

Lifting Heavy Patients in their Homes: A biomechanical study of equipment that can be used by EMS providers

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Firefighters and EMS providers continue to be challenged when lifting heavy patients in their homes. This study investigated the biomechanical efficacy of four devices that could be used by two-person teams when lifting patients from the floor, from a reclining chair, or from a Simulated Inflatable Seat at chair height. Fourteen firefighter-paramedics, working in two-person teams, were instrumented with motion capture and electromyographic sensors. The Binder Lift™ and the Simple Strap were used to lift patient actors, and were compared to current lifting methods. Postural data and the peak dynamic spine shear forces at the L5/S1 level were reduced when using the Simple Strap, the Binder Lift, and the Simulated Inflatable Seat. In summary, each of these devices has been shown to have biomechanical support for their use by EMS providers.

INTRODUCTION

In an analysis of fire service injuries, Haynes and Molis (2017) noted that the overall number of injuries experienced by firefighters in the United States has been declining for the past 20 years. Yet, in 2016 there were still an estimated 62,085 injuries; 12,780 of these injuries occurred during non-fire emergencies. Sprains, strains, and muscular pain account for 60% of the injuries suffered by firefighters while performing non-fire emergency tasks, such as EMS and other rescue operations (Haynes and Molis, 2017). Injury risks associated with patient-handling are compounded by the obesity epidemic in the US. About one-third of American adults are classified as overweight ($25 < \text{BMI} < 29.9$), and about 40% are obese ($\text{BMI} \geq 30$) (National Center for Health Statistics, 2017).

Focus groups with firefighter/paramedics (FFPs), organized for the purpose of discussing challenges experienced when handling heavy patients, revealed that patients were frequently found in a bathroom (Lavender et al., 2017). These bathroom patient handling situations included patients in the tub or shower, patients that were wedged between the toilet and wall (or tub), or patients lying on the bathroom floor. Another common situation was finding the patient in a bedroom, having fallen between the bed and a wall or a heavy piece of furniture (e.g. dresser). In sum, these discussions indicated that FFPs need to lift these patients in restricted spaces which severely limits the number of FFPs that can assist in these efforts.

The objective of this work was to biomechanically evaluate two devices that can be used when moving patients from the floor to a chair. Specifically, this study compared: (1) “The Simple Strap” which is a long strap with one buckle that can be used to create a simple sling, with handles, for lifting the patient. (2) A commercially produced product, the Binder Lift™ which is a device wraps around the torso below the arms and has multiple handles that can be used for lifting the patient. And (3), the normal two-person lifting technique (control condition) that would typically be used in these situations..

Three lifting tasks were assessed in this study. In the first task, a patient seated on the floor in a constrained space (simulated bathroom) was lifted to a stairchair. The second lifting task, consistent with task description information provided by the focus group participants, a patient was lifted from a reclining chair (‘recliner’) to a stairchair. In the third lifting task a patient was lifted from a surface at chair level to a stairchair. This last situation simulated lifting from an inflated seat device (e.g. Manger ELK Lifting Cushion, a device designed to raise a patient seated on the floor to a height of 56 cm off the floor through inflation of a stack of 50 cm x 50 cm “air mattresses”). In each of these tasks the patient was lifted to by two FFPs. A third individual (research team member) assisted the EMS providers by positioning the stairchair behind the patient as instructed by the FFPs.

METHODS

Fourteen professional FFP (13 males, 1 female) participated in this study. Each was instrumented with surface electromyographic (EMG) electrodes on ten trunk muscles which consisted of the left and right erector spinae, latissimus dorsi, external oblique, internal oblique, and rectus abdominus. Motion capture markers were placed on each participant to track postures and movements. A calibration process was used to convert the EMG signals to muscle forces (Dufour et al., 2013) that could be used in a biomechanical model that estimates spine loads (Hwang et al., 2016).

Once the data collection process was initiated, the team of firefighters coordinated the timing of their activities, as they would do in actual patient handling situations. The patients, actors weighing between 91 and 103 kg, were instructed by the investigators to follow instructions provided by the FFPs but not to assist the FFPs in the lifting process.

Data analysis. The EMG and kinematic data were used in a subject-specific biologically-assisted 3D dynamic spine model that has been developed in the Biodynamics Laboratory at The Ohio State University (Hwang et al., 2016). The model computes the time varying spine compression force at each vertebral level and shear forces acting on each of the intervertebral discs within the lumbar spine, as well as the time varying muscle forces. Once the compression force and the lateral and anterior shear forces were obtained, peak values during each task were extracted from the data stream for analysis; the highest compression on the spine occurs at L4/L5 and the highest shear loading occurs at L5/S1. Likewise, peak kinematic data were extracted from the time varying data stream.

RESULTS

Spine anterior shear loading when lifting from the recliner was significantly reduced when using the Binder Lift, and even more so when using the Simple Strap ($p < .05$). Using the Simple Strap also significantly reduced the L5/S1 anterior shear force when lifting from the simulated inflated seat ($p < .05$). While there were no significant differences in anterior shear from use of either the Binder Lift or the Simple Strap when lifting in the bathroom ($p = 0.13$), there were similar trends in the data.

The data from the subjective evaluation of the effort required to perform the lifting tasks using the Binder Lift and the Simple Strap relative to the normally used method showed that most participants reported the Binder Lift was at least a little easier to use than the

conventional approach. This was particularly true for the bathroom and simulated inflated seat conditions. Overall, the Simple Strap was rated positively with regards to reducing effort, although two of the 14 participants did indicate that this device made the task “a little harder” in the bathroom and with the recliner.

DISCUSSION

The data presented here show that lifting patients from the floor or from a recliner can lead to significant spinal loading, even with the moderate weight actor-patients that volunteered for this study. Both the Binder Lift and the Simple Strap showed reductions in spinal loads relative to the performance of these tasks without additional equipment. It is interesting to note that subjective assessment data more strongly favored the use of the Binder Lift, while the biomechanical data tended to favor the Simple Strap for the sampled lifting tasks.

When it comes to lifting obese patients from the floor, Boatright (2002) advocated for the use of inflatable air bags to raise the patient and facilitate lateral patient transfers. While not the primary purpose of the current study, the data comparing the lifts from the floor with the lifts from the simulated inflated seat at chair level strongly support the use of this type of equipment to perform the most strenuous part of the lifting task (lifting from floor level). These findings are consistent with Larouche et al. (2019) who, based on their analysis of field observations, reported that the transfers of patients sitting on a raised surface were less physically demanding than when lifting patients from the ground.

In summary, the results of this study support the use of the Binder Lift and the Simple Strap when FFPs need to lift patients. The data from conditions involving the simulated inflated seat also suggests there would be value in using equipment that mechanically raises patients from the floor to chair level. Future studies should focus on how useful and usable the Binder Lift, Simple Strap, and Slip Preventer are in daily EMS operations.

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