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Original Article

Using Shoulder Straps Decreases Heart Rate Variability and Salivary Cortisol Concentration in Swedish Ambulance Personnel

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ABSTRACT

Background: Previous research has shown that paramedics are exposed to risks in the form of injuries to the musculoskeletal system. In addition, there are studies showing that they are also at increased risk of cardiovascular disease, cancer, and psychiatric diseases, which can partly be explained by their constant exposure to stress. The aim of this study is to evaluate whether the use of shoulder straps decreases physical effort in the form of decreased heart rate and cortisol concentration.

Methods: A stretcher with a dummy was carried by 20 participants for 400 m on two occasions, one with and one without the shoulder straps. Heart rate was monitored continuously and cortisol samples were taken at intervals of 0 minutes, 15 minutes, 30 minutes, 45 minutes, and 60 minutes. Each participant was her or his own control.

Results: A significant decrease in heart rate and cortisol concentration was seen when shoulder straps were used. The median values for men (with shoulder straps) at 0 minutes was 78 bpm/21.1 nmol/L (heart rate/cortisol concentration), at 15 minutes was 85 bpm/16.9 nmol/L, and at 60 minutes was 76 bpm/15.7 nmol/L; for men without shoulder straps, these values were 78 bpm/21.9 nmol/L, 93 bpm/21.9 nmol/L, and 73 bpm/20.5 nmol/L. For women, the values were 85 bpm/23.3 nmol/L, 92 bpm/20.8 nmol/L, and 70 bpm/18.4 nmol/L and 84 bpm/32.4 nmol/L, 100 bpm/32.5 nmol/L, and 75 bpm/25.2 nmol/L, respectively.

Conclusion: The use of shoulder straps decreases measurable physical stress and should therefore be implemented when heavy equipment or a stretcher needs to be carried. An easy way to ensure that staff use these or similar lifting aids is to provide them with personalized, well-adapted shoulder straps. Another better option would be to routinely sewn these straps into the staff's personal alarm jackets so they are always in place and ready to be used.

1. Introduction

About half of all reported occupational injuries in Sweden are related to musculoskeletal strain injury [1]. It is well-known that emergency medical professionals suffer from various kinds of stress. According to a report published by The Swedish Social Insurance Agency [2], the length of sick leave taken by medical personnel in 2008 was more than 14 days. The report also indicated that nurses in general are eligible for sick leave of 10 days/year, whereas other health-care personnel are eligible for 13 days/year. These statistics also include musculoskeletal injuries. Internal figures for the ambulance district investigated show that between 2011 and 2013 there was an average of 9 days of sick leave for nurses and 23 days for paramedics. The Swedish Work Environment Authority's Statute Book AFS 2012:2 [3] states that is inappropriate for a personnel to lift objects weighing over 25 kg. It also

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describes that lifting aids should be used when lifts cannot be avoided and that the workplace should be designed in such a way that different kinds of harmful stress are avoided wherever possible. In the case of an emergency medical (ambulance) service, however, this can be hard to achieve when work has to be performed in different environments by two people. The profession requires that sick or injured persons should be cared for in all environments (indoors or outdoors), seasons (summer or winter), and at all hours; in some cases, these medical personnel also work under time pressure. Another aspect is that the team's composition varies in terms of physical conditions of work, age, height, sex, and education. Developments in the ambulance service have evolved from carrying patients on stretchers to having stretchers that in most cases are rolled (flexible); however, in some cases, manual lifting of individuals needs to be performed and heavier equipment has to be carried between the ambulance and place of care [4]. Examples of devices available in the ambulance service used for transferring patients are lifting belts, sliding boards, shoulder straps, stair climbers, mattresses for dragging, and stretchers. The Swedish ambulance service requires at least one of the team members to be a registered nurse for the administration of drugs. The nurse always has the medical responsibility for the patient. The team may consist of one nurse and one nursing assistant, called "paramedics," or two nurses.

There is strong evidence that professional life in general, regardless of profession, involves a high risk of injury to the lower back. Different prevalence rates have been reported, and the estimated annual and long-term risk rates of suffering from back pain during work varies between 27% and 62.5% [5–7]. The risk of suffering from back pain related to work at some point in one's career is 84–91% [8,9]. The major risks identified are heavy lifting [10–12], repetitive or sudden twisting movements [9,11], stress [10,12], and deficiencies in the psychosocial environment [13]. Lower back pains are a major occupational hazard, specifically for ambulance service personnel, with reports indicating a 32–67% frequency of lower back pain related to work in the past year [14–16]. As much as 10–13% of these medical personnel took a shorter or longer sick leave [17,18]. The reasons are similar to those reported in other professions with a predominance of lifting, twisting movements, and sudden unexpected movement from the patient. Injuries to the back and upper extremities are not just an emergency event for the individual. The median time per sick leave for lower back pain is 5 days [19] and it was the most important cause of early retirement. All these imply the individual's suffering and cost to the society [20,21].

Although ambulance service personnel perceive themselves as "healthy" [22], there are obvious indications that in addition to neck/back pain, a number of individuals also suffer from cardiovascular disease, cancer, and psychiatric disorders, conditions in which stress and strain are considered to be an underlying cause [20,23]. Studies show that proper use of assistive devices and lifting techniques can prevent overload and back problems [24,25].

Salivary cortisol measurement is a simple and established method and its result correlates well with the cortisol level in the blood [26]. The reason for taking cortisol samples in the morning is that cortisol follows a circadian rhythm with higher values generally being recorded after awakening followed by rapidly decreasing values [27,28]. Heart rate is a clinical indicator of stress, and thus, we measured this in our study population [29].

1.1. Study Objective

The aim of this study was to evaluate whether the use of shoulder straps reduces physical work. By applying psychosocial and psychological methods, heart rate and secretion of salivary cortisol before, during, and after carrying the stretcher were measured.

2. Materials and methods

2.1. Study design and methodology

This study was conducted in an ambulance organization in southern Sweden. When the study started, this organization consisted of 12 ambulances on duty for 24-hour shifts and eight ambulances on duty for daytime shifts only. The total number of employees was 164. All employees were requested to participate in this study by postal mail. The only exclusion criterion was treatment with any medication that interferes with heart rate and/or cortisol value.

The study was conducted in such a way that pairs of participants carried a standardized stretcher (alfabår) with a dummy. The total weight, including the stretcher (39 kg) and dummy [approximately 73 kg (160 pound)], lifted by the participants was 112 kg. The only previous occasion they used this equipment was in connection with an employment test. Therefore, their previous experience was only minimal. The dummy was carried over a flat terrain for 400 m for about 10 minutes, on two different days. The first time was without and the second time was with the shoulder straps (Easylift Shoulder, AB GERMA, Kristianstad, Sweden). The participants changed their position after covering 200 m: the first at the head end and the second at the foot end or vice versa. The same geographical path was used on both days. Heart rate was registered using the monitor brand Polar RS 400 (Polar Electro, Bromma, Sweden) that logged the heart rate every 15 seconds throughout the period of salivary cortisol sample collection. Salivary cortisol samples were collected in neutral cotton-based Salivette tubes (Sarstedt, reference 51.1534, Numbrecht, Germany) just before carrying the stretcher and 15, 30, 45, and 60 minutes after collecting the first sample. To prevent interference with the results, the participants were informed that they should avoid smoking, taking Swedish snuff, brushing their teeth, drinking coffee, and tea in the morning before the test.

2.2. Study period

All data collection took place between October 17, 2012, and March 25, 2013. However, one participant suffered a physical injury, and thus, the sample from this participant was collected on September 4, 2013. Samples were collected between 7:46 AM and 9:23 AM. The tests were cancelled in poor weather such as rain or snow to ensure the conditions for sample collection are as similar as possible. The temperature during tests ranged from +15°C to −5°C. Data collection took place on work-free days. At least one of the researchers participated as a supervisor on every occasion.

2.3. Participants

All 164 employees in the organization received oral and written information about the study during workplace meetings and all were invited to participate. This organization included 99 men and 65 women of whom 129 were nurses and 35 were paramedics. The age range was 31–62 years (mean = 43.4 years; median = 42 years) for men and 27–56 years (mean = 40.8 years; median = 41 years) for women. A total of 38 employees (25 men and 13 women) were interested in participating; of these 38, three were excluded because of medication use. Of the remaining 35 employees, 21 were randomly selected from a numbered code list by a nonparticipating individual. One woman had to drop out immediately before start because of her own injury. All remaining participants completed the study.

Table 1
Salivary cortisol concentrations (nmol/L) and heart rate values (bpm) before (0 minutes), during (15 minutes), and after (30–60 minutes) carrying a heavy stretcher with and without shoulder straps

Sex	Time point (min)	Male		Female	
Straps		Without	With	Without	With
Salivary cortisol (nmol/L)		$n = 14$	$n = 13$	$n = 5$	$n = 6$
	0	21.9 (15.1–54.2)	21.1 (12.9–39.0)	32.4 (17.5–69.4)	23.3 (16.9–49.8)
	15	21.9 (14.5–45.2)	16.9 (11.2–32.9)	32.5 (17.1–64.4)	20.8 (18.0–46.0)
	30	24.3 (13.6–50.0)	16.0 (11.1–31.4)	33.0 (17.3–51.1)	22.1 (15.5–37.2)
	45	21.5 (12.6–45.0)	14.8 (10.7–26.5)	29.2 (16.2–40.2)	20.8 (15.0–29.0)
	60	20.5 (12.4–31.2)	15.7 (10.2–23.5)	25.2 (13.6–35.3)	18.4 (14.3–26.6)
Heart rate (bpm)		$n = 14$	$n = 14$	$n = 6$	$n = 6$
	0	78 (60–95)	78 (54–88)	84 (73–109)	85 (68–97)
	15	93 (70–108)	85 (60–104)	100 (67–159)	92 (75–99)
	30	82 (59–103)	79 (59–94)	89 (62–111)	81 (68–96)
	45	72 (64–92)	76 (53–90)	86 (55–120)	78 (66–85)
	60	73 (61–90)	76 (54–94)	75 (60–103)	70 (64–76)

Values are given as median and range.

2.4. Demographic data

Fourteen of the participants were men and six were women. The median ages were 43 years (32–53 years) and 41 years (31–44 years) for men and women, respectively. Eleven men were nurses and three were paramedics; five women were nurses and one was a paramedic. The experience of these participants in health-care and prehospital emergency services varied between 7 years and 33 years (mean = 17.4 years) and 4 years and 28 years (mean = 11.2 years) for nurses, respectively, compared with 15 years and 30 years (mean = 25.5) and 5 years and 29 years (mean = 19.3) for paramedics.

2.5. Data collection

All participants were informed about the purpose and structure of the study. Heart rates were monitored throughout the period of saliva cortisol sample collection. The logged heart rate files were saved in Polar Pro Trainer 5 (Polar Electro, Bromma, Sweden). Salivary cortisol samples were stored frozen at Unilab Skaraborg's Hospital (Skövde, Sweden) and were later analyzed by a commercial RIA method using Spectria cortisol RIA$^{\text{I125-coated tubes}}$ kits (Orion Diagnostica, Trosa, Sweden). The method is described in detail elsewhere [30,31]. Simultaneously with the first test, a study-specific questionnaire with background data was completed.

2.6. Data processing

All tests for heart rate monitoring and cortisol levels were implemented and all results were analyzed for heart rate; however, we could not analyze cortisol samples in two cases due to insufficient amounts of saliva collected. After exporting the data from Polar Pro Trainer 5, statistical calculations were performed and analyzed in Microsoft Excel 2010 and STATISTICA, version 10 (STATSOFT, Uppsala, Sweden). Some briefly manifested high heart rate artifacts, at frequencies between 200 and 250 bpm, but these were excluded before processing the data.

2.7. Ethical permission

Ethical permission for the study was obtained from the Regional Ethical Review Board in Gothenburg (2012-06-25 Dnr: 356-12). Permission to conduct the study was given by the manager concerned in the ambulance service. Before the study, participants received both written and oral information about the study and were informed that participation was voluntary and could be cancelled without giving any reasons at any point in time. All participants signed a written agreement that they would participate. Data collection followed the principles of the Declaration of Helsinki [32].

3. Results

The effort phase runs between the first and second cortisol tests (duration 15 minutes), and the recovery phase runs between the collection of second and fifth samples (duration 45 minutes). Table 1 presents the median and range for heart rates and salivary cortisol concentrations for the time points 0 minutes, 15 minutes, 30 minutes, 45 minutes, and 60 minutes after the start of carrying the stretcher, grouped according to sex of the participants.

3.1. Effects of using shoulder straps

The use of shoulder straps when carrying a stretcher clearly shows that distributing the load over the whole body decreases the effort involved, resulting in lower heart rate and lower cortisol concentrations. Significant differences were seen in all phases (Fig. 1). The overall physical effort of carrying a stretcher is indicated as the area under the curve and is calculated as the average heart rates during each phase × time span. The results for 15 minutes, 45 minutes, and 60 minutes are recorded and analyzed. Significant differences are seen when shoulder straps are used (Fig. 2).

In most participants (18/20), heart rates and salivary cortisol secretion/concentration decreased significantly and the return to normal-resting heart rates in the recovery phase was quicker when shoulder straps were used. Individual differences in response to using shoulder straps were seen (Fig. 3).

Individual participants' characteristics

When the group was sorted according to sex, there were no observed significant differences in heart rates in the aforementioned phases. In men, but not in women, significance differences were observed in the effort phase and in the total phase but not during the recovery phase. There were no significant differences between heart rate and/or cortisol concentrations and age.

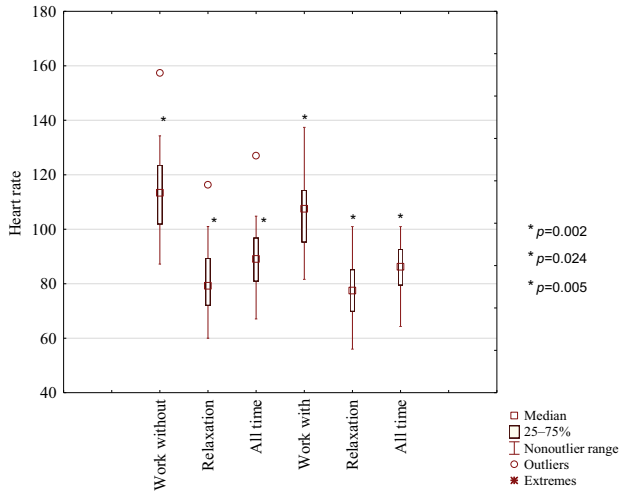

Fig. 1. Heart rate during carrying a stretcher and relaxation. A comparison of effects between use and nonuse of the shoulder straps.

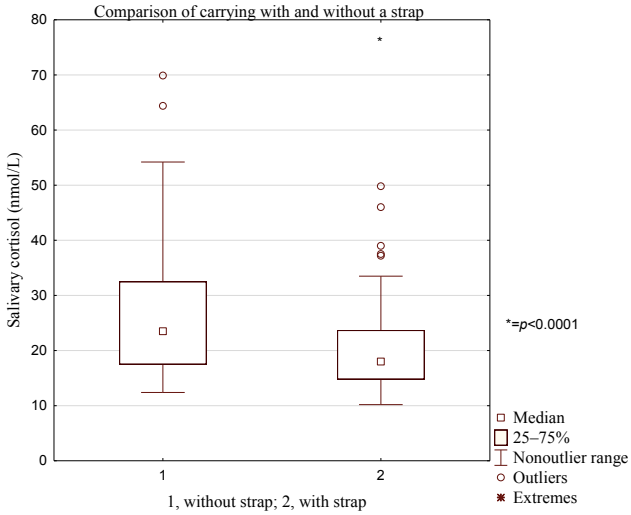

Fig. 3. Salivary cortisol concentration (nmol/L) after carrying a stretcher with and without using shoulder straps.

We wanted to estimate the metabolic condition and body mass index, waist circumference and hip circumference, and the ration of waist and hip circumference. However, the participants did not agree to taking these estimations, and thus, these were not compared.

4. Discussion

The first main finding in this study is that lifting aids (e.g., shoulder straps) reduce the strain on the body, which results in lower heart rate and lower concentrations of the stress hormone cortisol. The second finding concerning the use of shoulder straps is that the participants could carry the patient for a much longer time without setting down the stretcher and taking retakes. Participants often said spontaneously that they had less pain in their hands and arms when they used shoulder straps, which can be interpreted as shoulder straps really distributing the workload over the whole body in a positive way. One possible explanation for two individuals' increased heart rate response and the lack of clear-cut benefit in using shoulder straps is that that they were unaccustomed to using them, and that the shoulder straps may not have been optimally adjusted to the individual.

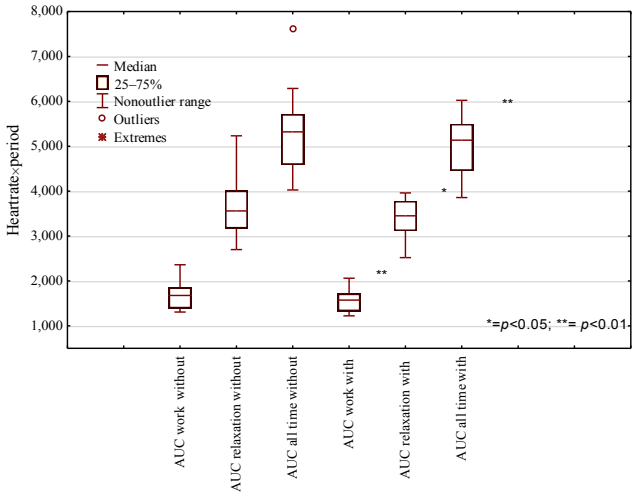

Fig. 2. Area under the curve from baseline (AUC_0) representing total workload (heart rate × timespan) during carrying a stretcher and relaxation. A comparison of effects between use and nonuse of the shoulder straps.

4.1. Psychosocial aspects

When it will be a normal habit to use the shoulder straps more people will use them. It results in a mental effect and a positive effect of the psychosocial character. The participant's sense of distress will be less and the hypothalamic–pituitary–adrenal axis (LHPA) response adjusted to a minimal increase in salivary cortisol concentration.

4.2. Psychological aspects

When there are optimal ergonomic conditions in place, one will feel safe and more confident in doing the work. You will relax and consequently, this will decrease the sense of stress due to the activation of the LHPA axis, eventually resulting in decreased cortisol concentrations. It is in agreement with other studies on ambulance personnel, they found that somebody always had pronounced cortisol response, and this was considered a risk factor for increased chances of burn out and cardiovascular disease. Our study results clearly show that the shoulder straps tested should be used when equipment and stretcher are to be carried. This investigation shows that this aid, simple in itself, reduces the physical effort, resulting in a decrease in both heart rate and salivary cortisol concentrations. An easy way to ensure that staff use these devices or similar lifting aids is to provide them with personalized, well-adapted shoulder straps. Another better option would be to routinely sewn these straps into the staff's personal alarm jackets so they are always in place and ready to be used.

4.3. Generalizability

A comparison between participants and nonparticipants according to age and sex shows no significant differences. The median age for all men and women who are employees of the studied organization was 42 years and 41 years, respectively, compared with 43 years and 42 years, respectively, for the participants in this study. Of the total 99 male employees and 65 female employees in the organization, 14 men and six women were included in the study, of whom 16 (80%) were nurses and 4 (20%) paramedics

compared with 129 (79%) nurses and 35 (21%) paramedics in the whole group. Thus, the cohort studied seems to be a suitable representative for the whole group and results can probably be generalized to the whole group.

4.4. Consequences of these findings

It is important to implement these findings (use of shoulder straps) in daily work in an organization such as the one studied. In recent times, stretcher carrying is reduced due to the availability of new and advanced stretcher systems; however, in some cases, shoulder straps may be necessary when heavy equipment is carried to and from the patient. This type of carrying will probably increase as the number of ambulance and assessment services requiring equipment at the place of care is increasing in most Swedish ambulance organizations. There will be instances where carrying patients will become even more strenuous, partly due to heavier and more cumbersome stretchers, and primarily due to an increasingly heavier population. There is also more requirement to monitor the patient during the transport. Therefore, more sophisticated electronic instruments are used and the total weight is increasing. Every reduced workload on the body is valuable during a full professional life in the ambulance service [33]. Thus, every organization should carefully consider what devices should be carried with due consideration of weight of devices. In the study organization, the equipment for emergency treatment and monitoring of patients weighs between 25 kg and 30 kg.

The Swedish Work Environment Authority's [3] current recommendation for the maximum weight to be lifted (25 kg) exceeds several times daily in the ambulance profession. This is true even more often in locations and environments neither designed nor intended as workplaces, and both during the days and nights, as well as when working in harsh weather conditions. Usually, assignments must be handled by two members of staff who may be of varying age, sex, experience, education, and physical ability. The strain often come after the ambulance personnel have been sitting idly in the ambulance for a shorter or longer period and are expected to act immediately without being able to warm-up beforehand.

4.5. Strengths and weaknesses

The study has been well controlled because the study protocols were adhered to meticulously and all participants completed the tests. All participants were in their own control. All participants completed the test on the exact same route, carried the same stretcher, and used the same shoulder straps, so they all completed the tests in the same external physical conditions. A loss of only two cortisol samples and a complete heart rate measurement confirm a secure outcome.

The main limitation of the study group was the sample size. In addition, the limited number of women participants prevented us from drawing firm conclusions based on sex differences. The recovery phase was unfortunately not the same for everyone as no demands were made to the participants to be in privacy and total rest during this time. Despite this, all spent the recovery phase in the same room.

4.6. Future aspects

A reasonable assumption, however, that has not yet been explored is the possibility that various types of backpack equipment bags in the ambulance service that should also be carried like this as much as possible. The effect of unloading the body would probably be similar to that of the shoulder straps investigated.

Although the survey has been conducted in the prehospital field, the results may be generalized, and may thus be transferred to other occupations using similar lifts.

Conflicts of interest

None of the authors have any conflicts of interest in this article. None of the persons listed in the acknowledgments has been involved in the design, processing, analysis, and interpretation of results and description of the results in the manuscript.

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