Perceived efforts and back injury risks of physical therapists in patient transfers between bed and wheelchair

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In assisted patient transfers, the perceived exertions by the therapists and the measured hand coupling forces during transfers correlated poorly. This low correlation indicated the therapist's grading system for the assessment of the rehabilitation levels of the patients is unreliable. Gender and years of work experience of the therapists had no effect on the reliability of the subjective assessment. Perceived exertion levels underestimated the minimal assist lifts and overestimated the maximal assist lifts. The maximum spine load of 2100 N was found in the assisted transfer of a 59 Kg patient The spine load for a 95th percentile patient was estimated to be 3721 N, which exceeded the NOISH recommended value. Use of a gait belt seemed to be beneficial in reducing the spine load, because of the large horizontal component of the hand coupling forces that occur in this type of patient transfers.

1. Introduction

Hignett [1] surveyed several studies related to work-related back pain in hospital workers and summarized that frequent patient handlers had a 3 to 7 times higher prevalence rate of back pain compared to infrequent handlers. Physical therapists (PTs) are healthcare workers who have frequent patient handling tasks. In Holder's *et al.* [2] survey of 623 PTs and PT assistants, they found 62% and 56% respectively had low back pain at some point in their professional carrier. The three most stressful activities reported to cause injury was transferring, lifting, and responding to sudden movement of patients. Based on a survey of 928 PTs, Bork *et al.* [3] reported 45% had had a history of lower back pain with the most likely cause being "lifting or transferring depe ndent patients". One Canadian survey of 311 physical therapists also noted higher incidence rate of lower back pain in PTs than the general population [4]. Patient handling, stooping, lifting, carrying, pushing and pulling were the activities frequently de scribed by the PTs as the cause of the injury.

Garg and Owen [5,6] evaluated specific patient handling activities. They found that for a two person manual lifting technique of transferring patients from bed to wheelchair, the lower back compressive forces were between 4223 to 4557 N. Their force values for transferring from wheelchair to bed averaged 4395 N. In their 1992a study, they evaluated a nursing assistant's job. Their assessments for transfer from wheelchair to bed and bed to wheelchair were 4887 N and 3991 N, respectively for a 50th percentile patient. Winkelmolen, *et al.* [7] evaluated five manual techniques for moving patients up in the bed and revealed that all of the lifts for a 75kg patient, the spine loading ranged from 3869 to 4487 N. Ulin *et al.* [8] found the average compressive forces two nursing subjects lifting totally dependent patients from bed to wheelchair to be at 6066 to 6521 N. Marras *et al.* [9] found that various patient lifting techniques, on average generated 6420 N and peaked at 9100 N. All of the above studies found the spine loading is far above the NIOSH recommended safe limit of 3400 N [10]. However in all of the above studies the "patient" being transferred was totally dependent. This is not always the situation in the healthcare field. Often patients can assist the healthcare worker in their mobility, but do require some exertion from the therapists. In reality, for dependent patient transfers, therapists are most likely to seek additional help. For non-dependent patients, the decision of getting help lies on the judgment of the therapist.

The typical assisted transfers performed by PTs in hospital settings are referred to as a stand pivot transfer. Usually the patient is assisted from bed to chair or chair to bed and the transfer consists of three parts: the initial lift to stand the patient, pivot toward the chair or bed, and lowering to the destination surface. The assistance provided by the PT is subjectively graded depending on the level of help that is needed to stand the patient. Patient assistance level of approximately 25%, 50% and 75% in the transfers are subjectively graded as minimal, moderate, or maximal assistance by the PTs. This grading is used to track the patient's progress in a rehabilitation program. This study investigated the non-dependent or assisted patient transfers and the study objectives were to (1) investigate whether the therapists can correctly perceive the assistance level, and (2) assess the back injury risks of the therapists from the assisted transfers.

2. Method

Six experienced PTs and PT assistants (2 male assistants, 1 male therapist, and 3 female therapists) participated voluntarily in this study. They have been screened for recent history of low back pain, acute injuries, or other conditions contraindicated. Their patient handling experience ranged between 1 to 20 years with a mean 5.7 years of experience. Their average age, height and weights were 29.3 years, 172.9 cm, and 72.3 Kg, respectively.

One able bodied healthy male with normal balance was used as a subject to simulate the “patient” in the transfer experiments. The height and weight of the patient was 160 cm and 59 Kg, respectively. Prior to the experiments, this person was coached to vary his effort level to simulate minimal, moderate or maximum assistance levels during the transfers according to instructions. The minimal, moderate and maximum level approximately corresponding to 25%, 50%, and 75% assistance level during the transfers.

Figure 1. Experimental setup for patient transfer tasks from wheelchair and from bed.

All participants were volunteers. They were made aware of the nature of the experiment before their participation in the experiments and informed consents were obtained. A motorized Hill-Rom mobilization table was used as a bed and a typical hospital wheelchair was used in the experiments. Prior to the each experimental session, the therapists according to his or her choice adjusted the height of the bed. A gait belt (Smith-Nephew nylon flat belt) was secured to the patient's waist. The gait belt is an assistive device, which is customarily used during real patient transfers in hospitals to improve the coupling and control during transfers. Two Warner Instrument's force gages (model FDK 60) were secured to the transfer belt near the lateral sides of the waist to record the hand coupling forces during the transfers. The force gages were tested with known weights and proved accurate and reliable and no calibration was necessary. The therapist held the handles of the force gages and applied pull forces to perform the patient transfer task (Figure1). The force gages were mechanical type and recorded the maximum pull force during each transfer.

Two types of transfers were investigated, from a bed to wheelchair and from wheelchair to bed. Marras *et.al* [9] found that the therapists encounters the highest amount of lower back stress during the initial phase of the transfers when he or she assisted the patient to stand up from a seated position on a bed or on a wheel chair. In accordance to the above, this experiment recorded the effort needed to assist the patient to a standing position from a seated position on bed or on wheel chair. Each therapist performed 36 such lifts, 6 lifts, each for minimal, moderate and maximum level of assistance from bed to wheelchair and from wheelchair to bed. Three of the therapists initiated the transfers from the bed and then proceeded to wheelchair and the remaining three vice versa. Eighteen index cards with six cards each designated with numbers one, two, or three (1=minimal, 2=moderate, 3=maximal) were shuffled to produce a random order of the transfers assigned to avoid any learning phenomena of the therapist. The cards were flashed to the patient without the therapist in sight of the card and the therapist was verbally instructed to perform the lift. The therapists were also blinded to the readings of the gages. At the end of each transfer, the therapist rated their perceived exertion on a 0 to 10 rating scale. Rest pauses were provided between transfers as needed.

No instructions were provided to the therapists about the postures to be adopted, except to perform the trials in a comfortable manner typically assumed when working in the field. The posture of each therapist was recorded on videotape. The video recorder was positioned at a right angle to the participants. Body markers were applied to each therapist to resolve of the location of the joints. Only one camera was needed for this study, as the forces were essentially symmetrical and were in a plane parallel to the sagittal plane.

In addition to the above six trials, in a separate set of experiment, the hand forces for performing dependent transfers were determined. This value was obtained from one of the larger male therapist performing a 100% assisted lift on the patient. Two of these lifts were performed from the bed and two from the wheelchair. The average total hand force was consistent at 405 N from both surfaces.

2. Results

The average difference between the two hand force readings was less than 15 N, which indicated that very little twisting actions were involved in standing the patient. In the subsequent analysis the two hand force readings were summed up to determine the total hand coupling force. Figure 2 illustrates an example of the hand coupling forces and the perceived exertions recorded from one of the subjects for 36 lifts. The summary of the hand force and perceived exertion data are provided in Table 1.

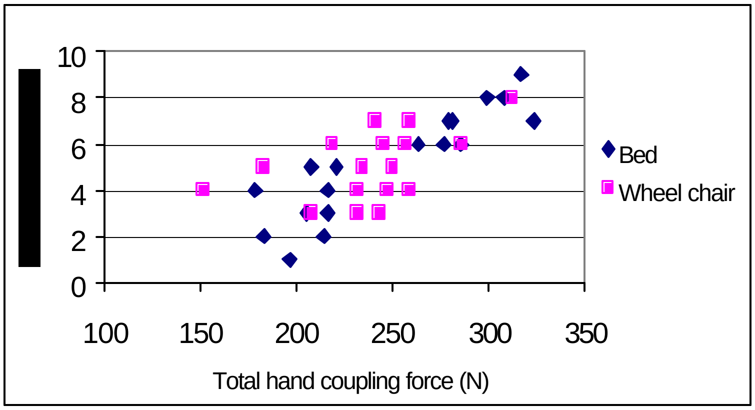

Figure 2. The hand coupling force and perceived exertion for a therapist during patient transfers.

Intra-therapists reliability in terms of perceived exertion proved to be better for the transfers from the bed, as the correlation coefficient between the perceived exertions and coupling forces ranged between 0.67 to 0.89. The correlation coefficient ranged between 0.10 to 0.75 for the transfers from wheelchair. No noticeable effect on the therapists' reliability could be determined based on the experience level of the therapist or the gender of the therapist. A higher height of the bed, in which the patient was closer to a standing position, revealed lower measured forces, but not necessarily lower perceived exertions (see therapists number 1 and 4 in Table 1). Transferring the patient from the wheelchair, which was at a lower height (18 inches from the floor to the seat) than the bed (ranged from 22 to 28 inches from floor the top of the bed), did reveal a higher perceived exertion in most. The perceived exertion averaged 4.45 from the bed and 5.29 from the wheelchair. Inter-therapists reliability in terms of correlation coefficient between the perceived exertion and the measured force based on all six therapists' data yielded extremely low value. The correlation coefficient ranged between 0.21 and 0.00 for transfers from bed and from wheelchair, respectively.

The average hand forces for minimal, moderate and maximal perceived transfers were compared to the 100% assisted (dependent) transfer force value (406 N) in Table 2. The perceived exertions that equaled 1 through 3 were grouped to minimal, 4 through 6 to moderate, and 7 through 10 to maximal assisted transfers for computing the average forces. The average force for minimal assisted transfers should have been approximately 25%, but were underestimated significantly by the therapists, as the average force was 54% of the dependent transfer. The moderate assisted transfers were closer, but still fairly underestimated the 58% value at 50%. The maximal assistance values overestimated the 65% value at 75%.

Table 1. Hand forces and perceived exertions in patient transfers

Therapist	From bed					From wheelchair				
	Coupling Forces (N)		Perceived Exertion		Corr	Coupling Forces (N)		Perceived Exertion		Corr
	Mean	Range	Mean	Range		Mean	Range	Mean	Range	
1 M	161.5	124-209	2.2	1-4	0.69	266	203-363	4.7	3-6	0.75
2 M	248.1	178-323	5.2	1-9	0.89	238	151-312	5.1	3-8	0.50
3 F	225.8	124-272	4.8	1-9	0.79	204	120-283	5.2	1-9	0.54
4 F	127	103-158	5.5	2-9	0.82	198	140-249	5.2	1-9	0.10
5 M	252.1	207-339	3.9	1-8	0.67	276	227-343	5	2-8	0.75
6 F	159.3	109-196	5.2	2-8	0.84	173.5	96-232	6.5	4-9	0.58

Table 2. Average hand forces for minimal, moderate and maximal assisted transfers compared to that of 100% assisted (dependent) transfer.

Type of transfer	Minimal assist		Moderate assist		Maximal assist	
	Average force (N)	% dependent transfer	Average force (N)	% dependent transfer	Average force (N)	% dependent transfer
Bed	221	54	231	57	254	63
Wheelchair	217	54	240	59	272	67
Overall	219	54	236	58	263	65

The compressive force at lower back (L5/S1) for the therapists were determined using the University of Michigan's 3D SSPP software. The joint angles at the beginning of the lift were entered from the video recording. The hand forces were entered from the force gage recording with a line of action parallel to the forearm axis. The lower back compressive force did not reveal any posture and associated patient-handling load as a hazard. The peak spinal compression force for a large male therapist was 2100 N, and for a small female was 1732 N. All of the spinal compression forces were below the NIOSH recommended threshold value of 3400 N.

3. Discussion

Poor inter-therapists reliability in terms of low correlation coefficients (0 to 0.21) between the subjective levels of exertion and the actual hand forces indicated that the therapists were not consistent in grading the transfers. On the other hand, most of the intra-therapist reliability values were higher, indicating that the individual perceptions of exertion varied consistently. This low inter-therapist and high intra-therapist reliability may indicate that the therapists' perception varied according to their strength capability in handling a patient rather than the absolute value of the effort needed for the transfers. Thus from an inter-therapists standpoint, the therapist's grading system for assisting patients proved to be unreliable. On average, the therapists tended to significantly underestimate the minimal assist transfers and slightly overestimate the maximum assists. Learning and experience did not appear to contaminate the results as three therapists were more consistent as they performed the transfers, and the other three were more inconsistent during the experiment (see Table 1). It appeared that patient transfers from lower height, as that from the wheelchair, perceived to be more strenuous.

In this laboratory study the patient with low body weight (59 Kg) was deliberately chosen to avoid the risk of back injury to the participant therapists. Extrapolating the spinal compressive forces while performing a maximum assist transfers to a 50th percentile male/female patient (75.5 Kg) for the larger male therapist via proportion, the load on the spine would be 2692 N and for a 95th percentile patient (103 Kg) 3721 N. Thus, assisted transfers with larger patient can pose considerable risk of back injury.

It was noted that the angle of line of action of pull forces from horizontal averaged 30° for small female therapists and 36° for larger male therapists. Due to this inclined line of action, the force vector therefore was larger in the horizontal direction compared to that in the vertical downward direction. This resulted in the lower back compressive force to be small even though the hand coupling forces were significant. Had the forces been more vertical, the spinal compressive forces would have been greater. This is usually the case when transferring patient without a transfer belt in which the therapist grasped the patient from under the axillae. Thus the patient transfer using a gait belt appeared to make this patient handling activity comparatively safer in terms of spinal compressive force.

Limitations of this study included that the patient was transferred only from sit to stand, where a complete pivot transfer might have generated more torsional or shear forces on the spine. Additionally, the patient in this study was compliant, cooperative, and had normal balance. In the field, some patients can be agitated and resistive, which may add more spinal forces in terms of dynamic loading.

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References

[1] S. Hignett, Work-related back pain in nurses. *Journal of Advanced Nursing* **23**(1996) 1238-1246.

[2] N. Holder, H. Clark, J. Diblasio, C. Hughes, J. Scherpf, L. Harding, and K. Shepard, Cause, prevalence, and response to occupational musculoskeletal injuries reported by physical therapists and physical therapist assistants, *Physical Therapy* **79**(1999) 642-652.

[3] B. E. Bork, *et. al.*, Work-related musculoskeletal disorders among physical therapists, *Physical Therapy* **76**(1996) 827-835.

[4] M. Mierzejewski and S. Kumar, Prevalence of low back pain among physical therapists in Edmonton, Canada, *Disability Rehabilitation* **19-8**(1997) 307-317.

[5] A. Garg and B. Owen, An ergonomic evaluation of nursing assistants' job in a nursing home, *Ergonomics* **35-9**(1992a) 979-995.

[6] A. Garg and B. Owen, Reducing back stress to nursing personnel: an ergonomic intervention in a nursing home. *Ergonomics* **35-11**(1992b) 1335-1375.

[7] G. H. Wilkelmolen, J. A. Landeweerd and M. R. Drost, An evaluation of patient lifting techniques, *Ergonomics* **37-5**(1994) 921-932.

[8] S. Ulin, D. Chaffin *et. al.*, A biomechanical analysis of methods used for transferring totally dependent patients, *Sci Nursing* **14-1**(1997) 19-27.

[9] W. S. Marras, K. G. Davis, B. C. Kirking, and P. K. Bertsche, A comparative analysis of low-back disorder risks and spinal loading during the transferring and repositioning of patients using different techniques. *Ergonomics* **42-7**(1999) 904-926.

[10] T. R. Waters, V. Putz-Anderson, A. Garg, and L. J. Fine, Revised NIOSH equation for the design and evaluation of manual lifting tasks, *Ergonomics* **37-5**(1993) 921-932.