Applied Ergonomics 70 (2018) 167–174

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Comparing the biomechanical and psychophysical demands imposed on paramedics when using manual and powered stretchers

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ARTICLE INFO

Keywords:
Physical ergonomics
Occupational biomechanics
Paramedics
Lifting
Equipment

ABSTRACT

The aim of this investigation was to compare the effect of three different stretchers (two powered and one manual) on the biomechanical and psychophysical demands experienced by paramedics when performing routine stretcher handling activities. Eight experienced paramedics performed stretcher raising, lowering, unloading and loading tasks. Video data of task performance and static force requirements were recorded and input into a posture matching program with a quasi-static linked segment model (3DMatch) to compute peak and cumulative L4/L5 compression and shear forces and shoulder moments during each activity. Ratings of perceived exertion (RPE) were recorded from paramedics upon the completion of each task.

Use of powered stretchers with load assist functionality reduced the demands on paramedics. Peak L4/L5 forces were reduced by 13–62% and 58–93% for compression and shear respectively when using powered stretchers to perform routine stretcher handling activities. Shoulder flexor moments and RPE scores were reduced by 16–95% and 29–60% respectively when using the powered stretchers compared to the manual stretcher. However, cumulative forces showed mixed results. Although powered stretcher use decreased peak forces, loading and unloading a powered stretcher took 1.5 to 3.4 times longer then when using the manual stretcher, which may explain the mixed results regarding cumulative forces. Based on the RPE scores, paramedics preferred power stretchers relative to the manual stretcher. This study demonstrates that powered stretchers can reduce peak biomechanical and psychophysical exposures associated with the development of musculoskeletal disorder (MSD) during routine stretcher handling activities with minimal increases in cumulative exposures.

1. Introduction

Paramedics are primary providers of pre-hospital emergency medical care. Tasks associated with the job, including stretcher handling, patient handling, and the provision of emergency care predispose paramedics to work related injuries (Hogya and Ellis, 1990; Maguire et al., 2005, 2014). Performing these tasks has predisposed paramedics to musculoskeletal disorders (MSD), where prevalence rates have been estimated at 34.6 injuries per 100 paramedics per year, the highest rate of reported for any industry (Maguire et al., 2005). Manual stretcher use continues to be a leading concern exposing paramedics to considerable physical demand (Lavender et al., 2000). Transportation of patients via manual stretchers requires paramedics to physically raise and lower the stretcher (with the patient) to and from the ground. As well, paramedics are required to support the weight of the stretcher (and patient) while they load and unload the stretcher into and out of the back of an ambulance. These are often identified as the most physically demanding tasks of the job (Coffey et al., 2016; Fischer et al., 2017; Prairie and Corbeil, 2014). Several researchers have observed increased biomechanical exposures at the low back (L4/L5 joint) during the task of loading and unloading stretchers to and from the ambulance (Cooper and Ghassemieh, 2007; Prairie and Corbeil, 2014) and when raising the manual stretcher (Lavender et al., 2000) where loads have often exceeded recommended NIOSH Limits (Waters et al., 1993). Considering the demands associated with stretcher handling related activities, paramedic services are increasingly interested in the prospective benefits of emerging powered stretcher and load system technologies to address the concerns associated with manual stretcher handling.

Powered stretchers aim to reduce the stresses imposed on paramedics when performing stretcher handling related tasks. Current powered stretcher models rely on either a hydraulic mechanism or dual powered actuator system to automatically raise and lower the stretcher from the ground or to load and unload the stretcher into and out of the patient compartment of an ambulance. This reduces the weight handled by the paramedics. However, when load weight reduction is used as an

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https://doi.org/10.1016/j.apergo.2018.03.001
Received 25 August 2017; Received in revised form 28 February 2018; Accepted 1 March 2018

ergonomic intervention, at least with reference to standard manual materials handling, users can change their movement behaviours, sometimes attenuating the prospective benefits conferred by the weight reduction (Faber et al., 2007). Therefore, it is important to observe and compare how paramedics perform stretcher handling tasks when using a traditional manual stretcher and emerging powered stretcher options.

Adopting powered or facilitated options for patient handling and conveyance is a common strategy for MSD prevention within the health care sector, but it is not without limitation. Broadly considered, the use of assistive devices to aid in performing patient handling tasks have reduced peak spine loads but increased cumulative spine loads compared to manual devices (Daynard et al., 2001). Specific to the paramedic sector, Prairie and Corbeil (2014) found that workers experienced higher physical stresses when loading and unloading a powered stretcher as a result of the increased weight of powered stretchers relative to manual stretchers, albeit in the absence of powered load assist functionality. Moreover, the use of assistive equipment for patient handling tasks can take significantly longer to perform than with the use of manual devices (Daynard et al., 2001). These findings further reinforce the need to evaluate the biomechanics and perceived exertion associated with the use of manual and powered stretchers when performing stretcher-handling tasks common to paramedic work. It is important to identify prospective benefits and limitations that may influence decisions on whether to implement powered stretcher technologies as part of an MSD prevention strategy.

Emerging research suggests that powered stretchers may minimize exposure to physical stresses inherent to stretcher handling related tasks. Sommerich et al. (2015) evaluated the physical stresses imposed on paramedics when loading and unloading, comparing between two commercially available powered stretchers. Their results demonstrated how design differences between competing powered stretcher models could influence physical stresses to the paramedic, but those differences were not explored with direct reference to the physical stresses imposed on paramedics when using a manual stretcher. Moreover, previous efforts have often focussed on powered stretchers (Prairie and Corbeil, 2014) in the absence of power load capabilities. As such, this is the first study to directly compare powered stretcher to manual stretcher use where the powered stretchers also share equivalent powered load/unload capability.

The current study compared the effect of two commercially available powered stretcher models: Stryker Power-Pro™ XT with Power-Load™ (Power1), and the Ferno IN∫X™ (Power2) relative to the manual Ferno 35-A Mobile Transporter™ (Manual), on the biomechanical and psychophysical demands imposed on paramedics during the performance of stretcher handling activities. The objective of the investigation was to determine if the peak and cumulative L4/L5 compression and shear forces and shoulder moments experienced by paramedics were reduced when using a powered stretcher relative to when using a manual stretcher when raising, lowering, unloading and loading the stretcher. We hypothesized that the use of powered stretcher and load systems would significantly reduce the perceived physical demands, peak and cumulative low back forces and shoulder moments experienced by paramedics when performing stretcher handling related task.

2. Methods

2.1. Participants

This workplace-based research study took place on-site at a local paramedic service station, using active-duty service equipment. Eight full time paramedics volunteered to participate in the study (Table 2). All participants were free of physical injury at the time of the study. Each participant provided written, informed consent and the study was approved by the University of Waterloo Research Ethics Board. Paramedics assigned to modified duties or those with an injury that restricted their ability to handle a manual or powered stretcher were excluded from the study.

Table 1
Participant demographics.

	Female (n = 3)	Male (n = 5)
Age (year)	32 ± 1.5	38 ± 10.5
Mass (kg)	56 ± 5.3	83 ± 14.3
Height (cm)	167 ± 5.7	183 ± 11.7
Experience (year)	11 ± 4.5	19 ± 8.1

2.2. Protocol

Participants, working in pairs, were required to perform four stretcher handling activities common to most paramedic calls. Activities included raising, lowering, unloading and loading the stretcher from the back of an ambulance. Theses activities were included because they are most often perceived as physically demanding by paramedics (Coffey et al., 2016; Fischer et al., 2017; Morales et al., 2016). Each paramedic performed each task at a self-selected pace in the lead and follower role, using Manual, Power1 and Power2 stretchers. Paramedics did not have previous experience using Power1 and Power2; however, approximately 4 h of training was provided on each powered stretcher prior to participation in the study. Biomechanical data and ratings of perceived exertion (RPE) were obtained from the paramedic performing the lead role (e.g. the paramedic operating the handle/button during the raise and lower tasks, or at the foot of the stretcher when loading and unloading the stretcher). A description of each stretcher and its associated features relative to the performance of each task is summarized in Table 1. A 77 kg mannequin was secured to each stretcher, approximately replicating the mass of an average patient (Fischer et al., 2017).

2.3. Instrumentation

Static force requirements were measured off-line to estimate the minimum forces required to manipulate each stretcher model during the prescribed activities. Static force requirements included push/pull forces to move the stretcher in/out of the ambulance as well as the supportive forces required to lift the foot/head end of each stretcher when raising/lowering and loading/unloading. Forces were recorded by a researcher using a DFX-200 digital Chatillon force gauge (MRM Precision Instruments, Brampton, ON) while each stretcher was loaded with a mannequin (77 kg). All static force measures were recorded three times, with the mean force used in subsequent analysis. The postures used by the lead paramedic were video recorded in the sagittal plane (Sutherland et al., 2007) during the performance of raise, lower, unload and load tasks. Psychophysical ratings of perceived exertion (RPE) were obtained using a Borg 6–20 scale (Borg, 1990). RPE were obtained immediately following the completion of each individual stretcher handling related task. Lastly, a semi-structured interview was conducted with each pair of paramedics after they had completed the four tasks using all three stretcher types. Paramedics were asked to comment on their preference of stretcher, benefits and risks/concerns associated with each stretcher model used in the study and lastly were asked to rate the realism of the tasks relative to their everyday job. The semi-structured interviews were voice recorded and transcribed where thematic analysis was applied to reveal common themes within the responses. These data added user-specific context supplementing the result from the biomechanical assessment.

2.4. Data processing and analysis

All video files were converted to AVI format and then decimated from a frame rate of 30 Hz–3 Hz (Andrews and Callaghan, 2003). Video