy ward managers, and group managers. The ward-related factors assessed were: patient-nurse ratio, ratio of height-adjustable beds, occupancy, number of wards equipped with lifting aids and measurement time per shift (Table 3). The patient-nurse ratio and the occupancy were calculated by dividing the number of patients per ward in the measured shift by the number of nurses and the number of beds, respectively. The ratio of height-adjustable beds was calculated by dividing the number of height-adjustable beds by the number of patients. Lifting aids included small aids (e.g. gliding boards) or technical aids (e.g. lifters).

*Description of the care-related variables*

The following care-related factors were assessed per nurse and per shift (Table 4): number of patient transfers, ratio of patient transfers with lifting aids, total time lifting a patient's body weight, number

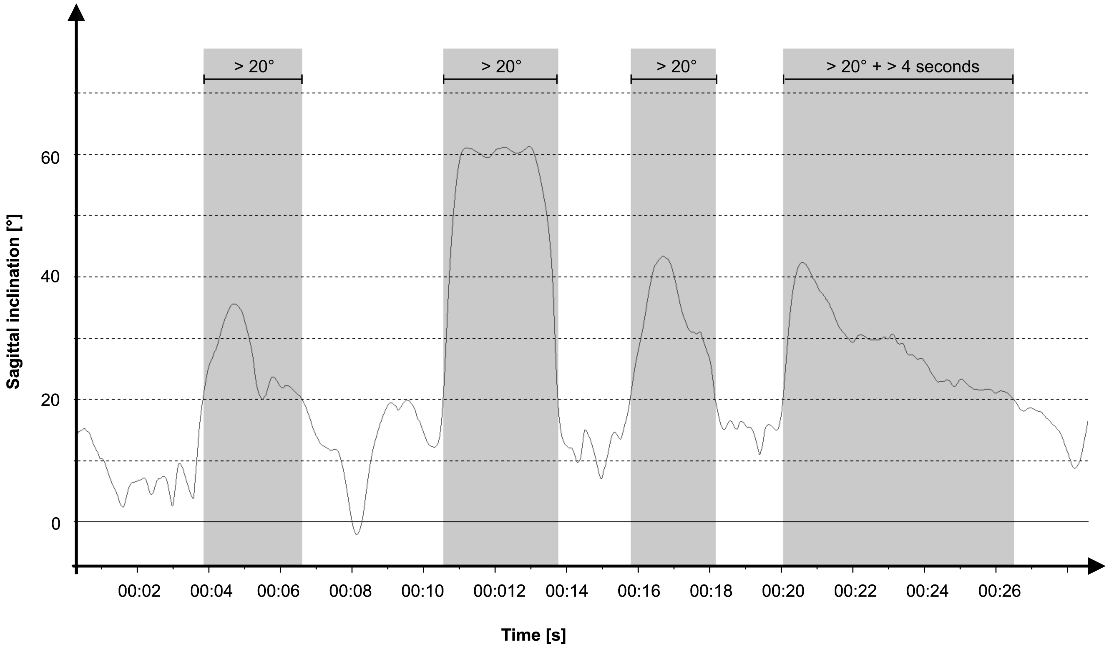


**Fig. 4.** The determination of inclination intervals over 20°.

of patients provided with personal basic care (Stage 1, Stage 2, and Stage 3), personal basic care intensity score, and the number of non-basic care tasks leading to static inclinations. We defined patient transfers as manual patient-handling tasks, for which increased compressive forces on vertebral disc L5/S1 has been described (Theilmeier *et al.*, 2006). According to Theilmeier *et al.*, patient transfers include the following 11 activities: lifting the patient to sit upright in bed, raising the patient from a lying to a sitting position on the edge of the bed, moving the patient from the edge of the bed into a chair, moving the patient from a sitting into a standing position, lifting the patient into or out of the bath tub, moving the patient to the headboard of the bed, transferring the patient from bed to bed, lifting the patient from the floor, inserting and removing a bedpan, lifting the patient's legs, and carrying the patient. All patient transfers performed were identified on video and were counted for each nurse and shift. To find out how much time was spent lifting heavy weights, the time for all patient transfers was added up; however, only the time spent by the nursing staff actually lifting a patient or a part of a patient (e.g. trunk or leg) was taken into account. The ratio of patient transfers with aids was calculated by dividing the number of patient transfers with aids by the total number of patient transfers performed.

To assess the intensity of the personal basic care tasks performed by the nurses, a new assessment instrument was developed. We created a group of tasks that were designated as personal basic care and included the following individual tasks: bed preparation, washing patients or residents, dressing and undressing, applying care products, changing nappies or inserts, combing hair, and shaving. Depending on the extent to which a patient was in need of assistance, the intensity of required personal basic care provided by the nurse could vary widely. Therefore, the personal basic care performed by the nurses was

Table 2. Nurse-related factors stratified by working area.

| Factor | Nursing home | Hospital | *P* value |
|---|---|---|---|
| Age (years) | 44.2 (10.6) | 37.8 (9.9) | 0.152 |
| Height (cm) | 169.1 (9.4) | 173.2 (7.7) | 0.274 |
| BMI (kg/m$^2$) | 24.7 (3.2) | 24.6 (4.3) | 0.949 |
| Work experience (years) | 14.3 (13.0) | 15.4 (8.4) | 0.481 |
| Gender (female) | 5 (55.6%) | 11 (61.1%) | 1.000 |
| Part-time employment | 5 (55.6%) | 1 (5.6%) | 0.008 |
| Registered nurse | 8 (88.9%) | 18 (100%) | 0.333 |
| Managerial position[a] | 3 (33.3%) | 7 (38.9%) | 1.000 |

Continuous values are mean values (standard deviations).
Categorical values are counts (percentages).
[a]Managerial position is ward manager, deputy ward manager, or group manager.

Table 3. Ward-related factors stratified by working area.

| Factor | Nursing home | Hospital | *P* value |
|---|---|---|---|
| Patients per nurse and per shift (*n*) | 9.0 (7.5–10.6) | 6.0 (5.5–6.5) | <0.001 |
| Ratio of height-adjustable beds | 100% (100%–100%) | 59.2% (46.6%–71.8%) | <0.001 |
| Occupancy rate | 99.6% (99.1%–100%) | 92.9% (90.7%–95.1%) | <0.001 |
| Ratio of wards equipped with lifting aids[a] | 100% (62.9%–100%) | 50% (29.0%–71.0%) | 0.012 |
| Measurement time per shift (minutes) | 313.1 (304.7–321.5) | 308.6 (299.2–318.0) | 0.468 |

Values are mean values (95% CI).
[a]Lifting aids are gliding boards, lifters, etc.

Table 4. Care-related factors per nurse and per shift stratified by working area.

| Factor | Nursing home | Hospital | *P* value |
|---|---|---|---|
| No. of patient transfers | 26.5 (21.9–32.1) | 6.5 (4.6–8.9) | <0.001 |
| Ratio of patient transfers with lifting aids (%) | 0.4 (0.1–0.7) | 0.0 (0.0–0.0) | 0.014 |
| Total time lifting a patient's body weight (seconds) | 88.0 (69.0–112.1) | 15.5 (10.3–23.2) | <0.001 |
| No. of patients provided with basic care—Stage 1 | 0.6 (0.3–1.0) | 1.6 (1.2–2.2) | 0.001 |
| No. of patients provided with basic care—Stage 2 | 0.8 (0.4–1.2) | 0.4 (0.2–0.6) | 0.076 |
| No. of patients provided with basic care—Stage 3 | 4.8 (4.0–5.6) | 1.4 (1.0–1.8) | <0.001 |
| Basic care intensity score (points) | 17.4 (15.0–20.1) | 7.5 (6.3–8.9) | <0.001 |
| No. of non-basic care tasks leading to static inclinations | 113 (93.3–139.1) | 98.9 (88.7–110.3) | 0.211 |

Values are mean values (95% CI).

classified as one of three stages as follows: Stage 1, the nurse only made the bed; other personal basic care tasks were not performed (1 point); Stage 2, the nurse made the bed and performed <50% of the personal basic care tasks (2 points); and Stage 3, the nurse made the bed and performed >50% of the personal basic care tasks (3 points). The number of patients provided with personal basic care by the nurses was determined using the video footage. These frequencies were then multiplied by the corresponding stage factor (1, 2, or 3 points) and added to obtain a total score for each nurse, which was termed the basic care intensity score. The development of such an instrument was necessary because even though the patient chart included an assessment of the daily nursing care required, this information did not state who exactly performed each single task.

To take the non-basic care tasks into account, such as distributing or collecting food, clearing up, disposal, cleaning, treatment care or pushing/pulling wheelchairs or beds, we used a different method, because it is not feasible to count every single task and to determine exactly where a task starts and ends. Therefore, all static inclinations over 20° were selected and counted by the software application WIDAAN 2.75 and with the help of the corresponding video sequence. Then, a decision was made as to whether it was a personal basic care or non-basic care task that led to each single static inclination.

### *Ethical issues*

Prior to the measurements being taken, all patients and residents or their family members or caregivers, on the participating wards were informed about the study objectives, measurement system used, and video recording. All people who were filmed gave their consent to being filmed in advance. Overall, only 12 patients (10 in hospitals and 2 in nursing homes) did not consent to being recorded. These patients were cared for by non-participating nurses. A few situations (11 in hospitals and 5 in nursing homes) occurred where patients did not feel comfortable being filmed in a special situation although they had given their consent in advance. We then switched off the camera and the nurses' postures were recorded by the measurement system alone.

The study design was approved by the Ethics Commission of Hamburg Medical Council, Germany.

### *Statistical analyses*

Frequencies and mean values for categorical and continuous variables, whichever appropriate are reported. Where necessary, continuous variables were log-transformed. Continuous variables were compared using *t*-test, categorical variables were compared using chi-square test in order to compare inclinations over 20° between nursing homes and hospitals. Analysis of covariance (ANCOVA) was performed with respect to the individual nurse to compare the duration of inclinations between the facility groups with adjustment for gender, basic care intensity score, and number of patient transfers. $P$ values <0.05, two tailed, were considered significant. Statistical analyses were performed using SPSS 19.0 and the Statistical Package R version 2.13.2 (R Development Core Team, 2011).

## RESULTS

In this study, 27 nurses (16 women and 11 men) aged between 20 and 65 years participated. Table 2 shows that the group of nursing home nurses was not significantly different from the group of hospital nurses in terms of age, height, BMI, and work experience. Half of the nursing home nurses were part-time employees, in contrast to 1 of the 18 nurses from the hospitals. All nurses reported that they needed a short time to get used to the measurement system when they first wore it. After that, however, there were no problems in wearing it, and they hardly felt it when performing their daily work.

All the wards were almost fully occupied on the days of the study, with an average of 99.6% capacity in the nursing homes and 92.9% in the hospitals (Table 3). Therefore, the measurements constituted a typical nurse's workload. The patient–nurse ratio indicates that nursing home nurses took care of one-third more patients on average (9.0 versus 6.0; $P < 0.001$). The mean measurement time per shift was 313 min in nursing homes and 308 min in hospitals. All nursing home wards were equipped with lifting aids and with 100% height-adjustable beds. The hospital wards, in contrast, were on average half equipped with aids and the rate of height-adjustable beds ranged from 0 to 100%.

Table 4 summarizes the care-related characteristics. The nursing home nurses performed a mean of 26.5 patient transfers per shift and per nurse, that is about four times more frequently than in hospitals (26.5 versus 6.5, $P < 0.001$). The corresponding time spent lifting or carrying a patient's body weight (or part thereof) was on average 88 s compared to 16 seconds per shift ($P < 0.001$). The analysis of the usage of aids during patient transfers showed that nursing home nurses only used them for 0.4% of lifting activities, although all nursing home wards were equipped with lifting aids. Hospital nurses did not use aids at all.

By adding up the number of patients provided with personal basic care (Stages 1–3), it revealed a mean of 6.2 patients per shift and per nurse in the nursing homes and 3.4 patients in hospitals. The proportion of patients provided with especially intensive personal basic care (Stage 3) was 3.4 times higher in nursing homes than in hospitals (4.8 versus 1.4; $P < 0.001$). The basic care intensity score ranged from 1 to 27 points (data not shown) and the mean score was 2.3 times higher in nursing homes than in hospitals (17.4 versus 7.5 points; $P < 0.001$). The number of non-basic care tasks, in contrast, was quite similar.

Table 5 shows that nursing home nurses performed approximately one-third more inclinations over 20° than nurses who worked in hospitals (1541–1160; $P = 0.005$) and that they spent almost twice as long working in a forward bending position (112–63 min; $P < 0.001$).

ANCOVA regarding the individual nurses showed that the total duration of inclinations was significantly related to two variables (Table 6): the first is the working area, with an increase of 25.3 min in nursing homes [95% confidence interval (CI) 2.4–48.2; $P = 0.032$]; the second is the basic care intensity score with an increase of 2 min per score point (95% CI 1.1–2.8; $P < 0.001$). The corresponding model was adjusted for the number of patient transfers and gender but these variables had no significant effect.

## DISCUSSION

Our results show that sagittal trunk inclinations are very frequent in nursing professions and that nurses spend on average up to 2 h per morning shift working in a bent-forward position. It was also shown that there is a link between the extent of personal basic care tasks performed by the nurses, the working area, and the total duration of inclinations. The duration increased as the patients' need for care increased.

What lends strength to our study is that a new measurement system for detecting trunk postures was used that enabled the nurses to move freely and unhindered in the course of their daily work. Previous measurement systems involved laboratory systems that either only allowed investigation of contrived situations or were connected to external system components that hindered the ability of the nurse to move freely (Morlock *et al.*, 2000). Using the special software application, it was possible to synchronize the video footage and the measurement data and to analyse the work situation for each trunk posture. In this way, typical shifts were mapped, as opposed to mere individual or contrived situations. In addition, we succeeded in finding facilities, nursing staff, patients, and residents who not only accepted the use of the measurement system but also gave their consent to having their daily routine filmed. On the other hand, the filming was the main reason that many interested facilities eventually decided not to participate. It is very likely that the participating facilities tended to have good or presentable working conditions and that the mean values determined for inclinations over 20° were underestimated. Another reason for an underestimation is that all nurses stated that the measurement system barely hindered their daily work, but it can be assumed that using the video camera probably prompted the nurses to perform their work 'especially well', which may mean that they changed the way in which they went about some of their work (Hawthorne effect). In addition, the patients may also have changed their behaviour because of the presence of the camera. Some nurses even reported that during the measurements, some patients made an unusual effort to cooperate with them. Moreover, the proportion of personal basic care tasks might have been underestimated because although all the patients and residents had given their consent to filming in advance, the video camera was switched off a few times in special situations when the patients requested it. This only occurred during personal basic care tasks to protect the patient's privacy; therefore, inclinations performed while the video camera was switched off could not be assigned. Further inaccuracy was associated with the building of the variable 'no. of non-basic care tasks leading to static

Table 5. Number, duration, and frequency of inclinations over 20° per nurse and per shift stratified by working area.

| Inclinations | Nursing home | Hospital | *P* value |
|---|---|---|---|
| No. of inclinations | 1541 (1340–1743) | 1170 (1027–1313) | 0.005 |
| No. of static inclinations | 448 (383–512) | 255 (209–300) | <0.001 |
| Total duration of inclinations (minutes) | 112 (94–131) | 63 (49–76) | <0.001 |
| Frequency of inclination (per minute)[a] | 4.9 (4.3–5.5) | 3.8 (3.3–4.2) | 0.004 |

Values are mean values (95% CI).
[a]Frequency was calculated by dividing no. of inclinations per nurse and per shift by measurement time.

Table 6. Variables associated with the primary outcome variable 'total duration of inclination'.

| Variable | Effect (95% CI) | *P* value |
|---|---|---|
| Working area (nursing home or hospital)[a] | 25.3 (2.4–48.2) | 0.032 |
| No. of patient transfers | 0.3 (−0.08–0.7) | 0.117 |
| Basic care intensity score (points) | 2.0 (1.1–2.8) | <0.001 |
| Gender | 6.9 (−12.8–26.7) | 0.478 |

[a]Reference variable: hospital.

inclinations'. Only the static inclinations were used here, which means that all inclinations that lasted <4 s were not taken into account concerning this variable. We had to make this compromise because with the static inclinations alone, a total of ~20 000 forward bending instances had to be assigned. Another limitation of this study was that only one person per ward was tested on three consecutive days. To map the overall workload variability on a ward, several people would need to be tested on different days, but measurements using the CUELA system required a high logistical input by both the participating facilities and the research team; therefore, a compromise had to be found to make the input feasible for both sides.

The nursing staff who participated in this study assumed many inclinations that were outside the neutral range, and the average frequency of inclinations per minute exceeded significantly the limit of twice per minute during a shift (Table 5). It should also be noted that sagittal trunk inclinations are often combined with lateral inclinations and/or torsional movements, so that 19% of all inclinations over 20° are also combined with a torsion and/or lateral inclination (Freitag *et al.*, 2007). The hospital nurses worked on average 20% of the measured time in a forward bending position and the nursing home nurses 38%. Jansen *et al.* (2001) showed that nurses in nursing homes spend 21% of their working time bent forward by >20°. This value is less than that in the present study because Jansen *et al.* measured only the inclination of the lumbar spine and not the mean trunk inclination. Hodder *et al.* (2010) detected that personal support workers in long-term care facilities spent 50% of their working time with the trunk flexed beyond 9.2° and spent 25% of their time flexed beyond 30°. This is comparable with the results for the nursing home nurses in the present study, although Hodder *et al.* measured only the thoracic inclination.

Manual patient handling exposure did not show a significant effect and accounted only for a small period of the measured time, with an average of 0.5% in nursing homes and an average of 0.1% in hospitals. This corresponded to 26.5 and 6.5 patient transfers, respectively (Table 4). Hodder *et al.* (2010) observed an average of 19.7 patient transfers per shift in long-term care facilities, which corresponded to <4% of the working time. This number of patient transfers is smaller than in the present study, whereas the proportion of time in which the nurses spent performing patient transfers is longer. The smaller number resulted from the authors not counting the tasks 'lifting the patient to sit upright in bed' and 'lifting legs' as patient transfers. In contrast to the present study, the longer time period resulted from the preparation time before and after a patient transfer which Hodder *et al.* took into account. If only the lifting procedures in our study had been used for an exposure analyses, 99.5% of the working time in nursing homes and 99.9% of the working time in hospitals would be ignored. This may explain why preventive measures that have focused only on training techniques for proper lifting and the use of lifting aids cannot result in a substantial change concerning back problems, as these measures are only effective for a very small time period of each shift and disregard the strain that arises from working in a bent-forward position for 2 h. Also Hodder *et al.* concluded that in addition to patient transfers, other patient care tasks should not be overlooked in their capacity to contribute to risk of injury.

Another important factor was the evaluation of static inclinations. Potential damage from static postures was mainly thought to be due to muscle exhaustion, changes in metabolism, pain sensitivity, and the pattern of movements, which eventually lead to excessive stress on the musculoskeletal system (Bonato *et al.*, 2003; Ma *et al.*, 2009). In the current study, a large number of static inclinations were detected (Table 5). An average of 29.1 and 21.6% of the inclinations in nursing homes and hospitals were static inclinations. Engels *et al.* (1996) reported that nurses themselves regard static trunk postures as one of the main stress factors. By using heart rate and electromyograph measurements, it was shown that the back musculature of nurses is greatly exhausted towards the end of a shift, such that the risk of injury increases during the shift (Hui *et al.*, 2001). Lee and Chiou (1995) and Knibbe and Friele (1996) also found that nursing staff are often exposed to static postures and that this is an important factor in the evaluation of physical strain for nurses.

The total duration of inclinations was significantly related to working in nursing homes and higher levels of basic care intensity scores. The scores show that the proportion of personal basic care tasks in nursing homes is particularly high (Table 4). This was where the majority of patients requiring almost total personal basic care were found (Stage 3). By using the OWAS procedure (Ovako Working Posture Analysing System), Hignett (1996) also showed that tasks performed in the vicinity of the patient cause a higher proportion of awkward body positions than tasks not performed in the vicinity of the patient. Therefore, it can be deduced that nursing staff in nursing homes, who mostly have to care for older and immobile patients, are exposed to increased physical strain from frequent bending in the course of their daily work compared with hospital nurses.

## CONCLUSION

The study demonstrated that sagittal trunk inclinations are an important factor in the evaluation of physical strain in nursing staff. The number of inclinations was highly dependent on the working area and on the group of patients who were being cared for. The higher the proportion of personal basic care tasks performed by the nurses, the higher was the number of inclinations. Therefore, it is very likely that there is a real opportunity to reduce the physical strain for nurses if future preventive measures focus not only on manual patient handling but also on devising a training concept to reduce the huge amount of inclinations in everyday nursing work.

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