Applied Ergonomics 45 (2014) 895–903

Contents lists available at ScienceDirect

Applied Ergonomics

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

Paramedics on the job: Dynamic trunk motion assessment at the workplace

Jérôme Prairie [a], Philippe Corbeil [a,b,*]

[a] Groupe de Recherche en Analyse du Mouvement et Ergonomie, Université Laval, Département de Kinésiologie, 2300 rue de la Terrasse, Quebec, QC, Canada G1V 0A6

[b] Centre de Recherche du Centre Hospitalier Affilié Universitaire de Québec, Hôpital de l'Enfant-Jésus, 1401 18e rue, Quebec, QC, Canada G1J 1Z4

ARTICLE INFO

Article history:
Received 21 September 2012
Accepted 12 November 2013

Keywords:
Three-dimensional trunk motion
Emergency medical service
Musculoskeletal disorder

ABSTRACT

Many paramedics' work accidents are related to physical aspects of the job, and the most affected body part is the low back. This study documents the trunk motion exposure of paramedics on the job. Nine paramedics were observed over 12 shifts (120 h). Trunk postures were recorded with the computer-assisted CUELA measurement system worn on the back like a knapsack. Average duration of an emergency call was 23.5 min. Sagittal trunk flexion of >40° and twisting rotation of >24° were observed in 21% and 17% of time-sampled postures. Medical care on the scene (44% of total time) involved prolonged flexed and twisted postures (~10 s). The highest extreme sagittal trunk flexion (63°) and twisting rotation (40°) were observed during lifting activities, which lasted 2% of the total time. Paramedics adopted trunk motions that may significantly increase the risk of low back disorders during medical care and patient-handling activities.

1. Introduction

A paramedic's job can be described as evaluating and stabilizing patients' condition before the patients receive medical attention at the hospital. Among healthcare workers and the general population, paramedics have the highest percentage of early retirement, most often due to musculoskeletal disorders (Hogya and Ellis, 1990; Pattani et al., 2001; Rodgers, 1998; Sterud et al., 2006, 2008). More than 63% of paramedics' work accidents result from overexertion (push, pull, raise, hold, etc.) or bodily reaction (reach, lean, slip, climb, stumble, etc.) (CSST, 2012). Many studies have demonstrated that low back disorders are a common health problem among paramedics (Crill and Hostler, 2005; Hogya and Ellis, 1990; Jones and Lee, 2005; Studnek et al., 2010). One factor, or a combination of several, may underlie these low back disorders (Corbeil and Prairie, 2012). For instance, plausible explanations include the physical demands of the job (Aasa et al., 2005; Barnekow-Bergkvist et al., 2004; Putz-Anderson et al., 1997) and the execution of tasks in awkward postures (Doormaal et al., 1995).

Most studies have analyzed paramedics' work using questionnaires (Jones and Lee, 2005), interviews (Hignett et al., 2007) or simulations in the laboratory (Aasa et al., 2008; Barnekow-Bergkvist et al., 2004; Lavender et al., 2000a,b), but, given the wide variety of scenarios and work strategies, these studies did not allow for a complete representation of the situation. We found only two studies (Doormaal et al., 1995; Ferreira and Stanley, 2005) that analyzed paramedics' posture on the job. Both studies used the Ovako working posture analysis system (OWAS method) (Karhu et al., 1977, 1981) to describe the paramedics' general posture during a work shift (Doormaal et al., 1995) or during activities performed in an ambulance's patient compartment (Ferreira and Stanley, 2005). Doormaal et al. (1995) found that 16–29% of a work shift was spent in harmful positions and that strenuous situations occurred particularly often during emergency tasks.

One limitation of the OWAS method is that information is obtained from a static posture analysis ("snapshot") every 30 s. Consequently, the physical constraints of the job are determined by the observation of only two pictures per minute and dynamic motion assessment is ignored. However, dynamic motion characteristics may play an important role in the development of low back disorders (Davis and Marras, 2000; Marras et al., 2010). New technologies permit the more accurate collection of information about postural risk factors of dynamic trunk motion by using direct measurements of paramedics' movements obtained during field observations (Ellegast and Kupfer, 1999; Marras et al., 2010; Plamondon et al., 2007).

The aim of this study was to document the trunk motion exposure of paramedics on the job using continuous recordings of

* Corresponding author. Kinesiology Department, Laval University, 2300 rue de la Terrasse, Quebec, QC, Canada G1V 0A6. Tel.: +1 418 656 5604; fax: +1 418 656 2441.
E-mail address: philippe.corbeil@kin.ulaval.ca (P. Corbeil).

0003-6870/$ – see front matter © 2013 Published by Elsevier Ltd.
http://dx.doi.org/10.1016/j.apergo.2013.11.006

back posture (CUELA system) during work activities, from the arrival on the scene to the delivery of the patient to the hospital. We hypothesized that trunk motion exposure to risk factors for low back disorder was likely to be more significant when work duties were accomplished in urgent situations and also when the paramedic perceived the work duties as highly physically demanding, rather than not very physically demanding.

2. Methods

2.1. Description of the work

This study was conducted at the *Coopérative des techniciens ambulanciers du Québec* (CTAQ) in Quebec City, Canada. This organization employs over 300 paramedics and operates 26 ambulances.

Paramedics receive emergency calls from dispatchers and drive an ambulance to the assigned location. They may also provide interfacility ambulance transportation (e.g., prescheduled, medically necessary transfers between hospitals and other healthcare facilities). Calls are allocated on a priority basis: priority 1 or *urgent* for calls requiring immediate transport because of a threat to life or limb; other priority codes are classified as non-urgent for routine calls that cannot be delayed but are not urgent (i.e., priority 3) and those that can be delayed without being detrimental to the patient.

This study focuses on work situations involving ambulance transport calls for emergencies (i.e., 911 calls) considered to be both urgent and non-urgent. More specifically, these work situations are defined as including all activities occurring between the arrival on the scene (i.e., when the paramedic exits the ambulance) and the delivery of the patient to the hospital (i.e., when the stretcher loaded with a patient is removed from the ambulance at the hospital).

The work duties of paramedics were divided into seven tasks. The first task, movements in the field, includes all paramedic movements without the patient (e.g., retrieving and storing equipment in the ambulance, walking to access patients). The second task, medical care in the field, is defined as all activities occurring at the place where the patient is located before the patient is installed on transport equipment. For ambulatory patients, this task ends when the paramedic enters the ambulance patient compartment. All activities performed in an ambulance patient compartment with or without the patient are grouped in the third task. Patient-handling activities are included in the fourth task. Patient-handling activities include transferring or moving the patient from one surface to another (e.g., home bed to stretcher, stairchair to stretcher) and repositioning or moving the patient on the same surface. The movements of the stretcher loaded with a patient belong to task #5 and those with the stairchair loaded with a patient to task #6. Stretcher-patient activities, defined as loading and unloading from the ambulance patient compartment, are included in task #7.

2.2. Participants

Nine male full-time paramedics were observed for 8 or 12 h during both day and night work shifts. Participants were recruited via an electronic mailing list and word of mouth. The participants' demographic characteristics are presented in Table 1. None were experiencing musculoskeletal disorders at the time of the study. Each participant signed an informed consent form prior to participating in the study.

2.3. Equipment

The instrumentation consisted of a digital video camera (JVC GZ-HD30u) and the CUELA measuring system (computer-assisted recording and long-term analysis of musculoskeletal loading, BGIA, Sankt Augustin, Germany). The CUELA system was developed for measuring trunk movements in real-life situations (Ellegast and Kupfer, 1999; Freitag et al., 2007) and was used to quantify paramedics' back posture amplitudes during work activities. The CUELA system is worn on the back like a knapsack and acquires movements at a frequency of 50 Hz in three dimensions: flexion in the sagittal, frontal and transverse planes. The CUELA consists of a triaxial accelerometer and gyroscope placed on the first thoracic and last lumbar vertebrae and a digital angular sensor placed between the thoracic and lumbar vertebrae. After the data were collected, the signals were processed to determine the position of the trunk as a function of time in the sagittal, frontal (lateral), and transverse (twisting) planes of the body. These data were further processed using a dual-pass 4th-order Butterworth filter with an 8 Hz low-pass cut-off. Trunk velocities were derived from the first time differential of the trunk position data using a ±5-point numerical differentiation (±100 ms window).

Table 1
Paramedics' demographic and physical fitness characteristics (mean and standard deviation).

Characteristics	Men ($n = 9$)
Age (years)	37 (10)
Weight (kg)	79 (9)
Height (cm)	178 (6)
Body mass index (kg/m^2)	25.0 (2.4)
Experience (years)	16.0 (12.0)
% Fat	20.3 (3.9)
VO_2max (ml/kg/min)[a]	43.3 (9.6)
Back health[b]	2.8 (0.6)
Musculoskeletal fitness[b]	2.6 (1.0)
Overall fitness[b]	2.9 (0.6)

[a] Maximal consumption of oxygen; sub-maximal test on treadmill.
[b] Standardized tests of the Canadian Society for Exercise Physiology; score scale 1–5: 1 = to improve, 2 = acceptable, 3 = good, 4 = very good and 5 = excellent.

2.4. Data collection

Data were collected over six weeks in August and September 2009 on nine day and three night shifts. During a shift, the paramedics worked in pairs and shared the responsibility of driving and attending to patients. Data were collected on one member of the team, who might perform both roles during the shift. At the beginning of each work shift, 30 min of preparation time was allotted to install the CUELA system, familiarize the paramedic with it and explain the experimental procedures. Following installation, the CUELA sensors (Fig. 1) were calibrated using an anatomical position (Freitag et al., 2007). Data collected using the CUELA system and the video made by the observer were recorded during the activities from the arrival on the scene to the delivery of the patient to the hospital. Video recordings made it possible to ensure the accurate allocation of the measured data to the tasks performed.

The fitness component of the appraisal involved a series of physical tests and measurements. The physical evaluation included anthropometric measurements (height, body mass, skinfold measurements), cardiorespiratory fitness, and musculoskeletal fitness (hand grip, push-ups, abdominal endurance, back extension, trunk flexibility, vertical jump); each muscle test was performed in accordance with a standardized protocol (Canadian Society for Exercise Physiology, 2003; Ehrman, 2010). A single-stage treadmill walking test was used to assess the maximal oxygen consumption. Physical evaluation was performed within one month following completion of the field data collection. The participants' physical fitness characteristics are presented in Table 1.