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International Journal of Industrial Ergonomics 36 (2006) 247–256
International Journal of INDUSTRIAL ERGONOMICS
www.elsevier.com/locate/ergon

Ergonomics in the rescue service—Ergonomic evaluation of ambulance cots

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Received 20 September 2004; accepted 25 October 2005
Available online 5 January 2006

Abstract

In a comparative ergonomic study, three combinations of stretchers with incorporated transporters from brand-name manufacturers—so-called "ambulance cots" or "roll-in systems"—were tested with respect to their ergonomic quality. In addition to work analyses during the use of ambulance cots, the strain on the circulatory system of 12 professionals was measured in four standardized carrying tests: carrying of the stretcher on a staircase at normal speed and at increased speed, lifting of the stretcher onto the gurney, and loading the ambulance cot into, as well as unloading it from, an ambulance. Static and dynamic components of the muscle strain of six muscle groups were determined electromyographically. The tests consisted of "normal" carrying, as well as explicitly rapid carrying, of a dummy (78 kg) up and down a flight of stairs using the commercially available ambulance cots, which weighed between 48.5 and 50 kg including a mattress for the patient. Model-specific influences of the cots aside, the rapid carrying led to substantially increased strain on the circulatory system (work-related increases of approximately 10 beats per minute (bpm)). The "lifting of the stretcher onto the gurney" and the "loading/unloading of the roll-in system" cause significantly less strain, but still lead to substantial "physiological costs" of approximately 50 bpm. Increased speed significantly increases muscle strain. The static components of the standardized electromyographic activity, sEA (%), with values of 50% and more, show that even carrying times of only approximately 30 s cause fatigue. Additionally, the test subjects (Ss) subjectively assessed the design elements of the stretchers as well as the gurneys via a questionnaire with approximately 50 items which had been developed specifically for that purpose. The detailed subjective assessment offers a differentiated view of the work situation. The evaluation suggests several concrete changes in order to improve the design with respect to the ambulance cots' weight, their shape and positioning of handles, and the mechanism of the height adjustment of the gurney. Changes in the design were also recommended in order to reduce the extraordinarily high strain on the paramedics which was measured via peripheral-physiological methods. It became clear that one system which is widely used in several countries has marked weaknesses.

Relevance to industry

The results of this study reveal the necessity for industry to manufacture user-friendly and safe ambulance cots for the existing market. Paramedics cannot risk using equipment which is inadequate or works in a deficient way. Furthermore, an ergonomic design of the product additionally increases the safety and user-friendliness of the system during a rescue operation. Due to the ergonomic design, less effort is needed during the transport of the patient, which, at the same time, means lower physical strain for the paramedics' backs and their hand–arm–shoulder systems.

Keywords: Product ergonomics; Physical workload; Subjective assessment; Ambulance cots

1. Introduction

Even though physical stress in the workplace is of somewhat lesser importance today than it used to be, prevention of work-related back and joint problems remains an important task which can only be solved by

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doi:10.1016/j.ergon.2005.10.002

occupational medicine and ergonomics together (cp. Hartmann, 2000). Although the lifting of heavy loads at work is limited and regulated, for example by the *Lastenhandhabungsverordnung* in Germany (1996)—a special "Ordinance on Safety and Occupational Health during Manual Material Handling—" it is not always possible to impose weight restrictions in the transportation of sick and injured people and for emergency medical services. Such heavy lifting can lead to long-term damage (see, e.g., Ayoub and Mital, 1989), which is currently recognized as an occupational disease. In the course of transporting sick and injured people, paramedics experience the "heavy loads" which are mentioned in "Occupational Disease no. 2108" in our country. This also applies to both male and female paramedics in the civilian as well as the military sectors in other countries (cp. Furber et al., 1997; Knapik et al., 1998, 2000; Restorff, 2000; Rice et al., 1996a, b). The latter often operate under extreme time pressure combined with alarmingly bad overall conditions. The weight to be carried (the sum of the weight of stretcher and patient) frequently exceeds 100 kg. Thus, it appears necessary to make use of all possibilities to reduce strain. In order to increase risk prevention, ergonomically optimized stretchers and gurneys should be utilized. Design features of three common commercial ambulance cots (roll-in systems—as combination of stretcher and gurney) as well as their resulting stress and strain were determined in a comparative ergonomic study by objective measurements and subjective assessments in order to document the existing state and derive suggestions for improvements.

2. Methods

An important starting point to improve the paramedics' stress and strain situation is the selection of an ergonomically optimized combination of stretcher and gurney. The assessed roll-in systems—with respect to the ergonomic state—are two frequently used products from the companies Ferno and Stollenwerk, well known in Europe and the USA (cp. Niesser, 1998), as well as a newly developed product by the American company Stryker.

In the test series (TS), simulation of real work situations was attempted. Therefore, data on patient transportation were collected by the German Red Cross for an extended period of time before the tests were carried out. The patient's weight was recorded and the statistical analysis of the data from 263 patients resulted in an average patient weight of 78 kg. The transportation data further permitted the calculation of the mean number of floors to which the patients had to be carried. The resulting value was slightly less than the 2nd floor. Therefore, the TS included a patient dummy of 78 kg, which had to be carried over a distance of one floor:

- carrying of the stretcher on a staircase at normal speed (both upstairs and downstairs; TS01),
- lifting of the stretcher onto and off the gurney including lifting of the roll-in system (TS02),
- loading the roll-in system into, and unloading it from, an ambulance (TS03), and
- carrying of the stretcher on a staircase at increased speed (both upstairs and downstairs; TS04).

The approximately 4-h-testing procedure was carried out with the help of 12 male subjects (Ss) whose occupation is patient transportation. They all had sufficient—and in some cases very extensive—experience in their jobs. All of them were well versed in the use of the different ambulance cots. Their characteristics are represented in Table 1. On account of the lack of a representative number of professional female firefighters and paramedics in the organization which has supported this investigation, data for female Ss were not collected. In order to balance the conflicting goals of representative results on the one hand, and justifiable time commitment for the on-call test Ss on the other, the number of persons was limited to 12, and the entire testing procedure was distributed over 2 days. The sequence of the tests and the ambulance cots was randomized for all Ss and after any test a rest of 10 min followed.

Table 1
Characteristics of the test subjects

Subject	Age (years)	Weight (kg)	Height (cm)	Left-/right-handed	Gender	Job experience (years)	Employer
01	24	84	188	r	m	4.5	Fire Department
02	32	98	192	r	m	11	Fire Department
03	39	84	187	r	m	20	Fire Department
04	20	63	170	r	m	1	German Red Cross
05	39	95	186	r	m	10	German Red Cross
06	35	125	181	r	m	0.5	German Red Cross
07	36	73	174	r	m	7	Fire Department
08	29	65	170	r	m	6.5	Fire Department
09	32	105	185	r	m	9	German Red Cross
10	28	89	178	r	m	8	Fire Department
11	21	72	182	r	m	1	German Red Cross
12	35	95	188	r	m	3	German Red Cross
$\bar{x} \pm S_d$	30.8 ± 6.5	88.2 ± 17.9	181.8 ± 7.3	—	—	6.8 ± 5.5	—