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AMBULANCE WORK
**Relationships between occupational demands,
individual characteristics and health-related outcomes**

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CAPRICCIO

Just nu när jag för tillfället
förhåller jag mig passiv mot hela omvärlden
och har ingenting för mig och är ensam i mitt rum,
faller det mig in,
att kanske min obetydliga person
befinner sig, just nu, i någons medvetande
på annat håll,
långt härifrån.

Det skulle vara lustigt att veta,
var jag på detta sätt kan ha betydelse för tillfället.
Möjligen spelar jag en större roll
på en annan plats än hemma hos mig själv,
där ju ingenting händer i kväll.

Vid närmare eftertanke
finner jag att detta är en trasslig härva.
Ett ansvar så stort
som jag aldrig annat
gör mig ängslig, jag ville,
om jag kunde, samla in från alla håll och kanter
alla garnändar, alla trådstumpar jag slängt ut i världen,
knyta hop dem efterhand som jag fick tag i dem
och nysta det hela
till ett runt litet nystan,
som jag ledigt kunde hålla i min hand.

Ur "100 DIKTER" av Hjalmar Gullberg

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ABSTRACT

AMBULANCE WORK

Relationships between occupational demands, individual characteristics and health-related outcomes

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Although musculoskeletal disorders (MSDs) and other health complaints are an occupational problem for ambulance personnel, there is a lack of knowledge regarding work-related factors associated with MSDs and other health complaints. The overall aim of this thesis was to investigate the relationships between occupational demands, individual characteristics and health-related outcomes among ambulance personnel.

A random sample of 234 female and 953 male ambulance personnel participated in a national questionnaire survey on work-related factors, and musculoskeletal and other health complaints. Physical demands was associated with activity limitation due to neck-shoulder and low-back complaints among the female personnel. Among the male personnel, physical demands was associated with low-back complaints and activity limitation due to low-back complaints. Psychological demands was significantly associated with neck-shoulder complaints, sleeping problems, headache and stomach symptoms among both female and male ambulance personnel. Worry about work conditions was associated with musculoskeletal disorders and sleeping problems, headache and stomach symptoms.

A local sample of 26 ambulance personnel was followed during a 24-hour work shift and for the next two work-free days. Subjective stress- and energy levels, and cortisol levels were measured at regular intervals, and heart rate was registered continuously by electrocardiogram (ECG). Autonomic reactivity to standardized tests before (pre-work) and at the end of the work shift (post-work) was also investigated. For the whole group, baseline values of heart rate were higher pre-work than post-work, but autonomic reactivity did not differ. Increased reactivity to the mental test, modest deviation in heart rate variability (HRV) pattern during the late night hours at work and higher morning cortisol values during work than during leisure time were observed in personnel with many health complaints, but not among their co-workers without or with few complaints. Ambulance personnel with many health complaints also reported higher psychological demands and tended to be more worried about work conditions.

Heart rate (HR), lactate level (LL) and perceived exertion (RPE) were investigated in 17 female and 48 male ambulance personnel during a simulated standardized work task “carry a loaded stretcher”. The ambulance personnel had to carry the loaded stretcher (920

N) up and down three flights of stairs twice. The high physiological strain (HR, LL, RPE) for the male, and near or at maximal strain for the female ambulance personnel, implied the importance to identify what kind of physical capacity is most important for ambulance personnel. Therefore, the explained variance of developed fatigue by tests of cardiorespiratory capacity, muscular strength and endurance, and coordination was investigated. The results showed that VO₂max and isometric back endurance were important predictors for development of fatigue when carrying a loaded stretcher.

The influence of body size on the relationships between maximal strength and functional performance was investigated in a methodological study. The results confirm that the assessment of physical performance could be confounded by the body weight. Therefore, the models for explaining development of fatigue when carrying the loaded stretcher were adjusted for height and weight. Including height in the models significantly increased the explained variance of accumulated lactate among female, but not among male personnel. Lactate levels were higher among short compared to tall female personnel. Weight had no effect on any of the models.

In conclusion, the national survey showed that self-reported physical demands was a risk factor of having MSDs, and that self-reported psychological demands and worry about work were important risk factors of having MSDs and other health complaints. Stress monitoring of ambulance personnel during work and leisure time showed that physiological and subjective stress markers did not show any differences between the 24-hour ambulance work shift and leisure time afterwards. However, ambulance personnel with many health complaints had certain physiological changes during the work shift in comparison with the next two work-free days. The physiological and subjective responses during carrying a loaded stretcher, especially among the female ambulance personnel, showed that female and male ambulance personnel could be exposed to internal exposures at different levels when performing the same work task. A better understanding of the relationships between occupational demands and health-related outcomes require further studies on age- and gender matched groups in long-term perspective studies.

Key words: ambulance, autonomic reactivity, body size, cortisol, demand-control-support, emergency personnel, fitness, gender, heart rate variability, low-back pain, neck-shoulder pain, occupational, physical capacity, work simulated test, worry

ORIGINAL PAPERS

This thesis is based on the following papers, which are referred to in the text by their Roman numerals:

- I.** Aasa U, Brulin C, Ängquist K-A, Barnekow-Bergkvist M. Work-related psychosocial factors, worry about work conditions, and self-reported complaints among Swedish ambulance personnel. (Accepted by *Scandinavian Journal of Caring Sciences*)
- II.** Aasa U, Barnekow-Bergkvist M, Ängquist K-A, Brulin C. Relationships between work-related factors and disorders in the neck-shoulder and low-back region among female and male ambulance personnel. (Submitted)
- III.** Aasa U, Kalezic N, Lyskov E, Ängquist K-A, Barnekow-Bergkvist, M. Stress monitoring of ambulance personnel during work and during leisure time. (In manuscript)
- IV.** Aasa, U, Jaric S, Barnekow-Bergkvist M and Johansson H. Muscle strength assessment from functional performance tests: Role of body size. *Journal of Strength and Conditioning Research*, 2003;17(4);664-670.
- V.** Barnekow-Bergkvist, M, Aasa U, Ängquist K-A, Johansson H. Prediction of development of fatigue during a simulated ambulance work task from physical performance tests. *Ergonomics* 2004;47;1238-1250.

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INTRODUCTION

Historically, the ambulance service has been considered mainly to be a transport function. Demands from the society and progress in medicine have transformed the ambulance service into an advanced form of emergency medical care. The Swedish ambulance service has to deal with about 800,000 cases a year. One quarter of the emergency call-outs can be categorized as critical¹. In Sweden, the organisation of prehospital emergency care has differed considerably between regions, but is nowadays regulated by the Swedish National Board of Health and Welfare (SOSFS 1995:8) and Swedish laws (SFS 1994:953). Most ambulance personnel in Sweden (63%) are employed by the county councils, but also private companies (22%) and municipalities (15%) have organized ambulance services. In Sweden, most ambulance personnel are ambulance technicians, but more nurses are being employed². The main reason for this is that from November 2005, medicines can be distributed during call-outs only by registered personnel (nurses and physicians).

Musculoskeletal disorders (MSDs) and other health complaints, for example sleeping problems are common among health care personnel working in different health care settings³⁻⁹. This problem has also been recognized among ambulance personnel¹⁰⁻¹³, but little is known about the magnitude of the health complaints and which work-related factors that place ambulance personnel at risk of developing ill health. Up to now, studies on ambulance work have mostly focused on the relationships between exposure to major disasters or distressing events and symptoms of post-traumatic stress disorder (PTSD)¹⁴⁻¹⁹.

Thus, this thesis focuses on the relationships between occupational demands included in ambulance work, individual characteristics and health-related outcomes. In order to facilitate the understanding of work-related factors in relation to health effects, several theoretical models have been presented²⁰⁻²⁵. The model in Figure 1 is based on the biomechanical exposure-effect model by Winkel and Mathiassen²⁵, proposing pathways between external exposure, acute response (inside the individual) and health effects. In this thesis, the exposure-effect model gives a structure for investigating and interpreting the effects of physical and psychosocial factors on health among ambulance personnel (Figure 1).

Figure 1. An exposure-effect model focusing on physical demands and psychosocial factors. Modified from Winkel and Mathiassen²⁵. This thesis is based on five studies, which are referred to under data collection by their Roman numerals.

Work-related exposure

External exposure refers to physical and psychosocial factors in the work environment that cause an internal exposure in the body. The external exposure is similar for all workers doing exactly the same work task²⁵, for example the weight of the lifted material, the distance carried and time limits. Within the epidemiological, physiological and psychological literature, different terminology may be used for external exposure. The term physical exposure has been used for several ergonomic risk factors and other physical environmental factors such as noise, lighting and temperature. In this thesis physical exposure specifically refers to ergonomic factors as work postures, movements and material handling and are henceforth called physical demands. Further, the term psychosocial factors is an umbrella term for several psychological and social factors such as psychological demands, control over the work situation and social support. Sometimes these factors are described as work organization factors²⁶. For psychological demands, the term stressor²⁷ or load²⁸ or demands^{29,30} are used. Henceforth in this thesis, the term psychological demands is used. The term social support is henceforth used to represent work-related social factors.

Physical demands

Physical demands can be measured in terms of intensity, frequency and duration by self-reports, observational methods or direct measures. As described by Winkel and Mathiassen²⁵ exactness increases from self-reports to observational methods to direct measurements. However, self-reports offer a possibility to study large representative samples in order to increase the external validity. Further, questions can be designed to measure the

exposure in general terms regarding time and work content, while direct methods cover exposure only for specific tasks during the recording time.

Psychosocial factors

In this thesis the demand-control-support model, which was originally introduced by Karasek³¹ and further developed by Karasek and Theorell³² as well as by Johnson and Hall³³ was used to investigate psychosocial factors. This model includes psychological demands (containing both quantitative, e.g., time pressure, and qualitative questions, e.g., role conflict), decision latitude (authority over decisions and skill discretion) and social support (support from co-workers and superiors). Psychosocial factors are most often measured via self-reports, observations or interviews.

Internal exposure and acute responses

The balance between physical demands, psychological demands and individual characteristics defines the internal exposure^{25,34}. The internal exposure causes acute physiological responses within the body such as altered muscle blood flow regulation, metabolic changes, impaired coordination or muscular fatigue³⁵. In addition, exposure to high forces might lead to micro-ruptures in tendons, muscles, cartilages and connective tissues³⁶.

The acute responses to high dynamic physical demands like lifting and carrying, tasks with aerobic as well as anaerobic components, are often analyzed with physiological methods as measurement of oxygen uptake, heart rate and/or level of lactate accumulation in blood³⁷. In addition, responses to physical demands can be measured by psychophysical measurements as ratings of perceived exertion (Borg 6-20)³⁸.

The acute responses to psychosocial factors are often assessed by psychophysiological measurements, for example changes in heart rate (HR), heart rate variability (HRV), blood pressure (BP)³⁹⁻⁴⁶, corticosteroids and other hormone levels⁴⁷⁻⁵⁰ as well as changes in muscle activity^{51,52}.

Health effects

Subjective health complaints such as sleeping problems, headache and stomach symptoms may represent a variety of disease conditions^{53,54}. These subjective symptoms appear under some circumstances to be stress-related^{8-10,55,56}. Similarly, pain, ache and discomfort, and subjective activity limitation are common ways of identifying musculoskeletal disorders. Thus, a work-related musculoskeletal disorder is not a disease diagnosis, but include several disease conditions^{57,58}.

Different kinds of exposures and acute responses can be harmful to different body structures or organs through various pathways. One proposed explaining theory for development of MSDs due to heavy and/or repeated physical demands is that, if time to recover from physical demands is not sufficient, short-term negative effects will accumulate and long-term negative (chronic) health effects such as MSDs may develop⁵⁹. If, however, time for the body to recover from the acute responses to physical demands is sufficient, inherent reparative processes will offset the degenerative effects and adaptation such as improved strength or improved oxygen transportation will occur.

Time for recovery is also important for avoiding negative health effects due to psychosocial factors. Accumulated exposure to psychosocial risk factors is seen as possible cause of general health complaints³², sleeping problems⁵⁵, and musculoskeletal complaints^{49,60,61}. In their study, Karasek and Theorell (1990) found that ill health was most often occurring when the psychological demands of the job were high and the worker's decision latitude was low³². It is hypothesized that insufficient recovery from work-related neuroendocrine reactions may lead to situations in which extra effort has to be exerted to rebalance the psychophysiological state of sustained activation^{22,23,34}. This energy mobilization might be at the expense of restoring and rebuilding activities in the body. Furthermore, an explaining theory for a relationship between psychological demands and neck-shoulder complaints is that increased muscle activity evoked by psychological demands, initiate similar processes as in low load static work⁶². This is supported by for example the finding that feelings of being stressed and exhausted at work were associated with increased muscle activity in the neck-shoulder region among female cashiers, whereas feelings of being

stimulated and focused, or objectively measured workload, were not associated⁵².

Modifying factors

Circumstances that can influence the relationships between physical demands and psychosocial factors, acute responses and/or long-term health effects are called modifying factors. The International Classification of Function (ICF)⁶³ presents a model for classifying individual characteristics as modifying factors (body structure, body function and personnel characteristics) where body structure (e.g., anthropometry) and function (e.g., maximal oxygen uptake, muscle strength and endurance), as well as personnel factors (e.g., age, gender, coping strategies) are prerequisites for activities during work and during leisure time and participation in social life. In addition, these characteristics determine the effects of physical demands and of psychosocial factors on the individual. Further, it is generally agreed that some individual factors are interrelated, such as body size, physical performance and muscle strength, for review read McMahon (1984) and Åstrand (2003)^{37,64}.

Description of ambulance work

Exposure factors in ambulance work

Ambulance work consists of emergency call-outs and short or long waiting periods at the ambulance station⁶⁵. During the waiting periods, the personnel are engaged in for example management of cars and equipment or just waiting for the next emergency call-out. The call-outs can be minor accidents, acute illnesses or serious accidents and disasters. At some ambulance stations, routine transports, for example transportation of patients to and/or from the air ambulances, are also included in the duties. Ambulance personnel always work in pairs, at some ambulance stations they have fixed pairs but more often the co-worker varies. Despite a general reduction in the physical demands of many occupations such as increased automation in different fields of work, ambulance work during call-outs still

includes physically demanding tasks⁶⁵⁻⁶⁸, for example lifting patients from bed to stretcher, carrying a stretcher in the stairs and lifting a patient on a backboard⁶⁷.

Ambulance personnel are also exposed to mentally demanding tasks^{17,19,56,69}, especially accidents involving children, road traffic accidents and violence incidents^{18,56}. Furthermore, psychosocial factors might be important risk factors. For example, it was reported that although 80% of the ambulance personnel in Scotland were highly satisfied with the ambulance job, only 35% were satisfied with the organization¹⁴. However, no earlier study has systematically studied psychosocial factors in the ambulance service.

Acute responses to ambulance work

In a study on male ambulance personnel, where heart rate was recorded during work shifts, the results showed that ambulance work consisted of periods of high activity, often above the anaerobic threshold, interspersed with waiting periods⁶⁵. In another study of emergency physicians, heart rate and mean diastolic blood pressure was elevated during an 8-hour night shift⁴⁰. Further, endocrine reactions (cortisol responses) in ambulance personnel during and after the handling of patients in life threatening situations were increased compared with the handling of patients who were not⁵⁰, and in another study catecholamine levels correlated with the degree of self-reported stress levels in ambulance personnel⁴⁷. An increased knowledge about physiological as well as subjective responses to ambulance work can give a more comprehensive view of the relationships between occupational demands and health-related outcomes^{34,70}. In addition, more knowledge about the physiological and subjective responses can contribute to highlight which individual characteristics will modify the relationships between work-related exposure and health-related outcomes.

Health-related outcomes among ambulance personnel

In an earlier Swedish study, 44% of the ambulance personnel reported musculoskeletal or other health complaints due to work during the past 12

months¹⁰. In the US, high back injury rates were documented for emergency medical technicians and paramedics¹¹. Earlier studies on ambulance personnel have mostly focused on postures and biomechanical loads as probable risk factors of musculoskeletal disorder⁶⁶⁻⁶⁸. Another study showed that lack of social support at work was an important predictor for post-traumatic distress, fatigue, and burnout symptoms¹⁹. Among nursing personnel working in hospitals, the exposure to work-related physical demands increased the risk of reporting ill health^{3,9,71,72}. In one study, nurses and nursing aides were found to be at particular risk of back injury during patient transfers, which require sudden movements in non-neutral postures⁷³. In addition, the exposure to work-related psychosocial risk factors increased the risk of having MSDs^{3,4,74,75}. No study has, however, systematically investigated associations between work-related physical demands and psychosocial factors and health related outcomes among ambulance personnel.

Individual characteristics as possible modifiers

Physical capacity

Physical capacity can be classified into aerobic capacity, muscular strength and endurance, flexibility and co-ordination^{37,76-78}. The relative importance of physical capacity on performance of work tasks depends upon the task in question, the individual performing the task and the environment in which it is performed^{63,79}. Among ambulance personnel the most physically demanding tasks are lifting and carrying a patient on a stretcher. Theoretically, the heavy dynamic work of the legs during these tasks requires high maximal strength and endurance in the leg muscles (reflecting peripheral aerobic capacity), as well as a high maximal oxygen uptake (cardio-respiratory capacity). In addition, the high static load on shoulders, arms, hands and trunk requires high maximal strength and static endurance in these muscles. High physical capacity has also been suggested to be an important individual characteristic, enhancing ambulance work performance. Surprisingly therefore, Gamble *et al.* found that VO₂max among the male ambulance personnel in the UK was not higher than among the general male population⁶⁵ possibly indicating a mismatch between the physical demands and the physical capacity of ambulance personnel⁸⁰.

Many studies have reported associations between maximal performance of lifting and carrying tasks and physical capacity among military personnel⁸¹⁻⁸⁶. These studies suggest that aerobic capacity, muscular strength and endurance, and measurements of anthropometry are important predictors for maximal performance⁸¹⁻⁸⁶. There is, however, no information on development of fatigue (heart rate, lactate level or perceived exertion) during these tasks. Still, high aerobic capacity, maximal strength and endurance, and measurements of anthropometry could also be important predictors for development of fatigue during performance of heavy ambulance tasks.

At most ambulance stations, preemployment tests are currently used to select ambulance personnel with the aim to reduce work-related injuries. The tests included in these test batteries at the ambulance stations vary, but a work simulated task - carry a loaded stretcher in the stairs - is included in most test batteries. Although this test is widely used, it has not been standardized and the physical capacity needed for the performance has not been evaluated.

Age and gender

Physical capacity as aerobic power and muscular strength decreases with older age³⁷. In agreement with this, Gamble *et al.* (1991) found decreased VO₂max with older age among ambulance personnel⁶⁵. A decline in physical capacity might imply an increased risk of musculoskeletal injury due to a mismatch between the individual's work capacity and the work requirements^{87,88}, particularly regarding heavy physical tasks. In addition, the risk of most musculoskeletal disorders increases with increasing age up to 55-59 years of age^{89,90}. Among health care personnel in the UK, ambulance personnel were reported to have the highest number of early retirement, which was most often caused by musculoskeletal disorder^{12,13,91}.

Traditionally, personnel involved in pre-hospital emergency care have been men⁹², in Sweden about 20% of the ambulance personnel are women. Due to increasing demands on medical competence⁹³, more registered nurses are recruited to the ambulance service, and since more women than men are registered nurses, the number of female personnel is

increasing. In earlier research, risk of MSDs was found to be higher among women than among men also when the analyses were adjusted for job title⁹⁴, but it has later been suggested that the different association pattern for women and men might be due to the fact that, although they have the same job-title, they do not have the same work-tasks^{95,96}. For ambulance personnel who always work in pairs and even change head and rear position equally when carrying a stretcher, the external exposure for heavy tasks is often the same. It was therefore an important objective to investigate whether associations between occupational demands and health-related outcomes are the same for female and male ambulance personnel.

AIMS OF THE THESIS

In consideration of the lack of knowledge regarding relationships between occupational demands, individual characteristics and health-related outcomes among ambulance personnel, the rationale for this thesis was to investigate the work environment of ambulance personnel with regard to physical and psychosocial factors, the prevalence of ill health, the physiological responses to ambulance work and the influence of physical capacity. The intent was to recognize risk factors separately for female and male ambulance personnel.

The specific aims were

- to investigate the relationships between work-related psychosocial factors, worry about work conditions and health complaints (sleeping problems, headache and stomach symptoms) among female and male ambulance personnel, respectively (I).
- to investigate the relationships between work-related physical and psychosocial factors, worry about work conditions and MSDs (neck-shoulder and low-back complaints, activity limitation and sick leave due to complaints) among female and male ambulance personnel, respectively (II).
- to assess physiological and subjective stress markers during a 24-hour ambulance work shift and during the next two work-free days, and relate these parameters to self-reported health complaints (III).
- to study the effects of body size on the relationship between performance tests and muscle strength (IV).
- to evaluate development of fatigue during a simulated ambulance work task (carrying a loaded stretcher) and to identify which tests from a battery of physical performance tests could best predict the development of fatigue among female and male ambulance personnel, respectively (V).

MATERIALS AND METHODS

This thesis is based on an epidemiological survey (I and II), a field study (III) and two laboratory studies (IV and V). An overview of the methods for data collection in studies I-V are presented in Table 1.

Table 1. Methods used in studies I-V

Studies I and II

The questionnaire survey provided information about relationships between work-related physical demands (II) and psychosocial factors (I, II), and health complaints such as sleeping problems, headache, stomach symptoms (I) and disorders in the neck-shoulder and low-back region (II). In addition, the influence of worry about work conditions (I, II) on these relationships was investigated. All analyses were performed separately for female and male ambulance personnel.

Subjects

A random sample of 1500 subjects (300 female and 1200 male ambulance personnel) was selected from a total of 4000 (800 female and 3200 male) Swedish ambulance personnel. Of these 234 (78%) female and 953 (79%) male ambulance personnel answered and returned a questionnaire. No difference regarding geographic distribution in Sweden was found between the personnel who answered the questionnaire and those who did not.

Data collection

Questionnaire

A questionnaire was developed on the basis of questions from validated and reliable questionnaires^{32,97} and from an earlier used questionnaire on health care personnel⁹⁸, but also specific questions about ambulance work were included. The questionnaire provided information about individual

characteristics, sleeping problems, headache and stomach symptoms⁹⁸, musculoskeletal disorder⁹⁹ and exposure to physical demands⁹⁸ and psychosocial factors³², and worry about work conditions⁹⁸.

Individual characteristics included: age (years), sex, smoking (no/yes), and physical activity during leisure time, i.e., exercising regularly more than once a week (no/yes). Information about level of education (ambulance technician/registered nurse), duration of employment (years) and proportion of total working time spent on emergency call-outs (%) was also achieved.

Health complaints were assessed by seven questions. The response alternatives were never, seldom, sometimes and often. By means of a factor analysis in the form of principal component extraction the questions were grouped together into three areas representing sleeping problems, headache and stomach symptoms. The question with the highest factor loading in each of the three areas was chosen to represent the complaint. This question was dichotomized; never/seldom represented no complaints and sometimes/often represented complaints.

Musculoskeletal disorders were measured by the Standardized Nordic Questionnaire⁹⁹. Since the neck and shoulders function as a unit, we merged the reports of musculoskeletal disorders in these regions. Three different outcomes for neck-shoulder and low-back disorders, respectively, were chosen: 1) musculoskeletal complaints, at least one episode of pain, ache or discomfort during the past 12 months, 2) activity limitation, difficulties in performing activities at work or during leisure time during the past 12 months due to musculoskeletal complaints in the particular region, and 3) sick leave, for at least one day during the past 12 months due to musculoskeletal complaints in the particular region. The response alternatives were yes or no.

Work-related physical demands included questions concerning work postures, movements and material handling documented to be related to disorders in the neck-shoulder and low-back region²⁶. The questions were grouped together into two indices by means of a factor analysis: 1) work in awkward postures including questions about work in three different forward bent and twisted postures, and 2) handling heavy tasks including four questions about frequency of lifting, carrying and pushing. For each area,

the scores of the responses to the questions were added and an average score value was calculated giving a continuous scale varying between 1.0 and 4.0. These indices were used for descriptive statistics and in the univariate logistic regression analyses. Due to significant correlations between these two indices, an index of all seven questions was constructed to be used in the multiple logistic regression analyses; the scores of the responses to the questions were added and an average score value was calculated giving a continuous scale varying between 1.0 and 4.0. A low value represented low physical demands and high value high physical demands.

Work-related psychosocial factors included three indices with measures of psychological demands (five questions) and influence on the work situation, also called decision latitude (six questions), and social support (six questions). For each of the three indices the scores of the responses to the questions were added and an average score value was calculated giving a continuous scale varying between 1.0 and 4.0. A low value represented a positive situation and a high value a negative situation.

Worry about work conditions was assessed by ten questions on worry about physical and psychological demands as well as medical competence, which could be associated with severe emergency situations. The response alternatives were not at all worried, somewhat worried and a lot worried; these were coded at values 1 to 3. The questions were grouped together into different areas by means of a factor analysis in the form of principal component extraction with a varimax rotation using eigenvalues greater than one, giving three areas: 1) worry about being diseased or injured at work including questions about work situations in which the own health could be affected, 2) worry about making mistakes including questions about the own competence and 3) worry about being subjected to threats and/or violence at work including questions on situations during call-outs. The scores of the responses to the questions were added and an average score value was calculated giving a continuous scale varying between 1.0 and 3.0 for each index. These indices were used in the univariate analyses (II). In addition, an index of all ten questions was constructed to be used in the multiple logistic regression analyses (I, II); the scores of the responses to the questions were added and an average score value was calculated giving a continuous scale varying between 1.0 and 3.0. A low value always represented little worry and a high value a lot of worry about work conditions.

Statistical methods

Mean (M) and standard deviation (SD) for parametric, median (Md) and interquartile range for non-parametric (iqr), and prevalence (%) and 95% confidence interval (CI₉₅) for dichotomized data were used for descriptive statistics. Independent samples t-test for parametric and the Mann-Whitney U-test for non-parametric data were used for analyses of differences between two groups, and for differences between more than two groups ANOVA or the Kruskal-Wallis test was used. Chi-square test was used for dichotomized variables.

Logistic regression analyses were performed in order to investigate associations between health outcome measures (sleeping problems, headache and stomach symptoms (I), musculoskeletal complaints, activity limitation and sick leave due to complaints in the neck-shoulder and low-back regions, respectively (II)) and the determinants (work-related physical (II) and psychosocial (I, II) factors and worry about work conditions (I, II)). All analyses were adjusted for potential confounding factors; nurse education, employment years, physical activity and smoking (I and II), and body mass index (BMI, kg x m⁻²) (II).

Study III

This field study assessed physiological and subjective stress markers during a 24-hour work shift and during the next two work-free days (48 hours) (Figure 2) and related these parameters to self-reported health-complaints. In addition, associations with work-related psychological demands and worry about work conditions were studied.

Figure 2. Time schedule for data collection of perceived stress and energy scores (SEQ), salivary cortisol (cortisol) and ECG during a 24-hour work shift and during the next two work-free days (in all 72 hours).

Subjects

Two female and twenty-four male ambulance personnel from a total of three female and 32 male personnel working at a local ambulance station volunteered for this study. No difference regarding age or employment years was found between the personnel who participated and those who did not. The ambulance personnel were categorized into two groups according to number of health complaints. Ambulance personnel reporting three or more of five health complaints (neck-shoulder complaints, low-back complaints, headache, stomach symptoms or sleeping problems) were regarded as having many symptoms (n=12) and the other ambulance personnel (n=14) as having few symptoms. Ambulance personnel with many, in comparison with few, health complaints reported more often psychological demands ($p<0.001$) and tended to be more worried about work conditions ($p=0.052$).

Data collection

Questionnaire

The same questionnaire as in studies I and II was answered and provided information about individual characteristics, sleeping problems, headache and stomach symptoms⁹⁸, musculoskeletal disorder⁹⁹ and exposure to psychological demands³², and worry about work conditions⁹⁸.

Diary

The ambulance personnel noted their meals, coffee breaks, events, time of falling asleep and waking up in a diary. They also noted time, duration, and reason for the emergency call-outs. The diary covered three 24 hour-registrations (72 hours). At the end of the work shift and at the end of the two work-free days, the participants also estimated their average physical and mental demands during the previous 24 hours on a six-point scale (0-5), ranging from "not at all" to "very much".

Stress-Energy

The diary also included the Stress-Energy Questionnaire (SEQ), which describes perceived stress and energy¹⁰⁰. The overall question, which was to be answered by choosing an adjective from a checklist, was “How have you felt during the last ten minutes?”. The checklist includes six adjectives for each dimension of Stress (positive items: rested, relaxed and calm, and negative items: tense, stressed and pressured) and Energy (positive items: active, energetic, and focused, and negative items: dull, inefficient and passive). A six-point scale (0-5) for each item, ranging from “not at all” to “very much”, where high values indicate a high stress and energy level, respectively is used. Stress and Energy scores were calculated as mean ratings of the six items after reversal of the items standing for low stress and energy, respectively. Thereafter, the scores were compared with scale values representing the neutral point of the respective scale¹⁰⁰. For the Stress scale the neutral point (neither stressed nor calm) is 2.4 and for the Energy scale the corresponding value is 2.7¹⁰⁰. The ambulance personnel were instructed to answer the question at four predetermined points during the work shift and during the next two work-free days, coordinated with the cortisol measures (see below).

Salivary cortisol

Saliva samples of cortisol (nmol x l⁻¹) were collected using Salivette (Saarstedt, Nürnberg, Germany) tubes. The ambulance personnel were instructed to collect samples at five predetermined points (19.00 and 21.00 h and at 07.00, 11.00 and 15.00 h) during the work shift and during the next two work-free days. The samples were kept at - 18° C until analyzed (Spectria cortisol RIA) at the University Hospital in Umeå.

Heart rate variability

Heart rate variability was assessed during all three days (72 hours) using a 2-channel ECG recording device (DL700 Holter-recorder, Braemar Inc, Bunnsville, MN). Data was digitized and analyzed off-line in both time- and frequency domains. Mean values of one-hour intervals were calculated and used in subsequent analyses.

Heart rate and blood pressure reactivity

Heart rate (HR) and blood pressure (BP) responses to three tests of autonomic reactivity were recorded by OMRON M4 (OMRON MATSUSAKA Co., Ltd, Matsusaka-City, JAPAN). Ambulance personnel were asked to lie down on a bed in a quiet and dark room and rest for 15 minutes in order to obtain baseline recordings. After baseline recordings, three tests were presented, with rest periods in between (see below). The tests consisted of 1) rising to standing, 2) mental arithmetic (Math): series of additions and subtractions were presented during two minutes and the subjects were instructed to solve as many as possible within the time limit, and 3) hand grip: subjects performed a maximum hand grip with their right hand for five seconds, followed by a calculated 30% grip force for two minutes. The tests reflected different aspects of autonomic nervous system reactivity (cardiovascular regulation, reaction to cognitive efforts and physical exercise reflex) as well as they were easy applicable in conditions of working shift. The test protocol: Rest (15 min), Standing (2 min), Rest (10 min), Math (2 min), Rest (5 min), Hand grip (2 min). Autonomic reactivity was calculated as the difference between values during the tests and baseline values.

Statistical methods

Independent samples t-test or chi square test were used to investigate whether individual characteristics and work-related factors were similar for ambulance personnel with few and many health complaints. Paired samples t-test was used to investigate whether baseline measures and autonomic reactivity were similar pre-work and post-work.

Repeated-measures analysis of covariance was performed separately for the mean values of the stress- and energy scales, the different cortisol values, the baseline values and for the reactivities to the three tests, with Time as within-subject variable, Group (ambulance personnel with few and ambulance personnel with many health complaints) as between-subjects variable and Age as a covariate. HRV was analyzed using repeated measures analysis of covariance with the day when the recordings were

done and the hour of the day as within-subject variables, Group as between-subjects variable and Age as a covariate.

Bivariate correlations between stress- and energy scores, salivary cortisol, worry about work conditions and psychological demands were established with Spearman rank correlation coefficients.

Study IV

This methodological laboratory study investigated the influence of body size (weight) on the relationships between functional performance tests and maximal concentric muscle strength performance.

Subjects

Twenty-one healthy male students aged 20-28 years volunteered to participate in the study.

Data collection

Physical performance tests

Maximal concentric muscle torque of knee and hip extensors (Nm) was measured in a BiodexTM isokinetic dynamometer, at the angular velocity of $60^\circ \times s^{-1}$ (Biodex, New York, USA). The subjects also performed four physical performance tests, which should activate the knee and hip extensors, but should be differently affected by body size: maximal isometric lift (N), one-leg rising (cm), vertical jump (cm) and box lift (ms).

Anthropometric measures

The subjects were weighed in light sports clothing without shoes to the nearest 1 kg.

Statistical methods

In order to investigate the relationship between functional performance and muscle strength adjusted for body weight, as well as the relationship between performance and body weight adjusted for muscle strength, linear regression analyses with functional performance as outcome measure and muscle strength and body weight as determinants were performed.

Study V

This laboratory study investigated development of fatigue during a simulated ambulance work task (carrying a loaded stretcher). It also investigated which tests from a battery of physical performance tests that could best predict development of fatigue during the simulated task. In addition, the effects of height and weight on the development of fatigue were also investigated. The analyses were performed separately for female and male ambulance personnel.

Subjects

From a total staff of 19 female and 68 male ambulance personnel, 17 healthy female and 55 healthy male ambulance personnel volunteered for the study. No difference regarding age or employment years was found between the personnel who volunteered and those who did not. All female and 48 male ambulance personnel completed all tests. The reason for not completing all tests (7 male personnel) was lack of time. The male personnel worked at two ambulance stations in the north of Sweden. As only seven female personnel worked at these two stations, this group was supplemented from adjacent ambulance stations.

Data collection

Questionnaire

Questions about individual characteristics (age, employment years, education, physical activity and smoking), the same as in the questionnaire (I and II) were answered before the tests were performed.

Heart rate, lactate accumulation and perceived exertion

The subjects performed a two-person manual carrying of a stretcher with a total load of 920 N. Subjects were required to walk up and down three flights of stairs (51 steps) two times with a five-minutes rest period in-between. Acute responses to (development of fatigue) carrying the loaded stretcher was evaluated by 1) time $>70\%$ of the individual HR_{peak} ; the time $\geq 70\% HR_{peak}$ was multiplied with the total time (min) of the test in order to adjust for the self-selected pace. 2) Accumulated lactate ($mmol \times l^{-1}$) in capillary blood and 3) perceived exertion according to the (6-20) RPE-scale³⁸. Heart rate was continuously registered by a Polar Sport Tester (Polar Electro OY, Kempele, Finland). The blood sample was taken before and immediately after the task for analyses of blood lactate ($mmol \times l^{-1}$) in an YSI 1500 Sport L-Lactate analyser (YSI Inc, Yellow Springs, Ohio, USA).

Physical performance tests

The selection of physical performance tests was based on video recorded observations of ambulance work, on consultations with experienced personnel within the ambulance staff, and on review of the literature^{76-78,83,84,101}. The test battery included five physical performance tests: 1) maximal oxygen uptake on a cycle ergometer ($l \times min^{-1}$ and $ml \times kg^{-1} \times min^{-1}$), 2) maximal isometric lifting strength (N), 3) isometric back muscle endurance (s), 4) one-leg rising (0-15) and 5) one leg standing balance (s). In addition, maximal concentric isokinetic muscle torque was measured for four muscle groups - knee and shoulder extensors and flexors (Nm) at the

angular velocity of $90^\circ \times s^{-1}$ (BiodexTM isokinetic dynamometer, Biodex, New York, USA).

Anthropometric measures

Height was measured with an accuracy of 1 cm while subjects were standing without shoes. The subjects were weighed in light sports clothing without shoes to the nearest 1 kg. BMI was calculated as body mass per squared body height ($kg \times m^{-2}$).

Statistical methods

Differences regarding individual characteristics between female and male ambulance personnel were statistically tested by t-test, Mann-Whitney test or Chi-square. Linear regression analyses were performed to study which tests could best explain the development of fatigue during carrying the loaded stretcher. The models were adjusted for the effects of height, weight, age, employment years and smoking. Three models were elaborated for predicting time $>70\%$ of HR_{peak} , lactate level and perceived exertion for female and male personnel separately.

RESULTS

Ambulance personnel

Most of the male personnel were ambulance technicians and had been employed for more than 10 years (I, II). Although a higher proportion of the female than of the male personnel were nurses (29% vs 19%), most of the female personnel were also ambulance technicians (I, II). Female personnel were younger and had been employed for a shorter time than the male personnel (Figure 3). Most of the female (71%) and half of the male (48%) ambulance personnel were physically active at least once a week (I, II). Half of the male (53%) and one-fourth of the female (26%) ambulance personnel was classified as overweighted (BMI >25 kg x m⁻¹). Smoking was more common among the female (17%) than among the male (9%) ambulance personnel. Age, height and weight of the ambulance personnel were similar in studies I-III and V (Table 2).

Figure 3. The distribution of number of employment years among female (n=234) and male (n=953) ambulance personnel.

Table 2. Individual characteristics^a of the subjects included in this thesis.

	Studies I and II		Study III		Study IV	Study V	
	Female personnel n=234	Male personnel n=953	Female personnel n=2	Male personnel n=24	Male personnel n=21	Female personnel n=17	Male personnel n=48
Age (years), M (SD)	37 (8)	40 (9)	32 (4)	37 (10)	24 (2)	32 (8)	36 (9)
Employment (years), Md (iqr)	8 (10)	14 (12)	5 (4)	10 (8)	-	5 (4)	12 (9)
Height (cm), M (SD)	169 (6)	181 (6)	-	-	182 (8)	168 (8)	180 (7)
Weight (kg), M (SD)	68 (9)	84 (10)	-	-	80 (10)	69 (7)	84 (12)
Nurse education, %, (CI ₉₅)	29 (25-37)	19 (16-21)	50	46 (24-67)	-	34 (1-61)	35 (21-49)

^aMean (M) and standard deviation (SD), Median (Md) and interquartile range (iqr) or percent (%) and 95% confidence interval (CI₉₅)

Studies I and II

Self-reported health

Significantly more female than male personnel reported headache, neck-shoulder complaints and activity limitation due to neck-shoulder complaints, whereas a higher proportion of the male personnel reported low-back complaints and activity limitation due to low-back complaints (Table 3). Forty percent of the ambulance personnel reported three or more health complaints. Older ambulance personnel reported a higher number of health complaints than their younger co-workers.

External exposure

Self-reported work-related factors were in general equally distributed by female and male ambulance personnel (Table 4). The highest mean score value for physical demands was found for work in awkward posture and for psychosocial factors the highest value was found for psychological demands during emergency call-outs. The prevalence (somewhat/a lot) of worry about work conditions for the single items included in the indices varied between 58-80% (not shown in table).

Table 3. Prevalence^a of health complaints among female (n = 234) and male (n = 953) ambulance personnel.

	Female personnel	Male personnel	p-value ^b
Sleeping problems, sometimes/often, % (CI ₉₅)	29 (24-35)	33 (30-36)	0.150
Headache, sometimes/often, % (CI ₉₅)	48 (42-55)	32 (29-35)	<0.001
Stomach symptoms, sometimes/often, % (CI ₉₅)	24 (18-29)	24 (21-26)	0.500
<i>Neck-shoulder disorder</i>			
Complaints during the past 12 months, % (CI ₉₅)	53 (47-60)	46 (43-49)	0.047
Activity limitation during the past 12 months, % (CI ₉₅)	10 (6-14)	7 (6-9)	0.041
Sick leave during the past 12 months, % (CI ₉₅)	15 (10-19)	12 (10-14)	0.243
<i>Low-back disorder</i>			
Complaints during the past 12 months, % (CI ₉₅)	46 (40-52)	60 (57-63)	<0.001
Activity limitation during the past 12 months, % (CI ₉₅)	11 (7-15)	23 (21-26)	<0.001
Sick leave during the past 12 months, % (CI ₉₅)	14 (10-19)	11 (9-13)	0.139

^aPercent (%) and 95% confidence interval (CI₉₅), ^bChi-square test

Table 4. Descriptive statistics^a of physical demands and psychosocial factors among female (n = 234) and male (n = 953) ambulance personnel.

	Female personnel	Male personnel	p-value ^b
Physical demands (1.0-4.0)			
Work in awkward postures, Md (iqr)	2.5 (1.0)	2.5 (1.0)	0.215
Handling heavy tasks, Md (iqr)	2.0 (0.8)	2.0 (1.0)	0.217
Psychological factors (1.0-4.0)			
Psychological demands (call-outs), Md (iqr)	2.6 (0.6)	2.6 (0.6)	0.645
Psychological demands (station work), Md (iqr)	1.8 (0.8)	1.8 (0.5)	0.345
Decision latitude (call-outs), Md (iqr)	1.7 (0.5)	1.8 (0.5)	0.001
Decision latitude (station work), Md (iqr)	2.1 (0.7)	2.1 (0.7)	0.407
Social support at work (1.0-4.0), Md (iqr)	1.8 (0.8)	1.8 (0.5)	0.719

^a Median (Md) and interquartile range (iqr) ^bMann-Whitney U-test

Relationships between external exposure and health

Physical demands (I) was a significant risk factor of activity limitation due to neck-shoulder and to low-back complaints among the female ambulance personnel; among the male ambulance personnel physical demands was associated with low-back disorders (Table 5). Psychological demands (I, II) was significantly associated with complaints in the neck-shoulder and low-back region as well as sleeping problems, headache and stomach symptoms among the female personnel (Tables 5 and 6). Among the male personnel psychological demands as well as social support were independently associated with both neck-shoulder complaints and activity limitation due to neck-shoulder complaints, activity limitation due to low-back complaints, sleeping problems, headache and stomach symptoms. Adding worry about work conditions to the models (Step 2, Tables 5 and 6) decreased the strength of the ORs of the physical and psychosocial risk factors.

Although female and male personnel were equally worried about work conditions, the combination of female gender and worry about work conditions increased the risk of neck-shoulder complaints (OR 2.6, CI₉₅ 1.7-3.8) more than the combination of worry and male gender (OR 1.8, CI₉₅ 1.3-2.4) (Figure 4). However, the combination of male gender and worry about work conditions increased the risk of sleeping problems (OR 2.0, CI₉₅ 1.4-3.0) more than the combination of worry and female gender (OR 1.5, CI₉₅ 0.8-2.9).

None of the potential modifying factors (nurse education, employment years, physical activity, smoking (I and II), and BMI (II)) were significantly associated with any of the health-related outcomes, neither musculoskeletal complaints, sleeping problems, headache nor stomach symptoms.

Table 5 Associations^{a, b} of the multiple logistic regression analyses between neck-shoulder (N-S C) and low back (L-B C) complaints and activity limitation (Act lim), and work-related factors and worry about work among female (n = 234) and male (n = 953) ambulance personnel.

	Female personnel		Male personnel		Female personnel		Male personnel	
	N-S C	Act lim ^c	N-S C	Act lim ^c	L-B C	Act lim ^d	L-B C	Act lim ^d
<i>Step 1</i>								
Physical demands	1.2 (0.6-2.0)	4.1 (1.4-12)	1.0 (0.7-1.3)	1.3 (0.8-2.0)	1.2 (0.7-2.2)	2.2 (1.4-3.4)	1.4 (1.1-1.8)	1.6 (1.2-2.2)
Psychological demands	2.4 (1.0-5.4)^e	0.7 (0.2-3.3) ^c	1.9 (1.3-2.7)^e	3.5 (1.8-6.7)^e	2.3 (1.1-4.6)^f	1.8 (0.5-6.3) ^f	1.3 (0.9-2.0) ^c	2.2 (1.4-3.4)^e
Social support	1.5 (0.8-2.9)	1.9 (0.7-5.6)	1.6 (1.2-2.1)	1.7 (1.0-2.8)	1.0 (0.5-2.0)	1.7 (0.7-4.3)	1.6 (1.1-2.1)	1.6 (1.2-2.3)
<i>Step 2</i>								
Physical demands	1.0 (0.5-1.8)	2.8 (0.9-8.5)	1.0 (0.7-1.2)	1.2 (0.8-1.9)	1.0 (0.6-1.9)	2.2 (0.8-5.8)	1.4 (1.0-1.8)	1.6 (1.2-2.2)
Psychological demands	2.1 (0.9-5.1) ^c	0.7 (0.1-3.4) ^c	1.7 (1.2-2.5)^e	3.0 (1.5-5.8)^e	2.3 (1.1-4.7)^f	1.2 (0.3-4.7) ^f	1.2 (0.8-1.8) ^c	2.0 (1.3-3.1)^e
Social support	1.5 (0.8-3.0)	2.4 (0.8-7.5)	1.5 (1.1-2.0)	1.6 (0.9-2.6)	1.0 (0.5-2.1)	1.0 (0.4-2.7)	1.4 (1.0-2.0)	1.5 (1.1-2.2)
Worry about work	2.0 (0.8-5.0)	2.0 (0.4-9.8)	1.8 (1.2-2.6)	2.3 (1.2-4.6)	2.0 (0.9-4.7)	5.3 (1.4-10)	2.0 (1.4-3.0)	2.0 (1.2-3.1)

^aOdds ratios (OR) and 95% confidence interval (CI₉₅), ^badjusted for nurse education, age, smoking, physical activity and BMI, ^cactivity limitation due to neck-shoulder complaints, ^dactivity limitation due to low-back complaints, ^eduring call-outs, ^fduring station work

Table 6. Associations^{a, b} of the multiple logistic regression analyses between sleeping problems, headache and stomach symptoms, and work-related risk factors among female (n = 234) and male (n = 953) ambulance personnel.

	Sleeping problems ^c		Headache ^c		Stomach symptoms ^c	
	Female personnel	Male personnel	Female personnel	Male personnel	Female personnel	Male personnel
<i>Step 1</i>						
Psychological demands	2.4 (1.1-5.4)^d	2.2 (1.5-3.2)^d	1.4 (1.0-1.9)^d	1.6 (1.0-2.4)^d	2.4 (1.0-5.8)^d	1.8 (1.2-2.7)^d
Social support		2.1 (1.6-2.9)	1.4 (0.9-2.2)	1.5 (1.1-2.0)		1.6 (1.2-2.2)
<i>Step 2</i>						
Psychological demands	2.0 (0.8-4.7) ^d	1.9 (1.3-2.8)^d	1.4 (0.6-2.9) ^d	1.5 (1.0-2.1)^d	2.0 (0.8-4.9) ^d	1.6 (1.1-2.4)^d
Social support		2.0 (1.4-2.7)	1.8 (0.9-3.1)	1.4 (1.0-1.9)		1.5 (1.1-2.1)
Worry about work	2.1 (1.0-5.2)	2.1 (1.4-3.1)	2.3 (1.0-5.1)	1.7 (1.2-2.6)	2.4 (1.3-4.3)	1.6 (1.0-2.5)

^aOdds ratios (OR) and 95% confidence interval (CI₉₅), ^badjusted for nurse education, years of employment, smoking and physical activity, ^csometimes/often, ^dduring call-outs

Figure 4. The combined effects of worry about work conditions and gender on complaints in the neck-shoulder region (A) and on sleeping problems (B). Results of multiple logistic regression analyses: Odds ratios adjusted for nurse education, age, physical activity, smoking and BMI are shown in the figure.

Study III

Physiological and subjective responses to a 24-hour work shift

The average number of emergency call-outs during the 24 h work shift was 5.0 (range 2-7) and all call-outs, except a bus accident, were due to acute diseases or minor accidents. Diary data showed that all ambulance personnel were able to sleep continuously for more than five hours during the night at work and no differences in number of call-outs, sleep hours, wake up time and self-reported physical and mental demands were found between ambulance personnel with few and those with many health complaints.

Questionnaire data showed that ambulance personnel with many health complaints reported higher psychological demands ($p < 0.001$) and tended to be more worried about work conditions ($p = 0.052$) than ambulance personnel with few health complaints.

Stress-Energy

The stress and energy scores during the 24-hour work shift and during the next two work-free days in comparison with the neutral point of the stress (2.4) and energy (2.7) scales, respectively¹⁰⁰ are shown in Figure 5. The repeated measures analyses of covariance showed a significant change for the energy ($p=0.010$) and a tendency for a change for the stress scores ($p=0.051$) during the work shift, but the stress- and energy scores during the work shift did not differ from the stress scores during the next two work-free days. Ambulance personnel with few and many health complaints reported similar scores.

Figure 5. Average stress and energy scores during the 24-hour work shift and the next two work-free days among ambulance personnel ($n=26$). The dotted lines indicate the neutral points of the stress- and energy scores, respectively.

Salivary cortisol

The repeated measures analyses of covariance showed that cortisol values varied over time ($p=0.027$) with the highest values in the mornings (Figure 6). The tests also showed an interaction between time and group ($p=0.028$). The interaction effect was due to higher cortisol values the morning at work among ambulance personnel with many, in comparison with few health complaints ($p=0.038$). Further, among ambulance personnel with many health complaints significant differences between morning cortisol values during the morning at work and the next two work free mornings were found. There was, however, no differences between work free day 1 and work free day 2 with respect to cortisol levels in ambulance personnel with many complaints.

Figure 6. Average cortisol values during the 24-hour work shift and the next 48 hours among ambulance personnel with many ($n = 12$) and few ($n = 14$) self-reported health complaints.

Spearman correlations showed that worry about work conditions was positively associated with the morning cortisol value during work during work ($r_s=0.59$, $p=0.002$).

Heart rate variability

HRV assessed through low frequency (LF) and high frequency (HF) spectral powers differed significantly between the groups (i.e., few vs many health complaints) (LF $p < 0.001$, HF $p < 0.001$). Subjects with many health complaints showed generally higher LF and lower HF spectral power values with less circadian variation. Significant differences between HRV measures during work and work free days 1 and 2 were found in ambulance personnel with many health complaints. The difference in LF spectral power between the day at work and work free day 1 (figure 7) was significant ($p = 0.025$), as well as the difference between day at work and work free day 2 ($p = 0.038$). The difference in HF spectral power was significant between day at work and work free day 1 ($p = 0.022$) and day at work and work free day 2 ($p = 0.025$). These differences are mostly due to increased LF and decreased HF spectral powers late in the night and in the morning of the work day. There were no differences between work free day 1 and work free day 2 with respect to HRV measures in subjects with many complaints. Subjects with few health complaints did not show significant differences between day at work and work free days with respect to HRV values.

Heart rate and blood pressure reactivity

Paired samples t-test showed that the baseline value of heart rate was higher pre-work compared with post-work among ambulance personnel with few health complaints ($p = 0.043$) and tended to be higher among ambulance personnel with many ($p = 0.060$). The repeated measures analyses of variance showed that autonomic reactivity to standardized tests (rising to standing, mental arithmetic, handgrip) did not differ pre-work compared with post-work. However, repeated measures analyses of covariance showed that subjects with many, compared with subjects with few health complaints, had higher systolic blood pressure reactivity in response to the mental arithmetic test ($p = 0.038$) pre-work as well as post-work.

Figure 7. Low frequency (LF) spectral power during the 24 hours work shift among ambulance personnel with many ($n = 12$) and with few ($n = 14$) health complaints. * indicates the time of day with maximal deviations of LF spectral power between work and leisure time.

Study IV

Body size, muscle strength and physical performance

The influence of body weight on the relationship between physical performance and muscle strength differed with regard to the performance tests. First, maximal isometric lifting strength, a performance test exerted *against an external object*, was significantly correlated with the concentric strength of the knee extensors ($r_p=0.59$, $p<0.01$). However, when this association was adjusted for body weight, neither knee extensor strength nor body weight was significantly associated with lifting strength, although they together were able to explain 43% of the explained variance of the lifting performance ($R^2=0.45$, $p<0.01$). When the same analyses were made for hip extensors, no associations were found between lifting strength and the concentric strength of the hip extensors in the unadjusted analyses, whereas in the adjusted analyses, a significant association was found for body weight, and together hip extensor strength and body weight could explain 43% of the lifting performance ($R^2=0.43$, $p<0.01$). Next, one-leg rising, which is a performance test exerted *against the load of ones own body*, was not associated with concentric strength of the knee or hip extensors. However, when the association between one-leg rising and knee extensors strength was adjusted for body weight, knee extensors strength became positively ($r_p=0.47$, $p<0.05$) and body weight negatively ($r_p=-0.55$, $p<0.01$) associated with one-leg rising performance. Finally, vertical jump and box lift, which both are *fast ballistic movement tests* and tests of *velocity*, were not associated with either knee or hip extensors strength in the univariate or adjusted analyses.

Study V

Acute responses to carrying of a loaded stretcher

Nine of the female (53%) and five (10%) of the male ambulance personnel reached their HR_{peak} during carrying the loaded stretcher. Time $>70\%$ of HR_{peak} , lactate level (Figure 8) and perceived exertion were significantly ($p<0.001$) higher for female (RPE=16.8) than for male ambulance

(RPE=14.0) personnel. No significant difference was found regarding developed fatigue between ambulance personnel ≥ 45 and < 45 years of age, for male or female personnel.

Figure 8. Lactate levels when carrying a loaded stretcher in the stairs among female (n=17) and male (n=48) ambulance personnel.

Physical performance

The female ambulance personnel performed better than their male co-workers in the isometric back endurance and the standing balance tests (Table 7). The male personnel, however, had higher VO₂max and performed better in the isometric lifting strength test. Compared with 34-year old women and men in the general Swedish population¹⁰¹ the female personnel had better balance and the male personnel had higher VO₂max and better balance, but performed lower in isometric back endurance.

Table 7. Mean values of the physical performance tests of the female (n = 17) and male (n = 48) ambulance personnel in study V compared with reference values¹ Significant better performance than that of the female personnel.² Significant better performance than that of the male personnel.³ The reference material is from the study by Barnekow Bergkvist *et al.*¹⁰¹.

Prediction of development of fatigue

In general, test performance could explain more of the developed fatigue for the female than for the male personnel (Table 8). For the female personnel 75% (R²=0.75) of time $> 70\%$ of HR_{peak} could be explained by VO₂max (l x min⁻¹) and maximal concentric shoulder extension strength, and 75% (R²=0.75) of perceived exertion could be explained by one-leg rising,

isometric back endurance and maximal concentric knee flexion strength. For the male personnel the best model was accumulated lactate level including VO_2max ($\text{l} \times \text{min}^{-1}$) and isometric back endurance, which could be explained to 42% ($R^2=0.42$). Height, but not weight, could contribute to the explained variance of developed fatigue, but only among the female personnel. Neither age or employment years, nor smoking did influence development of fatigue in any of the models.

Table 8. Multiple regression models[†] for explaining developed fatigue during carrying a loaded stretcher among female (n=17) and male (n=48) ambulance personnel.

		Model equations ^{††}	R^2 ^{†††}
Female personnel	Time >70% of HR_{peak}	$= 773.859 - 149.037 \cdot \text{VO}_2\text{max} - 2.835 \cdot \text{isokinetic shoulder extension strength}$	0.75
	Accumulated lactate level	$= 22.988 - 5.884 \cdot \text{VO}_2\text{max}$	0.62
		$56.259 - 4.453 \cdot \text{VO}_2\text{max} - 0.222 \cdot \text{height}$	0.77
	Perceived exertion	$= 23.130 - 0.204 \cdot \text{one-leg rising} - 0.006 \cdot \text{isometric back endurance} - 0.053 \cdot \text{isokinetic knee flexion strength}$	0.75
Male personnel	Time >70% of HR_{peak}	$= 237.039 - 0.927 \cdot \text{isometric back endurance}$	0.10
	Accumulated lactate level	$= 13.285 - 1.695 \cdot \text{VO}_2\text{max} - 0.021 \cdot \text{isometric back endurance}$	0.42
	Perceived exertion	$= 19.888 - 1.657 \cdot \text{VO}_2\text{max}$	0.10

[†] according to the regression formula: $Y = a + bX_1 + cX_2$

^{††} all predictors in the models were significant

^{†††} the squared correlation coefficient, adjusted for differences in variance between variables

DISCUSSION

This thesis has a multidisciplinary design. Information about self-reported health and work-related factors and physiological responses to ambulance work – during a 24-hour work shift and during a standardized work simulated task - were combined.

Main findings

Health

The national survey of the Swedish ambulance personnel (I) showed that twenty-five percent of the female and 20% of the male ambulance personnel reported two or more health complaints of sleeping problems, headache and stomach symptoms sometimes or often. A high prevalence of similar health complaints and/or symptoms of posttraumatic stress disorder among ambulance personnel has also been found in earlier studies^{14,17-19,56,102}. It was earlier also reported that MSDs¹⁰⁻¹³ are an occupational problem for ambulance personnel and this was found in this national survey (II) too. Still, among the female personnel, the 12-month prevalence of neck-shoulder and low-back complaints was slightly lower or similar than among 34-year old women in a Swedish population based investigation¹⁰³. The same was also found for neck-shoulder complaints among the male ambulance personnel, but for low-back complaints the prevalence was higher, 60% compared with 41%, than among 34-year old men in Sweden¹⁰³.

A substantial proportion of ambulance personnel reporting musculoskeletal complaints did not report activity limitation or sick leave due to the complaints. This was also found in previous studies on health care personnel⁷ and among 34-year old Swedish women and men¹⁰³. The findings in the national ambulance survey (II) that different work-related factors were associated with pain, ache or discomfort and activity limitation motivate investigations of associations between work-related factors and different outcome measures of MSDs^{7,104-106}. Further, it has been suggested that different interventions for low-back disorders might have differing

effects on pain, ache or discomfort, 'injuries', sickness absence or long-term disability¹⁰⁴⁻¹⁰⁶.

A substantial part of the ambulance personnel who reported musculoskeletal disorders also reported sleeping problems, headache and/or stomach symptoms. Although single health complaints were not associated with increasing age, older ambulance personnel reported a greater number of complaints. This might be an indication of development of ill health with increasing age¹⁰⁷, but this can not be concluded from the design of this survey of ambulance personnel.

Among the female and male ambulance personnel, sleeping problems and stomach symptoms were equally frequent, but a higher proportion of the female personnel reported headache and neck-shoulder complaints, whereas among the male personnel, a higher proportion reported low-back complaints. Earlier studies have found that the prevalence of health complaints including MSDs was higher among women than among men⁵⁴ and Åkerstedt *et al.* found that female gender was a risk factor of sleeping problems in the working population⁵⁵. The different prevalence of MSDs among female and male ambulance personnel could indicate that women and men do different work tasks^{95,96} or that they are differently affected by ambulance work tasks (see below).

Work-related exposure and health effects

The results of the national survey on Swedish ambulance personnel showed that MSDs were associated with physical demands, psychological demands and lack of social support (II) and that the other health complaints were associated with psychological demands and lack of social support (I). Although the self-reported prevalence of physical demands and psychosocial factors were similar among female and male ambulance personnel, the risk association patterns were in part different.

Physical demands

Even though female and male ambulance personnel reported the same frequency of work in awkward postures and handling heavy tasks, physical demands was a significant risk factor of activity limitation due to neck-shoulder complaints only for the female personnel. The reason for this might be that physical demands were investigated in a frequency dimension, and the amplitude of the external exposure was not investigated²⁵, which might lead to an underestimation of the physical demands in terms of internal exposure on the neck-shoulder region among female compared to male ambulance personnel. For example, as the female personnel in general are shorter, loading a patient into the ambulance vehicle will involve lifting the stretcher to or above the shoulder height for most of the female but few of the male ambulance personnel. Further, the fact that ambulance personnel always work in pairs will also result in higher demands in terms of internal exposure in female personnel when carrying the stretcher together since the female personnel will often be the shorter in the pair. A higher internal exposure among the female compared to the male personnel might increase their risk of musculoskeletal disorders⁸⁸ in the neck-shoulder region.

Physical demands was associated with activity limitation due to low-back complaints among both female and male ambulance personnel. Among the female personnel physical demands was the only significant risk factor, whereas among the male personnel, physical demands together with psychological demands and lack of social support (see below) were independently associated. This might indicate that physical demands is not a dominating risk factor of low-back disorders among the male personnel and therefore allowing more than one factor, physical, psychological or social support to contribute in the multiple logistic regression analyses.

Psychosocial factors

Psychological demands was independently associated with most health complaints among both female and male ambulance personnel. This might not be surprising since ambulance work during emergency call-outs can be very mentally and emotionally demanding^{17,19,56,69}. An imbalance between perceived demands from the environment and the individual's perceived

resources to meet those demands³⁴, for example inadequate medical competence, might result in increased experience of psychological demands.

The mean score value of psychological demands among the ambulance personnel in the national survey was, however, lower in comparison with values for physicians, waiters, air traffic controllers, symphony musicians and air craft mechanics¹⁰⁸. One explanation could be that the experience of psychological demands differs between occupations. Since the psychological demands index includes both quantitative and qualitative questions there might be difficulties in interpreting the questions in relation to different jobs. Furthermore, questions on psychologically demanding tasks included in ambulance work, for example questions on accidents involving children, road traffic accidents and violence incidents^{18,56} are not included in the index. Thus, this questionnaire might not fully capture the psychological demands included in ambulance work. Despite this, psychological demands on call-outs yielded the highest mean score of the three psychosocial indices for both female and male ambulance personnel.

Both female and male ambulance personnel reported that they had control over what to do and how to do it and that their work required skill and creativity (*decision latitude*). Thus, decision latitude was not found to be an important risk factor of health complaints among ambulance personnel.

Social support at work is considered to modify stress at work, and to serve as a buffer against health risks under stressful conditions^{33,109}. In a study on nurses working in hospitals it was concluded that social support played a significant role in helping nurses to cope with work-related demands¹¹⁰. Both female and male ambulance personnel in the national survey (I and II) reported that they had supporting colleagues, got on well with their superiors and colleagues, and experienced a positive spirit in the work team. Still, lack of social support was independently associated with several of the health complaints including MSDs among the male personnel.

A majority of the ambulance personnel reported *worry about work conditions*. As the nature of ambulance work includes difficult and dangerous situations, the occurrence of worry about work conditions among ambulance personnel might not be surprising^{56,110,111}. Worry is a common

human experience and may represent constructive problem-solving activity that makes it possible for the individual to cope with certain situations or problems^{112,113}. However, worry may also lead to increased stress and anxiety¹¹⁴. Among the ambulance personnel, worry about work conditions was significantly associated with several health complaints including MSDs, indicating that worry about work conditions among ambulance personnel enhances stress instead of reducing it. Although female and male personnel were equally worried about work conditions, the analyses indicated a gender effect for worry about work. In the interaction analyses the risk of neck-shoulder complaints was higher for worried female than for worried male ambulance personnel (II). On the other hand, the risk of sleeping problems was higher among the worried male personnel, compared to the worried female personnel. These findings suggest that health outcome in ambulance work might be gender related. There are several possible explanations to this. First, biological differences^{115,116} may cause varying vulnerability to different work conditions. Second, conditions outside work, such as family responsibilities, may have an impact, and may be unevenly distributed among women and men^{70,116-118}.

It has been suggested that exposure to repeated traumatic experiences among nurses could contribute to PTSD symptoms such as anxiety¹¹⁰. However, due to the cross sectional design of this study on ambulance personnel, the direction of the observed associations between worry about work conditions and health complaints is uncertain^{119,120}. On the other hand, the construction of the questions, to be worried about a specific work condition, was such that they may reflect a real work situation, that is, ambulance personnel who have to work with unpredictable high physical and psychological demands are at a higher risk to become more worried. Therefore, those situations that the personnel are worried about should be considered when prevention of ill health among ambulance personnel is discussed.

Acute responses

The associations found in the national survey (I, II) between the occupational demands and health complaints gave rise to questions about what impact the physical demands and the psychosocial factors included in ambulance work would have on health-related outcomes. In study III,

physiological and subjective parameters were followed during a 24-hour work-shift and during the next two work-free days. In study V, development of fatigue when carrying a loaded stretcher was evaluated by physiological and subjective parameters.

Physiological and subjective responses to a 24-hour work shift

Overall, the 24-hour work shift was not considered mentally or physically demanding. In addition, the stress and energy scores reported during the 24-hour work shift were low compared to the estimated neutral points¹⁰⁰. A reason for this might be that the work shift was not as demanding as the shifts when big accidents occur and according to the reports, most time during this work shift was spent at the ambulance station. Thus, ambulance personnel possibly relate the stress level to the worst imaginable disaster or other difficult emergency situations, whereas other occupational groups have quite other frames of reference. However, stress and energy scores tended to be higher pre-work compared to during the work shift, and together with the relative increase of HR pre-work, this might indicate a non-specific arousal at the beginning of the work shift. Higher HR pre-work than post-work has been found also among emergency physicians⁴⁰.

Cortisol, measured in saliva, was chosen to represent endocrine response to the ambulance work shift, as this is a commonly accepted and used indicator of stress in different occupational fields^{49,50}. With regard to psychological stress, Härenstam and Theorell found that employees in work sites with many, compared to few, psychosocial problems had higher cortisol levels¹²¹. In the present study on ambulance personnel (III), worry about work conditions, but not psychological demands, was associated with the morning cortisol level during the work shift. Further, ambulance personnel with many health complaints had significantly higher morning cortisol level during work than those with few health complaints. In agreement with this, the cortisol level at 10.00 h was associated with anxiety in a study on rescue workers¹²². Since ambulance personnel with many health complaints tended to be more worried about work conditions, this kind of questions could be a relevant indicator of cognitive stress, linked to physiological response in the body, for example cortisol secretion after awakening^{123,124}.

Testing autonomic function is an important area in clinical neurophysiology and a variety of tests, for example the tests used in this study, have been used for diagnosing a big variety of disorders¹²⁵, and for investigating autonomic reactivity in patients with stress-related ill health^{42,126}. This, together with earlier reports on PTSD and other stress-related complaints among ambulance personnel^{14,17-19,56,102} was the reason why it was considered interesting to investigate whether ambulance work influence autonomic reactivity to standardized tests in the present study (III). The results showed, however, no difference in autonomic activity pre-work compared to post-work, although ambulance personnel with many health complaints had higher systolic blood pressure while responding to the mental arithmetic test.

Differences between ambulance personnel with many and ambulance personnel with few health complaints were also found in monitoring of HRV data. HRV data indicated higher sympathetic and lower parasympathetic activity during late night and early morning hours of the work shift, compared to non-working days among ambulance personnel with many health complaints. According to the diary notes, we do not think that this increase in the sympathetic activity during work can be attributed to altered sleep pattern or to changes in the workload during the night of the work shift. In the group with health complaints the findings of change in morning cortisol values together with HRV suggest an occurrence of increased sympathetic tonic activity. However, higher vascular reactivity and different HRV^{41,44} and cortisol values¹²⁷ in this group might also be age-related.

Rather normal HRV variables and cortisol levels in the days following the working day is a positive finding, since it indicates that work-related physiological effect among the ambulance personnel with many health complaints seems be short lasting. Differences between work-days and nonworkdays in heart rate and systolic blood pressure were found to be more pronounced in female nurses facing high psychological demands⁴⁵. In another study on the general population, differences in cortisol levels in response to awakening between work-days and nonworkdays were found to be associated with worry and chronic work over-load¹²³.

Responses to carrying a loaded stretcher in the stairs

The simulated ambulance work task, *carrying a loaded stretcher in the stairs*, was chosen considering that ambulance personnel are often engaged in transferring patients on stretchers and, when there is no available elevator in apartment houses, ambulance personnel have to carry the stretcher up and/or down the stairs.

In contrast to earlier studies, which evaluated maximal performance of carrying tasks⁸¹⁻⁸⁴, the internal exposure in terms of development of fatigue during carrying the stretcher was evaluated in this study on ambulance personnel by physiological and subjective responses (V). The internal exposure when carrying the loaded stretcher regarding HR, lactate level and perceived exertion, shows that female and male ambulance personnel are exposed to internal exposures at different levels when performing the same work task. Furthermore, the performance near or at maximal capacity when carrying the stretcher the second round indicates that this design might be hazardous¹¹, especially for the female ambulance personnel. The reason for carrying the loaded stretcher two rounds was that this is a frequently used preemployment test at ambulance stations in Sweden. This implies that future investigations should focus on relevance^{128,129} of carrying the stretcher two rounds with full load in a test and how lifting aids could decrease the development of fatigue⁸².

A recent study showed that women who were required to exceed one-third of their aerobic capacity during work were at a higher risk of ill health than women working below one-third⁸⁰. The high internal exposure on the ambulance personnel when carrying heavy loads (V), together with the finding that work-related physical demands was a risk factor of reporting MSDs among ambulance personnel (II), emphasize that it is important to either adapt strenuous ambulance work tasks to the physical capacity of the personnel¹³⁰ and/or improve the individual's physical capacity¹³¹.

Effect modifiers

The high internal exposure on the male, and near or at maximal internal exposure on the female ambulance personnel when carrying the loaded

stretcher, implied the importance to identify what kind of physical capacity is most important for ambulance personnel.

The single most important test for explaining the developed fatigue during carrying the stretcher was $VO_2\text{max}$ ($l \times \text{min}^{-1}$) for both female and male ambulance personnel. In accordance with earlier studies, for review see Rayson *et al.* (2000)⁸³, the absolute $VO_2\text{max}$ ($l \times \text{min}^{-1}$) explained more of developed fatigue than $VO_2\text{max}$ adjusted for body mass ($ml \times \text{kg}^{-1} \times \text{min}^{-1}$). Isometric back endurance was another important test. This test has not been included earlier in work task prediction studies, but since it seems to have a significant prediction value, it should henceforth be considered. For female ambulance personnel one-leg rising and maximal isometric lifting strength were able to explain an additional part of the developed fatigue. Rice and Sharp⁸⁴ also found that isometric lifting strength was a strong predictor of maximal carry performance, especially among female military personnel.

Although other studies on different occupational groups have shown that there is no natural correspondence between work-related metabolic demands and the physical capacity of the individual^{80,132,133}, the ambulance personnel included in this study were supposed to have a high physical capacity since they all had accomplished a heavy preemployment test prior to their employment. The results showed, however, that the female ambulance personnel were not stronger and had not higher aerobic capacity ($VO_2\text{max}$) compared to 34-year old women in the Swedish population based investigation mentioned above¹⁰¹. They had, however, had better balance. The importance of a good balance for firefighters and rescue workers has earlier been recognized¹³⁴⁻¹³⁶. The male ambulance personnel had higher $VO_2\text{max}$ ($l \times \text{min}^{-1}$), but lower endurance in the back muscles compared to 34-year old men in the study¹⁰¹. Taking into consideration these findings, a heavy and strenuous preemployment test alone does not secure that the ambulance personnel have higher physical capacity than women and men in the general population or that they have a level of physical capacity that is relevant for heavy ambulance tasks. Therefore, exercise programs including different aspects of physical capacity (e.g., aerobic capacity, endurance in the back muscles, maximal strength, which have shown to be important predictors of development of fatigue) would be of great value for the individual in order to reduce development of fatigue during work

The influence of body size on the relationships between maximal strength and functional performance was investigated (IV) and the results of this study confirm that the assessment of physical performance could be confounded by the body weight. Therefore, the models for explaining development of fatigue when carrying the loaded stretcher were adjusted for height and weight. Including height in the models significantly increased the explained variance of accumulated lactate among female but not among male personnel - the shorter female personnel developed more lactate than the taller female personnel when carrying the stretcher. As lactate production is related to the amount of working muscles, a big muscle mass will increase the ability to produce anaerobic performance with subsequent smaller relative increases of accumulated lactate. This implies that a taller woman would have an advantage in terms of greater muscle mass, as compared to a shorter woman. Including weight in the models did not influence the explained variance. This is in agreement with earlier studies, which have shown that when performance includes carrying of a heavy external object, the adverse effect of the own body weight has a negligible influence on the total load^{137,138}. They furthermore showed that heavier persons were more able to perform prolonged load-carrying tasks, indicating that a *bigger stature* is more favorable for load-carrying tasks.

Although increasing age is considered a risk of most musculoskeletal disorders⁹⁰, the age of the female and male ambulance personnel was not significantly associated with MSDs (II) or sleeping problems, headache and stomach symptoms (I). The “healthy worker effect” could be a reason for this and is discussed under Methodological issues in this thesis regarding employment time. Ambulance personnel with many health complaints, however, were older than ambulance personnel with few health complaints. This was found in the national survey (I, II) as well as in the field study (III), suggesting that age might be associated with increasing number of symptoms rather than with single symptoms of ill health among ambulance personnel at work¹⁰⁷. Due to the cross-sectional design of the national survey, we can not conclude whether this is due to a higher incidence or a longer duration of the complaints.

Methodological issues

Design

This thesis was based on studies of *cross-sectional designs*, two studies covering associations between work-related factors and sleeping problems, headache, stomach symptoms and MSDs, one methodological study and two studies covering the assessments of acute responses to ambulance work. A disadvantage with a cross-sectional design is that it has not the ability to analyze the development of symptoms and disorders since data concerning both exposure and outcome are collected at the same time⁹⁷. Ideally, prospective studies should be used when the objective is to explain the causal relationships between work-related factors and health. Still, cross-sectional can give valuable information about the association patterns. Another issue of consideration is the risk of healthy workers effect¹³⁹. A healthy workers selection will bias the risk estimate towards the null. Further, if the healthy workers selection differs between women and men, it could result in different risk association patterns for women and men⁹⁵. In the questionnaire survey, female ambulance personnel had shorter employment time, which could indicate that it is more common among female than among male ambulance personnel to leave the employment because of ill health or other work-related factors. However, the raised demand for registered nurses in the ambulance service for the past ten years has increased the number of newly employed female nurses, which contributes to the skewed distribution of employment years among the female personnel.

Representativity

The questionnaire survey (I, II) included a random sample of 1500 from the total of 4000 Swedish ambulance personnel with a participation rate of 79%. The dropout group did not differ regarding geographic distribution in Sweden from those who answered and returned the questionnaire. Together, the randomization, the response rate and drop out analysis strengthen that the national sample can be considered representative for Swedish ambulance personnel in general. Due to practical considerations the subjects in studies III and V were not random samples of ambulance personnel. In study III, 26

from a total of 38 ambulance personnel at a local ambulance station participated in the study, and in study V, 48 male and 17 female from a total of 68 male and 19 female ambulance personnel working at stations in the Northern part of Sweden, completed all tests. Age and employment years did not differ between the personnel who participated and those who did not (III, V). Further, age, height, weight, smoking and physical activity as well as the proportion of call-outs and waiting periods at the station and the prevalence of health complaints did not differ between ambulance personnel in the national survey (I, II) and the local samples (III, V). The ambulance personnel in studies III and V could therefore at least to this extent be considered representative of Swedish ambulance personnel.

As more men (80%) than women (20%) are employed in the ambulance service the national sample was stratified for gender before the randomization in order to secure a sufficient number of female personnel (I, II) and the same proportion of female and male personnel were randomly selected from the ambulance study population. Subsequently, in studies I, II and V all the analyses were performed separately for female and male ambulance personnel. The reason for this was to investigate whether associations between work-related factors and different health-related outcomes are the same among female and male ambulance personnel or not¹⁴⁰. Further, for study populations when the number of participants differs, as in the present study, separate analyses are important. However, the higher number of male participants increases the statistical power and contributes to a higher number of significant associations between work-related factors and health among the male personnel. Thus female and male ambulance personnel should be compared with caution regarding the number of significant associations.

Data collection

The questions included in the questionnaires in studies I, II and III were chosen considering the demands of ambulance work and, if suitable, earlier tested and/or used questionnaires were chosen. Prior to the study, all questions were tested for comprehensibility and relevance as well as for reliability among ambulance personnel. The test-retest reliability of the questions varied between $r_s=0.60-1.00$, except for physical demands where lower values, $r_s=0.49-0.75$, were found. Lower test-retest reliability for the

physical demands implies a lower precision of physical exposure¹⁴¹. Therefore, the interpretation of the significance of the OR for the different work-related factors included in the questionnaire survey should be interpreted with caution - generally few significant associations between physical demands and MSDs, compared to for example associations between psychological demands and MSDs, can at least partly depend on lower test-retest reliability for physical demands. However, as the aim of the study was to investigate general physical demands in a national sample, exposure methods such as observation or direct measures were not feasible.

The Nordic Questionnaire is commonly used for investigating MSDs and evaluations of ergonomic workplace programs and was also used in this study. Reliability and validity for the questionnaire are considered acceptable on group level^{99,142,143} - in this study on ambulance personnel, the test-retest reliability was $r_s=0.85-1.00$. A limitation with the Nordic Questionnaire is that it does not grade intensity of symptoms; still it provides different outcome parameters, of which complaints (pain, ache, discomfort) during the preceding 12 months, activity limitation and sick leave due to the complaints were used to represent different levels of severity.

CONCLUSIONS AND PRACTICAL

IMPLICATIONS

- In general the ambulance personnel reported a positive psychosocial work environment. Still, psychological demands and worry about work conditions were significant risk factors of having disorders in the neck-shoulder and low-back regions, sleeping problems, headache and stomach symptoms.

This indicates the importance of a positive psychosocial work environment in the ambulance service. Those work situations that ambulance personnel worry about, for example the occurrence of threats and violence, indicate important issues for preventive strategies. Thus, a work organization that provides measures for enhancing the management of difficult emergency situations should be encouraged.

- Overall, physiological and subjective stress markers did not show differences between the 24-hour ambulance work shift and leisure time afterwards. However, increased reactivity to the mental test, modest deviation in heart rate variability pattern during the late night hours at work and higher morning cortisol values during work than during leisure time was observed in personnel with many health complaints, but not among their co-workers without or with few complaints.

A better understanding of relationships between these changes in physiological measures and occurrence of health complaints will require further studies on a larger sample of age- and gender matched groups in long-term perspective studies.

- Associations were found between self-reported physical demands and musculoskeletal disorder - among the female personnel physical demands was a significant risk factor of reporting activity limitation due to neck-shoulder complaints. Physical demands was also

associated with activity limitation due to low-back complaints among both female and male ambulance personnel.

Therefore, technical improvements such as the design of ambulance vehicles are needed in order to facilitate physically demanding tasks. For example the height of the ambulances for loading and unloading patients should be lowered in order to reduce the load on the neck-shoulder region among short personnel.

- It is evident that ambulance work includes physically demanding tasks. One-half of the female and 10% of the male ambulance personnel reached their HR_{peak} during carrying the loaded stretcher in the stairs.

This finding further emphasizes the importance of using facilitating lifting equipment as shoulder straps or a harness in order to decrease the physical exposure during carrying a loaded stretcher.

Furthermore, the very high internal exposure on the ambulance personnel when carrying a loaded stretcher up and down the stairs two rounds, indicates that this design of the test might be hazardous for many ambulance personnel. Future investigations should focus on how relevant, in relation to ambulance work, it is to carry the stretcher two rounds with full load in a test.

- Development of fatigue was higher when carrying a loaded stretcher in the stairs among short compared to tall female personnel.

It is therefore important that principles of ergonomics are taken into account by all ambulance personnel, especially when organizing lifting in pairs. When carrying a stretcher in the stairs, for example, the height of the ambulance personnel should be considered – the taller person should carry the rear end when carrying the stretcher in the stairs in order to minimize the load on the shorter person.

- In general, aerobic capacity, and muscular strength and endurance of the ambulance personnel in this study was not higher than among 34-year old women and men in a Swedish population study.

Physical exercise programs designed for the demands of ambulance work could be useful in order to decrease the vulnerability for overstrain when performing heavy tasks. VO_2 max and isometric back endurance were important predictors for development of fatigue when carrying a loaded stretcher. For the women also maximal strength was important. Therefore, exercises aiming at improve these capacities should be included in the training program.

SAMMANFATTNING PÅ SVENSKA

Att arbeta inom svensk ambulanssjukvård – samband mellan arbetets krav och personalens hälsa

Ambulanssjukvården har under de senaste åren befunnit sig i stark utveckling. Allt fler avancerade medicinska undersöknings- och behandlingsmetoder har införts i det dagliga arbetet. Socialstyrelsen har beslutat att från 2005 skall de som administrerar läkemedel inom ambulanssjukvården vara legitimerad personal. Detta har inneburit att fler sjuksköterskor har anställts och att antalet kvinnor inom ambulanssjukvården ökat.

Tidigare undersökningar har visat en hög förekomst av muskuloskelettala och andra kroppsliga symptom som kan sättas i samband med arbetet hos ambulanspersonalen. Det saknades emellertid en samlad bild av den fysiska och psykosociala arbetsbelastningen inom ambulanssjukvården och hur den påverkar personalen. Huvudsyftet med denna avhandling var därför att undersöka sambandet mellan arbetets krav och personalens hälsa med fokus på både fysiska, psykologiska och sociala faktorer.

I den nationella kartläggning år 2000 av arbete och hälsa inom ambulanssjukvården, besvarade 234 kvinnor och 953 män en enkät. Förekomsten av självrapporterade besvär var 53% och 46% i nacke-skuldra och 46% och 60% i ländryggen för kvinnor respektive män. Andelen kvinnor och män som hade sömnsvärigheter, huvudvärk och magbesvär varierade mellan 23% och 48%. Sammanfattningsvis skattade ambulanspersonalen en generellt god psykosocial arbetsmiljö. Höga krav i arbetet var ändå en riskfaktor för såväl besvär i nacke-skuldra och ländrygg som för sömnsvärigheter, huvudvärk och magbesvär både hos kvinnorna och männen. För männen var även bristande socialt stöd en riskfaktor. Oro för att utsättas för hot, drabbas av skada eller för den egna kompetensens otillräcklighet var en signifikant riskfaktor för såväl besvär i nacke-skuldra och ländrygg som sömnsvärigheter, huvudvärk och magbesvär hos både kvinnorna och männen. Dessa samband visar att det är viktigt med en positiv psykosocial arbetsmiljö inom ambulanssjukvården. De

arbetssituationer som personalen upplever mycket svåra eller oroande bör utredas och i möjligaste mån åtgärdas.

Upplevd stress och fysiologiska reaktioner följdes under ett 24 timmars arbetsskift och de nästkommande två arbetsfria dygnet genom upprepade skattningar av upplevd stress och energi, mätningar av stresshormon (kortisol) samt kontinuerlig EKG-registrering. Två kvinnor och 24 män deltog i undersökningen. Dessutom mättes deltagarnas stressreaktivitet före och efter arbetsskiftet. Generellt visade de subjektiva och fysiologiska stressmarkörerna ingen skillnad i belastning under arbetsskiftet jämfört med lediga dagar. Men ambulanspersonal med många symtom på ohälsa hade högre morgonkortisolnivå och ett förändrat hjärtvariabilitetsmönster nattetid under arbetsdygnet jämfört med personal med få symtom. De hade också större blodtrycksförändring vid ett matematiskt test än personal med få symtom samt skattade högre krav och mer oro över arbetsuppgifter.

Många arbetssituationer inom ambulanssjukvården ställer höga fysiska krav på personalen. För både kvinnorna och männen var fysisk belastning en riskfaktor för ländryggsbesvär. För kvinnorna var fysisk belastning även en riskfaktor för nack-skulderbesvär. Detta kan ha samband med deras kortare längd och mindre muskelstyrka och därför bör sådana arbetssituationer som är mer belastande för kortare personal i möjligaste mån åtgärdas, tex höjden vid lastning i och ur ambulanser.

Utveckling av trötthet under arbetsbelastning undersöktes genom registrering av hjärtfrekvens, mjölksyranivå och skattad ansträngning under bårbärning i trappa. Sjutton kvinnor och 48 män deltog i undersökningen. De bar en 92 kg tung bår tre trappor upp och ned, två gånger med en fem minuters paus emellan. Den höga arbetsbelastningen innebar arbete på eller nära maximal hjärtfrekvens för 53% av kvinnorna och 10% av männen, höga mjölksyranivåer i blodet och högt skattad ansträngning och pekade på vikten av att undersöka vilken typ av fysisk kapacitet som bäst kan förklara belastningen. Samma försökspersoner fick därför genomföra ett testbatteri bestående av maximal syreupptagningsförmåga, maximala styrke- och uthållighets- och koordinationstester. Resultaten visade att ambulanspersonal med hög maximal syreupptagningsförmåga och med uthålliga

ryggmuskler inte blev lika trötta under bårbärning som de med en lägre kapacitet. För kvinnorna var även maximal styrka viktig för prestationen.

Eftersom längd och vikt kan ha betydelse för hur mycket kraft man kan prestera i en viss situation studerades även sambandet mellan funktionella test av fysisk kapacitet, maximal styrka och kroppsstorlek. Resultaten visade att sambandet mellan styrka och funktionella test påverkas av den egna kroppsvikten – en storvuxen individs styrka kan tex överskattas i tester där man lyfter eller bär en tung börda om man inte justerar sambandet för kroppsstorlek. Därför undersöktes kroppslängdens och viktens betydelse för arbetsbelastningen under bårbärning i trappa. Hos männen kunde varken längd eller vikt ytterligare förklara utvecklingen av trötthet, men hos kvinnorna bidrog längden till att förklara utvecklingen av trötthet, vilket innebar mindre trötthet för längre kvinnor.

Det är därför viktigt att all personal på ambulansstationerna tar hänsyn till ergonomiska principer då man arbetar i par. Vid bårbärning i trappa är det tex viktigt att den längre personen bär fotändan och den kortare huvudändan av båren för att på så sätt minska skillnaden i belastning mellan den längre och den kortare personen. Det är också viktigt att öka användandet av lyft- och bärhjälpmedel genom att utvärdera användbarheten av befintliga hjälpmedel och utveckla nya.

Då aerob kapacitet, muskulär styrka och uthållighet hos ambulanspersonalen inte var högre än hos 34-åriga svenskar i allmänhet, skulle regelbunden träning av fysisk kapacitet kunna minska risken för överbelastning vid tunga lyft. Eftersom aerob kapacitet, uthållighet i ryggmusklerna och maximal styrka hade stor betydelse för utveckling av trötthet under bårbärningen, bör träningsprogram för ambulanspersonal innehålla övningar för att öka dessa kapaciteter.

Framtida studier bör vara prospektiva och inkludera åldersmatchade grupper av både kvinnor och män för att en större kunskap om sambanden mellan arbetets krav och personalens hälsa ska kunna erhållas.

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**Teori är när man vet allting
men ingenting fungerar.
Praktik är när allt fungerar
men ingen vet varför.
I vår familj är teori och praktik förenade.
Allting fungerar men ingen vet varför.**

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REFERENCES

1. Gårdelöf B. Snabb utveckling av de nya ambulanserna. Från akuta sjuktransporter till mobil akutsjukvård. *Läkartidningen*. 1998;1-2:6-9.
2. Suserud BO. Emergency nursing in Sweden. *Emerg Nurse*. 2001;9:10-13.
3. Alexopoulos EC, Burdorf A, Kalokerinou A. Risk factors for musculoskeletal disorders among nursing personnel in Greek hospitals. *Int Arch Occup Environ Health*. 2003;76:289-294.
4. Josephson M, Lagerstrom M, Hagberg M, Wigaeus Hjelm E. Musculoskeletal symptoms and job strain among nursing personnel: a study over a three year period. *Occup Environ Med*. 1997;54:681-685.
5. Lagerstrom M, Hansson T, Hagberg M. Work-related low-back problems in nursing. *Scand J Work Environ Health*. 1998;24:449-464.
6. Lagerstrom M, Wenemark M, Hagberg M, Hjelm EW. Occupational and individual factors related to musculoskeletal symptoms in five body regions among Swedish nursing personnel. *Int Arch Occup Environ Health*. 1995;68:27-35.
7. Trinkoff AM, Lipscomb JA, Geiger-Brown J, Brady B. Musculoskeletal problems of the neck, shoulder, and back and functional consequences in nurses. *Am J Ind Med*. 2002;41:170-178.
8. Edell-Gustafsson UM, Kritz EI, Bogren IK. Self-reported sleep quality, strain and health in relation to perceived working conditions in females. *Scand J Caring Sci*. 2002;16:179-187.
9. Trinkoff AM, Storr CL, Lipscomb JA. Physically demanding work and inadequate sleep, pain medication use, and absenteeism in registered nurses. *J Occup Environ Med*. 2001;43:355-363.
10. Hedlin M, Petersson G, Arbetarskyddsstyrelsen. *Kartläggning av ambulanspersonalens arbetsmiljö*. Solna: Arbetarskyddsstyrelsen; 1998.
11. Hoga PT, Ellis L. Evaluation of the injury profile of personnel in a busy urban EMS system. *Am J Emerg Med*. 1990;8:308-311.
12. Pattani S, Constantinovici N, Williams S. Who retires early from the NHS because of ill health and what does it cost? A national cross sectional study. *BMJ*. 2001;322:208-209.

13. Rodgers LM. A five year study comparing early retirements on medical grounds in ambulance personnel with those in other groups of health service staff. Part II: Causes of retirements. *Occup Med.* 1998;48:119-132.
14. Alexander DA, Klein S. Ambulance personnel and critical incidents: impact of accident and emergency work on mental health and emotional well-being. *Br J Psychiatry.* 2001;178:76-81.
15. Bledsoe BE. Critical incident stress management (CISM): benefit or risk for emergency services? *Prehosp Emerg Care.* 2003;7:272-279.
16. Jonsson A, Segesten K. Daily stress and concept of self in Swedish ambulance personnel. *Prehospital Disaster Med.* 2004;19:226-234.
17. Jonsson A, Segesten K, Mattsson B. Post-traumatic stress among Swedish ambulance personnel. *Emerg Med J.* 2003;20:79-84.
18. Thompson J, Suzuki I. Stress in ambulance workers. *Disaster Management.* 1991;3:193-197.
19. van der Ploeg E, Kleber RJ. Acute and chronic job stressors among ambulance personnel: predictors of health symptoms. *Occup Environ Med.* 2003;60 (Suppl 1):40-46.
20. Armstrong TJ, Buckle P, Fine LJ, et al. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. *Scand J Work Environ Health.* 1993;19:73-84.
21. Frankenhaeuser M. A biopsychosocial approach to work life issues. *Int J Health Serv.* 1989;19:747-758.
22. McEwen B. Stress, adaptation and disease: Allostasis and allostatic load. *Ann N Y Acad Sci.* 1998;840:33-44.
23. Ursin H. The psychology in psychoneuroendocrinology. *Psychoneuroendocrinology.* 1998;23:555-570.
24. van der Beek AJ, Frings-Dresen MH. Assessment of mechanical exposure in ergonomic epidemiology. *Occup Environ Med.* 1998;55:291-299.
25. Winkel J, Mathiassen SE. Assessment of physical work load in epidemiologic studies: concepts, issues and operational considerations. *Ergonomics.* 1994;37:979-988.
26. Bernard BP, United States. Department of Health and Human Services. Public Health Service. Centers for Disease Control and Prevention. National Institute for Occupational Safety and Health. *Musculoskeletal disorders and workplace factors: a critical review of epidemiological evidence for work-related musculoskeletal*

- disorders of the neck, upper extremity, and low back*. Cincinnati, OH: NIOSH; 1997.
27. Selye H. *The stress of life*. New York: McGraw-Hill; 1956
 28. Ursin H, Knardahl S. Personality factors, neuroendocrine response patterns, and cardiovascular pathology. In: Orlebeke J, Mulder G, Van Doornen L, eds. *Psychophysiology of cardiovascular control*. New York: Plenum Press; 1985:715-731.
 29. Frankenhaeuser M. A biopsychosocial approach to work life issues. In: Johnson J, Johansson H, eds. *Work organization, democratization and health*. Baltimore, MD: Baywood Publications; 1991.
 30. Melin B, Lundberg U. A biopsychosocial approach to work-stress and musculoskeletal disorders. *J Psychophysiol*. 1997;238-247.
 31. Karasek R. Job demands, job decision latitude, and mental strain: Implications for job redesign. *Adm Sci Q*. 1979;285-307.
 32. Karasek R, Theorell T. *Healthy work: stress, productivity, and the reconstruction of working life*. New York, N.Y.: Basic Books; 1990.
 33. Johnson JV, Hall EM. Job strain, work place social support, and cardiovascular disease: a cross-sectional study of a random sample of the Swedish working population. *Am J Public Health*. 1988;78:1336-1342.
 34. Frankenhaeuser M, Lundberg U, Fredrikson M, et al. Stress on and off the job as related to sex and occupational status in white-collar workers. *J Org Beh*. 1989;10:321-346.
 35. Blair S, Djupsjöbacka M, Johansson H, et al. Neuromuscular mechanisms behind chronic work-related myalgias: An overview. In: Johansson H, Windhorst U, Djupsjöbacka M, Passatore M, eds. *Chronic work-related myalgia. Neuromuscular mechanisms behind work-related chronic muscle pain syndromes*. Gävle: Gävle University Press; 2003.
 36. Punnett L, Gold J. Work-related upper extremity disorders: epidemiologic findings and unresolved questions. In: Johansson H, Windhorst U, Djupsjöbacka M, Passatore M, eds. *Chronic work-related myalgia: neuromuscular mechanisms behind work-related chronic muscle pain syndromes*. Gävle: Gävle Univ. Press; 2003.
 37. Åstrand P-O. *Textbook of work physiology: physiological bases of exercise*. 4. edn. Champaign, IL: Human Kinetics; 2003.
 38. Borg G. *Borg's Perceived exertion and pain scales*. Champaign, Ill.: Human Kinetics; 1998.

39. Heart rate variability: standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation*. 1996;93:1043-1065.
40. Adams SL, Roxe DM, Weiss J, Zhang F, Rosenthal JE. Ambulatory blood pressure and Holter monitoring of emergency physicians before, during, and after a night shift. *Acad Emerg Med*. 1998;5:871-877.
41. Cacioppo JT, Burlinson MH, Poehlmann KM, et al. Autonomic and neuroendocrine responses to mild psychological stressors: effects of chronic stress on older women. *Ann Behav Med*. 2000;22:140-148.
42. De Vente W, Olf M, Van Amsterdam J, Kamhuis J, Emmelkamp P. Physiological differences between burnout patients and healthy controls: blood pressure, heart rate, and cortisol responses. *Occup Environ Med*. 2003;60:54-61.
43. Evans O, Steptoe A. Social support at work, heart rate, and cortisol: A self-monitoring study. *J Occup Health Psychol*. 2001;6:361-370.
44. Fluckiger L, Boivin JM, Quilliot D, Jeandel C, Zannad F. Differential effects of aging on heart rate variability and blood pressure variability. *J Gerontol A Biol Sci Med Sci*. 1999;54:219-224.
45. Goldstein IB, Shapiro D, Chicz-DeMet A, Guthrie D. Ambulatory blood pressure, heart rate, and neuroendocrine responses in women nurses during work and off work days. *Psychosom Med*. 1999;61:387-396.
46. Steptoe A, Roy M, Evans P. Psychosocial influences on ambulatory blood pressure over working and nonworking days. *J Psychophy*. 1996;10:218-227.
47. Lehmann M, Dorges V, Huber G, Zollner G, Spori U, Keul J. [Behavior of free catecholamines in blood and urine of ambulance men and physicians during quick responses]. *Int Arch Occup Environ Health*. 1983;51:209-222.
48. Lim CS, Ong CN, Phoon WO. Work stress of firemen as measured by heart rate and catecholamine. *J Hum Ergol (Tokyo)*. 1987;16:209-218.
49. Sluiter JK, van der Beek AJ, Frings-Dresen MH. The influence of work characteristics on the need for recovery and experienced health: a study on coach drivers. *Ergonomics*. 1999;42:573-583.

50. Sluiter JK, van der Beek AJ, Frings-Dresen MH. Medical staff in emergency situations: severity of patient status predicts stress hormone reactivity and recovery. *Occup Environ Med.* 2003;60:373-375.
51. Lundberg U, Dohms IE, Melin B, et al. Psychophysiological stress responses, muscle tension, and neck and shoulder pain among supermarket cashiers. *J Occup Health Psychol.* 1999;4:245-255.
52. Rissén D, Melin B, Sandsjö L, Lundberg U. Surface EMG and psychophysiological stress reactions among female employees at supermarkets. *Europ J Applied Physiol.* 2000;83:215-222.
53. Eriksen HR, Ihlebaek C, Ursin H. A scoring system for subjective health complaints (SHC). *Scand J Public Health.* 1999;27:63-72.
54. Ihlebaek C, Eriksen HR, Ursin H. Prevalence of subjective health complaints (SHC) in Norway. *Scand J Public Health.* 2002;30:20-29.
55. Akerstedt T, Knutsson A, Westerholm P, Theorell T, Alfredsson L, Kecklund G. Sleep disturbances, work stress and work hours: a cross-sectional study. *J Psychosom Res.* 2002;53:741-748.
56. Clohessy S, Ehlers A. PTSD symptoms, response to intrusive memories and coping in ambulance service workers. *Br J Clin Psychol.* 1999;38:251-265.
57. Buckle PW, Devereux JJ. The nature of work-related neck and upper limb musculoskeletal disorders. *Appl Ergon.* 2002;33:207-217.
58. Waddell G. *The back pain revolution.* Edinburgh: Churchill Livingstone; 1998.
59. Buckle P, Devereux J, Europeiska arbetsmiljöbyrån. *Work-related neck and upper limb musculoskeletal disorders.* Bilbao Luxembourg: European Agency for Safety and Health at Work; Office for Official Publications of the European Communities; 1999.
60. Ariens GA, van Mechelen W, Bongers PM, Bouter LM, van der Wal G. Psychosocial risk factors for neck pain: a systematic review. *Am J Ind Med.* 2001;39:180-193.
61. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Systematic review of psychosocial factors at work and private life as risk factors for back pain. *Spine.* 2000;25:2114-2125.
62. Johansson H, Arendt-Nilsson L, Bergenheim M, et al. Epilogue: An integrated model for chronic work-related myalgia "Brussels Model". In: Johansson H, Windhorst U, Djupsjobacka M, Passatore M, eds. *Chronic work-related myalgia: Neuromuscular mechanisms*

behind work-related chronic muscle pain syndromes. Gävle: Gävle University Press; 2003.

63. World Health Organization (WHO). *International classification of functioning, disability and health (ICF)*. Geneva: World Health Organization; 2001
64. McMahon. *Muscles, reflexes and locomotion*. Princetown, NJ: Princeton University Press; 1984.
65. Gamble RP, Stevens AB, McBrien H, Black A, Cran GW, Boreham CA. Physical fitness and occupational demands of the Belfast ambulance service. *Br J Ind Med*. 1991;48:592-596.
66. Doormaal MT, Driessen AP, Landeweerd JA, Drost MR. Physical workload of ambulance assistants. *Ergonomics*. 1995;38:361-376.
67. Lavender SA, Conrad KM, Reichelt PA, Johnson PW, Meyer FT. Biomechanical analyses of paramedics simulating frequently performed strenuous work tasks. *Appl Ergon*. 2000;31:167-177.
68. Lavender SA, Conrad KM, Reichelt PA, Meyer FT, Johnson PW. Postural analysis of paramedics simulating frequently performed strenuous work tasks. *Appl Ergon*. 2000;31:45-57.
69. Neale AV. Work stress in emergency medical technicians. *J Occup Med*. 1991;33:991-997.
70. Lundberg U. Psychophysiology of work: stress, gender, endocrine response, and work-related upper extremity disorders. *Am J Ind Med*. 2002;41:383-392.
71. Engels JA, van der Gulden JW, Senden TF, van't Hof B. Work related risk factors for musculoskeletal complaints in the nursing profession: results of a questionnaire survey. *Occup Environ Med*. 1996;53:636-641.
72. Trinkoff AM, Lipscomb JA, Geiger-Brown J, Storr CL, Brady BA. Perceived physical demands and reported musculoskeletal problems in registered nurses. *Am J Prev Med*. 2003;24:270-275.
73. Engkvist IL, Hagberg M, Hjelm EW, Menckel E, Ekenvall L. The accident process preceding overexertion back injuries in nursing personnel. PROSA study group. *Scand J Work Environ Health*. 1998;24:367-375.
74. Smith DR, Wei N, Zhao L, Wang RS. Musculoskeletal complaints and psychosocial risk factors among Chinese hospital nurses. *Occup Med*. 2004;54:579-582.
75. Violante FS, Fiori M, Fiorentini C, et al. Associations of psychosocial and individual factors with three different categories of

- back disorder among nursing staff. *J Occup Health*. 2004;46:100-108.
76. Bergkvist M, Rahm M, Hedberg G, Arbetsmiljööinstitutet. *Utvärdering av test för bedömning av styrka, rörlighet och koordination*. Solna: Arbetsmiljööinstitutet; 1992.
 77. Bernauer EM, Bonanno J. Development of physical profiles for specific jobs. *J Occup Med*. 1975;17:27-33.
 78. Hogan J. Structure of physical performance in occupational tasks. *J Appl Psychol*. 1991;76:495-507.
 79. Pransky GS, Dempsey PG. Practical aspects of functional capacity evaluations. *J Occup Rehabil*. 2004;14:217-229.
 80. Karlqvist L, Leijon O, Harenstam A. Physical demands in working life and individual physical capacity. *Eur J Appl Physiol*. 2003;89:536-547.
 81. Knapik JJ, Harper W, Crowell HP. Physiological factors in stretcher carriage performance. *Eur J Appl Physiol Occup Physiol*. 1999;79:409-413.
 82. Knapik JJ, Harper W, Crowell HP, Leiter K, Mull B. Standard and alternative methods of stretcher carriage: performance, human factors, and cardiorespiratory responses. *Ergonomics*. 2000;43:639-652.
 83. Rayson M, Holliman D, Belyavin A. Development of physical selection procedures for the British Army. Phase 2: relationship between physical performance tests and criterion tasks. *Ergonomics*. 2000;43:73-105.
 84. Rice V, Sharp M. Prediction of performance on two stretcher-carry tasks. *Work*. 1994;4:201-210.
 85. Stevenson JM, Bryant JT, Andrew GM, et al. Development of physical fitness standards for Canadian Armed Forces younger personnel. *Can J Sport Sci*. 1992;17:214-221.
 86. Stevenson JM, Deakin JM, Andrew GM, Bryant JT, Smith JT, Thomson JM. Development of physical fitness standards for Canadian Armed Forces older personnel. *Can J Appl Physiol*. 1994;19:75-90.
 87. Chaffin DB, Herrin GD, Keyserling WM. Preemployment strength testing: an updated position. *J Occup Med*. 1978;20:403-408.
 88. Reimer DS, Halbrook BD, Dreyfuss PH, Tibiletti C. A novel approach to preemployment worker fitness evaluations in a material-handling industry. *Spine*. 1994;19:2026-2032.

89. Arbetsmiljöverket (1998) Sifferfakta om belastningsergonomi, arbetsrelaterade besvär och anmälda belastningsskador.
90. Kilbom s, Armstrong T, Buckle P, et al. Musculoskeletal Disorders: Work-related Risk Factors and Prevention. *Int J Occup Environ Health*. 1996;2:239-246.
91. Rodgers LM. A five-year study comparing early retirements on medical grounds in ambulance personnel with those in other groups of health service staff. Part I: Incidences of retirements. *Occup Med*). 1998;48:7-16.
92. Wood I, Davies S. Beyond the department's doors: pre-hospital emergency care. *Accid Emerg Nurs*. 1994;2:149-154.
93. Socialstyrelsen. *Medicinsk kompetens i ambulansalarmering*. Stockholm: Socialstyr.; 2002.
94. de Zwart BC, Frings-Dresen MH, Kilbom A. Gender differences in upper extremity musculoskeletal complaints in the working population. *Int Arch Occup Environ Health*. 2001;74:21-30.
95. Kennedy SM, Koehoorn M. Exposure assessment in epidemiology: does gender matter? *Am J Ind Med*. 2003;44:576-583.
96. Messing K, Punnett L, Bond M, et al. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med*. 2003;43:618-629.
97. Kuorinka I, Forcier L, Hagberg M. *Work related musculoskeletal disorders (WMSDs): a reference book for prevention*. London: Taylor & Francis; 1995.
98. Brulin C, Gerdle B, Granlund B, Hoog J, Knutson A, Sundelin G. Physical and psychosocial work-related risk factors associated with musculoskeletal symptoms among home care personnel. *Scand J Caring Sci*. 1998;12:104-110.
99. Kuorinka IA, Jonsson B, Å K. Standard Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergonomics*. 1987;233-237.
100. Kjellberg A, Wadman C, Arbetslivsinstitutet. *Subjektiv stress och dess samband med psykosociala förhållanden och besvär: en prövning av stress-energi-modellen*. Solna: Arbetslivsinstitutet; 2002.
101. Barnekow-Bergkvist M, Hedberg G, Janlert U, Jansson E. Development of muscular endurance and strength from adolescence to adulthood and level of physical capacity in men and women at the age of 34 years. *Scand J Med Sci Sports*. 1996;6:145-155.

102. Boudreaux E, Mandry C. Sources of stress among emergency medical technicians (Part I): What does the research say? *Prehospital Disaster Med.* 1996;11:296-301.
103. Barnekow-Bergkvist M, Hedberg GE, Janlert U, Jansson E. Determinants of self-reported neck-shoulder and low back symptoms in a general population. *Spine.* 1998;23:235-243.
104. Frank JW, Brooker AS, DeMaio SE, et al. Disability resulting from occupational low back pain. Part II: What do we know about secondary prevention? A review of the scientific evidence on prevention after disability begins. *Spine.* 1996;21:2918-2929.
105. Frank JW, Kerr MS, Brooker AS, et al. Disability resulting from occupational low back pain. Part I: What do we know about primary prevention? A review of the scientific evidence on prevention before disability begins. *Spine.* 1996;21:2908-2917.
106. Waddell G, Burton AK. Occupational health guidelines for the management of low back pain at work: evidence review. *Occup Med.* 2001;51:124-135.
107. Croft P, Rigby AS, Boswell R, Schollum J, Silman A. The prevalence of chronic widespread pain in the general population. *J Rheumatol.* 1993;20:710-713.
108. Theorell T, Ahlberg-Hulten G, Sigala F, Perski A, Söderholm M. A psychosocial and biomedical comparison between men in six contrasting service occupations. *Work and Stress.* 1990;4:51-63.
109. Lundberg U, Frankenhaeuser M. Stress and workload of men and women in high-ranking positions. *J Occup Health Psychol.* 1999;4:142-151.
110. Kerasiotis B, Motta RW. Assessment of PTSD symptoms in emergency room, intensive care unit, and general floor nurses. *Int J Emerg Ment Health.* 2004;6:121-133.
111. Jonsson A, Segesten K. Guilt, shame and need for a container: a study of post-traumatic stress among ambulance personnel. *Accid Emerg Nurs.* 2004;12:215-223.
112. Davey G, Tallis F, Capuzzo N. Beliefs about the consequences of worrying. *Cogn Ther Res.* 1996:499-520.
113. Davey G, Tallis F, Capuzzo N. Trait factors and ratings of controllability as predictors of worrying about significant life stressors. *Pers Indivi Diff.* 1994:379-384.

114. Belzer K, D'Zurilla T, Maydeu-Olivares A. Social problem solving and trait anxiety as predictors of worry in a college student population. *Pers Indivi Diff.* 2002;573-585.
115. Karlqvist L. The importance of gender sensitive studies of work-related neck and upper limb disorders. In: Bildt C, Karlqvist L, eds. *Women's health in working life*. Stockholm: National Institute for Working Life; 2001.
116. Lagerlöf E, Menckel E (2001) Gender approaches in the EU Network; Workplace Health Promotion. In: *Women's health in working life* (ed. Bildt C, Karlqvist L), Vol. 2001:17. National Institute for Working Life, Stockholm.
117. Rollman GB, Lautenbacher S. Sex differences in musculoskeletal pain. *Clin J Pain.* 2001;17:20-24.
118. Vroman K, MacRae N. Non-work factors associated with musculoskeletal upper extremity disorders in women: Beyond the work environment. *Work.* 2001;17:3-179.
119. Ohlsson K, Attewell RG, Palsson B, et al. Repetitive industrial work and neck and upper limb disorders in females. *Am J Ind Med.* 1995;27:731-747.
120. Ohlsson K, Hansson GA, Balogh I, et al. Disorders of the neck and upper limbs in women in the fish processing industry. *Occup Environ Med.* 1994;51:826-832.
121. Harenstam A, Theorell T. Cortisol elevation and serum gamma-glutamyl transpeptidase in response to adverse job conditions: how are they interrelated? *Biol Psychol.* 1990;31:157-171.
122. Aardal-Eriksson E, Eriksson TE, Holm AC, Lundin T. Salivary cortisol and serum prolactin in relation to stress rating scales in a group of rescue workers. *Biol Psychiatry.* 1999;46:850-855.
123. Schlotz W, Hellhammer J, Schulz P, Stone A. Perceived work overload and chronic worrying predict weekend-weekday differences in the cortisol awakening response. *Psychosom Med.* 2004;207-214.
124. Schulz P, Kirschbaum C, Prussner J, Hellhammer D. Increased free cortisol secretion after awakening in chronically stressed individuals due to work overload. *Stress Medicine.* 1998:91-97.
125. Ravits JM. AAEM minimonograph #48: autonomic nervous system testing. *Muscle Nerve.* 1997;20:919-937.
126. LaManca JJ, Peckerman A, Sisto SA, DeLuca J, Cook S, Natelson BH. Cardiovascular responses of women with chronic fatigue

- syndrome to stressful cognitive testing before and after strenuous exercise. *Psychosom Med.* 2001;63:756-764.
127. Deane R. Differences in urinary stress hormones in male and female nurses at different ages. *J Adv Nurs* 2002;37:304-310.
 128. Innes E, Straker L. Validity of work-related assessments. *Work.* 1999;13:125-152.
 129. Sothmann MS, Gebhardt DL, Baker TA, Kastello GM, Sheppard VA. Performance requirements of physically strenuous occupations: validating minimum standards for muscular strength and endurance. *Ergonomics.* 2004;47:864-875.
 130. Ferreira J, Hignett S. Reviewing ambulance design for clinical efficiency and paramedic safety. *Appl Ergon.* 2005;36:97-105.
 131. von Restorff W. Physical fitness of young women: carrying simulated patients. *Ergonomics.* 2000;43:728-743.
 132. Nygard CH, Luopajarvi T, Cedercrutz G, Ilmarinen J. Musculoskeletal capacity of employees aged 44 to 58 years in physical, mental and mixed types of work. *Eur J Appl Physiol Occup Physiol.* 1987;56:555-561.
 133. Schibye B, Sogaard K, Martinsen D, Klausen K. Mechanical load on the low back and shoulders during pushing and pulling of two-wheeled waste containers compared with lifting and carrying of bags and bins. *Clin Biomech (Bristol, Avon).* 2001;16:549-559.
 134. Lusa S. *Job demands and assessment of the physical work capacity of fire fighters.* Jyväskylä: Univ.; 1994.
 135. Punakallio A, Lusa S, Luukkonen R. Functional, postural and perceived balance for predicting the work ability of firefighters. *Int Arch Occup Environ Health.* 2004;77:482-490.
 136. Williford HN, Duey WJ, Olson MS, Howard R, Wang N. Relationship between fire fighting suppression tasks and physical fitness. *Ergonomics.* 1999;42:1179-1186.
 137. Bilzon JL, Allsopp AJ, Tipton MJ. Assessment of physical fitness for occupations encompassing load-carriage tasks. *Occup Med.* 2001;51:357-561.
 138. Louhevaara V, Smolander J, Korhonen O, Tuomi T. Maximal working times with a self-contained breathing apparatus. *Ergonomics.* 1986;29:77-85.
 139. Eisen EA, Holcroft CA, Greaves IA, Wegman DH, Woskie SR, Monson RR. A strategy to reduce healthy worker effect in a cross-

- sectional study of asthma and metalworking fluids. *Am J Ind Med.* 1997;31:671-677.
140. Messing K, Kilbom Å. Towards a gender-sensitive research perspective. In: Kilbom Å, Messing K, Bildt Thorbjörnsson C, eds. *Women's health at work*. Solna: National Institute for Working Life (Arbetslivsinstitutet); 1998.
 141. Montgomery DC. *Design and analysis of experiments*. 4. edn. New York: Wiley; 1997.
 142. Baron S, Hales T, Hurrell J. Evaluation of symptom surveys for occupational musculoskeletal disorders. *Am J Ind Med.* 1996;29:609-617.
 143. Dickinson C, Campion K, Foster A, Newman S, O'Rourke A. Questionnaire development: an examination of the Nordic Musculoskeletal Questionnaire. *Appl Ergon.* 1992;23:197-201.

Dissertations written by physiotherapists, Umeå University 1989–2004

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Being a physiotherapist - Professional role, utilization of time and vocational strategies. Umeå University Medical Dissertations, New Series no 251, 1989. (Department of Physical Medicine and Rehabilitation)

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Influences from peripheral sense organs on primary and secondary spindle afferents via gamma-motoneurons - A feedback mechanism for motor control and regulation of muscle stiffness. Umeå University Medical Dissertations, New Series no 307, 1991. (Department of Physiology)

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The pattern of activation and relaxation during fatiguing isocinetic contractions in subjects with and without muscle pain. *Arbete och hälsa* 1991:47. Diss. 1992 (sammanfattning) (Departments of Clinical Physiology, National Institute of Occupational Health and Physical Medicine and Rehabilitation)

Gunnevi Sundelin

Electromyography of shoulder muscles - The effects of pauses, drafts and repetitive work cycles. *Arbete och Hälsa*, 1992:16. Diss (sammanfattning) (Departments of Anatomy, National Institute of Occupational Health, Division of Work and Environmental Physiology, Divisions of Occupational Medicine and Applied Work Physiology and Occupational Medicine)

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Visual and proprioceptive control of arm movement - Studies of development and dysfunction. Diss. (sammanfattning) 1994. (Department of Paediatrics)

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To grip and not to slip - Sensorimotor mechanisms during reactive control of grasp stability. Umeå University Medical Dissertations, New Series no 429, 1995. (Department of Physiology)

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Falls in the frail elderly – Incidence, characteristics and prediction with special reference to patients with stroke and hipfractures. Umeå Medical Dissertations, New Series no 483, 1996 (Department of Geriatric Medicine)

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Physical capacity, physical activity and health -A population based fitness study of adolescents with an 18-year follow-up. Umeå University Medical Dissertations, New Series no 494, 1997. (Departments of Physiology and Technology, National Institute for Working Life and Epidemiology and Public Health)

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Knee muscle function in healthy persons and patients with upper motor neurone syndrome. Umeå University Medical Dissertations, New Series no 505, 1997 (Departments of Physical Medicine and Rehabilitation and Clinical Neuroscience)

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Body Awareness - applications in physiotherapy. . Umeå University Medical Dissertations, New Series no 543, 1998 (Departments of Psychiatry and Family Medicine)

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The structure of knowing. Existential trust as an epistemological category. Umeå studies in the humanities, 145, 1999 (Department of Philosophy and Linguistics)

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Prediction and prevention of falls among elderly people in residential care. Umeå University Medical Dissertations, New Series no 671, 2000 (Departments of Community Medicine and Rehabilitation, Physiotherapy and Geriatric Medicine)

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Integrated jaw and neck function in man: studies of mandibular and head-neck movements during jaw opening-closing tasks. (Department of Odontology, Clinical Oral Physiology and Centre for Musculoskeletal Research, National Institute for Working Life, Umeå)

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The female soccer player – Injury pattern, risk factors and intervention. Umeå University Medical Dissertations, New series no 735, 2001. (Departments of Surgical and Perioperative Sciences, Sports Medicine, and Community Medicine and Rehabilitation, Physiotherapy)

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Rehabilitation in light of different theories of health. Outcome for patients with low-back complaints – a theoretical discussion. Umeå University Medical Dissertations, New series no 760, 2001. (Departments of Public Health and Clinical Medicine, Epidemiology, and Community Medicine and Rehabilitation, Social Medicine)

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Health problems and treatment effects in patients with non-specific musculoskeletal disorders. A comparison between Body Awareness Therapy, Feldenkrais and Individual Physiotherapy. Umeå University Medical Dissertations, New series no 774, 2002. (Department of Community Medicine and Rehabilitation, Physiotherapy and Department of Psychology)

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