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Musculo-skeletal Stress When Transferring Totally Dependent Patients

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Abstract

The high degree of musculo-skeletal stress arising during patient transfers is one of the principal factors responsible for back pain in nursing staff. This study reports on the musculo-skeletal stresses and corresponding strains occurring in nurses working with totally dependent patients and on training to minimize these and its effect on the nurses. Designed as an intervention study, it was performed in a specialist facility for intensive care of totally dependent patients and in a department of a hospital treating rehabilitation patients requiring intensive care. Aim of the study was to protect the nurses' dorsal health and to keep both younger and older nurses fit for work.

The study results confirm that the nurses are highly exposed to risk of considerable musculo-skeletal disorders and, in particular, that poor ergonomics are the deciding factor for the ensuing stresses and strains. Ergonomic training for these nurses focused mainly on improvement of load-handling techniques, avoidance of extreme body postures, creation of optimal spatial conditions and prevention of accidental falls. This was complemented by physical and functional training to optimize spinal stability. Proof of efficacy of this physical training was obtained.

Keywords: Musculo-skeletal stresses in nursing staff; Patient transfer in hospital; Totally dependent patients; Aging

Introduction

Mean absence rates of nursing staff from work is currently running at more than 20 days per annum in Germany. This figure is more than three times higher than for the least affected occupations (e.g. pharmacists: 5.2 days, medical profession: 6 days).

Musculo-skeletal disorders are the principal reason for the high absentee rate of nurses.

There is a close association between the health impairments suffered by nurses and the desire to seek another occupation [1,2]. Evanoff et al. [2] rate back pain as the principal motive for leaving the nursing profession. Very few nurses stay in this occupation for longer than ten years.

Other relevant factors include demographic change, which lies behind various trends currently discernible in the labor market [3], and this also applies to members of the nursing profession. The aging society is influencing not only the employment opportunities for nurses. It also means that demand for nursing services will continue to grow. The trend to shorter patient stays in hospitals is another factor increasing stress on nurses.

These trends make it all the more important to ensure that nursing staff are working under conditions favoring health care and protection and encouraging longest possible commitment to work in the nursing profession. Every feasible means of keeping experienced nurses in the profession should be used. Studies of musculo-skeletal disorders and design of effective programs to prevent or minimize these are essential.

Current status of research

Job analyses in hospitals and senior citizens 'homes confirm that nursing work involves seriously stressful physical activities. This is confirmed by surveys of the literature (Cf. Synopsis by Stern et al. [4]). These include transfer and positioning of patients, bed changing and making, and various other carrying activities. These regularly involve unfavourable body postures (e.g. bent postures for as much as two hours per shift, 1500 bending movements per shift), high compressive forces on inter-vertebral discs, as well as strains in the shoulder-neck and knee regions, especially during patient transfers, i.e. carrying or assisting patients from a bed to another horizontal surface or to a chair, which are regarded as the principal causal factors of back pain in nurses [5-8], especially in cases where the nurse is not using a technique reducing back stress. In such cases, disc compressive forces can rocket to levels as high as 9 kN during patient transfers, i.e. in many cases significantly above recognized upper continuous strain limits [9].

In Germany, it has only proved possible to attain the high scientific standard of international physiological and epidemiological studies of musculo-skeletal disorders in nurses and the resulting health risks in isolated cases. Most of the work is reports on studies organized by employers' liability associations and trade unions. Controlled intervention studies in this area are rather rare (e.g. [9-11]). Jäger et al. [12] succeeded in obtaining alleviation of lumbar spine stresses in nurses during patient transfer with the help of spine-protecting techniques and use of small aids. Michaelis [10] reported improvement in back condition and alleviation of physical stresses in nurses following introduction of various ergonomic techniques (Cf. Also [13-15]). Intervention studies on job design and behavioral ergonomics during patient handling tend to come mainly from Anglo-Saxon countries, Scandinavia and the Netherlands (Cf. Synopsis of these projects by Fray und Hignett [16]). But there are no known studies identifying specific techniques for handling of totally dependent patients, e.g. patients in trance coma.

Consequently, the authors of this report decided to conduct an

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intervention study on fitness for employment of nursing staff caring for totally dependent patients. The objective of this project was to reduce stresses on nurses during patient transfers to a level, at which their health care and protection was guaranteed for as long a period as possible, and the work could still be performed by older nurses.

The *working hypothesis* was defined as follows:

An ergonomically correct method of working in transfer of totally dependent patients yields a reduction in musculo-skeletal disorders and, consequently, a reduction in health risks for the nurses.

After extensive analysis of the stress-strain status of the study and control groups, various training exercises were practiced and then followed by repeat analyses.

Ergonomic and safety-compatible work processes

The focus of the intervention study conducted from 2011 to 2013 was on training in work techniques using ergonomically correct methods of working in the *study group*. Muscle development and functional training enabling the nurses to optimize their physical proficiency in patient transfer was also offered.

The *control group* continued to use conventional and mainly manual patient handling techniques. No muscle development and functional training was offered to the nurses in the control group.

A specimen graph plotting the physical stresses on a nurse over a time axis and a rating of the ensuing potential health risk showed that transfers of totally dependent patients expose nurses to a high health risk. Other physical work (e.g. bed baths) lies within the medium risk range; work in a sitting position (e.g. documentation) or therapy-associated operations (e.g. administering medication) generally involve no health risk (Figure 1).

We have workplace design and behavioral ergonomics at our disposal for assessment of health risk. Workplace design ergonomics, also known as workplace ergonomics, includes a large number of job design items, e.g. modifying the workplace to fit the dimensions of the human body; other items include technically safe job design and work organization. In the case of transfers of totally dependent patients this kind of job design modification is, for a variety of reasons, (e.g. limits to use of technical aids with trance coma patients) not enough to minimize nurses' health risk. Behavioral ergonomics have to be added in. These require the nurse to adapt her work behavior to comply with anthropometric, biomechanical and physiological laws. The behavioral

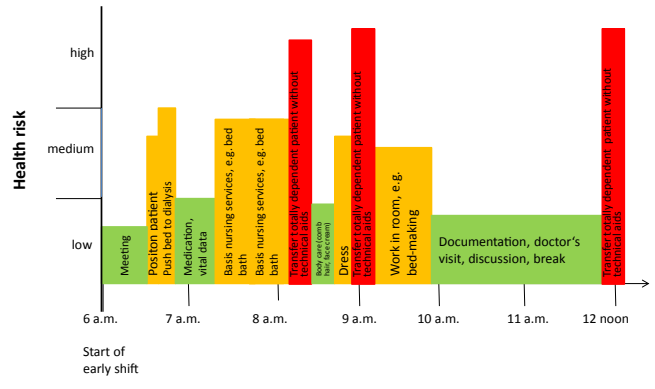


Figure 1: 2165-7556-S4-009_OmicsGroup-14-291 Specimen graph of physical stresses on a nurse on early shift and rating of health risk (*control group*).

adjustments recommended in this case are of a very prophylactic nature.

A checklist was used to assess the ergonomics of the patient transfer processes (Table 1).

The transfer training aims primarily to generate awareness of stress-optimized behavior and also to instill a routine into work procedures. It was split into five units of approx. one hour each. The trainee groups consisted of not more than 6 nurses, plus two experienced ergonomics trainers and one accompanying member of the project team. The first four units were held around a hospital bed without patient. Only the fifth unit had a patient in the bed. The units were structured to start with the nurses performing their normal working procedures, which were then ergonomically corrected.

The five training units were organized as follows:

1. Transfer from lying to sitting: transfer from bed to wheelchair without aids

2. Transfer from sitting to lying: transfer from wheelchair to bed without aids

3. Further work on items 1 and 2

4. Transfer from lying to lying: transfer from bed to shower recliner alone/with two nurses

5. Transfer with actual patient.

During the course of the five units the nurses were confronted in each lesson with ergonomic rules and correct ergonomic behavior. First priority was compliance with these and avoidance of wrong working methods.

The main aim of the muscular development and functional training also offered through the project was improvement of spinal stability, which is of key importance for risk limitation in patient transfer. Age-related decline in functional efficiency and the accompanying risk of work-related disorders can be counteracted by regular physical training [17].

A training program specifically designed for this project by two sports scientists was used to improve spinal stability. This program started with a short warm-up phase followed by the main training workout. It was held in a separate room of the Intensive Care building and was led by either a PE specialist or a physiotherapist. The aim was to have each nurse attending the workouts twice weekly over a period of five months, but this was not always possible because of absences on vacation, free days and night shift duties.

The training was in small groups of not more than six nurses and was timed to follow immediately after the early shift or before the start of the late shift. It was treated as work time and lasted approx. 20 minutes per unit, plus the time for changing in and out of training gear. Exercises were alternated regularly to maintain interest and enhance training performance.

Methods of Investigation

Nurses' body movements during patient transfer were recorded by digital video camera. Incorrect postures and movements and ergonomically correct alternatives were analyzed with Motion Toolbox software [18]. This software can track body movements, display angle data and calculate distance data. The video analysis was used to prepare

Criterion	Questions
1. Work safety	Have all stumbling blocks been removed?
2. Room to move	Has sufficient room for the transfer been made?
3. Aids (in the widest sense)	Are all aids to facilitating the transfer ready for use?
4. Helper	- Has the second nurse been informed? - Is he/she available on time? - Has transfer procedure been agreed? - Has one nurse been put in charge with the other acting as assistant?
5. Elimination of work duplication	Has the need for change of incontinence pad been checked prior to transfer?
6. Safe stance	- Have the nurses adopted a stable stance with feet slightly apart? - Are they using the forward step position for the actual transfer?
7. Straight upper body	- Is the upper body in a straight position during preparation and disposal of wheelchair? (kneeling on one knee recommended)? - Has bed height or working height been optimized by adjustment of bed or leg position?
8. Moving the patient without causing him/her discomfort	Is the patient transported by the buttocks and not by the belt of his pants? (only if applicable with patient in trance coma) Is a knee brace used to transport the patient?
9. Good visibility	- Are patient's arms not wrapped around his neck? - Has patient's head been placed in direction of transfer?
10.Head section of bed	In bed-to-wheelchair transfers has the head section of the bed been set at 70° to reduce stress?
11. Use of technical aids	Are technical and other small aids being used?
12.Proper use of aids	Are aids being used only by nurses with the necessary experience?
13. Minimum friction	Is every effort made to reduce friction during transfers?
14. Load handling	- Is patient's weight being transported, and not lifted and held? - When pulling/positioning the patient, does the nurse use his/her body weight by adopting step position and falling slightly backward, (i.e. weight shift)?
15. Avoidance of leverage effect	Does nurse avoid leverage effect by working as closely as possible to patient?
16. Twisting of upper body	Is nurse remembering not to twist upper body?
17. Use of abdominal and pelvic muscles	Are nurse's abdominal and pelvic tensed during actual transfer?
18.Solutions for nurses with limited capabilities	Are solutions available for nurses with limited capabilities?

Table 1: Checklist for assessment of ergonomics of transfer procedures.

an ABC analysis [19] of ergonomically incorrect and correct working methods. This was used to classify the urgency of redesign work.

Work flow studies based on REFA [20] were used to collect data on transfer frequencies, overall transfer duration and duration of individual operations. This made it necessary to accompany the nurses over the full period of their shift. It goes without saying that violation of the patient's private sphere was avoided. Data collection was subdivided into three sections: transfer preparation, actual transfer performance and transfer completion.

A biomechanical model was used for microanalysis of stresses (Cf. [21]), because this model focuses on inter-vertebral disc L5/S1, which is highly relevant and critical for members of the nursing profession (Cf. [22-24]). The available software enabled us to record snap shots of critical manual load handling operations and body postures. The software analyzed compressive and shear forces on disc L5/S1.

Ergonomic Assessment Worksheet (*EAWS*) was used to make summary risk assessments of physical stresses occurring during transfer. These assessments were based on analyses of video recordings of various transfers performed without any technical aids. *EAWS* [25] is an ergonomic tool for assessment of physical stresses acting on the whole body. Trained analysts were used to classify Sections 1 to 3 of the EAWS. These contain data on body postures and movements involving low external loads or force expenditure, static and dynamic applied forces and additional stresses and load handling operations. Section 4, which uses a 'microscopic' approach designed for planners, was dispensed with.

The *NASA Task Load Index TLX* [26] was used to collect data on strains perceived by the nurses during transfers. These subjectively perceived physical strains and time demands were classified after each transfer as either very high or very low. Physical strains relate to the extent to which physical activities were required (e.g. pressing, pulling, turning, controlling, activating etc.). Was the performed task easy or hard, calm or busy, relaxing or energy-consuming, recreational or laborious? Time demands relate to the nurses' perceived impression of time pressure dictating speed of task execution. Was it performed slowly and in a leisurely way or hurriedly?

The computer-assisted *Trunk Stability Test* (Pegasus Software) [27] was used to collect data on power profiles of spine-stabilizing muscles (spinal stability). Maximum isometric power of spine-stabilizing muscles was determined at three body levels, namely

- abdominal (trunk flexion) and dorsal (trunk extension) muscles
- lateral flexors of the trunk (leaning sideways left and right)
- rotator muscles of the trunk (turning left and right).

The muscle groups listed above are the main ones responsible for spine stabilization in both static and dynamic stress situations.

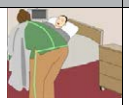
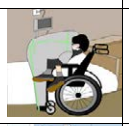
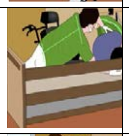
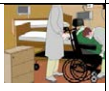
Prio-rity	Risk factor	Ergonomically incorrect working methods		Ergonomically correct working methods	
A	Unfavorable body posture	Nurse works from back only, without using thigh muscles		Nurse works from legs. Transfer performed by bodyweight shift backward from step position	
A	Unfavorable body posture	Bed height setting incorrect, not set at all, set too early or too late		Bed height setting correct. Mattress approx. 5 cm below nurse's iliac crest, knee bent if necessary or feet slightly apart	
A	Unfavorable body posture	Action performed too fast or jerkily		Elimination of jerky action, nurse in forward step position	
A	Unfavorable body posture	Leverage, i.e. working not close enough to patient puts overload on lumbar spine		Nurse working as close as possible to patient to reduce leverage	
A	Unfavorable body posture	Twisting, leaning forward and bending of upper body		Twisting, leaning forward and bending of upper body eliminated by application of principle: Leg power trumps trunk power	
A	Unfavorable body posture	Legs close together or leg in bed		Feet slightly apart, support from pelvis where necessary to ensure stable stance, also in forward step position when handling load	
A	Manual load handling	Patient's total or near-total bodyweight being held		Patient's weight is turned pushed or pulled onto nurse's thigh	
B	Unfavorable body posture	Upper body bent when making adjustments close to floor		Use knee and thigh or kneel on one knee when working close to floor	
B	Unfavorable working conditions	Incorrect cooperation between two nurses leads to forced postures and impedes momentum and gravitational forces		One nurse with one assistant work together from the start (no waiting)	
B	Unfavorable body posture and manual load handling	Head section raised too late or not at all: lengthens leverage		Head section raised to reduce leverage	
B	Manual load handling	Abdominal and pelvic muscles not tensed		Abdominal and pelvic muscles tensed	
B	Unfavorable working conditions	Work coat or other protective apparel defective or incorrectly worn		Protective apparel in good condition and properly worn (e.g. no buttons missing or undone)	
B	Unfavorable working conditions	Poor maintenance or careless use of equipment (beds, wheelchairs), e.g. wheelchair brake not		Optimization of maintenance management and attitudes to equipment	
B	Unfavorable working conditions	Lack of adequate space increases risk of falling and necessitates forced postures (see above)		Adequate room for transfer created by moving objects (e.g. bed, wheelchair) to one side or out of room altogether	
B	Unfavorable working conditions	Not enough nurses available to enable transfers by two nurses		Redesign of service planning to include employment of non-nursing staff as assistants	
B	Joint positions	Stresses from forced wrist postures and high finger force during transfer and holding		Elimination of forced wrist postures and high finger forces when moving and holding patient	

Figure 2: Ergonomically incorrect and correct methods of working.

Study participants

The *study group* consisted of 21 nurses, nurse assistants and teaching nurses working at the Specialist Facility for Intensive Care in Germany's state of Saxony. The *control group* worked in a hospital department responsible for care of rehabilitation patients requiring intensive nursing care. 56 nurses were employed there.

In both the study and the control group two thirds of the staff is less than 30 years of age. The mean duration of stay in the nursing profession of the younger nurses is less than 6 years. The equivalent figure for the older nurses (over 41 years of age) lies between 16 and 40 years.

The *study group* was caring for up to 20 patients either in trance coma or suffering a similarly severe sickness living in two residential facilities. The trance coma patients were either adults or adolescents of adult-equivalent stature and bodyweight. The trance coma patients cared for by the study group were in apallic state and classified in each case in the highest relevant rating of Barthel Index (FRB) for nursing service requirements [28].

The *control group* was selected because of its responsibility for care of similarly totally dependent patients. The nursing services and care provided by this group were less extreme than those required from the study group for its trance coma patients. Most of its patients were post-operative organ transplants or paraplegics, with whom communication was normally possible. The 51 patients undergoing rehabilitation remained there for varying periods of time.

Mean patient weight in the transfers observed in the control group was 76.6 kg (min. = 61.4 kg, max. = 85.0 kg), in the study group 71.4 kg (min=60.7 kg, max.=88.5 kg).

In addition to the difference in degree of help required between the patients in the two groups, the study group patients had to be transferred kinesthetically, while most of the control group patients could be transferred conventionally.

Results

Ergonomically incorrect and correct methods of working

With due regard to the risk factors listed in EAWS, comparisons were made of the essential elements of ergonomically incorrect and correct methods of working. These were based on the video analyses obtained with the Motion Toolbox software. An ergonomically incorrect method of working in patient transfers was characterized by prolonged moderate to extreme forward inclination of the trunk, lateral inclination and twisting of the trunk, working at an unnecessarily long distance from the patient's body, frequent holding, lifting and pulling of high percentages of the patient's weight, extreme and prolonged wrist positions and extreme and prolonged use of high finger forces. High-stress body postures and movements resulted, inter alia, from unfavorable workplace conditions and nurses' failure to coordinate properly. One frequently observed incorrect method of working resulted from subjectively perceived time pressure. Others were often attributable to lack of understanding of ergonomics. Other problems included, for example, defective or incorrectly worn protective clothing, failure to use wheelchair brakes creating risks for both patients and nurses, and were classified as ergonomically incorrect. Urgency of correction was defined by classification as either A priority for items constituting a high risk of overload of the musculo-skeletal system. Immediate improvement was recommended in these cases. B

Support	Group	Transfer phase	N	Min.	Max.	Mean	SD
One nurse alone	C	Preparation	9	0,08	2,00	0,92	0,70
		Actual transfer	9	0,33	2,33	1,28	0,67
		Completion	9	0,00	1,00	0,40	0,38
		Total	**9**	**1,00**	**4,33**	**2,60**	**1,29**
	S	Preparation	7	2,00	6,00	3,67	1,41
		Actual transfer	7	0,33	2,00	1,02	0,49
		Completion	7	1,00	5,00	2,60	1,28
		Total	**7**	**4,00**	**12,00**	**7,29**	**2,69**
Nurse + assistant	C	Preparation	6	0,00	1,50	0,44	0,65
		Actual transfer	6	0,67	2,00	1,28	0,57
		Completion	6	0,00	2,00	0,36	0,81
		Total	**6**	**1,00**	**4,50**	**2,08**	**1,43**
	S	Preparation	8	0,33	5,00	2,98	1,79
		Actual transfer	8	0,33	4,00	1,33	1,20
		Completion	8	0,33	5,00	2,85	1,42
		Total	**8**	**1,00**	**12,50**	**7,17**	**3,90**

Table 2: Descriptive statistics of duration of patient transfer (min.). C=control group; S=study group.

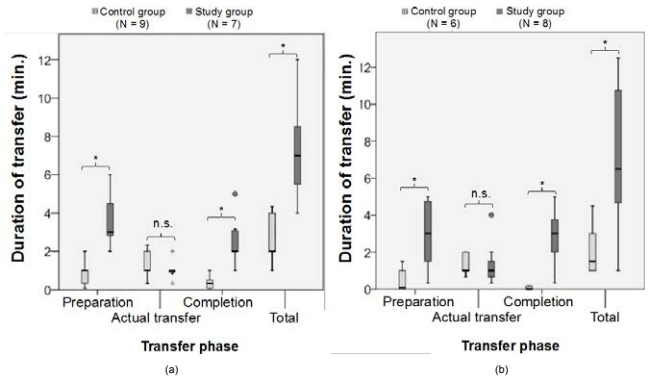


Figure 3: Comparison of transfer duration (a) one nurse (b) two nurses (with nurse in charge) between study and control group. n.s.: not statistically significant, *: statistical significance $p \leq 0.05$.

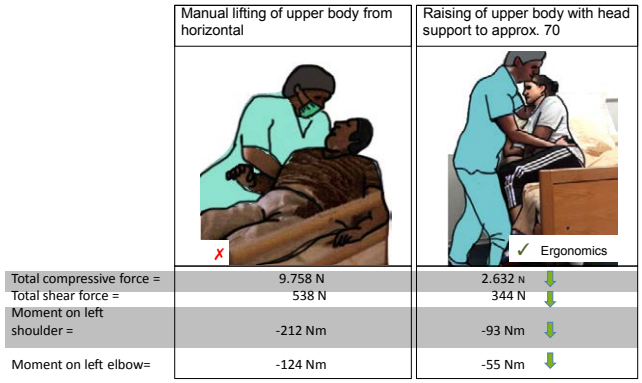


Figure 4: Comparison of stresses on lumbar spine from incorrect and correct methods of working.

priority items were those considered to constitute a potential overload risk. Although less urgent than the former group, improvement as soon as possible was recommended here. Items classified as C priority were regarded as constituting only a minor risk of overload of the musculo-skeletal system (Cf .Figure 2).

Duration of transfers

Figure 3 shows the duration of the whole transfer operations, broken down into preparation, actual patient transfer and completion, as performed by one nurse either working alone or assisted by a colleague (in both cases without technical aids).

The overall times for transfers by one nurse working alone ranged from 1 minute to approx. 4 minutes for the control group and between 4 minutes and 12 minutes for the study group. Mean duration was approx. 3 minutes and approx. 7 minutes for the control group and the study group respectively (Figure 3). These differences are significant ($p < 0.05$) (Table 2).

Overall transfer duration for transfers with assistance from a colleague was also investigated with an eye to time efficiency. The difference between the two groups in this case was also significant ($p<0.05$) (Table 2). Although the minimum overall duration for the study group declined sharply from 4 minutes alone to only 1 minute with assistance from a colleague, the mean overall duration remained at approx. 7 minutes in both cases (Figure 3).

One notable finding was the remarkably high proportion of time taken up by preparation and completion of the transfers and the relatively short time required for the actual transfer itself (Figure 3). Although the time differences between control group and study group for preparation and completion were statistically significant (Table 2) irrespective of whether the nurses were working alone or in pairs, no significance could be shown for the differences in performance of the actual transfer (Table 2).

It was observed that the time requirement for preparation by one nurse alone can take longer than when a colleague is assisting.

Biomechanical calculation of stresses on lumbar spine

The results obtained with the biomechanical model revealed considerable stresses on the lumbar spine when ergonomically incorrect methods were used for patient transfer. One such example of incorrect working is failure to raise the head section of the bed (Cf. Figure 4), which increased lumbar spine stresses to quite unacceptable levels and make urgent action essential. Patients in trance coma are totally incapable of acting on their own initiative and their bodies are frequently either unnaturally limp or unnaturally tense. This places even

higher demands on the nurses. The ergonomically correct procedure in this case is to raise the bed's head section, thereby eliminating the need to lift the patient's full body weight from the lying position. This yielded a decrease of roughly one third in stress on the lumbar spine.

Risk assessment

Given a mean patient bodyweight of more than 70 kg in both the study group and control group and a frequency of more than five patient transfers per nurse per shift – in addition to all other physically demanding tasks like positioning patients in bed, changing and making beds and other carrying duties, it is not surprising that the EAWS assessments yielded results showing either a possible or a high risk of biomechanical overload on the musculo-skeletal system. Unless risk limitation action is taken, it is impossible to exclude the possibility that these high stress levels will cause musculo-skeletal disorders.

The assessment showed that the risks arising from transfers were higher in the control group than in the study group (Figure 5). The reason for this was the transfer techniques used during the actual transfer. The study group's use of kinesthetic techniques brought a reduction in patient bodyweight actually lifted and held. Ergonomically undesirable postures and movements were also observed and evaluated during the preparatory and completion phases in both groups.

Patient transfers recorded in six videos were evaluated with EAWS for ergonomically incorrect methods of working. Six videos of ergonomically correct methods of working were also available. The ergonomically correct method of working significantly reduced the risk of musculo-skeletal system overload by nearly half. The high or possible risk predicted for the ergonomically incorrect method was reduced to possible or low risk for the ergonomically correct method.

Subjectively perceived strains and demands during transfers

Both the subjectively perceived physical strains as reported to the investigators and the time demands governing the transfer (as calculated directly from the video recordings) were higher in the study group than in the control group (Figure 6). It was, however, impossible to confirm this statistically ($p>0.05$).

Spinal stability

Before-after physical status of ten nurses taking part in the study was verified with the trunk stability test at the start of the study and after an interval of approx. 6 months, i.e. after they had completed the muscular development and functional training course.

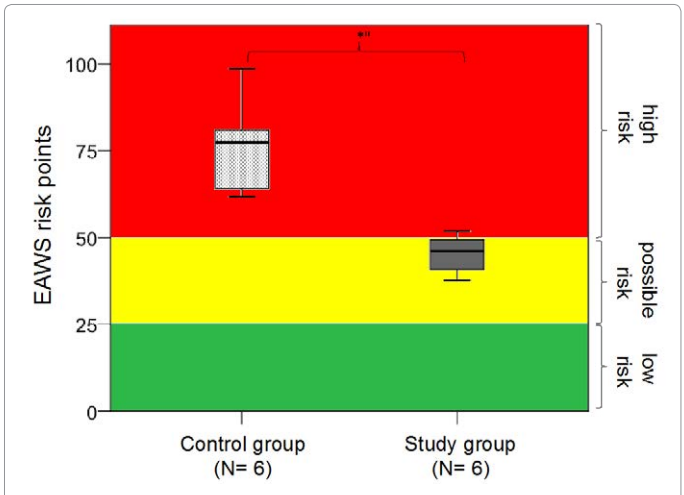


Figure 5: Comparison of EAWS risk points for lying-to-sitting transfer in study group and control group. *: statistically significant at p=0.05 level.

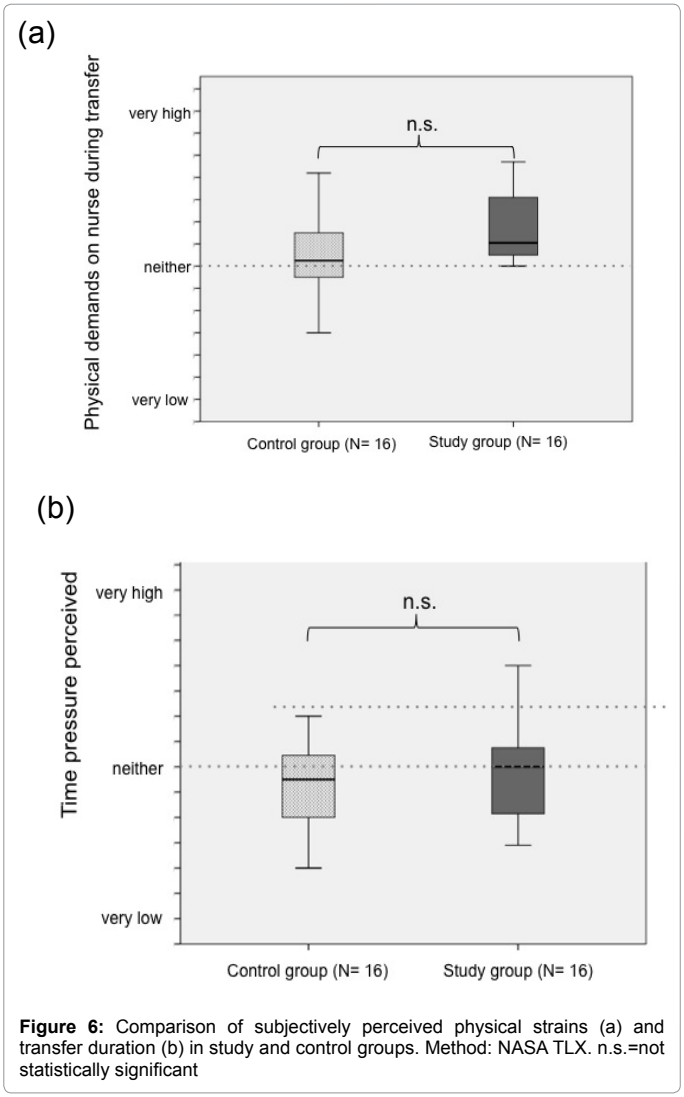


Figure 6: Comparison of subjectively perceived physical strains (a) and transfer duration (b) in study and control groups. Method: NASA TLX. n.s.=not statistically significant

The trunk stability test revealed that the training course had in nearly all cases raised the functional efficiency of the extension muscles (backward) and the flexion muscles (forward), and also of the muscles enabling lateral inclination to above the generally recognized target levels. Tone of the muscles enabling left and right rotation of the trunk also showed before-after improvement (Figure 7).

Discussion

Analysis of the data obtained for the study group and control group shows that the level of risk of musculo-skeletal system overload, to which nurses are exposed during patient transfers, is unacceptably high and that the transfer techniques are in need of redesign. EAWS stress evaluation revealed high or possible risk for the musculo-skeletal system. This was confirmed by calculations obtained with the biomechanical model. Stress bottlenecks in the musculo-skeletal system were identified and visualized with Motion Toolbox software. The data obtained made it possible to compare ergonomically incorrect and correct work techniques and design a comprehensive training

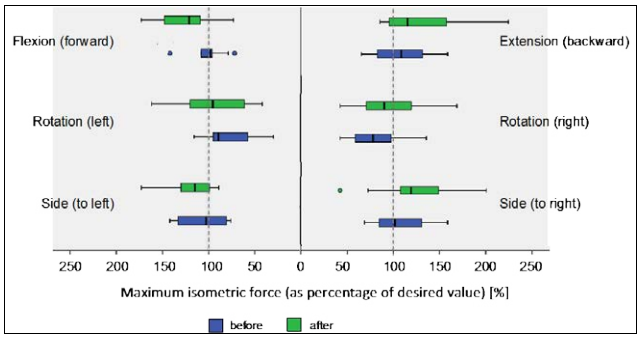


Figure 7: Max. isometric force on trunk in study group and control group before and after redesign (n=10).

program that makes due allowance for the risk factors involved. Work flow and time studies have shown that the training program should not focus solely on the actual patient transfer, but should also address the time-intensive preparation and completion phases, where training is also needed.

The training program had enabled the study group to almost halve the risk of musculo-skeletal system overload from biomechanical stresses caused by incorrect methods of working. The risk predictions obtained from the EAWS evaluation are statistically significant. Calculations with the biomechanical model showed that even quite minor corrections of ergonomic behavior, e.g. raising of the head section of the bed before starting the transfer, yield substantial reduction of stresses on the lumbar spine.

Although this training in transfer techniques minimized the risks for the musculo-skeletal system, it did not eliminate them completely. The principal reason for this lies partly in the nature of the general nursing duties themselves, which inevitably include demanding tasks (e.g. patient transfer and positioning in bed) that are often aggravated by lack of personnel, but also in basic human nature, which makes it more or less impossible to totally eliminate behavioral errors. This is the reason why muscular development and functional training aimed at optimizing spinal stability is so important. Optimal spinal stability is a key factor in helping to reduce the risk of potentially injurious stresses during patient transfer and making that procedure safe for the nurses. Measurements of spinal stability before and after participation in the muscular development and functional training course confirmed that this yielded tangible improvements.

The survey of subjectively perceived physical strains in the study group did not yield statistically significant higher results. It is assumed that patient passivity is the principal reason for this.

In summary, the study results do not refute the *working hypothesis* on which the study was based. Ergonomically correct methods of working when transferring totally dependent patients are capable of reducing musculo-skeletal stresses and, consequently, health risks for the nurses. The areas of ergonomic design most closely associated with avoidable physical stresses are optimization of load handling, avoidance of prolonged, high-stress body postures, provision of adequate work space and avoidance of accidental falls.

Specifically-designed muscular development and functional training to optimize trunk stability is also essential for reducing health risk in nurses performing patient transfers.

The question whether use of technical aids would further improve the results obtained with the aforementioned solutions needs to be investigated. Seminars on work organization should also be introduced as a supporting measure.

Bos et al. [29] demonstrate the favourable impact of training and educational measures, combined with intervention by qualified ergonomists during actual task performance, on incidence of back pain in nursing staff, thereby supporting our findings. As already stated under the heading *Current status of research*, there are very few controlled intervention studies in Germany indicating that correct back postures and appropriate work aids help to alleviate spinal stresses [9-11]. This is not the case in Anglo-Saxon countries, Scandinavia and the Netherlands [16]. The authors have analyzed this literature in greater detail in a research study for out-patient nursing care. The findings are more or less totally congruent with those for the patient group in our study [30]. It can only be assumed that certain other countries attach greater importance to healthy working conditions for their nursing staff, because they have issued guidelines for load handling containing instructions entitled, for example, *No manual patient lifting*, *No lift program* and *Safe patient handling* [31]. Politicians and associations actively ensure that these instructions are enforced. The following measures to achieve application of ergonomically correct work behaviour based on descriptions in the literature are recommended:

- The basic conditions of nursing work must be properly designed, i.e. technical aids must be made available [32] and adequate allowance must be made in nurses' work schedules for paid training periods [33].
- Introduction of ergonomically correct ways of working must be organised systematically and properly structured in the form of a project. It must include an analysis of actual pre-project status, planning of actions to be taken, implementation of these plans and, finally, project evaluation. Reference can be made to examples in the following bibliography [34].
- Training courses explaining ergonomically correct ways of working to nurses must be multidimensional and comprehensive. Training exercises alone do not always have long-lasting effects. Reference can be made to examples of multidimensional training courses in the following bibliography [35].
- To obtain long-lasting effect of a training course, a suitably qualified member of the employer institution's own staff should be appointed Health Officer or Ergonomics Officer [36].
- Follow-up refresher training courses are essential [37].
- Promotion of staff health must be recognised as one of the employer institution's corporate objectives [38].

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