The Impact of Stressful Postures on the Physical Workload in Nursing

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The Impact of Stressful Postures on the Physical Workload in Nursing

Doctoral Thesis
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Abstract

Nursing staff have an elevated risk of developing musculoskeletal disorders, in particular in the lower back area. Statistics produced by leading industrial nations show that back problems are the world’s number one work-related health problem, and that healthcare workers suffer from a greater occurrence of such problems than workers in other professions. In this context, many studies have examined manual patient handling activities, which was thought to be the main cause of musculoskeletal disorders of the lower back. But nurses have many other types of work to perform and several reviews have concluded that approaches which only focus on manual patient handling activities do not sufficiently reduce back problems in nursing professions.

Other risk factors for musculoskeletal disorders of the lower back discussed in the literature included repeated bending and the high proportion of static trunk postures. The main aim of this doctoral thesis was therefore to examine the influence of stressful trunk postures on the physical workload of nursing staff in hospitals and nursing homes. It focuses on the type, number and extent of stressful postures and on identifying activities that encourage their occurrence. We used our findings to derive strategies for reducing stressful postures in nursing, and examined whether nursing staff regard such a reduction as actually relieving their physical workload.

A secondary aim was to consider the older people potentially in need of care. The background to this is that, due to steadily rising costs, many older people are unable to afford care in a nursing home, and additionally that the forecast severe shortage of nursing staff in future gives reason to look for solutions that can reduce the demand for nursing staff. Among older people who still look after themselves, we therefore examined which stressful postures they adopt when carrying out domestic tasks such as cooking and washing laundry. From the results, we provided some examples of a better design of the domestic environment, which reduces stressful postures, when performing these tasks and helps older people to be able to look after themselves in their own homes for longer.

Keywords: nurses, musculoskeletal disorders, trunk posture, perceived exertion, ergonomics
Acknowledgement

“Everything is interconnected and has a meaning.
That meaning may remain hidden nearly all the time,
but we always know we are close to our true mission on earth
when what we are doing is touched with the energy of enthusiasm.”
(Paulo Coelho, The Zahir)

Carrying out research always means setting out along new paths. And this requires courage, curiosity, determination and enthusiasm. Many people have accompanied me along my path, some for a short stretch, while others are still with me today. What they all have in common is that with their commitment and knowledge, they have enriched this project in many different ways. I would like to express my heartfelt thanks to all these people, although I can only mention a few of them by name.

First and foremost, I would like to thank Professor Tore Larsson and Professor Albert Nienhaus, who supervised my doctoral thesis. Dear Tore, dear Albert, in your highly competent and charming way, you ensured that I was able to set out along this path in the first place. You gave me the freedom to decide for myself where the path was to take me, and at the same time, you gave me the feeling that someone would be there for me if the going got tough. In doing so, you created a wonderful space that not only enabled the project to flourish, but which also gave me the opportunity to learn an incredible amount. In addition, you, Tore, together with Kay, ensured that on every visit to Stockholm I always felt a little bit at home. Thank you very much for that.

I would also like to thank my employer, the Institution for Statutory Accident Insurance and Prevention in the Health and Welfare Services (BGW), for enabling me to continue my education, and first and foremost Dr. Thomas Remé, who always believed in me and my abilities, and who supported me in every respect.
Dear colleagues, I would like to thank you, too, for your support and your friendliness. You always knew how to create a positive atmosphere, one in which I felt at ease and enjoyed working, and that is the best prerequisite for creative and productive development processes. I would also like to take this opportunity to express my special thanks to Rachida Seddouki. Dear Rachida, in the past few years we have spent many exhausting, but many more pleasant, hours together. With your untiring diligence and courage in simply wanting to try out and step in to the unknown, you played a large part in the success of this project. It’s nice to know you’re there.

I would also like to thank Ingo Hermanns, who always had a sympathetic ear for all the technological challenges we encountered in recent years. His brilliant programming skills and friendly, helpful nature make him a real asset.

I also want to thank all the carers, residents and patients. At the start of the project, we had serious concerns about being able to find hospitals and nursing homes that would allow us to use the measuring system and video camera. We also wondered whether the residents and patients would allow us to film all the carers’ activities. However, we were most pleasantly surprised and are very grateful for the confidence that all parties had in us.

I want to conclude by thanking my family and friends. You are simply there for me and that is a great gift. Thank you, Klaus, for all your patience with me and for the wonderful drawings. Mum and Dad, I would like to dedicate this doctoral thesis to you to express my eternal gratitude that you are at my side.

Sonja Freitag
List of papers


Division of work between authors

**Paper 1:** Freitag, Ellegast and other colleagues further developed the measurement system for use in nursing professions and planned the study. Freitag performed the measurements. Freitag preprocessed and analysed the data. Freitag, Dulon and Nienhaus performed statistical analyses. Freitag wrote the manuscript. Ellegast, Dulon and Nienhaus appraised the manuscript critically.

**Paper 2:** Freitag and Ellegast planned the study. Freitag performed the measurements. Freitag preprocessed and analysed the data. Freitag, Dulon and Nienhaus performed statistical analyses. Freitag and Fincke wrote the manuscript. Ellegast, Dulon and Nienhaus appraised the manuscript critically.

**Paper 3:** Freitag, Fincke-Junod, Larsson and Nienhaus planned the study. Freitag, Fincke-Junod and Seddouki performed the measurements. Freitag and Seddouki preprocessed and analysed the data. Hermanns adapted the Software application WIDAAN to special evaluation requirements. Freitag, Dulon and Kersten performed statistical analyses. Freitag and Fincke-Junod wrote the manuscript. Dulon, Larsson and Nienhaus appraised the manuscript critically.

**Paper 4:** Freitag, Dulon, Larsson and Nienhaus planned the study. Freitag and Seddouki performed the measurements. Freitag and Seddouki preprocessed and analysed the data. Freitag, Dulon and Kersten performed statistical analyses. Dulon, Larsson and Nienhaus appraised the manuscript critically.

**Paper 5:** Seidel, Hjalmarson, Freitag, Larsson and Clarkson planned the study. Freitag introduced the measurement system and supported the data analysis. Seidel and Hjalmarson performed the measurements. Seidel, Hjalmarson and Brayne analysed the data. Seidel wrote the manuscript. Hjalmarson, Freitag, Larsson, Brayne and Clarkson appraised the manuscript critically.
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1 Introduction

Nursing staff have a higher risk than other occupational groups of developing musculoskeletal disorders (MSD), in particular back disorders, during the course of their working life [1-6]. Statistics produced by leading industrial nations show that back problems are the world’s number one work-related health problem and the most frequent cause of absence; an above-average proportion of those affected are health care and social service workers [7-9]. This is confirmed by current analyses carried out by the DAK, one of Germany’s largest statutory health insurers, according to which health care workers have the highest rate of absence: 4.4% [10]. A separate analysis of nursing staff in inpatient facilities [11] also showed that musculoskeletal disorders were primarily responsible for a rate of absence due to illness of 25.5% among this group of insured people.

Noticeable among nursing staff is also the long duration of sick leave due to musculoskeletal disorders, which was 19.9 days on average, as against an overall average of 11.5 days for all illnesses. Moreover, 73.3% of nursing staff said that they suffered moderate or severe back pain. Current studies from other countries show similar prevalence rates of between 59.8% and 73.5% for the past twelve months [12-14]. Along with the adverse effect on nurses’ health, high rates of occupational absence are also damaging in economic terms. Wenig et al. [15] assessed the annual cost of back pain in Germany at around EUR 49 billion, of which 54% consisted of indirect costs such as sick leave or early retirement.

The causes of musculoskeletal disorders in nursing are complex and, we now know that a single approach to prevention, such as training in ergonomic patient transfers, is not enough to reduce these complaints in the long term [16-18]. One possible additional factor in the occurrence of back problems are stressful postures, such as frequent bending or working in static positions [19-22]. Engels et al. [23,24] found that geriatric nurses spend 25% of their working hours adopting stressful postures. They also discovered that in addition to manual patient handling activities, nursing staff regarded working in awkward positions and frequent bending as very stressful. Yip [25] even sees frequent bending of the trunk while working as an independent predictor for the occurrence of new back disorders.

We suspected that postures of this kind play a major role in the physical strain of nursing staff, and that looking after older people who are often physically and cognitively impaired
places especially high physical demands. Only a few studies have examined stressful
postures in nursing staff [21,26,27] and most of those focused on manual patient handling
activities while paying little attention to other nursing activities.

The main aim of this doctoral thesis was therefore to quantify stressful postures in nursing
staff, to identify the causal factors and to derive suitable preventive measures. We also
investigated whether nursing staff really regard a reduction in stressful postures as a
reduction in the physical workload.

A secondary objective of this doctoral thesis was to consider the older people potentially in
need of care. The background to this is, firstly, the steadily rising financial cost of looking
after people in need of care, leading to a situation in which many older people are unable to
afford care in a nursing home. In Germany, the costs of full inpatient care average between
EUR 2,000 and EUR 3,000 per month, depending on the level of care required [28]. There
may also be additional costs for extra services. Secondly, the forecast severe shortage of
nursing staff in future [29,30] gives reason to look for solutions that can reduce the demand
for nursing staff. In addition, older people usually want to stay in their own homes and to
look after themselves for as long as possible. However, this becomes more difficult with age.
Older people aged over 75 years often experience substantial performance declines [31], as
both cognitive and physical abilities diminish and make it increasingly hard to cope with
everyday tasks [32]. Important factors for independent living are activities such as shopping,
cooking, cleaning and tidying up or laundry washing, among which cooking and washing are
especially important for older people [33,34]. With the help of video recordings, Seidel et al.
[35] discovered that most difficulties in performing daily tasks were the result of impaired
mobility, especially when bending. The need to bend was responsible for difficulties when
cooking (45%), washing (40%), cleaning and tidying up (32%) and shopping (23%). Most of
the test subjects themselves also said they had difficulty in bending. In this connection, we
examined the stressful postures that older people assume while cooking and laundry
washing, and whether the ergonomic design of domestic surroundings can reduce the
number of stressful postures.
2 Background

2.1 Influence of demographic change on the long-term care rate in Germany

According to the German Federal Statistical Office [28], at the end of 2011, 2.5 million people in Germany were in need of care, or 3.1% of the total population. This is known as the long-term care rate. However, the rate of need for care depends very largely on age. While around 5% of people in the age group between 70 and 75 were in need of care, the rate for 85- to 90-year-olds was 38% and from the age of 90 it was 58%. Only ten years previously, the long-term care rate across all age groups was 2.5%, but it rose continuously to 3.1% by 2011. Projected demographic trends indicate that the long-term care rate will continue to increase. In its 2010 report on demographic change [29], the German Federal Statistical Office assumed that by 2050, the proportion of people aged 60 and over in Germany will have risen to 40% (Table 1).

Table 1. Projected demographic trend in Germany by 2050 in the age groups with an increased risk of sickness and of needing care

<table>
<thead>
<tr>
<th>Age groups in years</th>
<th>Number of people in millions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2009</td>
</tr>
<tr>
<td>Total</td>
<td>81.7</td>
</tr>
<tr>
<td>60 – 70</td>
<td>9.2</td>
</tr>
<tr>
<td>70 – 80</td>
<td>7.8</td>
</tr>
<tr>
<td>80 – 90</td>
<td>3.7</td>
</tr>
<tr>
<td>90 and older</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Source: German Federal Statistical Office, Demographic Change (2010)

As the population ages, the number of people in need of care will continue to grow. Figure 1 shows the projected development in the number of people in need of care until the year 2050.
According to Federal Statistical Office calculations, the number of people in need of care in Germany will rise to 3.4 million by 2030, and to as many as 4.5 million in 2050, equivalent to a long-term care rate of 6.5%.

![Projected development in the total number of people in need of care in Germany, based on the ‘status quo scenario’, numbers in millions. Source: German Federal Statistical Office, Demographic Change (2010) and Care Statistics (2011)](image)

2.2 Care situation in Germany

At the end of 2011, of a total of 2.5 million people in need of care, 30% (743,000) were being looked after as inpatients in 12,400 nursing homes. Around 23% of people in need of care were being looked after by mobile home care services, and 47% by family members. In recent years, the trend has been towards professional care in nursing homes and by mobile home care services. Between 1999 and 2007, the number of people in need of care being looked after in nursing homes rose by around 24%, and the number of those looked after by mobile home care services by 21%, while care by family members rose only slightly, by 1% [29]. Reasons for this are, first of all, the increasing level of care required by individuals, primarily through multimorbidity in old age, as a result of which family members often feel unable to cope, and secondly, the increasing number of women who go out to work, which leads to a decline in family care since such care is mainly provided by women.

Overall, the care situation in Germany, especially in nursing homes, is becoming increasingly difficult. Along with demographic change, medical advances are resulting in an increasingly ageing society and to a situation where it is not only the proportion of people in need of care that is rising, but also the level of care needed. On the other hand, the age structure of the
nursing profession itself is changing. Federal Statistical Office figures show that in 2006, the majority of nursing staff (48.3%) were between 35 and 49 years old. Ten years previously, the largest proportion (48.4%) were younger than 35. Likewise, the proportion in the group aged 50 and over rose from 12.5% to 16.7% in the same period. Moreover, because of greater life expectancy and cost pressure on state pension funds, a gradual increase in the retirement age has been planned and partially implemented already. The proportion of older nursing staff will increase as a result. The rate of recruitment of young nursing staff is no longer sufficient to make up for the natural ageing process [36]. A further difficulty is that many nurses leave the occupation prematurely. Hackmann [37] found that hospital nurses continued in the profession for 13.7 years on average, and geriatric nurses for just 8.4 years. This is due, among other things, to family reasons, but mental and physical stress also plays a significant role [38]. In future, therefore, fewer and fewer qualified nursing staff will be available to cope with a steadily rising long-term care rate.

Accordingly, the German Institute for Economic Research [30] calculated that by 2050, the need for nursing staff will increase by 129% in the mobile home care sector and by 143% in the inpatient care sector (compared with data for the base year 2009). For purely demographic reasons there could be a shortage of 670,000 to one million nursing staff by the year 2050 unless appropriate countermeasures are taken. This development presents a major challenge in terms of promoting and maintaining nurses’ health and working capacity so as to enable them to practise their occupation until normal retirement age, even in changed conditions.

2.3 Significance of MSD prevention in nursing professions

An especially important factor in maintaining the health of nursing staff is the prevention of musculoskeletal disorders. These are degenerative disorders, meaning that the course of the disease is exacerbated with increasing age [39]. Consequently, periods of absence increase and grow longer [40]. Figure 2 shows how sharply the proportion of days of sick leave due to MSD rises with increasing age. In addition, Camerino et al. [41] confirm that nurses’ working capacity declines with increasing age.
Musculoskeletal disorders are also among the most frequent causes of long-term sick leave [42]. These, in turn, often lead to reduced work capacity or even work disability [43]. In Germany, a pension for reduced work capacity can be paid if this happens. Harling et al. [44] found that this is particularly frequent among nursing professions, where the proportion is between 30.5% and 38.9%, as against only 22.4% for other occupational groups. It was also found that diagnosis of a musculoskeletal disorder as the basis for drawing a pension for reduced work capacity occurs more frequently in nursing than in other occupational groups. To counter this development, it is important to initiate interventions in people with early symptoms of an MSD [45,46] and to identify at an early stage those nursing staff at an increased risk of having a reduced capacity to work [47,48].

Overall, it is clear how important it is to prevent musculoskeletal disorders in nursing, not only now but for future generations, especially in view of demographic change.
3 Objectives and research questions

One objective of this doctoral thesis was to quantify stressful postures among nursing staff, to identify the factors that cause and encourage them and to derive suitable preventive measures. We also aimed to examine the influence of stressful postures on the perceived physical workload by nurses. A secondary objective was to quantify stressful postures adopted by older people potentially in need of care while cooking and washing laundry, and to establish whether a more ergonomic design of the domestic environment can reduce the number of stressful postures. We carried out four empirical studies in all, two in hospitals and nursing homes during normal working shifts, and two under laboratory conditions. In doing so, we examined the following specific research questions:

Study 1:
- Is the newly developed CUELA measurement system suitable for use in nursing?
- Which stressful postures do nurses adopt during the morning shift?
- Which activities might be responsible for the occurrence of stressful postures?

Study 2:
- How long do nurses work per shift at a sagittal inclination greater than 20°?
- Are there differences between nurses in hospitals and nursing homes in this respect?
- Which factors encourage the occurrence of sagittal inclinations?

Study 3
- What influence do the factors ‘bed height’ and ‘different way of working in the bathroom’ have on the proportion of time that nursing staff spend in a sagittal inclination?
- Do nursing staff perceive a larger proportion of time spent in a sagittal inclination as an increase in physical strain?

Study 4:
- Which critical postures do older people assume when cooking and washing laundry?
- Which factors encourage the occurrence of critical postures?
4 Methods

4.1 Project overview

We performed four empirical studies with a total of 26 hospital nurses, 21 geriatric nurses and 27 older people over 75 years. All participants wore a special measurement system for detecting posture (see chapter 4.4) and were filmed by a video camera, at the same time. In study 1 and 2 the nurses wore the measurement system during their normal working time in the hospital or nursing home; study 3 and 4 took place under laboratory conditions.

Table 2 gives an overview of the study types, the objectives and the time course of the whole project.

<table>
<thead>
<tr>
<th>Study 1</th>
<th>Study 2</th>
<th>Study 3</th>
<th>Study 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Field study (Pilot)</td>
<td>Field study</td>
<td>Laboratory study</td>
</tr>
<tr>
<td>Objectives</td>
<td>1. Test of the new measurement system; 2. Quantification of awkward postures</td>
<td>1. Quantification of sagittal inclinations; 2. Comparison hospital and nursing home; 3. Investigation of factors influencing the occurrence of inclinations</td>
<td>1. Investigation of the impact of different working methods on the occurrence of sagittal inclinations; 2. Investigation of the link between inclinations and perceived exertion</td>
</tr>
<tr>
<td>No. of participants</td>
<td>8 hospital nurses</td>
<td>18 hospital nurses and 9 geriatric nurses</td>
<td>12 geriatric nurses</td>
</tr>
<tr>
<td>Type of participants</td>
<td>Field study</td>
<td>Field study</td>
<td>Laboratory study</td>
</tr>
<tr>
<td>No. of shifts measured</td>
<td>24</td>
<td>79</td>
<td>-</td>
</tr>
<tr>
<td>Facilities</td>
<td>2 hospitals</td>
<td>7 hospitals and 4 nursing homes</td>
<td>Laboratory conditions</td>
</tr>
<tr>
<td>Convenience sample</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
</tbody>
</table>
Study 1 (Papers 1 and 2) is a field study in which we examined whether the newly developed CUELA (German abbreviation for ‘computer-assisted recording and long-term analysis of musculoskeletal loads’) measurement system is suitable for use in nursing and which stressful postures occur in the course of hospital nurses’ everyday work. We analysed three morning shifts of eight hospital nurses, respectively, from five different departments. The results showed that the measurement system is well suited to use in nursing and that hospital nurses assume a large number of stressful postures, working very frequently in a bent-forward position. We also found initial indications that caring for people who are to a great extent in need of help leads to an increase in the number of stressful postures.

Study 2 (Paper 3) is another field study in which we investigated the length of time in which nurses on the morning shift work at a sagittal inclination greater than 20° and the factors that encourage this posture. We analysed three morning shifts of 18 hospital nurses and nine geriatric nurses, respectively. The results showed that hospital nurses spent an average of one hour and geriatric nurses an average of two hours per shift at a sagittal inclination greater than 20°. Basic care activities such as washing patients or making beds significantly increased the occurrence of sagittal inclinations.

Study 3 (Article 4) is a laboratory study in which we examined how the factors bed height and work method in the bathroom affect the proportion of time that nurses spend in a bent-forward position. We also examined the correlation between the time spent by nurses in a bent-forward position and the perceived exertion. To this end, we analysed twelve geriatric nurses who carried out prescribed basic care activities under different conditions at a patient’s bedside and in a bathroom and immediately after doing so rated the personal perceived exertion on the Borg scale. When the participants adjusted the bed to groin height, they spent significantly 28.0 percentage points longer in an upright position than when working at a bed that had not been raised. By using a stool in the bathroom, the nurses spent 25.7 percentage points longer in an upright position than when working standing up. The higher the proportion of time spent in an upright position, the less strenuous the nurses rated their work to be.
Study 4 (Paper 5) is also a laboratory study in which we examined which critical postures older people assume during the course of everyday housework and which factors encourage the occurrence of such postures. We observed 27 men and women aged over 75 while they were cooking and washing laundry. These activities required the adoption of many different postures, and therefore a certain degree of mobility. When cooking, the participants spent 3.2% of the time in a critical posture, and when washing laundry 10.1% of the time. A more ergonomic design of the domestic environment could reduce or eliminate critical postures and make it easier for older people to look after themselves in their own homes for longer.

4.2 Experimental design

4.2.1 Recruitment of facilities, nurses and older people

Due to the measurement system and the required video recordings, it was very difficult to find hospitals and nursing homes 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 hospitals and nursing homes for the studies 1 - 3. Those who were interested to participate in the study were provided with an information brochure. If the facilities were still interested to participate, a detailed information event was held at each facility and interested nurses and other staff members had an opportunity to try out the measurement system. This was done to help people decide whether they would like to participate in the study. All nurses who wanted to participate in the study had to be predominantly free of back pain. That means 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 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.

To find older people over 75 years for study 4, an advertisement was placed in a local newspaper to target the residential population near the study centre, and senior clubs were approached via mail requesting assistance with recruitment in the study. Participants received a compensation of 300 Swedish Crowns, and transportation service was provided for those who had difficulty travelling to the centre.

4.2.2 Information process for people involved in the studies

Due to a smooth performance of the measurements – especially in the field studies – it was very important to inform all people involved in the studies, thoroughly. Therefore, we created three different information brochures (see appendix B): one for the facilities’ managers, one for the participants and one for patients or residents and their visitors in the participating wards. As nursing staff sometimes have to leave their ward during the shift, some posters describing the project were hung up in the institution, additionally. In this way, non-participating staff members and visitors could be informed.

Participants in study 1 and 2 got their information brochure right after their decision to take part. The brochure informed about the study’s objectives, the measurement system used, the course of the measurements, the required clothes for attaching the sensors safely and what the participants have to pay attention for during the measurement. The brochure for patients and their visitors was provided two days before the measurements had been started. It condensed the project and asked for the patients’ support. Additionally, the need of video recordings was explained and assured that these recordings are only used for internal evaluation purposes.

One day before the measurements had been started, an information session with the respective ward manager, the participants and their ward colleagues was performed. The specific daily running of the ward was discussed in order to avoid disturbances possibly caused by the measurements. Additionally, the participants signed the declarations of consent. This was the consent for the video recordings, for the publication of taken photos.
and the assertion to wear the measurement system by their own choice. Afterwards, an
information session was performed in each patient’s room in order to answer questions and
to get the patients’ consent for the video recordings. Besides, the research team members
who would accompany the participants were introduced to the patients or residents.
In study 3 and 4, shortly before the start of the measurements, the participants were
informed about the course of the measurements and signed the declarations of consent.
Due to the laboratory conditions, no patients or residents had to be informed.

4.2.3 Plan of measurements

In study 1 and 2, the day before the measurements had been started, the technical
equipment was set up in a separate room on the respective ward and the measurement
system was adapted to the participant’s body shape to avoid delays on the first
measurement day. Afterwards, the participants filled in the questionnaires “participant” and
“ward”. On the following day, right after the handover from the night to the morning shift,
the system was attached to the participant and the functional capability of the sensors was
tested. Additionally, the video recordings were started. Both, at the beginning and at the
end of each measurement the participant had to perform special initialization movements;
these were necessary for the calibration of the sensors and enabled the checking of
potential sensor failure after the measurements had been taken.

Thereafter, the participant started with her or his normal work and was accompanied
continuously – except during the morning break – by a research team member who took the
video recordings. The measurement of the whole morning shift was divided into two
sections of two to three hours, respectively (Table 3). For security reasons, after each section
the collected data were stored on a notebook.

The measurement of the second section was stopped, as soon as the participant 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. These activities were
excluded from the measurement as they are normally performed seated and sitting postures
lead to different strain patterns that were not addressed in this study. Generally, each
participant wore the system for three consecutive shifts.
Table 3. Typical morning shift in participating hospitals and nursing homes and corresponding time flow of the measurements.

<table>
<thead>
<tr>
<th>Time</th>
<th>Section</th>
<th>Included in measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>06:00-06:30 a.m.</td>
<td>Handover from the night shift to the morning shift</td>
<td>x</td>
</tr>
<tr>
<td>06:30-07:00 a.m.</td>
<td>Attaching the measurement system to the nurse</td>
<td>x</td>
</tr>
<tr>
<td>07:00-10:00 a.m.</td>
<td>1st measurement period</td>
<td>x</td>
</tr>
<tr>
<td>10:00-10:30 a.m.</td>
<td>Morning break</td>
<td>x</td>
</tr>
<tr>
<td>10:30-01:00 a.m.</td>
<td>2nd measurement period</td>
<td>x</td>
</tr>
<tr>
<td>01:00-01:30 a.m.</td>
<td>Handover from the morning shift to the midday shift</td>
<td>x</td>
</tr>
</tbody>
</table>

In study 3 and 4 the participants individually came to the laboratory where the measurements took place. First, an information session was held and to get additional information about the participants, they filled in the questionnaire “participant” (study 3) or an interview was performed (study 4). Subsequently, the measurement system was attached and the participant familiarised with the laboratory environment, the provided utilities and the required activities. And only afterwards, the initialisation movements were performed and the measurements were started.

Each participant performed a predetermined sequence of activities. In study 3 that was: providing personal basic care at three different bed heights and providing personal basic care in the bathroom in three different working positions. Right after each test, the participants had to estimate on the Borg scale, how stressful they perceived the performed work to be, under the respective conditions (see chapter 4.8). In study 4 the required activities were cooking and laundry washing. Here, an estimation on the Borg scale was not performed.
4.3 Different data acquisition and evaluation methods for physical workload

In principle, most methods of recording physical workload during occupational activities can be divided into the following five categories:

**Analysis of activities using a questionnaire**

Questionnaires are used to ask about the general work routine and to record information such as the frequency and duration of postures assumed and loads handled. This method is easy to apply almost anywhere and is often the only possibility for recording an occupational strain that was experienced a long time ago. Its disadvantage is the high level of subjectivity, since the information is usually estimated and often overestimated. In Germany, this method is frequently used to investigate whether an employee’s sickness can be traced back to occupational exposure.

**Analysis of activities by observers**

In this method, specially trained observers accompany the test subjects and record the frequencies of certain postures and loads handled at specified intervals. One example of this is the OWAS method [49], which is used to classify postures and loads handled and to assess the risk they entail. This method has also been used for analysing nursing professions [23,26]. Its disadvantages are the very rough division into assessment categories and the possible subjectivity of observers. It is also difficult to register all movements fully and precisely during a fast sequence of activities. Another method in this category is to use mobile data collection devices. For example, an integrated scanner can be used to input predefined activities or postures using a barcode list and to assign them to a fixed point in time.

**Video analyses**

This method involves filming either an entire shift or individual periods of activity with a video camera. The actual analysis is performed only after the video recording has been completed. The advantage of video analysis is that a work situation can be observed as many times as required and that even a quick sequence of activities can be recorded fully and evaluated. However, even here body angles usually have to be estimated and it is often difficult to assess a body angle precisely in a two-dimensional image.
Other imaging methods

One example involves attaching markers to the test person and using fixed infrared cameras to record the signals reflected [50]. If the system is precalibrated, computers can be used to calculate the absolute spatial position of the markers and their movement. Biomechanical models that can be integrated into the analysis software enable the automatic assessment of the physical workload.

Such a system allows for an objective and precise three-dimensional movement analysis, but only in a small calibrated area. Therefore, only selected activities can be reconstructed under laboratory conditions and examined. A system of this kind is not suitable for analysing an entire shift in real conditions, such as in nursing.

Personal measurement systems

Personal measurement systems analyse movements via sensors attached to the test subjects that detect the body angles at the corresponding joints. In order to determine the loads handled, the required floor reaction forces can be recorded by means of pressure sensitive insoles. Ideally, the measurement data obtained in this way is stored in a battery-powered computer unit attached to the test subject. The advantages of this method are the objective, detailed recording of data and the possibility of using it in real conditions, since the test subject can move completely freely. This method, too, has been used to analysing nursing occupations [51,52]. In the present doctoral thesis the CUELA personal measurement system was used to collect data and is described in more detail in the next chapter.
4.4 CUELA measurement system

The body postures were measured by using the CUELA measurement system (Figure 3), as developed in the Institute for Occupational Safety and Health of the German Social Accident Insurance [53]. A combination of different sensors, attached at the thoracic and lumbar spine and at the hip and knee joints, provides the necessary information on position and angles and enables the kinematic reconstruction of the volunteers’ movements (Table 4).
Table 4. Joints and body regions covered by the CUELA system, their degrees of freedom and applied sensors

<table>
<thead>
<tr>
<th>Joint/body region</th>
<th>Degree of freedom</th>
<th>Sensors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thoracic spine</td>
<td>Sagittal and lateral inclination at the level of Th1</td>
<td>Inclinometers and gyroscopes</td>
</tr>
<tr>
<td>Lumbar spine</td>
<td>Sagittal and lateral inclination at the level of LS</td>
<td>Inclinometers and gyroscopes</td>
</tr>
<tr>
<td>Thoracic and lumbar spine</td>
<td>Torsion between thoracic and lumbar spine</td>
<td>Digital angle sensor</td>
</tr>
<tr>
<td>Hip joints</td>
<td>Flexion/extension</td>
<td>Potentiometers</td>
</tr>
<tr>
<td>Knee joints</td>
<td>Flexion/extension</td>
<td>Potentiometers</td>
</tr>
</tbody>
</table>

Figure 4. The user interface of the software WIDANN 2.75 that was used to evaluate the measured data, with an animated computer figure and synchronized video sequence.
Additionally the floor reaction forces were measured by special pressure-sensitive insoles in order to differentiate between walking, sitting and squatting more precisely. The sensors’ sampling rate is 50 Hz, so that even dynamic movements can be realistically mapped.

The collected data are stored on a memory card with a mini-computer attached at the participant’s back. No connection to external components was necessary, and the participants were able to move freely while performing their work. In addition, the participants 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 participant’s specific situation was shown for each trunk posture selected in the angle time diagram (Figure 4).

4.5 Definition of the joint angles

In this section the joint angles measured by the CUELA system are described. The movements of the trunk are divided in two areas, the thoracic spine and the lumbar spine area and they are measured in three planes: sagittal inclination, lateral inclination and torsion. The movements of the legs are measured in the sagittal plane.

4.5.1 Sagittal inclination of the trunk

Figure 5 shows the definition of the trunk angles for the sagittal movement plane. The inclination of the thoracic and the lumbar spine is built between the gravity axis (1) and the respective trunk axis (2: axis of the thoracic spine or 3: axis of the lumbar spine). The angle (a) describes the inclination of the thoracic spine and the angle (b) the inclination of the lumbar spine.

The sagittal trunk inclination is defined as the mean inclination of the whole trunk. For that a secant (4) is calculated from the measuring points of the thoracic and lumbar spine; the angle between this secant and the gravity axis then yields the sagittal trunk inclination (c).
4.5.2 *Lateral inclination of the trunk*

Figure 6 shows the definition of the trunk angles for the lateral movement plane. The lateral inclination of the thoracic and the lumbar spine is built between the gravity axis (1) and the respective trunk axis (2: axis of the thoracic spine or 3: axis of the lumbar spine).

The angle (a) describes the lateral inclination of the thoracic spine and the angle (b) the lateral inclination of the lumbar spine. The lateral trunk inclination is defined as the mean lateral inclination of the whole trunk. For that a secant (4) is calculated from the measuring points of the thoracic and lumbar spine; the angle between this secant and the gravity axis then yields the lateral trunk inclination (c).
4.5.3 Torsional movement of the trunk

Figure 7 shows the definition of the torsion of the trunk. This occurs when the spine is stronger twisted in the thoracic area than in the lumbar area. The torsion angle (α) is defined as the difference between the trunk axis on the thoracic level (1) and the trunk axis on the lumbar level (2). A rotation to the right yields a positive torsion angle and a rotation to the left yields a negative torsion angle.
4.5.4 Flexion of the hip and knee joints

Figure 8 shows the definition of the hip and knee joint angles in the sagittal movement plane. The hip joint angles (a) are built between the trunk axis (2) and the thigh axis (3). The knee joint angles are built between the thigh axis (3) and the lower leg axis (4). When standing upright that yields an angel of 180° for both, the hip joint angle and the knee joint angle. However, in the medical description of the neutral position the hip and knee joint angles are 0°. Thus, in the WIDAAN software a difference is built between 180° and the measured hip and knee joint angle, respectively, to be consistent with the medical description. In this doctoral thesis the hip and knee joint angles are only measured to identify postures and movements such as going, sitting, squatting and standing. An ergonomic evaluation was not performed.

Figure 8.
Definition of the hip and knee joint flexion
4.6 Trunk posture evaluation

4.6.1 Deviation of the joint angles from the neutral position

For the ergonomic evaluation of the measured trunk postures different angle classes were proposed, based on different standards and the current literature [54-56], (Table 5). The underlying idea in these classifications is that joint position should be regarded as most favourable when it is near the neutral position. The closer a joint angle is to the extreme value in the corresponding range of motion, the higher is the resulting risk of injury.

Table 5. Classification of the trunk postures into angle ranges, adapted from standards DIN EN 1005-4 and ISO 11226 [54,55].

<table>
<thead>
<tr>
<th>Trunk posture</th>
<th>Angle range</th>
<th>Acceptable (neutral range)</th>
<th>Conditionally acceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagittal inclination</td>
<td>$0^\circ \leq x \leq 20^\circ$</td>
<td>$20^\circ \leq x \leq 60^\circ$</td>
<td>$\geq 60^\circ$</td>
<td></td>
</tr>
<tr>
<td>Lateral inclination</td>
<td>$0^\circ \leq x \leq</td>
<td>20^\circ</td>
<td>$</td>
<td>-</td>
</tr>
<tr>
<td>Torsion</td>
<td>$0^\circ \leq x \leq</td>
<td>20^\circ</td>
<td>$</td>
<td>-</td>
</tr>
</tbody>
</table>

*Original limit value used by the standards is $|10^\circ|$.

According to the ISO 11226 and DIN EN 1005-4 standards [54,55], sagittal inclinations between $0^\circ$ and $20^\circ$ are defined as acceptable and correspond to an upright trunk position (Figure 9). In this position the pressure on the lumbar discs is least and rises with an increasing inclination. Here, an inclination was defined as first exceeding and then falling below the $20^\circ$ or $60^\circ$ limit (Figure 10). Inclinations between $20^\circ$ and $60^\circ$ 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 on average less than twice per minute during a shift. Sagittal inclinations over $60^\circ$ are defined as not acceptable. Lateral inclination or torsional movements of over $10^\circ$ are rated as critical by the DIN EN 1005-4 standard [54], which mainly applies to working with machines. But these angles can even occur during rapid walking. Thus, the angle classes suggested there were adapted to the dynamics of realistic nursing work (Table 5).
Figure 9. Evaluation of the sagittal inclination; 1=acceptable, 2=conditionally acceptable, 3=unacceptable

Figure 10. Recording the sagittal inclination intervals; Int=interval
4.6.2 Static postures outside of the neutral range

According to standard DIN EN 1005-1 [56], postures are designated as static postures if they are held for longer than 4 seconds, at a constant or slightly changing force. 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 [57,58]. Permanent inclination of the trunk (without support), as, for example often observed in the basic care of bedridden patients, is strictly speaking not a static posture, as the inclination of the trunk can vary during the task. There is nevertheless often an extended period in which the trunk is not erected into the neutral position (Figure 10, Interval 3), so that it can be assumed in this case that the risk of injury from muscular exhaustion is comparable.

4.6.3 High frequency of movements

The DIN EN 1005-4 standard [54] defines a body movement as being frequent if it is performed twice or more per minute for an extended period. The movement frequency is used as an additional condition for the evaluation of postures which do not correspond to the medically neutral position, but which cannot in principle be regarded as representing a major risk. One example is the sagittal inclination between 20° and 60°, which, according to the standard, lies in a conditionally acceptable angle range. This means that this posture is regarded as being acceptable if it is assumed on average less than twice per minute during a working shift. However, it is regarded as being unacceptable if it is assumed two or more times per minute.

4.7 Factors influencing the extent of sagittal inclinations

4.7.1 Identification of activities leading to sagittal inclinations

The daily duties of nurses include a variety of different tasks, such as washing patients, bed making or changing dressings. To find out which of these tasks most frequently lead to sagittal inclinations we compiled a list with all the tasks that could be found in inpatient nursing work. As there was a great many of different tasks, we summarized them to groups,
such as ‘bed making’, ‘clearing up/cleaning’, ‘basic care in bed’ or ‘patient mobilization’.

With the WIDAAN software we selected all sagittal inclinations over 60° and all static inclinations over 20° and assigned each of them to the corresponding task group, using the video footage.

4.7.2 Basic care intensity score

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. To assess this, a new 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. Additionally, the personal basic care performed by the nurses was 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 less than 50% of the personal basic care tasks (2 points); and Stage 3, the nurse made the bed and performed more than 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.

4.7.3 Different work methods while performing basic care tasks

To find out whether the work method during basic care activities affect the proportion of time that nursing staff work in a forward bending position, we investigated the following two factors: firstly, the height of the bed during basic care activities at the bedside and secondly, the work method (standing, kneeling, and sitting) during basic care activities in the bathroom. Bedside care activities included washing and drying the arms, legs, feet and back of the patient, and changing the bed sheet. The bathroom care activities included the washing and drying of legs and feet, and putting on pantyhose. All participants learned the standardized routine and performed two test runs.
Next, each participant performed the care routine three times in succession at three different bed heights: with the upper edge of the mattress at knee height, at mid-thigh height, and at hip height (Figure 11). Afterwards, the participants performed the standardized care routine in the bathroom, with the patient sitting on a chair at the washbasin. The participants performed the care activities three times in succession, adopting three different work methods: standing, kneeling or squatting, and sitting on a stool (Figure 12).

Figure 11. Standardized routine of different care activities at three different bed heights: upper edge of mattress at knee height, thigh height, and hip height.

Figure 12. Standardized routine of different care activities in the bathroom adopting three different work methods: standing, kneeling or squatting, and sitting on a stool.
4.7.4  **Non-basic care activities**

Additionally, we investigated the proportion of non-basic care activities, such as distributing or collecting food, clearing up, disposal, cleaning, treatment care or pushing/pulling wheelchairs or beds, leading to sagittal inclinations. For that, all static inclinations over 20° were selected and counted by the software application WIDAAN. With the help of the corresponding video sequence a decision for each single static inclination was made, as to whether it was a personal basic care or non-basic care task that had led to the static inclination.

4.7.5  **Load transfer activities**

We defined load transfer activities as tasks, for which increased compressive forces on vertebral disc L5/S1 has been described [59]. This includes tasks in which objects (sacks of washing, bed bars or instruments) and patients are moved. According to Theilmeier et al. [59] there are 11 manual patient handling activities which pose an increased injury risk for the nursing staff (Table 6).

<table>
<thead>
<tr>
<th>No.</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lifting upright in bed, perhaps together with raising the head</td>
</tr>
<tr>
<td>2</td>
<td>Raising from lying to sitting on the edge of the bed, or reverse</td>
</tr>
<tr>
<td>3</td>
<td>From the edge of the bed into a chair, or the reverse, without help from the patient</td>
</tr>
<tr>
<td>4</td>
<td>From sitting to standing, or the reverse</td>
</tr>
<tr>
<td>5</td>
<td>Lifting into or out of the bath</td>
</tr>
<tr>
<td>6</td>
<td>Raising the patient in the bed (possibly two helpers)</td>
</tr>
<tr>
<td>7</td>
<td>Transfer from bed to bed, bed to stretcher etc.</td>
</tr>
<tr>
<td>8</td>
<td>Lifting from floor (two people)</td>
</tr>
<tr>
<td>9</td>
<td>Inserting and removing bedpan</td>
</tr>
<tr>
<td>10</td>
<td>Lifting leg</td>
</tr>
<tr>
<td>11</td>
<td>Carrying patients, possibly with aids</td>
</tr>
</tbody>
</table>
In study 1 and 2 all load transfer activities performed were identified on video and were counted for each nurse and shift. To find out how much time in total was spent with lifting heavy weights, the time for all load transfer activities was added up. However, only the time spent by the nursing staff actually lifting an object, a patient or a part of a patient (e.g. trunk or leg) was taken into account; this does not include preparation time which is needed mostly before and after a patient transfer.

4.8 Determination of perceived exertion

We assumed that there is a link between the proportion of time nursing staff spent in a forward-bending position and the perceived exertion. Therefore, we investigated in study 3 the impact of different work methods on trunk posture and perceived exertion, while performing basic care activities at the bedside and in the bathroom. For the evaluation of perceived exertion we used the 15-point Borg’s RPE scale (R=rating, P=perceived, E=exertion) [60], (Table 7). This scale measures how strenuous a person perceives a particular performance to be. Scale values range from 6 (no exertion at all) to 20 (exhaustion). Prior to the measurements, the participants were informed how to use the Borg scale.

Table 7: Borg’s RPE scale, a 15-point scale for rating (=R) perceived (=P) exertion (=E)

<table>
<thead>
<tr>
<th>Rate of perceived exertion</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>No exertion at all</td>
<td>Extremely light</td>
<td>Very light</td>
<td>Light</td>
<td>Somewhat hard</td>
<td>Hard</td>
<td>Very hard</td>
<td>Extremely hard</td>
<td>Maximal exertion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Prior to the measurements, the participants were informed how to use the Borg scale.
4.9 Questionnaires and interviews

To obtain additional information about the participants and the respective wards, two questionnaires were developed for studies 1 to 3. The questionnaire “participant” asks, besides demographic data, about job position, working time and shift system etc. The questionnaire “ward” asks about the characteristics of the ward, such as type and number of beds, provided aids, proportion of registered nurses and nursing assistants per shift and predominantly patient age and mobility.

In study 4, prior to the measurements, interviews were conducted to obtain additional information about the older people, acting as participants. A research team member asked, besides demographic data, about chronic conditions, such as heart attack, stroke or arthritis. Moreover, it was asked for capability limitations, such as vision, cognition and locomotion and if there are disabilities affecting everyday housework activities.

4.10 Statistical analyses

In study 1, for any ward, we calculated the arithmetic mean and the standard deviation together with the median and 25th and 75th percentiles for the consecutive shifts measured. Differences between the wards were tested using the Kruskal–Wallis test. Statistical analyses were performed using SPSS 19.0.

In study 2, frequencies and mean values for categorical and continuous variables, whichever appropriate were reported. Where necessary, continuous variables were transformed by taking the logarithm. 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).

In study 3, prior to analysis, distribution of data was graphically checked and, if necessary, transformed by taking the logarithm. Categorical data were presented as count (percentages), continuous data were expressed as mean with standard deviations.
Comparisons of Borg scale data among the different working methods were performed by mixed models with nurses as random effects, adjusted for age and sex. Interaction between age and sex was checked, but p-values were not significant for all variables investigated. Marginal means with 95% confidence limits were reported. P-values were reported without correction for multiple testing. P-Values <0.05, two-tailed, were considered statistically significant. Statistical analysis was performed using the SPSS statistical software package 20 (IBM SPSS Statistics Inc, Chicago, IL).

In study 4 the proportion of time spent in each postural category and the number of ‘static postures’ (maintained for more than 4 seconds) were investigated. From the videotapes produced, a sub-task breakdown was made to record the frequency of critical postures according to specific tasks. Data were summarised by means and standard deviations. As a small number of variables showed evidence of non-normality, significance testing was consistently based on the Mann–Whitney test with a p-value of <0.01 considered statistically significant. Relevant data were extracted and analysed using STATA (College Station, TX, USA).

4.11 Ethical issues

In study 1 and 2 all participants, visitors and caregivers on the participating wards were informed about the study objectives, measurement system used, and video recording, prior to the measurements being taken. 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 nursing staff. 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 only recorded by the measurement system. The study design was approved by the Ethics Commission of Hamburg Medical Council, Germany. In study 4 the ethical approval was obtained from the local ethics research committee of the Karolinska Institute, Stockholm, and all participants provided informed consent.
5 Results

5.1 Nurses (study 1 – 3)

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. Overall, it was shown that the new measurement system is well suited for use in nursing professions and in this way, it was possible to investigate postures and activities of nursing staff under realistic working conditions in an objective and detailed manner.

5.1.1 Trunk postures

In the pilot phase (study 1) a mean of 1131 sagittal inclinations of over 20° per shift and participant were counted; this corresponds to an average frequency of 3.5 inclinations per minute and a total duration of 72 minutes nursing staff spent in a forward-bending position per shift (Table 8). Static inclinations of over 20° that lasted longer than 4 seconds occurred on average 237 times per shift and very pronounced inclinations of over 60° were counted 175 times. Additionally, it was shown that 19% of all inclinations of over 20° and 29% of over 60° occurred in combination with a lateral inclination and/or a torsional movement.

Table 8: Number, duration and frequency of sagittal trunk inclinations

<table>
<thead>
<tr>
<th>Trunk postures(^a)</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Nursing home</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hospital</td>
<td>Hospital</td>
<td>Nursing home</td>
</tr>
<tr>
<td>No. of shifts measured</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>52</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Measurement time per shift (min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>316 ± 42</td>
<td>308 ± 33</td>
<td>313 ± 21</td>
<td></td>
</tr>
<tr>
<td>No. Inc &gt;20°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1131 ± 377</td>
<td>1160 ± 329</td>
<td>1541 ± 309</td>
<td></td>
</tr>
<tr>
<td>No. Inc &gt; 60°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>175 ± 133</td>
<td>117 ± 85</td>
<td>311 ± 191</td>
<td></td>
</tr>
<tr>
<td>No.static inc &gt;20°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>237 ± 101</td>
<td>255 ± 97</td>
<td>448 ± 111</td>
<td></td>
</tr>
<tr>
<td>Total dur inc &gt; 20° (min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>72 ± 35</td>
<td>63 ± 26</td>
<td>112 ± 36</td>
<td></td>
</tr>
<tr>
<td>Frequency inc &gt;20° (min(^{-1}))</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 ± 0.9</td>
<td>3.8 ± 1.1</td>
<td>4.9 ± 0.9</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Values are means ± standard deviations
The results of study 2 confirmed the dimension concerning the sagittal inclinations found in study 1. Moreover, we discovered that geriatric nurses performed about one third more inclinations of over 20° (1541 vs. 1160; \( P=0.005 \)) and spent almost twice as long working in a bent-forward position (112 vs. 63; \( P<0.001 \)), compared to hospital nurses.

### 5.1.2 Factors promoting the occurrence of trunk inclinations

Most of the very pronounced inclinations of over 60° were caused by the tasks “bed making”, “personal basic care” and “clearing up/cleaning” (Table 9). The static inclinations of over 20°, too, were predominantly caused by these activities (data not shown). In addition, we found several other factors that affected the occurrence of sagittal inclinations significantly: On the one hand it was the facility (hospital or nursing home) the participant was working in and the amount and intensity of performed basic care activities (Table 9); but also the adjusted bed height and the work method in the bathroom had a significant influence on the total duration of sagittal inclinations.

The model revealed (Table 10) that working in a nursing home increases the total duration of inclinations by 25.3 minutes \( (95\% \, CI = 2.4 – 48.2; \, p = 0.032) \) and an increase of the basic care intensity score by one score-point corresponds to an extension of two minutes working in a bent-forward position \( (95\% \, CI = 1.1 – 2.8; \, p < 0.001) \). The model was adjusted for the number of patient transfers and gender but these variables had no significant effect.

### Table 9. Distribution of activities leading to sagittal inclinations > 60°

<table>
<thead>
<tr>
<th>Ward</th>
<th>Measurement [n]</th>
<th>Activities with inclinations &gt; 60° [%]</th>
<th>Clearing up, cleaning</th>
<th>Treatment care</th>
<th>Bed making</th>
<th>Basic care</th>
<th>Patient mobilisation</th>
<th>Handling bed linen</th>
</tr>
</thead>
<tbody>
<tr>
<td>GER</td>
<td>3</td>
<td>13.4 ± 11.7</td>
<td>8.5 ± 7.4</td>
<td>39.1 ± 13.2</td>
<td>21.4 ± 1.8</td>
<td>1.3 ± 2.3</td>
<td>9.4 ± 4.9</td>
<td></td>
</tr>
<tr>
<td>CH + INN</td>
<td>12</td>
<td>11.8 ± 8.7</td>
<td>3.1 ± 4.3</td>
<td>17.9 ± 9.5</td>
<td>20.9 ± 23.1</td>
<td>6.9 ± 8.9</td>
<td>9.4 ± 11.8</td>
<td></td>
</tr>
</tbody>
</table>
Table 10. Variables associated with the primary outcome variable „total duration of inclination“

<table>
<thead>
<tr>
<th>Variable (study 2)</th>
<th>Effect (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working area (hospital or nursing home)</td>
<td>25.3 (2.4-48.2)</td>
<td>0.032</td>
</tr>
<tr>
<td>No. of patient transfers</td>
<td>0.3 (-0.08-2.8)</td>
<td>0.117</td>
</tr>
<tr>
<td>Basic care intensity score (points)</td>
<td>2.0 (1.1-2.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Gender</td>
<td>6.9 (-12.8-26.7)</td>
<td>0.478</td>
</tr>
</tbody>
</table>

The bedside tests showed that raising the bed for performing basic care activities increased the proportion of time in an upright position, decisively (Figure 13). When the bed was at knee height, the participants spent 18.5% (±4.6) of the test duration in an upright position and 81.5% (±4.6) bending forward at an angle of more than 20°. The proportion of very pronounced inclinations of more than 60° was 28.4% (±13.4). When the bed was set at thigh height, the proportion of time spent in an upright position increased by 7.9 percentage points to 26.4% (±8.7) and the proportion of very pronounced inclinations of more than 60° decreased by 22.1 percentage points to 6.3% (±8.7). With the bed at hip height there were no longer any inclinations of more than 60° and the participants spent almost half the time working in an upright position.

The bathroom tests (Figure 14) showed that when the work method adopted was “standing”, the participants spent 13.1% (±4.9) of the test duration in an upright position and 86.9% (±4.9) bending forward at an angle of more than 20°. The proportion of very pronounced inclinations of more than 60° was 72.7% (±10.7). When the participants worked in a squatting or kneeling position, the proportion of time spent in an upright position increased by 19.6 percentage points to 32.7% (±30.4) and the proportion of inclinations of more than 60° fell considerably by 70.2 percentage points to 2.5% (±3.5). When the participants worked sitting on a stool, the proportion of time spent in an upright position rose by an additional 6.2 percentage points, but the proportion of very pronounced inclinations of more than 60° rose by 3.5 percentage points. The subjects’ work method varied widely when they used a stool. Some laid the leg of the patient across their own thigh, while others just lifted it slightly or left it on the floor. Four participants placed the patient’s leg on their thigh and consequently spent two and a half times the percentage of time in an upright position than the other participants (62.5% (±22.6) versus 27.1% (±13.8) (data not shown).
Figure 13. Proportion of trunk inclination in different angle classes for bedside tests, separated by bed height setting

Figure 14. Proportion of trunk inclination in different angle classes for bathroom tests, separated by working method
The model (Table 11) revealed that both, the bed height and the work method in the bathroom influenced the proportion of time spent in an upright trunk posture. When the bed was moved from knee to thigh height, the proportion of time in an upright position increased by 8.2 percentage points, but the effect was not significant. Only when the bed was moved to hip height was there a significant increase of 19.8 percentage points (reference: thigh height) or 28.0 percentage points (reference: knee height). Compared with the standing work method, the kneeling and sitting work methods led to a significant increase in the proportion of time spent upright, of 19.4 or 25.7 percentage points respectively. The model was adjusted for age and gender, but these variables showed no effect.

Table 11: Influence of different variables on the primary outcome variable “proportion of time

<table>
<thead>
<tr>
<th>Variable (study 3)</th>
<th>Effect (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bed setting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee height*</td>
<td>Thigh height</td>
<td>8.2 (-4.3-20.7)</td>
</tr>
<tr>
<td>Knee height*</td>
<td>Hip height</td>
<td>28.0 (14.7-41.2)</td>
</tr>
<tr>
<td>Thigh height*</td>
<td>Hip height</td>
<td>19.8 (7.0-32.5)</td>
</tr>
<tr>
<td><strong>Bathroom setting</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing*</td>
<td>Kneeling</td>
<td>19.4 (6.9-31.8)</td>
</tr>
<tr>
<td>Standing*</td>
<td>Sitting</td>
<td>25.7 (13.3-38.1)</td>
</tr>
<tr>
<td>Kneeling*</td>
<td>Sitting</td>
<td>6.4 (-6.0-18.8)</td>
</tr>
</tbody>
</table>

*Reference variable

5.1.3 The impact of sagittal inclinations on perceived exertion

All participants gave the highest Borg rating to work at the lowest bed setting (knee height) with a mean of 17 (±1.5), corresponding to the “very hard” rating on the Borg scale (Figure 15). When the bed was set to thigh level, all participants gave a lower rating than on the knee-high setting with a mean of 13 (±2.7). This rating corresponds to the perceived exertion “somewhat hard”. The highest bed setting, at hip height, received an average rating of 10 (±2.0) which corresponds to an exertion between “very light” and “light”.

In the bathroom, all participants awarded the highest Borg rating to the “standing” work method with a mean of 17 (±1.8), (Figure 16). This corresponds to the exertion “very hard”
on the Borg scale. All participants awarded a lower rating to the “kneeling” work method, on average 11 (±2.1), than to the “standing” work method. This corresponds to the perception “light”. On average, the work method “sitting on a stool” was given the lowest Borg rating with a mean of 10 (±2.6). This corresponds to an exertion between “very light” and “light”. When one compares the participants who placed the patient’s leg on their thigh while sitting on the stool with the other participants, the former group gave a mean Borg rating of 8 (±0.6) and the latter a rating of 11 (±2.6) (data not shown).

The model showed that a greater proportion of time spent in a forward-bending posture led to an increased perception of physical exertion (Table 12): a 10% increase in the duration of inclination increased the Borg rating significantly, by 1.1 points (95% CI 0.8–1.6; p<0.001). Age also had a significant effect when comparing the youngest (<30 years) and oldest (>45 years) participant groups. The younger participants rated their perceived exertion at 2.2 points (95% CI 0.1–4.3; p=0.042) higher on the Borg scale. Adjustment for gender had no significant effect.
Figure 16. Perceived exertion during bathroom care activities (Borg scale ratings), separated by working method, 6=no exertion at all, 20=maximum exertion

<table>
<thead>
<tr>
<th>Variable (study 3)</th>
<th>Effect (95% CI)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inclination &gt; 20°a</td>
<td>0.11 (0.08-0.16)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Measurement time (min)</td>
<td>0.08 (-0.17-0.33)</td>
<td>0.538</td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;30b</td>
<td>30-45</td>
<td>-1.4 (-3.1-0.3)</td>
</tr>
<tr>
<td>&lt;30b</td>
<td>&gt;45</td>
<td>-2.2 (-4.3-(-0.076))</td>
</tr>
<tr>
<td>30-45b</td>
<td>&gt;45</td>
<td>-0.08 (-2.7-1.2)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maleb</td>
<td>Female</td>
<td>1.83 (-0.23-3.89)</td>
</tr>
</tbody>
</table>

*Inclination = proportion of time in a forward bending trunk posture, bReference variable
5.1.4 Load Transfer Activities

Table 13 summarizes the load transfer activities measured in study 1 and 2. The geriatric nurses performed a mean of 26.5 patient transfers per shift and per nurse, that is about four times more frequent than in hospitals (26.5 versus 6.5). Materials, such as water crates or sacks of washing were moved on average 0.5 – 0.7 times per shift and nurse. The high mean frequency of 8 material transfers in study 1 is caused by the measurements in the OP; here, on average 36 devices were moved by one nurse per shift. In study 2 however, measurements were only performed in care units.

The analysis of the usage of lifting aids during patient transfers showed that geriatric 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 lifting aids at all. The corresponding time spent moving patient or materials was on average half a minute in hospitals and approximately 2 minutes in nursing homes.

Table 13: Mean frequency and duration of transfers per shift and per participant

<table>
<thead>
<tr>
<th>Variables†</th>
<th>Study 1</th>
<th>Study 2</th>
<th>Nursing home</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patient transfers (n)</td>
<td>10.7 ± 9.8</td>
<td>6.5 ± 5.1</td>
<td>26.5 ± 11.4</td>
</tr>
<tr>
<td>No. of material transfers (n)</td>
<td>8.3 ± 13.1</td>
<td>0.7 ± 1.5</td>
<td>0.5 ± 1.6</td>
</tr>
<tr>
<td>Total duration of transfers (min)</td>
<td>2.1 ± 1.3</td>
<td>0.5 ± 0.5</td>
<td>1.9 ±0.5</td>
</tr>
<tr>
<td>Ratio of patient transfers with aids (%)</td>
<td>not evaluated</td>
<td>0.0 ± 0.0</td>
<td>0.4 ± 0.1</td>
</tr>
</tbody>
</table>

†Values are means ± standard deviations

5.2 Older people (study 4)

The cooking activity lasted on average 12 minutes (±4) and the participants spent 25.5% of this time in a bent-forward position of over 20° (Table 14) and 3.2% in a critical inclination of over 60°; static inclinations of over 20° occurred on average 9.8 times. Critical trunk postures occurred while performing the following sub-tasks: retrieving from and putting in lower cabinets, retrieving from and putting in the refrigerator, disposing into the waste bin and other tasks (mainly related to searching for tools and materials).
Participants with locomotion difficulties had significantly more critical postures during retrieving from and putting in lower cabinets \((p \leq 0.01)\) and significantly more critical postures during other tasks were observed in men compared to women \( (p = 0.01)\).

Table 14. Time spent in postural categories and frequency of static postures

<table>
<thead>
<tr>
<th>Category</th>
<th>Time (%), M ± SD</th>
<th>Frequency of static TI (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooking</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TI &lt; 20°</td>
<td>74.5 ± 19.7</td>
<td>19.3 ± 6.9</td>
</tr>
<tr>
<td>TI 20°-60°</td>
<td>22.3 ± 19.4</td>
<td>8.3 ± 8.7</td>
</tr>
<tr>
<td>TI &gt; 60°</td>
<td>3.2 ± 1.5</td>
<td>1.5 ± 1.1</td>
</tr>
<tr>
<td><strong>Laundry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TI &lt; 20°</td>
<td>57.2 ± 13.4</td>
<td>2.1 ± 2.4</td>
</tr>
<tr>
<td>TI 20°-60°</td>
<td>32.7 ± 12.5</td>
<td>4.9 ± 1.9</td>
</tr>
<tr>
<td>TI &gt; 60°</td>
<td>10.1 ± 5.1</td>
<td>1.5 ± 1.2</td>
</tr>
</tbody>
</table>

\(\text{TI} = \text{trunk inclination}\)

Also washing laundry lasted on average 12 minutes \((±3)\) and the participants spent 42.8\% of this time in a bent-forward position of over 20° (Table 14) and 10.1\% in a critical inclination of over 60°; static inclinations of over 20° occurred on average 6.4 times. Critical trunk postures occurred during retrieving from and putting in the basket, putting in and retrieving from the machine, operating the machine and other tasks (such as: move basket, clean up, ensure the machine is empty, pick up from floor, fold laundry and put away). Individuals with cognitive difficulties took significantly longer to complete the laundry \((p \leq 0.01)\). Those using the front-loader spent 12\% of the time assuming a trunk inclination of ≥ 60°, whereas those using the top-loader only 6\%. Men had fewer critical postures than women during putting in and retrieving from the machine \((p \leq 0.01)\).
6 Discussion

We found that sagittal trunk inclinations are very frequent in nursing professions. The nurses in nursing homes spent on average two hours and in hospitals one hour per morning shift working in a bent-forward position – including many static and very pronounced inclinations over 60°. In contrast, the time for moving a patient’s weight made up only a few minutes of the total working shift. We also showed that the total duration of inclinations was significantly related to working in nursing homes with an increase of almost half an hour and the duration rose as the patients’ need for personal basic care increased.

Additionally we found that raising the bed to hip height, when performing selected personal basic care tasks and using a stool in the bathroom significantly increased the time participants worked in an upright posture. The greater the proportion of time the participants spent in an upright position, the lower they rated the perceived exertion.

In a laboratory study, Caboor et al. [27] found that adjustment of the bed height leads to a higher proportion of time in a neutral trunk position; however, a significant impact on perceived exertion by adjusting the bed height they could not detect. The authors assumed that this was due to the fact that most participants hardly changed the bed height and the authors concluded that most care staff do not know which bed height is best for them. Our field studies point in the same direction, as we observed that none of the nursing personnel adjusted the bed to hip height when performing basic care, even though there were height-adjustable beds in many of the hospital wards and all nursing home wards were completely equipped with height-adjustable beds. Furthermore, nursing personnel think that adjusting the bed height takes too much time [61]. But this is a misapprehension, as we could show that nursing staff would have to invest only a total of 3 to 5 minutes per early shift in adjusting bed heights appropriately when performing personal basic care activities.

Patient transfer activities did not have a significant impact on the total duration of inclinations 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. Here, we summarized only the time periods a patient’s weight was moved; preparatory steps before and the steps after the patient transfer took up much more time, but did not comprise moving a heavy weight. At this point it becomes clear that if only patient transfer activities are taken into account for
an exposure analysis, 99% of the working time would be ignored. This may explain why preventive measures that have focused only on training techniques for moving patients did not result in a substantial change concerning back problems. These measures were only effective for a small time period of each shift and disregarded the strain that arose from working 2 hours in a bent-forward posture. Also Hodder et al. [21] concluded that in addition to patient transfers, other patient care tasks should not be overlooked in their capacity to contribute to risk of injury.

Concerning the study with older people we found that during cooking the participants spent 25% of the time in a bent-forward position and 3% in critical postures. During laundry they spent 43% of the time in a bent-forward position and 10% in critical postures. These figures are very similar to Clark et al. [62] who estimated that bending accounts for 7% and 12%, respectively. Critical postures occurred primarily during retrieving from and putting in lower cabinets, the refrigerator, laundry basket or washing machine as well as disposing into the waste bin. During laundry critical postures only occurred when using the front-loader, because the placement of the loading door and control panel increased the need for bending and close vision. We found more critical postures in older people with locomotion difficulties during retrieving from and putting in lower cabinets. This is supported by Brauer et al. [63] who found that for balance-impaired elderly individuals it is more demanding to recover postural stability.

In this study, postures were assessed by using the classification from an ISO standard [55], but this standard applies to the adult working population and not to older people. For them lower threshold values may be more applicable, because muscle endurance, for example, generally decreases with age due to structural and biochemical changes [64]. Therefore, it is very likely that our results underestimate the amount of critical postures in older people during cooking and laundry. To reduce difficulties with cooking the provision of seating could support older people while preparing meals. The storage of materials most frequently used in locations where they can be easily accessed, could avoid many trunk inclinations, especially the critical ones over 60°. And using a top-loader or raising a front-loader to an appropriate height appears to be the preferred option for doing laundry.

What lends strength to our studies is the use of a new measurement system for detecting trunk postures that enabled the participants to move freely and unhindered. Previous
measurement systems often only allowed investigation of contrived situations in a laboratory environment or the participants were connected to external system components that hindered them to move freely. 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, for study 1 and study 2 typical shifts were mapped, as opposed to mere individual or contrived situations. In addition, we succeeded in finding institutions, nursing staff, patients, residents and older people who not only accepted the use of the measurement system but also gave their consent to be filmed.

On the other hand, several limitations should be pointed out: For all studies, institutions and participants were not selected at random but as a convenience sample, this could make the results less generalizable. Additionally, for the field studies 1 and 2 it is very likely that the participating institutions tended to have good or presentable working conditions as the filming was the main reason that many interested institutions eventually decided not to participate. As a result, the mean values determined for inclinations over 20° could be underestimated. Another reason for an underestimation is the assumption that using the video camera probably prompted the participants 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); this may also apply for the participants in the laboratory studies 3 and 4. Even the patients may have changed their behaviour because of the presence of the camera. Some nurses reported that during the measurements, some patients made an unusual effort to cooperate with them.

Moreover, the proportion of personal basic care tasks in the field studies might have been underestimated, too, because the video camera was switched off a few times during personal basic care tasks to protect the patient’s privacy; during this time, inclinations performed could not be assigned. Further inaccuracy occurred as we did not assign each inclination over 20° to the respective activity, only the static inclinations lasting over 4 seconds were used to keep the analysis feasible; however, with the static inclinations alone, a total of 20,000 inclinations still had to be assigned only in study 2. Another limitation of all studies was the small number of participants, but measurements using the CUELA system required a high logistical input by both the participating institutions and the research team. Therefore, a compromise had to be found to make the input feasible for both sides.
In study 3, most participants were unaccustomed with some of the working methods tested. So these work methods, perceived as unaccustomed, may have had an influence on the perceived exertion. Therefore, it is very likely that, after a period of habituation, the participants would have rated the new work methods as providing even greater physical relief.

7 Conclusions

Sagittal trunk inclinations are an important factor in the evaluation of physical strain in nursing staff. The duration nurses spent in a bent-forward posture during a morning shift was significantly 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. But also the work method during selected personal basic care activities - raising the bed to hip height and using a stool in the bathroom - had a significant impact on the proportion of time nurses worked in an upright posture; and these work methods are perceived as requiring the least exertion.

Therefore, future preventive measures should focus not only on manual patient handling but also on devising a training concept to reduce the huge amount of trunk inclinations. Provided that hospitals and nursing homes provide appropriate furniture, such as stools and height-adjustable beds, and nurses use these devices effectively, there is a real opportunity to reduce the physical strain in everyday nursing work.

The results from the study with older people suggest that if older people are forced to adopt critical postures during cooking and laundry these tasks may become too demanding to perform and eventually may lead to required support by other people. Therefore, the specific tasks leading to critical postures should be targeted by designers in order to improve the activities and to enable older people to live an independent life in familiar surroundings as long as possible.
8 Future project

Identifying and quantifying the main activities which contribute towards the occurrence of awkward postures in nursing is an important basis for developing future preventive concepts. A seminar on the reduction of awkward postures in nursing will therefore be developed and evaluated in a further study with the help of the findings from Studies 1 to 3. The objective of this seminar is, in the first instance, to create awareness of the physical strains that nursing staff hardly notice, even though they occur on a daily basis and very frequently during the course of a shift. Secondly, an important component will be the introduction of ‘ergonomic aids’, such as the stool used in Study 3 for nursing activities in the bathroom.

In order to evaluate the seminar, we will recruit six new nursing homes. In a baseline investigation preceding the seminar, 24 geriatric nurses will wear the CUELA measurement system during a morning shift. The seminar will subsequently be run on the participating wards and the 24 nursing staff will be measured again after a six-month interval. The goal is to prove metrologically that the seminar and the implementation of new work methods actually reduce the number and extent of awkward postures.
9 Reference list


Appendix B: Information brochures

Spannungsfeld Rücken
Wie erkracht sich eine Krankheitswelle und wie gesund das Körpergelenk nach einer Arbeitsstrecke durch die Schwerkraft? Die Ergebnisse von einer Studie der Deutschen Gesellschaft für Endokrinologie (DGE) haben entscheidende Hinweise liefern können.

Die Studie wurde von der Deutschen Gesellschaft für Endokrinologie (DGE) durchgeführt und zeigt, dass eine ausreichende Belastung der Rückenmuskulatur wichtig ist, um die Funktion der Rumpflasten zu beeinflussen. Die Ergebnisse legen nahe, dass eine ausreichende Belastung der Rückenmuskulatur wichtig ist, um die Funktion der Rumpflasten zu beeinflussen.

Die Studie wurde von der Deutschen Gesellschaft für Endokrinologie (DGE) durchgeführt und zeigt, dass eine ausreichende Belastung der Rückenmuskulatur wichtig ist, um die Funktion der Rumpflasten zu beeinflussen. Die Ergebnisse legen nahe, dass eine ausreichende Belastung der Rückenmuskulatur wichtig ist, um die Funktion der Rumpflasten zu beeinflussen.
Sie können unsbezogen sein ...

- Notwendig, um die Teilnehmer unserer Forschungs- arbeiten im Rechtsoberhalb zu sehen – insbesondere die Eingänge oder Folgeregeln und Anweisungen.
- Die Anfragen werden auf keinen Fall veröffentlicht – weder gleich noch nach Ablauf.
- Wir bitten Sie, Ihre Anfragen in die vorliegende Stelle zu legen und die
  Befragung ausführen, bevor wir ein Gesamtziel erreicht haben.

Wichtig für eine ausreichende Messung ist:

- Arbeiten Sie ganz positiv an und geben Sie, ohne Sorgen, einen guten Bezug zu Ihren Arbeitskollegen in Ihrer täglichen Arbeit.
- Teilen Sie Ihre Erfahrungen und geben Sie ihnen Ihre ich-deeke Antworten mit.

Sollten Sie während der Messung Fragen haben, die wir Ihnen nicht an der Stelle ermöglichen können, können Sie jederzeit erfragen, wann Sie Fragen haben. Sprechen Sie mich einfach an.

Ihr Ansprechpartner

Wenden Sie sich an unsere Stelle, um Informationen zu erhalten oder Fragen zu klären.

Wohnort:
Dipl.-Ing. Steine Freitag

Landes- und Kommunalverwaltungsberatung für Gesundheitsamt und Sozialhilfeberatungen (Betr.)

Verantwortungsbereich: Gemeinde- und Sozialhilfeberatung

Kommunalkartei: 20373 Hamburg

Kontakt
Dipl.-Ing. Steine Freitag

Telefon (040) 20373 0 52 55
E-Mail: steine.freitag@bgw-hamburg.de

Teilnehmer-Info

Werbung der medizinischen Mesung in der Pflege –

Teilnehmer-Info

Wie lange dauert die Messung?

- Die auszuführende Messung in den Pflegebereichen dauert 15 Minuten.
- Die Messung wird in der Pflegebereich durchgeführt, ohne dass Sie Ihre tägliche Arbeit unterbrechen.
- Der Messprozess dauert etwa 15 Minuten.

Liebe Pflegerin, lieber Pfleger,

wir danken Ihnen, dass Sie uns die BGW-Hamburg (Verant-
wortungsberatung in der Pflege) unterstützen. Sie unterstützen
mit unserer Forschung für gesündere Arbeitsverhältnisse in der Pflege.


In der Fachrichtungs-
presse und in Ihrer
Dokumentation
inhaltspapeterie
Ende
1993
Dokumentationen
der obersten
in der Sparte und
testen Sie das System
ablegen.

Was soll ich anziehen?

- Bitte tragen Sie eine Arbeitshemden für den Pflegebereich.
- Wegen der Sicherheit in der Pflege, tragen Sie Schuhe mit Schutzsohle und Kleidungsstücke wie beispielsweise Sportshirts.

Worauf müssen Sie achten?

- Während laufender Aktions- und Bewegungs-
dauer, ist es ratsam, die Dauer der Bewegung zu beachten.
- Sprechen Sie ich-deeke Fragen an die BGW-Hamburg behalten oder mit einer Virtuellen.
Wirbelsäulenbelastungen in der Pflege

Welchen Einfluss haben ungünstige Körperhaltungen auf die Entstehung von Rückenbeschwerden?
WELCHEN HINTERGRUND HAT DAS FORSCHUNGSPROJEKT?


In bisherigen Untersuchungen zu Ursachen von Rückenschäden wurde der Transfer von Patienten als einer der Hauptfaktoren für die Entstehung von Rückenschäden bei Pflegekräften genannt. Jedoch lässt sich bei entsprechenden Interventionsmaßnahmen, die auf technischen Methoden zum Patiententransfer basieren, kein ausreichender Effekt nachweisen.

Mit der Entwicklung eines personengruppenbezogenen Massensystems, das die Bewegungsmuster von Pflegepersonal unter realen Arbeitsbedingungen erfasst, ist es im Pflegebereich erstmals möglich, eine objektive, kontinuierliche und detalierte Erfassung der Körperhaltungen und Aktivitäten der Pflegekräfte unter Praxisbedingungen durchzuführen, um weitere Ursachen für die Entstehung von Rückenschäden aufdecken zu können.

Bisher von der BAW auf unterschiedlichen Krankenhausstationen durchgeführte Untersuchungen zeigten auf, dass einige Transfertätigkeiten (nicht eingeschlossen Vor- und Nachbereitungszeit) nur einen geringen Zeitanteil an der Arbeitszeit ausmachen, hingegen die Pflegekräfte sehr häufig Körperhaltungen annehmen, die anscheinend nicht von entscheidender Natur sind, jedoch bewertet werden können.

ARBEITEN ALTENPFLEGEKRÄFTE HÄUFIGER IN UNGÜNSTIGEN KÖRPERHALTUNGEN?


Es konnte gezeigt werden, dass die Pflegekraft auf der geriatrischen Station pro Arbeitszeit durchschnittlich 1,390-mal eine Oberkörperneigung über 20 Grad annahm. Dies entspricht einem Mehranteil von 52% gegenüber den Probanden der chirurgischen und internistischen Stationen (1,116-mal).

Auch die Häufigkeit der statischen Körperhaltungen lag auf der geriatrischen Station um 24% höher. Bei den starken Rumpfneigungen über 60 Grad, die im Mittel 205-mal pro Arbeitszeit eingenommen wurden, konnte gezeigt werden, dass auf der geriatrischen Station 70% durch Tätigkeiten am Patientenbett hervorgerufen wurden im Vergleich zu 42% auf den anderen Stationen.

Stellt die Häufigkeit der bisher in der Altenpflege erfassten ungünstigen Körperhaltungen die Regel dar und was bedeutet dies hinsichtlich der Erschöpfung von beruflichen Langzeitschäden? Im Rahmen des verfolgenden Messprojektes sollen auch hierzu Antworten gefunden werden.
Wirbelsäulenbelastungen in der Pflege

DAS CUELA-MESSSYSTEM


Eine vom Probanden getragene Kombination aus verschiedenen Sensoren liefert kontinuierlich Daten über die Beugung der Knie- und Hüftgelenke sowie über die Neigung der Wirbelsäule im Brust- und Lendenbereich. Parallel dazu erfassen drucksensitive Einlegezähnen die Fußdruckkräfte. Diese geben Auskunft darüber, wie hoch das jeweilige Gewicht ist, das gehebelt wird.

Alle erfassten Daten werden mithilfe einer Speichereinheit, die sich direkt am Probanden befindet, aufgezeichnet und gesichert. Das gesamte System wird über Akkus mit der erforderlichen Energie versorgt, so dass keine externen Kabelverbindungen benötigt werden und der Proband sich frei in seinem gesamten Arbeitsfeld bewegen kann. Die Abbildungen zeigen das Messsystem im Praxiseinsatz mit Probandinnen aus unterschiedlichen Arbeitsbereichen im Krankenhaus.

Abb. 5-8: Probandinnen mit dem CUELA-Messsystem unter verschiedenen Prüfbedingungen
Nach Beendigung der Messung befinden sich alle aufgezeichneten Daten auf einer Speicherkarte. Die Auswertung und Visualisierung der Messdaten übernimmt eine speziell entwickelte Software. Diese visualisiert die Daten mit einer dreidimensionalen Computerfigur (Abb. 9), mit der das aufgezeichnete Bewegungsmuster des Probanden dargestellt wird. Allerdings ist hier noch nicht sichtbar, welche Tätigkeit zu dieser Körperhaltung geführt hat.


Abb. 9: Erste Visualisierung der Messdaten mit einer Computerfigur. In dieser Bearbeitungsphase der Messergebnisse kann der aufgezeichnete Bewegungsmuster des Probanden nach wie vor Tätigkeit zugewiesen werden.

Abb. 10: Synchronisation der Messdaten mit der Videoaufnahme. Nun können zu den Messdaten die entsprechende Tätigkeit der Probanden zugewiesen werden.

Führungskräfte
BEVOR ES MIT DEN MESSUNGEN LOSGEHEN KANN...

Ein wesentlicher Aspekt für die problemlose Durchführung der Messungen ist die Zusammenarbeit mit dem Pflegepersonal und den Patienten/Bewohnern. Hierzu ist im Vorfeld ein Informationsaustausch dringend erforderlich.

Die Pflegekräfte erhalten vor Beginn der Messungen eine Broschüre, die die Ziele der Studie erläutert und die über den Ablauf der Messungen bzw. das Messsystem informiert. Zwei Tage vor Beginn der Messungen verteilt die teilnehmende Station einen von der BGW zur Verfügung gestellten Flyer an alle Patienten/Bewohner. Darin sind kurz und übersichtlich die wichtigsten Informationen zum Projekt zusammengefasst, und es wird um die Mithilfe der Patienten/Bewohner gebeten.

Darüber hinaus wird die Notwendigkeit der Videoaufnahmen erläutert und versichert, dass diese ausschließlich von der Forschungsabteilung der BGW zu interner Dokumentationszwecken verwendet, jedoch geblendet und nicht veröffentlicht werden.

Am Tag vor der ersten Messung findet eine Verabschiedung mit der BGW-Projektleitung, der Stationsleitung, dem Pflegepersonal und dem Probanden statt. Dabei werden beispielsweise Fragen zum Projekt geklärt und stationsspezifische Aspekte besprochen, damit der reibungslose Betrieb der Station auch während der Messzeit sichergestellt ist. Außerdem erfolgt die Anpassung des Messsystems an den Probanden, um die Messung am darauf folgenden Tag ohne große Verzögerung beginnen zu können.

Im Anschluss daran wird durch die Projektleitung und gegebenenfalls durch eine Pflegekraft der Station in jedem Patienten- bzw. Bewohnerzimmer ein Informationsgespräch durchgeführt, um Fragen zu beantworten und die mündliche Zustimmung der Patienten/Bewohner oder Angehörigen einzuholen. Zusätzlich wird die Mitarbeiterin der BGW vorgeben, die den Probanden während der gesamten Messung begleitet. Eingehende Erfahrungen in Krankenhäusern haben gezeigt, dass die meisten Patienten/Bewohner bereitwillig das Forschungsprojekt mit ihrem Einverständnis unterstützen.
EINE ARBEITSSCHICHT MIT DEM CUELA-MESSSYSTEM


Abb. 12:
Die Pflegekräfte geben bisher an, dass sie nach dem ersten Anlauf des Systems eine kurze Einarbeitungs­phase benötigten, danach jedoch die tägliche Arbeit mit dem System problemlos aus­führen.
WELCHE STATIONEN KÖNNEN AM PROJEKT TEILNEHMEN?

Es können alle Stationen teilnehmen, die das Forschungsprojekt unterstützen möchten. Zusätzliches Personal während der Messstage ist nicht erforderlich. Die Messungen umfassen jeweils drei aufeinander folgende Voll- oder Frühdienstschichten.

WELCHE VORAUSSETZUNGEN SOLLTEN DIE PROBANDEN ERfüLLEN?

Die Probanden sollten ausgebildete Kranken- oder Altenpflegekräfte sein und keine Vorschädigungen im Bereich der Bewegungsapparate haben, die sie dazu veranlassen/zwängen, bestimmte Tätigkeiten nicht mehr ausführen zu können. Auch sollten zum Zeitpunkt der Messungen keine Rückenschmerzen vorhanden sein, die die Pflegekraft eventuell veranlassen, die üblichen Bewegungsabläufe zu verändern. Das System ist an Körpermaße im Größenbereich zwischen 1,60 m und 1,90 m anpassbar und kann von Probanden mit einer Schulgröße von 37 – 45 getragen werden.

Abb. 13-15: Probanden während der Messungen
DAS PROJEKT IM ÜBERBLICK

Teilnehmen können alle Stationen.

Die Probanden sollten keine Verschleißungen des Bewegungssapparates haben und zum Zeitpunkt der Messung nicht an Rückenschmerzen leiden, die sie dazu veranlassen, Bewegungen anders als üblich auszuführen.

ihnen normalen Tagesablauf während der Messung nicht verändern.

zwischen 1,60 m und 1,90 m groß sein und eine Schultypie zwischen 37 und 45 haben.

Dauer der Messung 3 aufeinander folgende Frühdienste.

Vorbereitung Projektvorstellung durch das BGW-Team: Info-Gespräch mit Führungskräften

2 Tage vor der Messung:
Verteilen des BGW-Flyers an die Patienten/Bewohner durch die Stationen

1 Tag vor der Messung:
Vorbereitung mit der Projektleitung, der Stationsleitung, dem Pflegepersonal und den Probanden:
Auspicken des Messsystems an den Probanden.

Das BGW-Team und eine Pflegekraft der Station führen ein Info-Gespräch mit allen Patienten/Bewohnern der Station durch.

Zusätzlicher Personaldarf nicht erforderlich

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WENN DIE MESSUNGEN BEENDET SIND...


Wir bedanken uns für Ihre Unterstützung und freuen uns auf die Zusammenarbeit mit Ihnen. Gerne stehen wir Ihnen für die Bearbeitung von Fragen zur Verfügung.

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