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Psychosocial work conditions and musculoskeletal complaint – The role of affective stress response as a mediator of the effect of psychosocial risk factors on musculoskeletal complaints

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Abstract

The hypothesis tested in these two studies was that unfavourable psychosocial work conditions are expected to increase the risk of musculoskeletal complaints (MSC), and that this effect is at least partly mediated by affective stress responses. The testing followed Baron and Kenny's (1986) causal step approach. This means that the mediating role of affective stress responses is supported if unfavourable psychosocial work conditions significantly increase the risk of MSC and affective stress responses. In addition, the relation between MSC and psychosocial work conditions should be eliminated or significantly reduced when controlling for its effect on stress. One further requirement (only tested in study II) is that these relations should also hold after controlling for possible confounding between psychosocial and ergonomic workloads.

Study I, Assembly workers:
The results from the study of assembly workers showed that the relation between self-reported demands and shoulder complaints was fully explained by their relation to the affective stress response. This was taken as support for the hypothesis that the effect of psychosocial work conditions on musculoskeletal complaints (MSC), primarily in the neck and shoulder region, was mediated by the affective stress response. One weakness in the study of assembly workers was that no indicators of ergonomic workloads (awkward work positions, heavy lifting etc.) were included in the model. Although job rotation made it unlikely that ergonomic load differed very much from one assembly worker to another in the first study, it cannot be excluded that the results may partly have been an effect of confounding between psychosocial and ergonomic conditions. Another possibly critical aspect of this study was that the participants were very homogeneous with respect to work conditions. Thus it is likely that differences in self-reported psychosocial conditions reflect differences in evaluation of work conditions rather than actual differences.

Study II, Hospital workers:
In the second study, the stress mediation hypothesis was tested in a more heterogeneous group where there were substantial differences in actual work conditions. The study among hospital workers also included indicators of possibly critical ergonomic workload factors. The results among hospital workers did not support the hypothesis that the effects of psychosocial work conditions on MSC are mediated by the affective stress response. These results showed that the psychosocial variables were strongly related to stress and energy, and that neck and shoulder complaints were more common in the group with high demands and low skill utilisation. This was the only significant relation between psychosocial variables and MSC that was not explained by confounding with ergonomic workload. However, controlling for stress did not substantially reduce or eliminate this interaction effect. To summarise, the results for the hospital workers stand in contrast to those in the study of assembly workers.

Sammanfattning

Ogynnsamma psykosociala arbetsförhållanden förväntas öka risken för utvecklandet av muskuloskeletala besvär (MSB), den hypotes som har prövats i två studier är om den effekten delvis medieras av upplevd stress. Medierings hypotesen prövades enligt Baron and Kenny's (1986) steg för steg modell. Vilken innebär att en medierande effekt av upplevd stress stöds om relationen mellan MSB och de ogynnsamma psykosociala förhållandena elimineras eller minskas kraftigt när relationen kontrolleras för stress. I studie II fanns även möjligheten att pröva medieringseffekten på kombinationen av ogynnsamma psykosociala och ergonomiska arbetsförhållanden .

Studie I, Monterings arbetare:
Resultaten från studien med monterings arbetare visade att relationen mellan höga krav och besvär i skuldra helt kunde förklaras av deras relation med upplevd stress. Vilket togs som stöd för att effekten av ogynnsamma psykosociala förhållanden på MSB, primärt i skuldra, medieras av den upplevda stressen. En svaghet i den här studien var att inga ergonomiska aspekter av arbetssituationen inkluderades i modellen. Resultatet kan delvis ha påverkats av att rotationen mellan arbetsstationerna gjorde att den ergonomiska belastningen inte varierade så mycket mellan individerna. En annan aspekt av den här studien är att individernas likhet i arbetsuppgifterna påverkar skattningen av den psykosociala arbetssituationen på så sätt att den speglar subjektiva skillnader snarare än de faktiska.

Studie II, Sjukhus personal:
I den andra studien, så provades medieringshypotesen i en mer heterogen grupp av individer med faktiska skillnader i arbetsförhållanden. I den här studien så infriades inte hypotesen att ogynnsamma psykosociala arbetsförhållandens relation med muskuloskeletala besvär medierades av upplevd stress. Resultaten visade att den ogynnsamma psykosociala situationen hade ett starkt samband med upplevd stress och energi. Även att besvär i skuldra och nacke var mer vanligt bland dem som hade höga krav och samtidigt låg kontroll över användandet av kunskap i arbetet. Vilket var den enda signifikanta relationen mellan ogynnsamma psykosociala förhållanden och MSB som inte kunde förklaras av relationen med ergonomiska förhållanden. Sammanfattningsvis så fanns det inget stöd för hypotesen i studie II utan endast i studie I.

List of publications

1. Anders Kjellberg, Cecilia Wadman
The role of the affective stress response as a mediator of the effect of psychosocial risk factors on musculoskeletal complaints – part 1: Assembly workers.
International Journal of Industrial Ergonomics, 2007; 37 (5):367-374

2. Cecilia Wadman, Anders Kjellberg
The role of the affective stress response as a mediator of the effect of psychosocial risk factors on musculoskeletal complaints – part 2: Hospital workers.
International Journal of Industrial Ergonomics, 2007; 37(5):395-403

Contents

Introduction

The causal mechanisms behind work-related musculoskeletal complaints (MSC) have been widely investigated during recent years, but MSC are still among the most common health problems and thereby also constitute considerable costs for society. A compilation by Melin and Wigaeus-Tornqvist (2004) shows that 38% of sick leaves lasting more than 60 days in 1999 and 2000 were due to MSC, and MSC accounted for 61% of all work-related diseases reported in 2001. In the complex causal relations underlying the development of MSC, the psychosocial environment and perceived stress play a major role, along with physical exposure. Several models have been developed to elucidate the role of psychosocial factors, physical load, physiological responses, perceived stress and their interactions in the development of MSC (Melin & Wigaeus Tornqvist, 2004). An interesting aspect was mentioned by Bongers and co-workers in their 1993 and 2002 reviews of the primarily epidemiological research regarding these questions (Bongers, de Winter, Kompier, & Hildebrandt, 1993; Bongers, Kremer, & ter Laak, 2002). They suggest that the individual's subjective stress could be an important mediator of the relation between psychosocial factors and MSC. This explicit role of the subjective stress response as a mediator of psychosocial work conditions on MSC has to my knowledge not been formally tested in an analysis including both psychosocial and physical factors. However, some researchers have carried out similar analyses. Steen and Firth (1998) tested whether perceived stress mediated job demands and control regarding the relationship to anxiety and depression among nurses, but found no such mediation. Also Larsman and co-workers tested the mediation hypothesis regarding the relationship between job demands and stress. Their results indicated full mediation, where all of the effects of work demands on neck/shoulder complaints were influenced by perceived stress. Taken together these variables explained the variation of 20% in reported neck and shoulder symptoms (Larsman, Sandsjö, Klipstein, Vollenbroek-Hutten, & Christensen, 2004).

Several other studies have also tested the relationship between stress, psychosocial factors, physical factors and musculoskeletal outcomes, where all included variables have mostly been given the same theoretical status in the test. A more appropriate model consists of regarding the stress variable as part of a chain linking psychosocial factors with MSC, i.e. the mediation hypothesis. The aim of this thesis is therefore to add some pieces to this complex jigsaw puzzle of variables involved in the development of MSC, by formally testing the hypothesis that subjective stress response functions as a mediator of the effect of psychosocial work conditions on MSC. Subjective stress response can be described in different ways but Cohen, Kessler & Underwood (1995) and Spector (1998) have both proposed the affective stress response as an effective way of capturing subjective stress. Subjective stress is seen by both Cohen and Spector as a "negative emotional state in a stressful situation increasing the risk for any physical disease". Affective stress responses are described in terms of a psychological state (i.e. mood) and not in situational terms, and are therefore less confounded with the psychosocial variables than other measures of the subjective stress response.

In this thesis, mediation is to be understood as an explanation of the possible effect of psychosocial work conditions on MSC by a third variable: the affective stress response. The first sections below present a theoretical account of stress and mood, primarily those that are relevant to the instrument used in the two studies. The following sections briefly discuss MSC and present some models regarding the relationship between stress, prolonged low-level workload and MSC. Finally, the two empirical studies are presented, followed by a discussion of the results.

In both studies the affective stress response was measured with instruments based on the mood research tradition, and for the measurement of psychosocial factors we used questions based on the job strain model developed by Karasek and Theorell (1990).

The concept of stress

During the last century the concept of stress has undergone a number of changes regarding its definition, as well as the view of its role as a cause of diseases. As Karasek and Theorell (1990, p86) argued, stress theory is not so much a single theory as an umbrella term referring to a relatively new basic scientific approach to problems in human behaviour and health. The editors of psychological abstracts in the USA have for example changed their classification several times. In the first half of the century (1927-60) they included stress together with conflict, emotion, tension, danger and disaster. From 1961-65 they added anxiety, fear and frustration (Appley & Trumbull, 1986). In the 1970s, stress was put into the broader context to which it is referred even today: environmental, occupational, physiological, social stress jointly with stress reactions. The problems in defining stress are also reflected in all the diverse models called stress theories that have been developed by researchers in different fields and for different reasons over the years (Karasek & Theorell, 1990). Early stress research focused on describing the acute stress reaction in situations that threatened biological survival. Since the acute stressor could not be prevented by human intervention, a great concern was to understand how the individual copes with or bears this threat. When environmental and occupational stress later became the main issue, another problem came into focus, namely the causal link between the environment and the effect on the individual. Instead of one single cause-and-effect linkage, many environmental situations may accumulate in producing one single effect. The possibility of controlling these different stressors is then a very important new component of the new theoretical models (Karasek & Theorell, 1990).

Work-related stress models

In this thesis, stress is defined in line with the “psychological approach” which conceptualises stress as “the dynamic interaction between the individual and their working environment” (Cox, Griffiths, & Rial-González, 2000, p.35). From this perspective stress is assessed either in terms of person–environment interaction or cognitive processes and emotional responses, which underpin these interactions (Cox et al., 2000). This way of viewing stress has been developed from two older models that were criticised for their interpretation of stress in terms of a simple

stimulus–response pattern. These models (the "engineering approach" and the "physiological approach") did not include the psychological and social interactions between the individual and the environment. The "engineering approach" was put forward by Symond in 1947 when he defined stress as an independent variable, *i.e.* stress as an exposure factor, not a response. The other model, "the physiological approach" was put forward by Selye in 1950, and was based on the early research by Claude Bernard about "vital balance" and Walter Cannon's work on homeostatic processes. Selye argued that a non-specific reaction was involved as well as any specific source related to the stress response (Appley & Trumbull, 1986). Selye's model did not include cognitive factors or any other psychological characteristics, but included both short-term responses and long-term health effects. Individual differences in health consequences of stress were regarded as genetically determined (Cox et al., 2000). During the following years several researchers in physiology and psychology argued that stress, especially psychological stress, was more complicated than described by Selye's model. Stress is not a unitary or an all-or-nothing phenomenon, and the two main psychological stress models were formed:

- Interactional models, which emphasise the individual's interaction with the environment
- Transactional models, which emphasise the mechanisms underlying this interaction

There are two well-known *interactional* theories: the person-environment-fit theory formulated by French, Caplan & van Harrison (1982), and the job strain model (demand-control theory) developed by Karasek (1979). The person-environment-fit theory argues that stress is a result of two types of fit between the person and the environment: the fit between the needs of the individual and the possibilities offered by the environment, and between the demands on the individual and his/her capacity. An important aspect of the former fit is the extent to which the environment permits and encourages individuals to use their skills at work. The job strain (demand-control) model, on the other hand, regards strain (i.e. stress in Selye's terminology) as a result of exposure to high demands with no opportunity for the individual to have adequate control of the situation.

One well-known *transactional model* is "the effort-reward model" formulated by Johannes Siegrist (1996), focusing on cognitive processes and emotional reactions. Frankenhaeuser's model (1986) could also be regarded as transactional. Both these models deal with mechanisms that underlie the interaction between individuals and their environment.

Most other models are built on concepts similar to that of the job strain model, *i.e.* a possible imbalance between perceived demands and the individual's competence or capacity (Cox et al., 2000). All models of stress and the mechanisms that lead to diseases have "black boxes" that still need to be explained. One missing link in many models is for example the reason why some individuals respond with stress in a certain situation whereas others do not.

In the studies included in this thesis the job strain model is used to capture the psychosocial work environment. This model is described below together with two other models: "the effort and distress model" and "the effort-reward model".

The job strain model (demand-control)
Karasek developed the job strain model during the 1970s and it has been further tested and developed in collaboration with Theorell (Karasek and Theorell, 1990). The job strain model is widely used in studies to cover psychosocial aspects of the working environment and is also known as "the demand-control model". The model is based on data from studies of male workers, one survey from the United States and one Swedish. In his original paper, Karasek (1979) describes stress as an internal state of the individual, which he does not attempt to measure. Instead, the terms "job demands" and "job control" are used to assess the strain that the individual is exposed to, where job strain is regarded as the result of an unfavourable combination of psychological job demands and control. Although these terms could overlap to some extent in some situations, generally speaking psychological demands are defined with regard to work pace, whereas work effort and control are related to questions such as skill application and freedom to decide when and how to work, and what to do. In the late 1980s Johnson and his co-workers showed that social support also has a major impact on the individual experience of stress at the workplace. Since high social support seemed to work as a buffer in the working situation containing high demands and low control, social support was added to the model (Johnson & Hall, 1988; Johnson, Hall, & Theorell, 1989). Today the model utilises these three dimensions and defines different types of workload. Karasek and Theorell defined workload as "active" when both demands and control are high, and hypothetically this situation should lead to development of new behaviour patterns both at work and in leisure time. The model predicts that jobs at the opposite extreme (defined as "passive job") induce a decline in overall activity and a reduction in general problem-solving activity. The ideal working condition, according to the model, is a combination of low job demands and high control and social support.

The effort and distress model
One early attempt to identify the psychological characteristic of environmental demands was made by Marianne Frankenhaeuser. In her effort and distress model, she separated mental stress from physical stress (Frankenhaeuser, 1983; Frankenhaueser, 1986). This approach integrates social, psychological and biological perspectives. One of the strengths of the research behind the development of her model was the combination of field and laboratory studies showing findings regarding the pathways of the nervous and endocrine systems. New techniques played a major role in this respect. Effort and distress responses may occur one at a time, or together in different combinations in one and the same situation experienced by the individual. The various patterns of stress reactions are also associated with different patterns of catecholamine (adrenalin and noradrenalin) and cortisol release. Her conclusion was that adrenalin, but not cortisol, increases in both pleasantly engaging as well as in distressing situations. She also hypothesised that in order to achieve a state of effort without distress, personal control is the important factor (Frankenhaeuser, 1983; Frankenhaueser, 1986).

The effort-reward model
In the 1990s the social scientist Johannes Siegrist (1996) presented a model using conditions of effort and reward to explain individual work-related health effects.

According to Siegrist, his effort-reward model is a useful tool for analysing how a stressful experience can lead to chronic effects. The effort-reward model shifts the focus from control to reward, by studying disadvantageous health effects of high-effort/low-reward conditions at work (Siegrist, 1996). Siegrist postulates two main sources of effort: extrinsic demands representing the work demands, and intrinsic demands corresponding to the individual's motivation to exert effort in a demanding environment. Three dimensions of occupational gratifications are distinguished in the model: money, esteem or approval, and status control. These dimensions need to be in balance with the input of demands, obligations and the coping behaviour that the individual uses as a strategy to complete the work task. If there is an imbalance between the cost and gains, a state of emotional distress will develop in the individual. This is the case when inadequate payment, lack of esteem and approval are at hand in combination with high effort.

The concept of mood

The effects of unsatisfactory working conditions are often expressed using words such as tiredness, lack of concentration, irritation, i.e. expressions of mood. There is no explicit consensus regarding what differentiates mood from emotion, and both mood and emotions include feelings and influence cognitive processes (Morris, 1992). Generally, mood is believed to differ in some way from emotions by being less specific, less intense, and less likely to be triggered by a particular stimulus or event, however longer lasting. Morris (1989) argues that mood could serve as a cue in a self-regulatory system, where bad mood signals some deficit and good mood indicates a satisfactory state of affairs. Positive mood then results as a confirmation of a successful way of coping when the resources are judged to be adequate in a specific situation. Bad mood is more complex, but should then occur if the individual perceives inadequate resources to cope with the situation.

The structure of mood

Mood is generally measured using checklists of adjectives, which are reduced by factor analysis to a number of dimensions that are often assumed to conform to a circular arrangement, a circumplex model. The original two-dimensional scheme was defined by two bipolar dimensions: valence and level of arousal (Feldman, 1995). The circumplex model is also believed to have diagonal dimensions that capture mood differences, such as depressed-excited in one diagonal and afraid-calm in the other (figure 1).

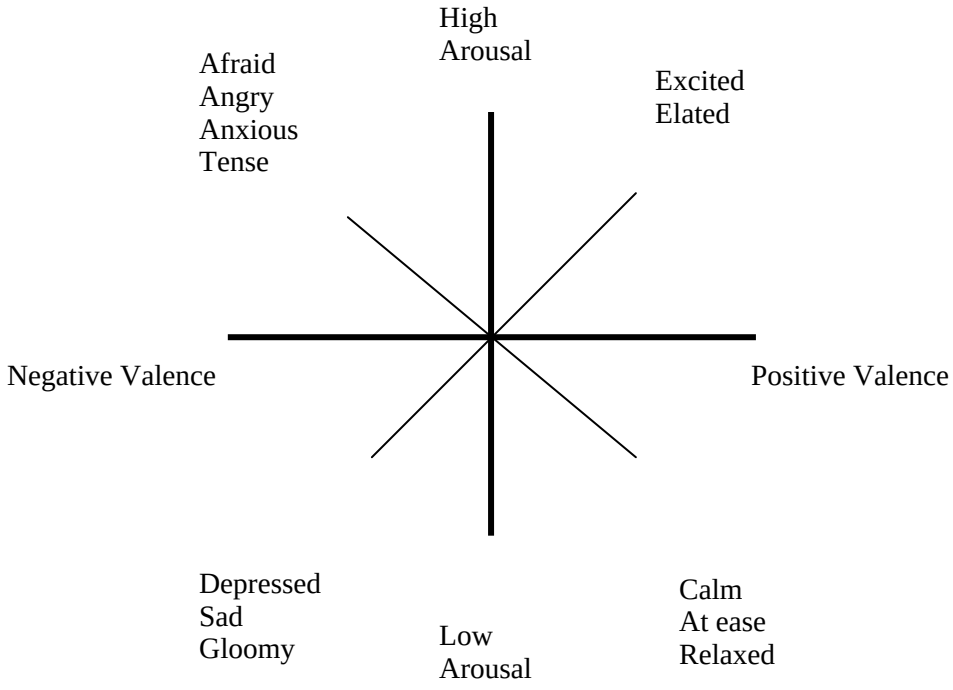

Figure 1. Valence/arousal circumplex model of mood adjectives (Russell's model 1980, adjusted by Feldman 1995).

Watson and Tellegen (1985) made an attempt to map the structure of mood by reanalysing a number of studies of self-reported mood. They proposed two main bipolar dimensions: Positive Affect (PA), described as zest for life, and Negative Affect (NA), represented as a state of unpleasant arousal or feeling upset. Their results confirmed their predictions in that Positive Affect and Negative Affect could be seen as higher order dimensions as they constantly emerged as the first two rotated dimensions. These two dimensions have also been identified in a variety of other languages, which led Watson and Tellegen to postulate them as the basic structure of mood. (McConville & Cooper, 1992).

In Sweden, Kjellberg and Iwanowski (1989) developed a similar instrument for measuring mood at work. Since they intended to use the instrument in workplaces in field studies, this influenced their choice of adjectives and the length of the instrument. The questionnaire therefore only included 12 adjectives, capturing the two mood dimensions of "stress" and "energy". They also made an attempt to estimate the neutral point of their scales, by letting the subjects estimate their mood state on two bipolar scales. The zero points of these scales were "neither passive nor active" and "neither stressed nor calm", respectively. These ratings were used to estimate the zero points of the two scales, and the neutral points for the stress and energy scale were estimated to be 2.4 and 2.7 respectively (Kjellberg & Iwanowski, 1989).

Musculoskeletal complaints

MSC, including soft tissue complaints of muscles, tendons, ligaments, joints, peripheral nerves and supporting blood vessels, constitute a worldwide public health problem in terms of human suffering and cost to society (Punnett & Wegman, 2004). Reported MSC have increased in the last decade, in Sweden as well as in the rest of Europe. The causal factors behind the complaints are complex, but it is known that repetitive work tasks, awkward working postures, heavy load and co-exposure with unfavourable psychosocial work conditions and perceived stress are factors that contribute to the problem (Bongers et al., 1993; Bongers et al., 2002; van der Windt et al., 2000). There is also a problem of how to diagnose and name the different complaints, since the complete picture behind MSC is not known. Words such as signs, symptoms, syndromes, illness, complaints, injury and disorders are often used in the literature to describe the problem. According to Hales and Bernard (1996), the following grouping of complaints is often used:

- Clinically well-defined (complaints such as tendonitis, carpal tunnel syndrome, and hand-arm vibrations syndrome)
- Less clinically well-defined (conditions such as tension neck syndrome)
- Non-specific (e.g. repetitive strain injury (RSI), cumulative trauma complaints (CTD), overuse syndrome, and cervicobrachial complaints

Clinicians can easily relate to the well-defined complaints but are not so familiar with the other two descriptions used by epidemiologists (Hales & Bernard, 1996). Musculoskeletal complaints are often intermittent and episodic during the early stages; furthermore, diagnostic criteria are not standardised and are often based on consensus (Punnett & Wegman, 2004). The emphasis on psychosocial factors as a cause of some MSC has been strengthened. This is especially true for upper-region complaints as shown by Bongers, de Winter et al. (1993) in their review, where they conclude that, “the large majority of the studies reported a relation between at least one work-related psychosocial factor and adverse upper extremity complaints”. The influence of biomechanical load is of course also important, as well as the interaction between muscle pain and muscle control. In the stress literature, a variety of theoretical models have been presented regarding plausible mechanisms of how psychosocial factors at work might increase the risk of musculoskeletal complaints. Some of these models are briefly described below.

Hypothetical mechanisms linking stress and musculoskeletal complaints

In the 1990s, Melin and Lundberg (1997) proposed that both mental and physical stressors might increase muscle tension during work, an increase that might interact with physiological stress response. The basic assumption of “the total workload model” is that a combination of the two stressors would increase the muscle tension even further than each stressor by itself. They also called attention to the importance of stressors outside work by including family-related factors (Melin & Lundberg, 1997), and this overall picture of the stress load leads to

sustained muscle tension. (Lundberg, 2002; Melin & Lundberg, 1997). Another conceptual model that takes the individual balance with the environment into consideration is “the allostatic load model” introduced by McEwan in 1993 (1993). The concept *allostatic load* was used since, according to McEwan, neither the concept of homeostasis nor allostasis takes into consideration the long-term effects of repeated stress. Homeostasis refers to the ability or tendency of an organism to maintain internal equilibrium – “a steady state” – and allostasis refers to the body’s ability to increase and decrease the activity of vital functions. The activation of the system is necessary for survival and for protection of the body, but health problems may occur if the system is over- or underactivated. McEwan (1998) describes four situations that are associated with allostatic load, where the first is frequent stress. The second type of allostatic load, a failing adaptation to repeated stressors, results in a prolonged exposure to stress hormones. The third type is an inability to shut off allostatic responses after termination of stress. In the fourth type, inadequate responses by some allostatic system trigger compensatory increases in other systems (McEwen, 1998). There are some new models proposing how prolonged low level workload influences MSC, and one well-known hypothesis is the “the Cinderella hypothesis” put forward by Hägg in 1991 (1991). The model is based on the way in which motor units in the trapezius muscle are recruited to build up the muscle force where low threshold motor units are always recruited first and also remain active until total relaxation of the muscle. This reinforcing stereotyped “Cinderella” recruitment pattern will occur in the involved muscles during prolonged low-level static contractions. This model is considered to be a good pedagogical tool for explaining that, duration of the load and the pauses become more critical than the level of the static load, i.e. showing the necessity of pauses and load variations (Hägg,1991, 2003). Another model conceptualising muscle pain and tension disorders is proposed by Johansson and Sojka (1991). Their research examines the muscle spindle, a mechanoreceptor sensitive to changes in muscle length, which is situated parallel to the normal muscle fibres. Their model provides a mechanism for the spread of increased muscle stiffness and pain to other muscles, and the effect of sustained activity on the muscle spindle will affect the precision of movements.(Johansson, Sjölander, Djupsjöbacka, Bergenheim, & Pedersen, 1999). This less precise control will in turn cause an increase in co-activation stabilising the musculature, and this will lead to the development of a vicious circle. This vicious circle might then be strengthened by mental stress activation of the sympathetic nervous system caused by pain or unfavourable working conditions (Johansson et al., 1999). Other theories linking stress with MSC are: the hyperventilation hypothesis, based on the well-established fact of over-breathing; the blood vessel-nociceptor interaction hypothesis presented by Knardahl (2002); and the nitric oxide/oxygen ratio hypothesis by Eriksen (2004). The assumption of the hyperventilation hypothesis is “that hyperventilation induced by job stress contributes to development of musculoskeletal complaints”. If breathing, as a result of psychosocial stress factors at work, exceeds the metabolic requirements for oxygen, hyperventilation (i.e. rapid rate of flow of CO_2) will occur (Schleifer, Ley, & Spalding, 2002). The influence of psychosocial risk factors on upper extremity disorders is then due to change in breathing patterns from the diaphragm to thoracic or chest breathing under stressful conditions. Hyperventilation could be seen as a fundamental component of fight or flight

response, which is a primary causal mechanism in stress-related disorders. (Schleifer et al., 2002). The blood vessel-nociceptor interaction hypothesis represents a different view to the conventional theory that muscle tension is causally related to perceived pain. Knardahl's hypothesis mainly concerns workload that produces sustained, low-level muscle activity and the hypothesis proposes that extended blood vessels are assumed to contribute to the perception of pain (Knardahl, 2002). Finally the nitric oxide/oxygen ratio hypothesis by Eriksen (2004) links psychosocial and ergonomic workload to MSC, especially neck complaints. According to Eriksen, this is due to the psychological work factors inducing stress on the individual or by ergonomic load at work such as prolonged head-down neck flexion. This will produce low-level contractions in the trapezius muscle combined with sympathetic vasoconstriction. These contractions then increase the nitric oxide/oxygen concentration in trapezius muscle fibres. This increase, if repeated, will in turn inactivate an increasing part of the enzymatic capacity for cellular respiration, which could contribute to pain sensations experienced by the individual.

The empirical studies

Study I: The role of the affective stress response as a mediator of the effect of psychosocial risk factors on musculoskeletal complaints 1: Assembly workers

Study II: The role of the affective stress response as a mediator of the effect of psychosocial risk factors on musculoskeletal complaints 2: Hospital workers

General aim

Affective stress

The two studies regard affective stress responses as linking psychosocial work factors with MSC. Stress is manifested in several ways: physiologically, behaviourally, and subjectively. Among the different aspects of subjective stress response, it has been proposed that affective response plays a central role. In their models of the stress process, Cohen et al. (1995) and also Spector (1998) propose, for example, that a negative emotional response to a stressful situation is a necessary requirement for physiological stress responses, which in turn increase the risk of physical disease. It is thus proposed that the affective response mediates the effects of work stressors on health. The two bipolar mood dimensions of the Stress-Energy questionnaire (Kjellberg & Wadman, 2002) capture subjective stress aspects of the individual's appraisal of the environment as an affective aspect of the stress response. The stress and energy dimension is closely related to the bipolar dimensions "positive affect" and "negative effect" proposed by Watson and Tellegan (1985) as zest for life or feeling upset. Although, the dimensions do no completely cover the individual's total feeling of the workload there is reason to believe that if the workload does affect mood, i.e. affective stress, there will be a response in at least one of the scales. Another

reason for using the affective aspect of subjective stress response is that it is less confounded with indicators of psychosocial conditions than other aspects of subjective stress response; affective stress response is expressed in terms of a psychological state and not in situational terms, as is the case for many stress appraisal measures (Peacock & Wong, 1990).

Mediation hypothesis

In order to test the role of stress as a mediator the causal step model modified by Baron & Kenny (1986) was used. This approach includes a series of steps that need to be completed to draw conclusions about the existence and strength of a mediation effect. This type of relations between variables has different names in different disciplines; in psychology the term "mediation" is used, sociologists have popularised the term "indirect effect", epidemiologists use "surrogate or intermediate endpoint effect" to describe this relation. It is important to distinguish between the meaning of moderator-mediator and a confounder in the relations between independent and dependent variables. Whereas a moderator affects the direction and/or strength of the relation between an independent and a dependent variable, a mediator explains part or all of the relations between these variables (Baron & Kenny, 1986). This differs from a confounding variable in that the confounding variable suggests that a third variable explains the relation without necessarily implying a causal relation. The indirect effect through a mediator implies that the independent variable causes a change in the mediator, which in turn affects the dependent variable (MacKinnon, Krull, & Lockwood, 2000). MacKinnon and co-workers have also performed tests of 14 different models for testing mediation regarding empirical power or Type-1 error rates. They found that the causal step model is the one most likely to miss real effects; but on the other hand, Type-1 errors, which are also desirable to avoid are unlikely to be committed (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Furthermore, none of the other proposed methods is applicable to cases like the present ones, where a dichotomised variable is used to indicate the presence of MSC.

Specific aim and hypothesis

The general aim of the two studies included in this thesis was to explore the role of affective stress response regarded as part of the chain of responses linking psychosocial work factors with MSC, as shown in Figure 2. Unfavourable psychosocial work conditions are expected to increase the risk of MSC, and this effect is at least partly mediated by affective stress responses.

According to the hypothesis, the psychosocial environment has no effect, or substantially reduced effects, on MSC in the absence of affective stress responses (studies I and II). Ergonomic work conditions might contribute to the stress response, and are also likely to have an effect on MSC that is independent of their effects on stress. A more complete model (study II), therefore also includes the biomechanical workload resulting from ergonomic work conditions. The model also indicates that the ergonomic work conditions and psychosocial factors are likely to be confounded. There may also be an interaction between psychosocial and ergonomic work conditions, implying that the effects of ergonomic work conditions are strengthened by unfavourable psychosocial conditions. So, by

following Baron and Kenny, the causal step approach specifies a series of tests of links in a causal chain, (MacKinnon et al., 2002).

A mediating role of the affective stress response means: first, that there is a significantly increased risk of MSC for those who have unfavourable psychosocial work conditions (in the studies defined with regard to demands, control and social support); further, unfavourable psychosocial work conditions should increase the risk of affective stress responses; and, finally, the relation between psychosocial work conditions should be eliminated or significantly reduced when controlling for the effect of stress responses. A further hypothesis was that there is an interaction between psychosocial and ergonomic work conditions, implying that the effects of ergonomic work condition are increased by unfavourable psychosocial work conditions.

A confirmation of these hypotheses would support the hypothetical mediating role of affective stress responses with respect to the effect of psychosocial work conditions on MSC.

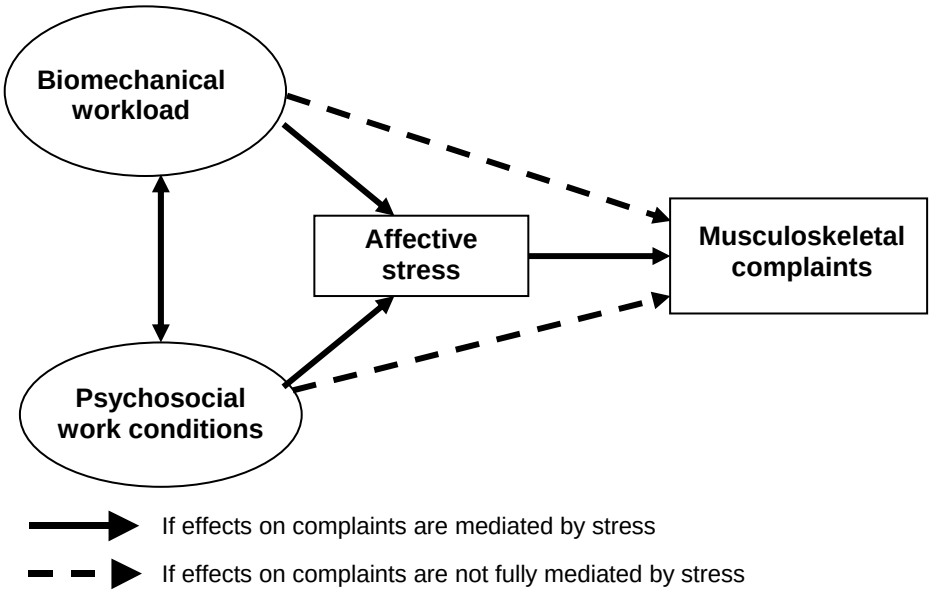

Figure 2. Hypothetical relations between work environment and stress.

General methods and design

Subjects

Study I

All assembly line workers from a car-body factory (n=208) and an electronics assembly plant (n=139) were asked to participate in the study. The response rates were 86% (n=179) for the car-body workers and 79% for the electronics workers (n=110). No more than one person failed to respond to any of the questions included in the analyses. Some of the odds ratios are therefore based on 287 persons. The car-body factory workers (128 men, 51 women, mean age 31 years,

mean employment time 11 months) had to handle heavy loads in their production-line work, whereas the electronics workers (48 men, 60 women, mean age 36 years, mean employment time 10.5 years) currently worked on a production line with lightweight materials. Both groups had a load on the back and upper regions such as the neck, shoulder and upper arm. In both workplaces, there was job rotation between the stations on the production line, thus limiting the difference in physical load within each group, and the work was organised in three shifts: morning, day and night.

Study II
The personnel included in study II worked in a big city hospital in Sweden (approximately 3,500 employees in total) and the study was part of a larger investigation regarding implementation of a digital imaging technique in the X-ray department in this hospital. The data used in the present paper were collected in 2001 as baseline measures before digital technology was installed at the X-ray department. All employees from the X-ray, orthopaedic and clinical physiology departments were invited to participate in the study. In the analyses the three departments were pooled together, thus forming a group of 267 persons including 119 X-ray workers (26 men, 93 women, mean age 49 years), 35 physiologists (12 men, 23 women, mean age 49 year) and 113 orthopaedic workers (25 men, 88 women, mean age 45 years). The response rate was 79% for the X-ray department, 76% for the physiology clinic and 67% for the orthopaedic department. The data analysed in this paper have not been presented in other reports on the project. Omitted reposes to single questions meant that the dataset was complete only for 239 persons, and that different analyses were based on slightly different groups. The group contained 23% state enrolled nurses, 38% registered nurses (including biomedical technologists), 22% physicians and 17% from other professions (including medical secretaries).

General procedures

All employees included in the two studies received oral and written information about the project by the researchers, as well as by their managers. All variables used in the analyses were collected by means of a questionnaire which the employees filled in at the workplace in their working time. The questionnaires included questions about stress, psychosocial factors, working postures, workload and health.

Measures

Affective stress responses The Stress-Energy questionnaire (Kjellberg & Wadman, 2002) was used to measure the affective stress response towards the end of a normal working day in both studies. The overall question which was to be answered by the questionnaire was: “How do you usually feel at the end of a normal working day?” The instrument includes a checklist of 12 adjectives, six in each dimension, and uses a six-point response scale (0-5) for each item, ranging from “not at all” to “extremely”.

Psychosocial work conditions A modified version of the Demand-Control Questionnaire (Karasek, 1979; Kasl, 1996) as developed by Theorell et al.

(Theorell et al., 1988) was used to assess psychosocial work conditions in the two studies. This meant that the work conditions were assessed with regard to *Psychological demands* and *Control,* which, in turn, could be subdivided into *Decision latitude* and *Skill discretion.* In addition, *Social support* was assessed using the questionnaire developed by Johnson and Hall (1988). In the logistic regression analyses all these variables were dichotomised by their median value.

Ergonomic work conditions. In study II, questions were asked about whether different work postures had been part of normal work during the last four weeks; the different postures were illustrated with a picture in connection with the question. The variables that had a response rate below 70% were not used in the analysis. The first seven variables were "yes-no" questions about whether various work postures were used in normal work tasks. The seven work positions were:

- Working in a squatting position
- Leaning forward or twisting the back sideways
- Holding the head in a forward position
- Working with the hands:
  - above shoulder level
  - beneath knee level
  - forward extended without support

Another three ergonomic load variables were also "yes-no" questions with a complementary response on a five-point scale ranging from "almost all the time" to "almost never" during the last four weeks. Those who stated that they worked in the posture/situation 50% or more of their normal working time were classified as exposed. These three postures were:

- Repetitive work every hour
- Standing or walking while working
- Sitting still while working

Finally a question dealt with manual handling of loads. In order to be classified as exposed, a person was required to lift 1-5 kg weights at least eleven times a day or handle weights of 5-15 kg at least once a day.

*Musculoskeletal complaint*s The Nordic Questionnaire, slightly modified (Kourinka et al., 1987), was used in both studies to measure reported complaints (pain) in different body regions during the last four weeks. In the analyses only the questions regarding complaints in the neck, shoulder, upper arms, upper and lower back were included. In the logistic regression analyses, these variables were dichotomised.

Statistical analyses

Since the MSC in both studies were assessed using a dichotomous variable, logistic regression analyses were performed to test their relation to psychosocial work conditions, stress, energy and potential confounding variables. The predictors were also dichotomised to obtain the strength of the relations, expressed in directly comparable odds ratios (OR). In all essential respects the results were the same when the full scales of the predictors were used. Tests of the mediation hypothesis were made with simple binary and multiple hierarchical logistic regression analyses. The strength of the relations was described as odds ratios (OR) and their confidence intervals (CI), and for the crude relations, Nagelkerke R^2. All analyses were performed in SPSS version 11.0.

In the hierarchic logistic analyses, demands, social support and skill utilisation were entered in the first block, and thus were controlled for each other. In the preliminary analyses, stepwise-entered two-way interactions between the psychosocial variables were entered in a second block (entered stepwise if $p<0.10$ and excluded if $p>0.20$). Finally, hierarchical logistic regression analyses were performed with the musculoskeletal complaints as dependent variables. In the first block of these analyses, the psychosocial factors were entered and thus controlled for each other. In the second block, the possible two-factor interactions between the psychosocial variables were entered stepwise, i.e. only interactions with *p* values below 0.10 were allowed in the model. These interactions were included in the models, since the effects of demands have been assumed to be modified by control and support conditions (Karasek & Theorell, 1990). In study II the next step included ergonomic variables, and the step thereafter contained stress and energy. Possible confounders were entered in the last step: age, gender (and employment time in study I). Conventionally, gender and age are entered first to assess the predictive power of other variables after control for differences in these respects. The advantage of putting gender and age in the last block of the analysis is that this model tells us whether there are any gender or age differences that are not explained by the variables entered in the preceding blocks, in addition to whether there are any exposure effects that are not explained by their confounding with gender.

The stress mediation hypothesis would be supported if a significant relation was obtained between psychosocial conditions and MSC, and if this relation was eliminated or substantially weakened when stress was entered in the analysis. It would be further supported if controlling for possible confounding with the variables did not change these relations.

Study I:

In study I, employment time, as a confounding variable, was also entered as well as a dummy variable representing the two companies in the last step.

Study II:

In study II, the decision latitude aspect of control was not included since it was unrelated to all MSC, and preliminary analyses also showed that no interaction with decision latitude approached significance. The second block in study II contained ergonomic variables (entered stepwise if $p<0.10$ and excluded if $p>0.20$). The stepwise procedure was chosen since the objective of this block was only to account for as many of the complaints as possible by ergonomic factors, not to identify the most critical ones.

Study II also included multiplicative interaction analyses between the ergonomic factors that had proved to be significantly related to MSC and psychosocial variables. To reduce the number of variables in the model, these terms were also entered stepwise, but their separate relations to MSC were tested in other analyses. Some of the analyses in study II included multiplicative indicators of interactions between psychosocial and work posture variables. In preliminary analyses, dummy variables representing the occupational groups and their interactions with the psychosocial variables were also included in the model. These variables did not add significantly ($p>0.10$) to the prediction of complaints and were therefore excluded in the final analyses. This means that the differences in MSC that existed between the occupational groups were explained by the psychosocial and ergonomic exposures. Differences between occupational groups

(state enrolled nurses, registered nurses, physicians and others) were tested with one-way analyses of variance and Turkey's post-hoc test, or with chi-square for category variables.

Summary of investigations

The results of the two studies are summarised in relation to what was expected from the steps of the mediation testing.

First there should be a significant relation between MSC and unfavourable psychosocial work conditions with respect to demands, control and social support.

The crude OR between psychosocial factors and MSC did not show a consistent pattern in the two studies. In study I, psychological demands showed a significant relation only with shoulder complaints, but all MSC except low back complaints were related to low social support. Low control was not related to any of the different musculoskeletal complaints.

In study II, upper arm complaints were significantly related to skill utilisation, as was social support. However, neither demands nor the overall control index were significantly related to MSC, although the multivariate analyses showed that for neck and shoulder complaints there was a significant interaction between demands and skill utilisation. This interaction reflected the fact that these complaints were more common in the group with high demands, only when skill utilisation was low.

Secondly, unfavourable psychosocial work conditions were expected to increase the risk of a stress response.

The simple logistic regression analysis that was performed, with psychosocial indicators as independent variables and stress and energy as dependent variables, was characterised by relations between high demands, low social support and high stress in both study I and study II.

The two studies differed however regarding the relationship between stress and control. In study I, the low stress group did not differ from the high stress group in either of the two subscales of control, whereas these differences were strong and significant in study II. This was also the case regarding the relations between energy and the psychosocial indicators. In study I there was a significant relation with all psychosocial variables and energy, except for the demands variable. In study II there was only a significant relation between low energy and low decision latitude, as well as the overall control variable (table 1). This criterion was subsequently only completely fulfilled in study II, whereas stress response only showed a significant relation to demands and social support in study I.

Thirdly, the relation between psychosocial and MSC should not be eliminated by controlling for work posture indicators.

This was only controlled for in study II where the interaction between demands and skill utilisation was in no case substantially reduced by this control, whereas it led to an elimination of the relation between social support and upper arm complaints.

Table 1. Crude odds ratios (OR) and 95% confidence intervals (CI) and Nagelkerke r^2 for the psychosocial factors regarding stress and energy, Study I and II.

Psychosocial risk indicators	Study I		Study II	
	Stress OR (CI) r^2	Energy OR (CI) r^2	Stress OR (CI) r^2	Energy OR (CI) r^2
High psychological demands	4.95 (2.97-8.23) 0.18	1.13 (0.71-1,81) 0.01	3.28 (1.88-5.71) 0.12	1.16 (0.69-1.94) 0.01
Low control	1.03 (0.65-1.65) 0.00	2.60 (1.60-4.22) 0.07	3.50 (1.98-6.15) 0.11	2.21 (1.13-3.72) 0.05
Low decision latitude	0,84 (0.52-1.34) 0.00	1.87 (1.16-3.01) 0.03	3.15 (1.79-5.53) 0.09	1.28 (0.77-2.14) 0.01
Low skill utilisation	1.46 (0.90-2.36) 0.01	2.42 (1.42-3.29) 0.06	1.77 (1.02-3.06) 0.02	2.76 (1.63-4.67) 0.08
Low social support	2.12 (1.303.42) 0.04	1.73 (1.08-2.78) 0.02	4.31 (2.41-7.74) 0.14	1.62 (0.97-2.71) 0.02

Fourthly, the relation between psychosocial factors and MSC should be eliminated, or at least significantly reduced, after control for stress:

This requirement in study I was true for shoulder complaints, where the relation between demands and complaints was eliminated after control for stress. However, the relation between neck complaints and the combination of low control and low social support remained unaffected by entering stress into the regression model. Rated energy was not related to the risk of any MSC.

Controlling for stress in study II did not eliminate or reduce the only significant relation that was obtained between psychosocial work conditions and MSC. This was true also of the few significant interactions found between psychosocial and ergonomic conditions.

Two other aspects of the results should be noted. First, positive involvement in the task (high energy ratings) did not decrease the risk of MSC in unfavourable psychosocial work conditions. Secondly, there was a relatively strong relation between stress and most of the studied musculoskeletal complaints in both studies; this was not the case for the psychosocial work factors.

Table 2. Odds ratios (OR) and 95% confidence intervals (CI) for shoulder complaints from a hierarchic logistic regression analysis, where the risk factors were entered into the model in five successive blocks (block II contained three two-factor interactions, entered stepwise into the model, none of which passed the inclusion criterion), n=289, Study I.

	Block			
	I	III	IV	V
Risk indicators	OR (CI)	OR (CI)	OR (CI)	OR (CI)
High psychological demands	**1.75 (1.04-2.96)**	1.05 (0.58-1.9)	1.15 (0.62-2.13)	1.15 (0.62-2.14)
Low control	1.16 (0.69-1.95)	1.18 (0.68-2.04)	1.21 (0.68-2.15)	1.21 (0.68-2.15)
Low social support	1.47 (0.87-2.49)	1.25 (0.71-2.17)	1.09 (0.60-1.96)	1.08 (0.59-1.98)
High stress		**3.88 (2.12-7.1)**	**3.65 (1.93-6.9)**	**3.65 (1.93-6.90**)
Low energy		1.04 (0.60-1.67)	0.90 (0.50-1.61)	0.90 (0.50-1.61)
Women (Ref. group: men)			**2.44 (1.36-4.39)**	**2.43 (1.34-4.34)**
High age (>40 years)			1.08 (0.58-2.04)	1.08 (0.57-2.06)
Long employment (>61 months)			1.94 (0.89-4.21)	1.91 (0.71-5.17)
Electronics workers (Ref. group: Car assembly workers)				1.02 (0.44-2.37)

Table 3. Odds ratios (OR) and 95% confidence intervals (CI) for *neck complaints* from a hierarchic logistic regression analysis, where the risk factors were entered into the model in five successive blocks. Block II contained three two-factor interactions, entered stepwise into the model, none of which passed the inclusion criterion (n=289), Study I.

	Block				
	I	II	III	IV	V
Risk indicators	OR (CI)	OR (CI)	OR (CI)	OR (CI)	OR (CI)
High psychological demands	1.34 (0.79-2.27)	1.40 (0.82-2.40)	1.06 (0.59-1.91)	1.24 (0.67-2.30)	1.28 (0.69-2.40)
Low control	1.02 (0.60-1.72)	0.49 (0.21-1.14)	0.51 (0.22-.1.20)	0.46 (0.19-1.13)	0.46 (0.19-1.15)
Low social support	**2.29 (1.34-3.90)**	1.30 (0.63-2.66)	1.22 (0.59-2.53)	0.90 (0.41-1.96)	0.83 (0.38-1.83)
Interaction contr x supp	-	**3.53 (1.2-10.60)**	**3.32 (1.09-10.11)**	**4.21 (1.28-13.90)**	**4.16 (1.2-13.8)**
High stress	-	-	**2.10 (1.16-3.80)**	**2.1 (1.1-3.96)**	**2.16 (1.13-4.11)**
Low energy	-	-	0.98 (0.56-1.70)	0.81 (0.45-1.47)	0.80 (0.44-1.45)
Women (Ref. group: men)	-	-	-	**2.1 (1.14-3.85)**	**1.89 (1.02-3.51)**
High age (>40 years)	-	-	-	1.38 (0.74-2.60)	1.23 (0.64-2.34)
Long employment (>61 months)	-	-	-	**3.25 (1.49-7.10)**	1.82 (0.68-4.89)
Electronics workers (Ref. group: Car workers)	-	-	-	-	2.18 (0.96-4.97)

Table 4. Odds ratios (OR) and 95% confidence intervals (CI) for neck complaints from a hierarchic logistic regression analysis, where the risk factors were entered into the model in four successive blocks, Study II.

	Block			
	I	II	III	IV
Risk indicators	OR (CI)	OR (CI)	OR (CI)	OR (CI)
High psychological demands	0.77 (0.38-1.57)	0.72 (0.35-1.50)	0.52 (0.23-1.14)	0.51 (0.23-1.14)
Low skill utilisation	0.84 (0.37-1.90)	0.92 (0.40-2.12)	0.79 (0.32-1.93)	0.68 (0.27-1.67)
Low social support	0.99 (0.56-1.78)	0.97 (0.53-1.76)	0.67 (0.35-1.28)	0.76 (0.39-1.48)
High demands and low skill	**2.96 (1.0-8.74)**	2.67 (0.89-8.13)	**3.13 (1.0-9.92)**	**3.76 (1.15-12.3)**
Working in a squatting position		**1.98 (1.11-3.52)**	**2.07 (1.14-3.76)**	**1.97 (1.06-3.66)**
Forward position of the head		**1.77 (1.01-3.10)**	1.69 (0.94-3.03)	1.69 (0.93-3.06)
High stress			**3.38 (1.74-6.58)**	**3.37 (1.71-6.65)**
Low energy			1.22 (0.67-2.20)	1.18 (0.65-2.17)
High age (>40 years)				1.29 (0.67-2.5)
Women (Ref. group: men)				**2.35 (1.15-4.82)**

Table 5. Odds ratios (OR) and 95% confidence intervals (CI) for shoulder complaints from a hierarchic logistic regression analysis, where the risk factors were entered into the model in four successive blocks, Study II.

	Block			
	I	II	III	IV
Risk indicators	OR (CI)	OR (CI)	OR (CI)	OR (CI)
High psychological demands	0.88 (0.43-1.77)	0.79 (0.38-1.62)	0.65 (0.30-1.38)	0.63 (0.29-1.35)
Low skill utilisation	0.76 (0.34-1.73)	0.88 (0.38-2.02)	0.75 (0.31-1.79)	0.67 (0.28-1.63)
Low social support	1.19 (0.68-2.13)	1.12 (0.62-2.03)	0.94 (0.51-1.74)	1.0 (0.53-1.87)
High demands and low skill	**3.08 (1.06-8.97)**	**2.62 (0.88-7.82)**	2.96 (0.97-9.04)	**3.51 (1.12-11.0)**
Forward position of the head		**1.75 (1.0-3.07)**	1.69 (0.96-3.0)	1.75 (0.98-3.1)
Hands above shoulder level		**1.74 (1.0-3.04)**	1.56 (0.88-2.76)	1.51 (0.84-2.71)
High stress			**2.27 (1.2-4.28)**	**2.29 (1.21-4.33)**
Low energy			1.32 (0.75-2.34)	1.36 (0.76-2.43)
High age (<40 years)				1.52 (0.80-2.86)
Women (Ref. group: men)				1.56 (0.78-3.10)

General discussion

The partial support we found for the mediation hypothesis could be due to several factors, one of which is the fact that our studies are based on the individual's perception of work conditions, stress and MSC. This means that there is a risk that the relation obtained between subjective demands and stress does not reflect a causal relation, but is the result of both variables measuring the same basic experience. The problem of using self-reports when measuring psychosocial factors and perceived stress cannot be completely avoided, but in our studies it might be reduced by stating questions about demands, control and social support in situational terms (the demand-control model) and using mood scales (the stress and energy model) for the assessment of subjective stress. As shown by study I where the actual work conditions were very similar in the two groups, the subjective ratings of these conditions still showed a large variation. This problem is somewhat different regarding the control variables, since stress and control variables are not as intimately related as stress and demands. It has also been shown that correlations between self-reports and expert ratings is higher for control than for demands (Theorell & Hasselhorn, 2005). Another reason for the different results in the two studies is that the meaning of control may differ between the two workplaces, as well as between occupational groups in the hospital study; thus, control ratings from groups with very different work tasks may not be directly comparable.

A relation between the psychosocial factors and MSC is critical for the test of the mediation hypothesis, since otherwise there is no effect to be mediated. Therefore, the failure of finding a fully mediating effect in study II could be due to the absence of this basic requirement for testing the hypothesis, in contrast to study I where shoulder complaints showed a strong relation to demands, control and social support. Different meaning attached to demands and control may have contributed to this result, as well as the strength and fluctuation of MSC and the individual’s work capacity due to MSC, in the different workplaces and between individuals. The more repetitive type of tasks among assembly workers may also have contributed to the different results.

Another factor that might lie behind the different results in the studies might be the heterogeneity of work tasks in the hospital group (study II). A consequence of this difference might be that psychosocial variables in study II to a larger extent reflect actual differences in the working conditions compared with study I (assembly workers), where differences in ratings of the psychosocial variables were predominantly of a subjective character. The effect of this difference could then be that a general rating bias such as negative affectivity was less likely to have had a common effect on ratings of work conditions, stress and complaints in study II. This interpretation implies a stronger relation between ratings of psychosocial work conditions, stress and complaints in the study of assembly workers than in study II. However, there was no such general tendency, the correlation between demands and stress was 0.49 in both studies and the correlations between the other psychosocial variables and stress were even higher in study II. In study I the relations between psychosocial variables and MSC were somewhat higher for demands and somewhat lower for control and social support. However the differences were rather small and far from statistically significant.

Thus, the influence of a general response bias explaining the differences in the two studies receives no clear support. The use of self-reported data for work conditions, stress as well as MSC remains a weakness for the two studies, although the subjective aspect of these variables is of critical importance and cannot be replaced by more objective indicators; rather, objective indicators could provide a complement to the subjective indicators. Waldenström has shown that expert assessment, which is primarily based on interviews with the worker, may be a feasible way to improve the measurement of psychosocial work characteristics (Waldenström, 2007). Another way of reducing the influence of personal bias would be to follow individual's development during a longer period, and then by analysing changes, constant differences in ratings bias could be partly eliminated.

Stress and the combination of high demands and low skill utilisation were the two strongest risk factors for neck and shoulder complaints in our studies. For upper arm complaints, however, the ergonomic work situation was the strongest predictor among the factors included in the model. High stress was closely associated with high demands in both the studies, whereas the control factor was significantly related to the perceived stress only in study II. Perceived stress has been shown to have a relation to muscle tension in the trapezius muscle measured by EMG (Lundberg et al., 1994; Melin & Lundberg, 1997; Rissén, Melin, Sandsjö, Dohns, & Lundberg, 2000), but the relations between psychosocial factors and MSC have been more inconsistent (Bongers et al., 1993; Bongers et al., 2002).

The same pattern was also shown in our results, where the psychosocial variables showed differences in their relation with MSC in the two studies, whereas high stress was strongly related with nearly all MSC in both studies. According to Bongers' model (Bongers et al., 1993; Bongers et al., 2002), workplace stress may lead to increased muscle activity and other physical responses that moderate the relation between mechanical load and the perception of MSC. The relation between high stress and MSC in our studies indicates that individuals perceive that resources are inadequate to cope with the perceived situation. In Bongers' review (Bongers et al., 2002), the strongest risk factor for upper extremity complaints was high perceived job stress, both in high- and low-quality studies. Stress factors not related to work also showed strong relations; however, only a few studies have included this in their analysis

The models mentioned in the thesis all give an interpretation of how MSC is developed and maintained. The allostatic load model describes an interesting overall explanation for the way in which prolonged stress subsequently leads to health implications, such as MSC. According to the model, health problems may occur if the system is over- or under-activated by intense and long-lasting stress. The balance between activity and recovery opportunities is of great importance for the body's ability to increase or decrease allostatic activity in order to maintain homeostasis (McEwen, 1993; McEwen, 1998). The different models included in this thesis all agree on the importance of work pauses, although they differ in their explanation of how MSC is developed.

In our studies, psychosocial aspects of the workplace (measured as demands and control) lead to stress. The levels of high energy and social support should function to support a decrease in activity over time, but in our studies this was not sufficient to suppress the perceived high stress. This implies that an increase in

vital functions will continue and thereby be over-activated, which in turn has health implications. As shown in our studies, high stress was strongly related with nearly all MSC. Bruce McEwan's model also explains how stress affects allostasis. At this point there is no adaptation to the repeated stressors, which results in a prolonged exposure to stress hormones. This disability to shut off the responses triggers other compensatory responses that make the individual weaker and a chronic condition develops. It is in this situation that the load starts to have a chronic effect (McEwen, 1998).

In conclusion, within the limits posed by the cross-sectional design of these studies, some support for the mediation hypothesis was found in study I, where the effect of demands on shoulder complaints was mediated by affective stress response. The cross-sectional design of the studies also limits the possibility to draw conclusions about causal relations between the variables included in the studies. The next step could be to investigate the role of affective stress response as a mediator on the development of MSC in a longitudinal study, preferably an intervention study. However, the real question is, whether epidemiological studies of this type, either cross-sectional or longitudinal, will provide any further knowledge about this complex matter. Today there are several models explaining the relations between psychosocial workload, stress, ergonomic workload and MSC. These relations have been tested in several ways, and the two studies included in this thesis add to an understanding of the complex matter of MSC by testing the mediation hypothesis. The results of the two studies were somewhat different and again showed that MSC is a complex topic. The models explaining relations could cooperate or interact with each other at different time intervals during the development of MSC. Melin and Lundberg (1997) included family-related factors in their model. By calling attention to the importance of stressors outside work they highlighted the fact that factors other than work may cause the stress response to continue to keep the motor units active, even in the absence of workload. Stress development demands energy mobilisation, and such mobilisation needs to be followed by periods of rest and recovery, which give attention to the question weather there should be different rest and recovery activities for different types of workload?

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