MUSCLE ACTIVITY DURING PATIENT TRANSFERS: THE INFLUENCE OF LIFT ASSISTS AND EXPERIENCE

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Abstract
Health care workers who handle patients are at increased risk of developing low back pain. Many studies have reported lumbar compressive loading during patient transfers but muscle activation levels (EMG) have rarely been reported. We examined EMG patterns during transfers from bed to wheelchair and vice versa in novices and experienced participants. Mean muscle activations using a ceiling lift were lower than the floor lift, which were lower than manual transfers (novices: all $p < 0.01$). Experienced handlers showed a similar pattern with the exception that the floor lift vs manual transfer comparison was not significant. Specifically, experienced handlers had lower mean EMG activity in the right upper and lower erector spinae ($p < 0.05$, for most tasks). Further examination of the muscle activation patterns differences between experience levels could lead to improved training techniques to develop better patient handling strategies.

Key words: EMG, patient transfer, lifting

ACTIVITÉ MUSCULAIRE LORS DU TRANSFERT DE PATIENT : INFLUENCE DE L'ÉQUIPEMENT DE LEVAGE ET DE L'EXPÉRIENCE

Résumé
Les travailleurs de la santé effectuant des déplacements de patients présentent un risque plus élevé de développer des douleurs lombaires. De nombreuses études ont rapporté une force de compression lombaire durant le transfert de patient, mais le niveau d'activité musculaire (EMG) a rarement été rapporté. L'électromyographie de participants novices et expérimentés a été examinée lors de transferts d'un lit à une chaise roulante, et inversement. La moyenne de l'activité musculaire était inférieure lors de l'utilisation d'un appareil de levage installé au plafond par rapport à un appareil de plancher, et inférieure par rapport à un transfert non assisté (novices $p< 0.01$ pour tout). La situation était semblable pour les participants expérimentés, sauf pour l'appareil de plancher par rapport au transfert non assisté, où la différence n'était pas significative. Les participants expérimentés présentaient une activité électromyographique inférieure pour les érecteurs du rachis inférieur et supérieur, à droite ($p< 0.05$, plupart des tâches). Une analyse plus approfondie des schémas d'activation musculaire selon les niveaux d'expérience pourra entraîner le développement de meilleures techniques d'entraînement pour améliorer les méthodes de déplacement de patients.

Mots clés : EMG, transfert de patient, posture

INTRODUCTION

Health care workers who handle patients are at increased risk of developing low back pain (3). In recent years, research into the musculoskeletal loads experienced by patient handlers has increased and the concept of "zero lift" in hospitals has been introduced (5). Many studies have determined the lumbar (L4-L5) joint moments, shear and compression forces (1,2,4) but muscle activation levels are rarely presented. Mechanical assists relieve some of the physical burden of the patient transfer but often require an increased duration. Electromyographic (EMG) analysis of patient transfers using different assistive devices can provide a better understanding of muscular loading during patient transfers. The purpose of this study was to investigate the response of the trunk musculature during patient transfers under three transfer assist conditions: single person manual transfer, floor lift, and ceiling lift.

METHODS

Six healthy males participated in the study. Four had little or no experience in patient handling. These novice patient handlers were trained in proper transfer techniques prior to the study. Two participants were experienced with all transfer methods used in the study. Three transfer conditions were used: 1. single person manual transfer, 2. a mobile floor lift, and 3. a ceiling type lift mounted on a moveable gantry. A compliant 92 kg male "patient" was transferred from bed-to-wheelchair and from wheelchair-to-bed in each condition. Each transfer was completed twice. Both the floor and ceiling lifts made use of a transfer sling; adjusting the sling was not included in the analysis. Other aspects of patient care such as adjusting the patient in bed were also examined.

Surface EMG was used to examine muscle activity during the tasks. Bipolar surface electrodes were affixed over the muscle bellies of four left/right muscle pairs after appropriate shaving and cleansing of the skin. The muscles examined were the upper erector spinae (UES), the lower erector spinae (LES), the ascending portion of the trapezius (TRP), and the latissimus dorsi (LAT). EMG signals were pre-amplified near the source and band-pass filtered from 10-500 Hz. Root-mean-square (RMS) EMG using a 220 ms window was A/D converted at 120 Hz.

EMG was normalized to 100% MVC based on a series of trials to elicit maximal contractions. All trials were recorded with video, which was synchronized with the EMG data.

Data analysis included time to completion for each transfer as well as several EMG measures. Average EMG (AEMG) and the Amplitude Probability Distribution Function (APDF) were calculated for each transfer. The RMS EMG values at the tenth, fiftieth (median) and ninetieth percentiles were analyzed. Data were analyzed using repeated measures ANOVA.**RESULTS**

Effect of Lift Assist:

The type of transfer had a significant effect on muscle activity (Fig. 1). This paper will focus on the transfers from bed-to-wheelchair, as the data for both directions was similar. In the novices, the ceiling lift had the lowest overall muscle activations (as measured by AEMG), being significantly lower than the floor assist ($p < 0.001$) and the manual transfer ($p < 0.001$). There was also significantly lower AEMG when using the floor lift than during the manual transfer ($p < 0.001$). Similarly, the experienced patient handlers required significantly less muscle activation when using the ceiling lift than either of the other two experimental conditions (floor, $p < 0.0001$; manual; $p < 0.02$). In all trials, the latissimus dorsi and trapezius muscles had relatively low activation levels.

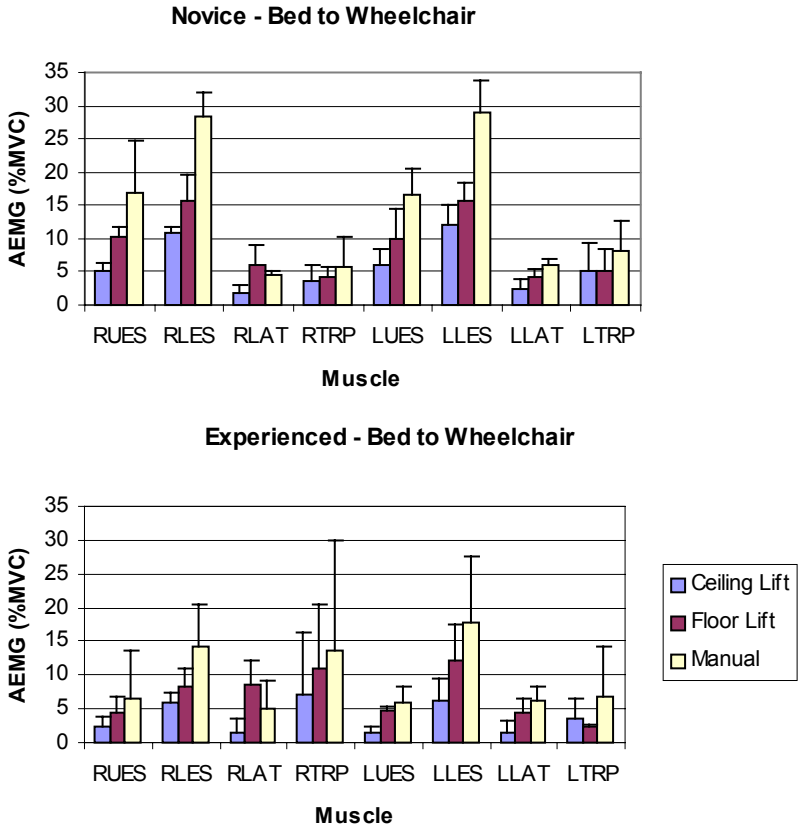

Figure 1. Mean EMG (plus standard deviation) during transfer tasks. Novices (top) used more erector spinae activity but similar or less TRP and LAT activity than the experienced patient handlers (bottom).

Effect of Experience:
Experience had a significant effect on muscle activation. Examining the AEMG data, novices had greater mean UES and LES activity than experienced handlers during manual and ceiling lift conditions, and more RUES for the floor lift assist (all $p < 0.05$; Fig.1). From the APDF data, experienced participants had greater trapezius activity than novices. As seen in Fig. 2, the right trapezius (RTRP) was significantly greater in the experienced patient handlers than the novices. Specifically, the tenth and fiftieth (or median) percentile RTRP activation levels in all transfer conditions and the ninetieth percentile when using the floor lift (all $p < 0.006$).

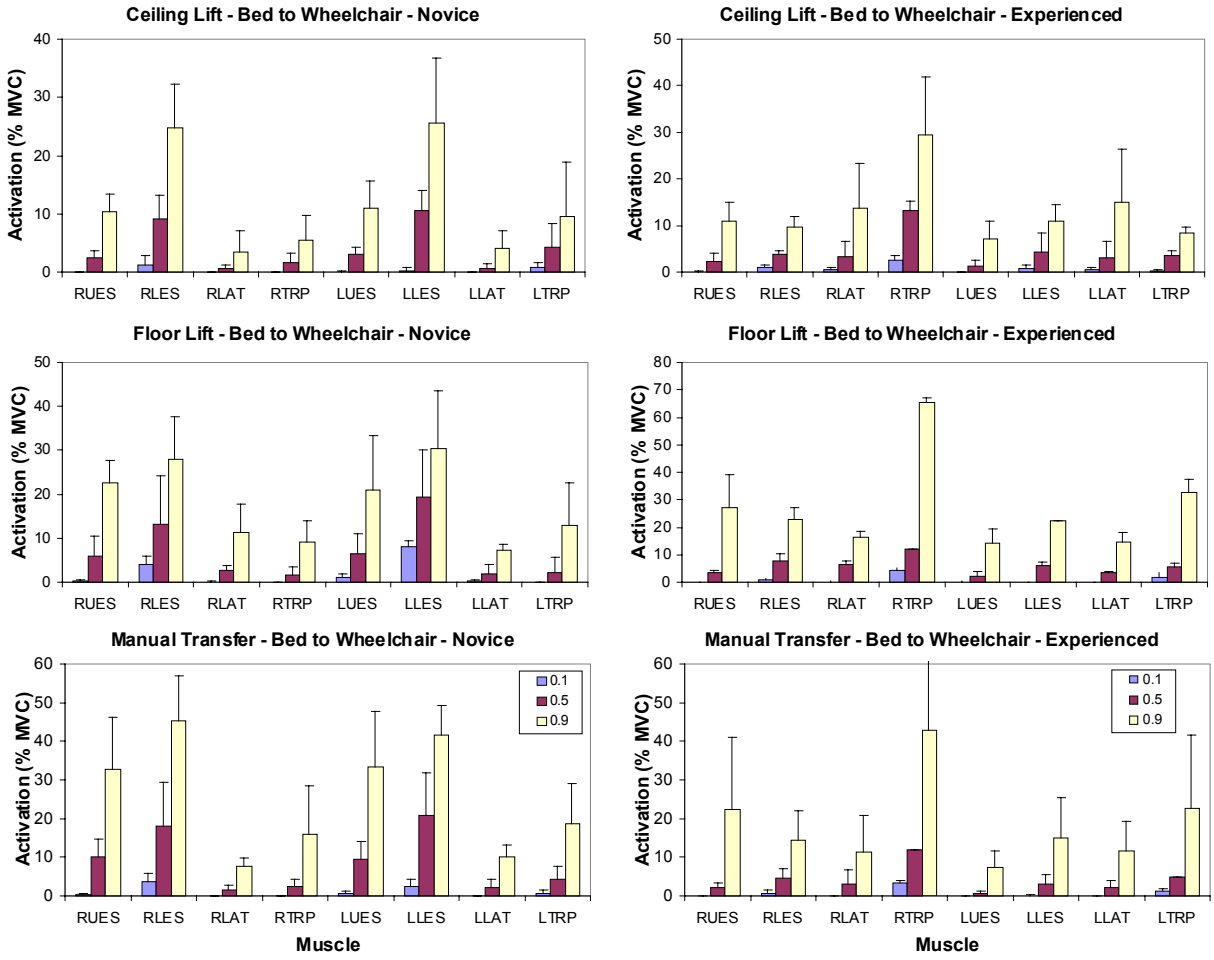

Figure 2. Amplitude probability distribution function (APDF) results for each condition. Presented are the 10th (0.1), 50th (0.5) and 90th (0.9) percentile activation levels (plus standard deviations) for each muscle. Novices (left) and experienced handlers (right) are shown

DISCUSSION

With a few exceptions, muscle activity was lowest when the patient was transferred using the ceiling lift, followed by the floor lift, with the highest activation levels occurring with the single person manual transfer. Based solely on muscle activity levels, the concept of "zero lift" policy is supported.

There was a trade-off between muscle activity level and the transfer time, especially when comparing the manual transfer and the ceiling lift transfer. For example, the mean manual transfer time was under 20 seconds but required a lower erector spinae AEMG of almost 30% MVC (AEMG) while the ceiling lift averaged just under 100 seconds with AEMG levels of less than 13% MVC. The floor lift required lower activation than the manual transfer but often took longer than the ceiling lift to complete (over 120 seconds). This trade-off is likely a

contributing factor in the reported reluctance of health care professionals to use lift assists, even when provided.

It appears that the experienced patient handlers, while having reduced erector spinae activity, increase the use of the trapezius muscles. Many studies have reported very high compressive forces in the lumbar spine (4). This strategy would act to reduce the compressive forces on the lumbar spine but may increase the risk of shoulder injuries. Whether this is a learned behaviour to protect the lumbar spine still needs to be determined through a larger sample size.

More research into the external forces and muscle activity levels during the normal workday in a health care facility must be conducted to fully evaluate the specific tissues at risk in health care workers. Further examination of muscle activation pattern differences between experience levels could lead to improved training techniques and better patient handling strategies.

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