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Muscle strain and perceived exertion in patient handling with and without a transferring aid

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Abstract. This study presents the results of an evaluation of a patient handling aid commonly used for transferring patients from bed to toilet or other type of chairs. The results of the study showed that use of the patient handling aid (sling) increased the rate of perceived exertion at the lower back and the shoulder. Investigation of the muscular activity using electromyography in the shoulder and the lower back regions revealed that there was significant increase in the *erector spinae* activity in the lower back region. The increase in the back strain in the sling transfer was related to the increase in lumbar flexion resulting from the relatively smaller size of the sling. *Trapezius* muscle on the other hand did not indicate any difference in activity. The results of this study indicate that for positive outcomes there is a need for ergonomic evaluation of the sling and the postures adopted by the patient handler while transferring the patient with the sling.

Keywords: Manual handling, patient handling aids, nursing staff, perceived exertion, electromyography, musculoskeletal disorders, back pain, patient transfer

1. Introduction

Statistics from around the world show that musculoskeletal injuries are quite common among health professionals, especially those who have to manually handle patients (Buckle, 1987, Hignett and Richardson, 1995, Pheasant and Stubbs, 1992, Scholey and Hair, 1989). According to these statistics, work related back injury/pain is found to be the most prevalent of all the musculoskeletal injuries. Research has been conducted to investigate the musculoskeletal problems of the health professionals. Most of these studies were oriented to nursing staff [2,6,9,15,25]. According to National Occupational Health and Safety Commission (NOHSC) of Australia, health professionals constitute nearly 58% of workers injured in workplaces [19]. Among these 13.3% were enrolled nurses, 23.2% registered nurses and 21.6% ward helpers. The report also indicated that the injury mechanism in about 54% of all occurrences was related to muscular stress and 48.6% of cases were resulted from the manual handling. The average cost of the workers' compensation for hospital and nursing home industries in 1991–1992 was $669 per employee [19]. This cost of workers' compensation did not include the cost related to the sick leave and early retirement resulting from the injuries.

There are many studies [6,14,15,25] that have investigated the handling of patients in hospitals and nursing homes. Some of these studies are survey based relying on questionnaires and checklists to

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subjectively identify the risk factors on the job. However, an objective assessment of the extent of the risk to which participants were exposed cannot be made from these studies. Garg et al. [12] carried out a study to investigate patient handling tasks. Thirty-eight (38) nursing assistants in a nursing home were asked to rank and rate 16 different patient handling tasks for the perceived stress to the low back. The results indicated that transfer of patients from toilet to wheelchair and from wheelchair to toilet were perceived to be the most stressful tasks in their nursing jobs. Garg et al. [12] further studied different transfers of patients such as from toilet to wheelchair, bed to wheelchair, bathtub to wheelchair, chairlift to wheelchair, etc. and found that the shoulder was perceived to be the most stressed part of the body during these transfers.

Haber et al. [14] and Garg et al. [12] studied various tasks performed by nursing staff and reported that lifting and transferring patients were the most frequent causative factors of low back pain among them. Garg et al. [10] further stated that most of the occupational related low back pain and injuries in nursing personnel had resulted from frequent manual lifting of patients with high levels of postural stress. The studies of Bell and Eng [2] and Takala and Kukkonen [25] indicated that manual lifts still prevailed despite the presence of mechanical lifters. The most often stated reasons for not using an aid were lack of space, time and additional person needed to use an aid. The nursing staff often needs to move or lift patients whose weights range from 37 kg to over 100 kg [10]. These weights are certainly in excess of the average lifting strength of the female population in America [10]. Dehlin and Jaderberg [4] considered that the loads lifted during nursing activity in geriatric wards often exceeded the maximum permissive load for single and repeated lift. The maximum permissive load was estimated by Poulsen and Jögensen [22] who measured the muscle strength and back compression by using the NOISH equation. Harber et al. [15] further observed that handling patients in hospitals and related institutions was complicated by the special conditions that applied. These conditions included attachments to patients, obstructions in a confined space, fighting patients, unstable footings and slippery surfaces. It is thus clear that manual handling of patients is the major cause of musculoskeletal injuries in nursing homes. Thus, to prevent or reduce injuries an ergonomic evaluation of the tasks and the workplace should be carried out to identify risk factors associated especially with high postural stress and exertion on the workers.

Training in proper patient handling techniques has often been recommended to reduce injuries among nurses. Main purpose of training in task performance appears to be to effect changes in manual handling behaviours of nurses so that they can reduce postural stress by adopting more upright or natural postures. The effectiveness of training in reducing injuries has been extensively studied but the evidence is debatable [5]. Many researchers have suggested that training in patient handling techniques should be only one component of an injury prevention program [10,11,14] and greater effort should be placed on finding alternative means to reduce task demands.

While mechanical aids (such as hoists) are preferable to reduce manual handling in hospitals/nursing homes, they are costly and require a lot of space to use and/or manoeuvre. Many hospitals/nursing homes find these devices beyond their means and can hardly afford. As an alternative, different types of transfer aids are currently being used in hospitals and nursing homes [2,9,10,12,25]. These aids mainly try to improve nurse's ability to grip the patient during the transfer process. Often a sling (Fig. 1) is used for transferring patients. It has cut outs (handles) at both ends for gripping and is generally used by wrapping it around patient's waist and pulling the patient to a standing position. However, this method is only applicable to those patients who are partially ambulant or ambulant but need some assistance to stand up from the chair. Garg et al. [10] have noted that nurses preferred a one-person transfer with the sling as they are concerned that the belt might slip during a two person transfer. For non-ambulatory patients, a modified technique in which the sling is put under the patient's buttocks (thighs) is used so

Fig. 1. Sling used in the experiments.

that it works as a movable seat for the patient. This also reduces the risk of the patient slipping out during the transfer. Another modification of the use of sling is a two-sling patient transfer [5] in which a sling is put under the thighs and the other behind the upper back of the patient.

The effectiveness of the sling in reducing body strain and over-exertion injuries has not so far been properly investigated. A small number of studies that are available in the published literature point to inconclusive result [5,7,9,26]. Many reasons such as differences in patient transfer techniques, age, skill, and experience of the participants, patient characteristics (ambulant, non-ambulant), etc. can be cited for the inconclusive results obtained by the researchers. The effectiveness of the sling in reducing musculoskeletal problems may also be affected by the design shortcomings of the sling, posture of the participants involved in transferring patients with the sling and the necessary training required to following proper posture. It is clear that there is need for further research on ergonomics evaluation of the sling along with proper training in its use in transferring patients.

The purpose of this study was to investigate the muscle strain and the perceived exertion by nursing staff during patient transfer with and without the use of the sling. The study was divided into two parts: First part consisted of a survey study on the subjective perception of the nursing work. The objective of the survey was to identify the task and the body parts considered to be most stressful by the nursing staff. The second part of the study dealt with the determination of muscular strain and perceived exertion levels experienced by the participants in the performance of patient transfer tasks.

2. Method

2.1. Survey study

The Registered Nurses (RN) and Assistants in Nursing (AIN) in hospitals and nursing homes perform various patient handling tasks. For the purpose of the survey study six patient transfer tasks were selected (Table 1). Twenty (20) participants (RNs and AINs) took part in the study. They were given survey questionnaires which listed six transferring tasks and included a body chart. Participants were asked to rank these tasks from the most stressful to the least stressful. After the participants have ranked the tasks (1 = most stressful, 6 = least stressful), they were further asked to map out two regions of the

Table 1
Ranking of the patient transfer tasks on perceived stress

Task	Mean ± SD	Rank order
Shower chair to low chair	2.2 ± 0.9	1
Low chair to shower chair	2.5 ± 1.3	2
Shower chair to bed	2.9 ± 1.6	3
Bed to shower chair	4.4 ± 1.4	4
Low chair to bed	4.4 ± 1.8	5
Bed to low chair	4.8 ± 1.3	6

Fig. 2. Shower chair.

body where they felt most stressed. To prevent any bias in their perception, participants with a history of musculoskeletal problems were excluded from the survey study.

2.2. Muscular strain and perceived exertion study: Experimental set up

Muscular strain was determined by measuring electrical activity of the active muscles by the technique of electromyography [1]. Perceived exertion levels experienced by the participants were measured on a Borg scale [8].

To determine muscle activity during transfer of a patient, a non-ambulant patient transfer task was simulated in the ergonomics laboratory. A two-person lifting technique was selected for patient transfer. The task performed was the transfer of a "patient" from a shower chair (Fig. 2) to a low armchair (Fig. 3). The shower chair, 58 cm high (from the floor), was made of aluminium with four 10 cm diameter swivel casters and brakes on the two rear wheels. The four wheels were free to rotate in any direction so that it was possible to manoeuvre the shower chair in a confined space. The side arms of the shower chair could not be removed but can be pulled back for easier patient transfer. The shower chair had footrest which could not be removed but could be pulled up to an upright position to either allow partial ambulant

Fig. 3. low arm chair.

patients put their feet on the floor or to allow nurses to come closer to the patient during care. The seat height of low armchair was about 28 cm from the ground and it was inclined at about 25 degrees to the horizontal. The height of the back rest was about 60 cm and tilted backward by about 20 degrees to the vertical (Fig. 2). There was a 22 cm height arm rest on each side of the chair. The armrests were not removable so nurses have to lift the patient so that they were clear of the arm rest during the transfer.

The shower chair was placed at an angle of about 45 degrees to the low arm chair. The footrests of the shower chair were pulled up to an upright position to allow more room for transfers. The wheels of the shower chair were locked and ensured to be secure. The "patient" (body weight 50 kg and height 163 cm) sat on the shower chair with feet dangling. The patient transfer was executed by a two-person lifting technique in which two participants worked as a pair. They stood with feet far apart, one foot towards the seated patient and the other foot towards the direction of the transfer movement. The participants were instructed to execute patient transfer slowly and smoothly. For manual transfer, each participant grasped the patient by putting one arm through the axilla and the other arm reaching to grip the belt of the patient's trousers (Fig. 4). For the sling transfer, each participant grasped the patient by putting one arm through the axilla and the other arm reaching to hold on to the cut outs (handles) of the sling with the patient seated on it (Fig. 5).

2.2.1. Electromyography

Electrical signals from the contracting muscles were recorded and analysed using a computerised system Flexcomp/DSP (Thought Technology, Montreal, Canada). Surface electromyography technique was used to pick up electrical signal on the skin surface. Disposable electrodes were placed on the muscles of interest following generally accepted guidelines [1]. The inter-electrodes distance was kept at 2 cm to minimise the noise and interference from other muscles. EMG Signals were sampled at the rate of 992 samples/sec and filtered through a high pass filter (20–500 Hz) and then rectified. A 50 Hz notch filter was used to eliminate line noise.

Fig. 4. Manual transfer.

Fig. 5. Transfer with a sling.

2.2.2. Selection of muscles for investigation

The result of the survey study showed that the shoulder and the lower back were perceived as the most stressed regions of the body during patient transfer. Within these regions, the anterior shoulder down to the middle of upper arm, the posterior shoulder up to the neck and down to T3 level and the lower back at L3 to L5 level, were identified as the most stressed parts of the body. This study therefore focused on muscles of the shoulder complex (scapula and glenoid-humerus joint) and the lumbar spine.

The shoulder is a complex biomechanical and anatomical structure. There are four muscle groups for shoulder flexion, another four muscle groups for scapula elevation and two other muscle groups for shoulder retraction [17]. The *upper trapezius* muscle is found to be active during elevation or retraction of the shoulder and during flexion or abduction of the upper extremity through a range of 180 degrees [1]. This is because the *upper trapezius* muscle has a role in the adjustment of the scapular and the stabilization of the proximal shoulder girdle during upper extremities exertion. Furthermore, the direction of pull of the *upper trapezius* muscles is more upward than the other shoulder muscles such as the rhombus muscles. In other words, the upward component of the pulling force from *trapezius* muscles is dominant in the resultant pulling force. Therefore, *the upper trapezius* muscles are regarded as the major muscles for scapular elevation. On the other hand, Westgaard et al. [27] have indicated that a high proportion of those reporting shoulder pains during the previous 12 months had clinical signs localized on the belly or tendons of the *upper trapezius* muscle. Therefore *upper trapezius* muscle activity was used as an indicator of shoulder muscle strain.

The muscles for lumbar spine extension are mainly *erector spinea* muscles. However, there are many small muscle branches at different level of the spine to form an *erector spinea* muscle [28]. The prime movers of lumbar spine extension are the *iliocostalis lumborum*, the *longissimus thoracis* and the *spinalis thoracis* [17]. Other deep small muscle branches of *erector spinae*, such as the *multifidi*, mainly work as a stabiliser or a facilitator for the spine movement. Basmajian and De Luca [1] have stated that *longissimus thoracis* and *spinalis thoracis* were always prominently active during spinal movements and the least active was *iliocostalis lumborum*. The *spinalis thoracis* is attached to the first two lumbar vertebrae only. It does not actually extend the whole lumbar spine. Therefore, the *longissimus thoracis* of the *erector spinea* muscle was selected for muscle activity measurement.

2.2.3. Experiment procedure

Ten participants served as volunteer nurses and one volunteered as the "patient". The mean age, body weight and height were 29.17 $\pm$ 3.31 years, 56.33 $\pm$ 14.40 kg, and 161.33 $\pm$ 8.19 cm respectively. Participants with any history of musculoskeletal problems, heart conditions or respiratory conditions were excluded from the study. A written consent was obtained from the participants after explaining them the objectives of the study and experimental procedures. The patient handling task was simulated in the ergonomics research laboratory. The shower chair and the low chair were positioned as described above and ensured to be stable for transfer before the experiment.

The patient transfer techniques used in the experiment were standardised using a video taped demonstration. The participants were instructed to practise the transfer until they felt confident with both transfer techniques. A five to ten minutes rest was given to the participants after the practice to prevent fatigue. The Ethics and human research committee of the UNSW approved this experimental procedure.

Prior to patient transfer simulation, participants were prepared for EMG data recording by placing disposable surface electrodes on the right and left *trapezius* and *erector spinae* muscles. Participants performed maximum voluntary contractions (MVC) of *trapezius* and *erector spinae* muscles. The patient was then made to sit on the shower chair and was reminded not to put weight on the feet by keeping the toes clear off the floor. The participants randomly performed three trials of transfer each with or without the use of the sling. The participants were allowed to have one minute rest between each transfer trial. A trigger switch was placed under the buttocks of "patient" to indicate the start and the end of the transfer. The participants were asked to rate the perceived exertion at the shoulder and the lower back immediately after the completion of the patient transfer.

2.2.4. Data analysis

The MVC values of *trapezius* and *erector spinae* muscles were determined. Other EMG data collected during the task were normalised with respect to the MVCs of individual muscles so that relative activities could be assessed and compared. The time base for each task was normalized to 100% and using the formula suggested by Mikra [18] and Grant et al. [13] the collected data was normalised. The normalised RMS values were expressed as percentage of corresponding MVC values and the time was expressed as percentage of task. This made it possible to compare muscle activities in a variety of conditions.

Electromyography activities and rating of perceived exertion (RPE) scores were analysed using statistical procedures to determine significance of the changes due to experimental conditions. Normalised EMG RMS values of individual muscles in each experimental condition were compared by paired t-test. Mean RPE scores for the shoulder and the lower back in each condition were also compared by paired t-test.

3. Results

3.1. Survey study

Table 1 shows the results of the survey part of the study. The task of transferring a patient from the shower chair to the low chair was found to be the most stressful task among the listed six patient transfer

Table 2
Electromyographic (EMG) activities of right and left *trapezius* muscles expressed as % of maximum voluntary contraction (MVC)

Transfer technique	R. *Trapezius* (% MVC)	L. *Trapezius* (% MVC)
Manual	23.59 ± 14.86	33.08 ± 19.51
Sling	23.00 ± 12.46	32.12 ± 16.41
Statistical significance (t-test)	$p = 0.42$	$p = 0.42$

Table 3
Electromyography (EMG) activities of right and left *erector spinae* muscles expressed as % of maximum voluntary contraction (MVC)

Transfer technique	R. *Erector spinae* (% MVC)	L. *Erector spinae* (% MVC)
Manual	66.20 ± 17.88	64.03 ± 24.67
Sling	73.71 ± 22.64	74.39 ± 30.19
Statistical significance (t-test)	$p = 0.01$	$p = 0.04$

Table 4
Rating of perceived exertion (RPE) at the shoulder and lower rack regions

Transfer technique	Shoulder (Mean $\pm$ SD)	Back (Mean $\pm$ SD)
Manual transfer	8.33 ± 1.21	9.50 ± 1.87
Sling transfer	10.93 ± 1.47	14.17 ± 1.47
Statistical significance (t-test)	$p = 0.01$	$p = 0.01$

tasks. The survey questionnaire also asked the participants to indicate the two body regions which they perceived to be most stressful during the task. Out of the total participants, 70% indicated the shoulder and 65% indicated the lower back as the most stressful regions during the performance of patient transfer tasks. The results of the survey study were used for the second part of the study which concentrated on determining muscular strain and the perceived exertion during the patient transfer from the shower chair to low chair.

3.2. Muscular strain

Figures 6 and 7 show electromyography activities of *trapezius* and *erector spinae* muscles respectively. Data from one of the participants was found to be unreliable and was excluded from the data set used for statistical analysis. RMS value of the electrical activity of a muscle was considered to represent muscle strain. The RMS values were normalised with the corresponding MVCs and expressed as percentage of the MVC. The mean muscle strain for the right *upper trapezius* muscles was 23.59 $\pm$ 14.86% for the manual transfer and 23.00 $\pm$ 12.46% for transfer with the sling. The mean values for the left *upper trapezius* muscles were 33.08 $\pm$ 19.51% for manual transfer and 32.12 $\pm$ 16.41% for the sling transfer. Statistical significance analysis (Table 2) showed that there was no significant difference in the muscle strain on the right or the left shoulder during the manual and the sling patient transfer.

Muscle strain for the low back, on the other hand, was significantly higher ($p < 0.05$) when the participants transferred a patient with the sling. Mean peak values of muscle strain for the right *erector spinae* muscle for the manual and sling transfers were 66.20 $\pm$ 17.88% and 73.71 $\pm$ 22.64% of MVC respectively (see Table 3). Mean peak values for the left *erector spinae* muscle in the manual and sling transfers were 64.03 $\pm$ 24.67% and 74.39 $\pm$ 30.19% of MVC respectively. Increase in the mean peak values of muscle activity on left *erector spinae* muscle was more than that on the right side. There was

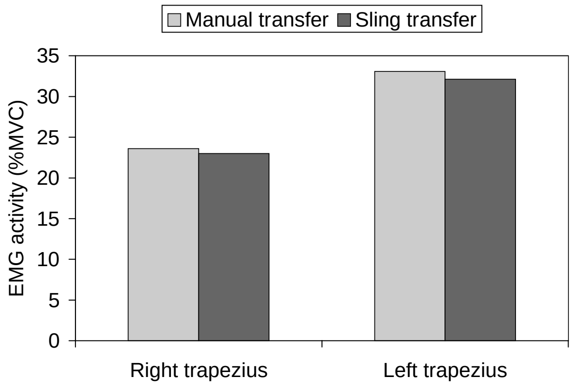

Fig. 6. Electromyography activities of *erector spinae* in manual and sling transfers.

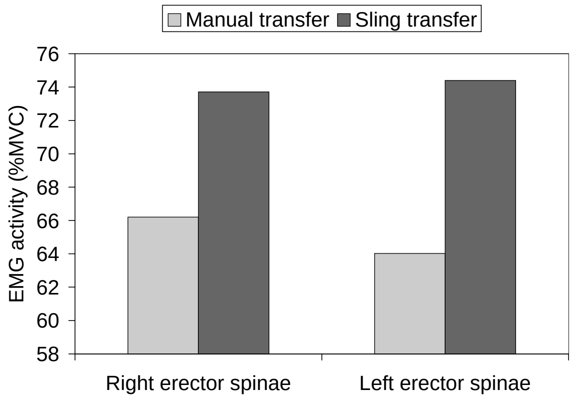

Fig. 7. Electromyographic activities of *trapezius* muscle in manual and sling transfers.

an increase of 10% MVC on the left side while there was only 7.5% MVC on the right side. However, the difference between the increase on left and right side was not statistically significant ($p = 0.26$).

3.3. Rating of perceived exertion

Figure 8 shows the results of rating of perceived exertion investigation for the shoulder and the low back regions. Table 4 compares RPE values for the patient transfer with and without sling.

The rating of perceived exertion on both the shoulder and the lower back are significantly higher ($p < 0.05$) for sling transfer. Mean scores of perceived exertions for the shoulder for the manual and sling transfers were 8.33 $\pm$ 1.21 and 10.83 $\pm$ 1.47 respectively. Mean perceived exertion scores for the lower back for the manual and sling transfers were 9.50 $\pm$ 1.87 and 14.17 $\pm$ 1.47 respectively. The increase of perceived exertion on the lower back is more than that of the shoulder. The average increase of perceived exertion ratings between the two transfer conditions on the lower back was 5.17 $\pm$ 2.14 but the average increase on the shoulder was only 2.50 $\pm$ 1.58. The increase of perceived exertion ratings at the lower back was significantly higher ($p = 0.05$) than the increase at the shoulder (Table 5). A comparison of perceived exertion ratings of the shoulder with the lower back during manual transfer ($p = 0.18$) showed no significant difference (Table 6). However, a significant ($p = 0.01$) was seen when the sling transfer was used.

Table 5
Comparison of increase in RPE for shoulder and lower back

The increase of the rating of perceived exertion	Mean ± SD
Shoulder	2.50 ± 1.38
Back	5.17 ± 2.14
Statistical significance (t-test)	$p = 0.05$

Table 6
Comparison of ratings of perceived exertion of the shoulder with the lower back in manual and sling transfer techniques

	Manual transfer (Mean ± SD)	Sling transfer (Mean ± SD)
Shoulder	8.33 ± 1.27	10.93 ± 1.47
Back	9.50 ± 1.87	14.17 ± 1.47
Statistical significance (t-test)	$p = 0.18$	$p = 0.01$

4. Discussion

Musculoskeletal disorders among nursing personnel are a matter of growing concern in Australia and other Western countries. Ergonomics interventions in terms of workstation modifications and/or providing job aids are common means of reducing or preventing the risk of musculoskeletal injuries. It is well accepted that increase in muscular strain can lead to musculoskeletal injuries. It is therefore critical that job aids such as a sling used for patient transfers by nursing personnel be assessed for their ability to reduce muscular strain during the occupational tasks. This investigation was undertaken to assess changes in muscular strain and the perceived exertion levels by the using a sling assisted patient transfer.

EMG investigation indicates that the use of the sling by the participants leads to a statistically significant increase in the muscle strain on the lower back. The results of the subjective rating of perceived exertion back up the EMG measurement. Therefore, the conclusion may be drawn that the use of the sling increases the back strain. This result is contrary to the expectation that the use of sling reduces back strain. The increase in the back strain in the sling transfer can be related to the increase in lumbar flexion (increased bending of the back) resulting from the relatively smaller size of the sling. Since the hand grip position in the sling transfer was lower than that in the manual transfer, there was an increase in the lumbar flexion resulting in higher postural stress. If the sling were long enough for the participants to grip it at a higher level than the manual transfer, the back could be maintained in more upright position thus reducing postural stress. It is important to note that the appropriate size of the sling depends not only on the anthropometry of the worker (nurse) but also of the patients. Larger size patients will require larger slings. The slings should either be available in different sizes or be made adjustable to meet individual worker's need for effective grip and also to allow them to adopt favourable postures. It becomes clear from this study that the size of the sling can play an important role in obtaining favourable results in the patient transfer.

Several studies have reported on the use of slings and other assistive devices in patient transfer. Garg et al. [10,11] have noted that the use of patient transfer aids such as hoists, belts, etc. may not necessarily lead to favourable outcomes (eg., reduction of postural stress) as compared to manual transfer. Tuohy-Main [26] found that the use of the sling in patient transfer could increase moment arm length resulting in higher compressive forces on the spine. Gagnon et al. [7] have shown that the use of belt (sling) increased compressive forces on L5/S1. Elford et al. [5] found that the use of sling had some beneficial

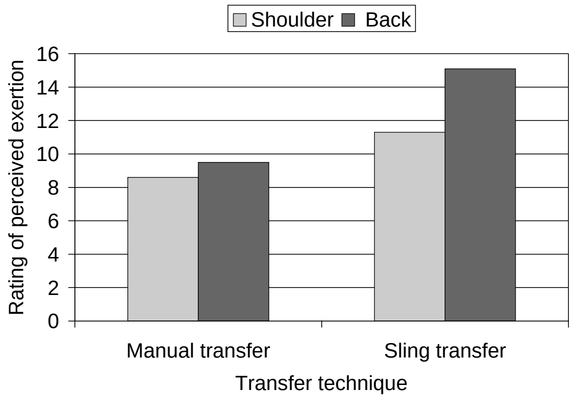

Fig. 8. Ratings of perceived exertion at the shoulder and low back regions in manual and sling transfers.

effect (less angular displacement, velocity and acceleration of the lumbar spine) to patient handlers in a seat to seat patient lifting task. It is clear that there is the need for a comprehensive ergonomic evaluation of the use of sling in patient transfer.

Although the EMG activity at the shoulder (*trapezius muscle*) did not show significantly higher value in the sling patient transfer, the rating of perceived exertion on the shoulder was significantly higher ($p = 0.01$). The lack of correspondence between the EMG and RPE results may be due to the complex nature of the shoulder joint. Though *trapezius* plays a major role in the biomechanics of the shoulder joint, other muscles such as rotator cuff can also share the load. As only *trapezius* was investigated in this study, it is difficult to support or reject this point. The rating of perceived exertion, on the other hand, reflects the overall load experienced by the participants.

The mean RPE values for the shoulder in manual and sling transfer were 8.33 $\pm$ 1.21 and 10.83 $\pm$ 1.47 respectively. These values are significantly ($p = 0.05$) lower than that of the lower back (9.50 $\pm$ 1.87 and 14.17 $\pm$ 1.47 respectively for manual and sling transfer). This result contradicts the result from the study of Garg and Owen [9]. They stated that the shoulder was the body part perceived to be the most stressed ($p \leqslant 0.01$). The contradiction of the result between these two studies may be due to a variety of factors such as difference in the techniques of transfer, skill of the participants, weight of the load lifted and previous lifting experience of the participants, etc. However, statistics from NOHSC [19] support the results of the present study. NOHSC showed that the injuries to the low back (40.3%) in nursing personnel was about six times that of the shoulder (6.9%). There is clearly a need of further research in this area to clarify the contradictory results.

5. Conclusions

In summary, conclusions reached from this study are:

1. Use of the sling for patient transfer increased muscle strain on the lower back. On average, an increase of 10% MVC on the left side and 7.5% MVC on the right side was observed.
2. Use of the sling increased the perceived exertion at both the lower back and the shoulder.
3. Increase in the rating of perceived exertion at the low back was higher than that at the shoulder.
4. Sling assisted patient transfer did not improve the safety of the nursing staff against musculoskeletal injuries and even increased the risk of over-exertion.

6. Further research

Future research in this area should consider motion analysis of the patient transfer task, synchronised with electromyography to reveal subtle changes in posture and/or technique that participants may employ during patient handling with the sling. Also, an ergonomic evaluation of the sling should be performed to match it with participants' anthropometric and individual characteristics

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