Work related neck–shoulder pain: a review on magnitude, risk factors, biochemical characteristics, clinical picture and preventive interventions

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The purpose of this review is to scrutinize the physiology of neck–shoulder pain and trapezius myalgia based on the most recent scientific literature. Therefore, systematic literature searches have been conducted. Occurrence of neck–shoulder pain, risk factors for development of neck–shoulder pain, and its work-relatedness are addressed. Furthermore, the latest information on the biochemical milieu within healthy and painful neck–shoulder muscles is reviewed. Finally diagnosis of and intervention for neck and shoulder pain are discussed.

Key words: algesic; biopsy; human; intervention; metabolism; microdialysis; muscle; myalgia; pain; neck; review; risk factor; shoulder; trapezius; work-related.

Musculoskeletal disorders comprise one of the most common and costly public health issues in Europe and North America1,2, and the cost in the Nordic countries and Holland has been estimated to encompass 0.5–2% of the GNP.3 Among these
disorders, persistent neck–shoulder pain, including myalgia, is one of the commonest. For several decades well-defined work-related physical and psychosocial factors have been shown to be associated with onset or worsening of pain in this region. In spite of abundant epidemiological knowledge, there is little to indicate that the incidence of neck–shoulder pain is diminishing. The pathophysiology of myalgia in this region has been reviewed in a number of papers, with the conclusion that there are multiple possible mechanisms. However, whether local muscular processes provide an explanation for this kind of pain is often questioned. In the case of chronic neck–shoulder pain, in particular, the muscular component is often considered uncertain. However, recently a relatively large number of studies using methods such as muscle biopsy and microdialysis have opened up new possibilities for elucidating the role of peripheral factors and changes in the biochemical milieu in muscle in the development and maintenance of pain and disorders.

Research in the field of work-related myalgia often concerns the plausible connection between muscular activity and muscle damage. This relationship, as well as knowledge of pathomechanisms, are partly but not sufficiently elucidated. Accurate and, ideally, standardized diagnosis of neck and shoulder myalgia is a prerequisite for adequate individual ergonomic interventions. Furthermore, prevention must rely on scientifically based knowledge regarding risk factors as well as the possible pathomechanisms behind the development of neck pain.

This review addresses the occurrence of neck–shoulder pain and trapezius myalgia, and risk factors for the development of these complaints. Furthermore, the significance of histological and biochemical alterations underlying pain, diagnostic possibilities, and interventional aspects of neck–shoulder pain will be reviewed.

**OCCURRENCE OF WORK-RELATED NECK–SHOULDER DISORDER**

There is a vast amount of epidemiological literature dealing with work-related neck–shoulder disorders as a major health problem in many occupations. Still, the work-relatedness in the sense of a well-established dose–response relationship or a calculated etiological fraction is poorly documented. This is due to several factors presenting varying degrees of difficulty for a straightforward interpretation. First of all, the term 'neck–shoulder disorders' covers a broad spectrum ranging from self-reported pain to a relatively well-defined clinical diagnosis. Therefore, incidence and prevalence of neck–shoulder disorders are difficult to compare across studies and countries. In the Finnish population the prevalence of neck pain has in the last two decades shown a steady increase and is the second most frequent musculoskeletal complaint. In the working population in general, the estimated prevalence of upper-extremity symptoms is in the range 20–30%. In a Canadian general population survey the 6-month prevalence of neck pain was more than 50% among all adults. Women more often than men experience neck pain and develop persistent pain, and most individuals with neck pain do not experience complete resolution of their symptoms and disability. Within certain occupations the prevalence is even higher than in the general population; among Danish computer users the 12-month prevalence of more than 7 days with neck pain was approximately 45%. The incidence of neck cases was 25% for women and 15% for men. In addition, those who reported previous symptoms were more likely to also develop symptoms in the follow-up period. Prevalence is highest when neck symptoms are quantified by self-reported duration, frequency, and intensity. The prevalence decreases when symptoms are to
be confirmed by physical examination findings. Thus, in a study of elderly female computer-users in EU countries, it was found that for as many as 60% of those with self-reported neck symptoms of a certain duration and intensity, a clinical examination could confirm one or more diagnoses, with trapezius myalgia (38%), tension neck syndrome (17%), and cervicalgia (17%) being the most frequent. For the individual, the consequences of neck–shoulder pain may range from minor episodes of short duration with limited activity, through recurrent episodes with diminished work capacity and performance, to severe and disabling episodes or chronic disability. Therefore, for society the economical consequences similarly range from short-term sick leave, through recurrent long-term sick-leave periods, to early retirement and/or disability pension.

**Risk factors identified in the scientific literature**

In 2001 a large review presented a state-of-the-art overview scrutinizing the available documentation on possible risk factors for work-related upper-extremity disorders. The conclusion stated that strong evidence was found for a causal relationship between neck disorders and highly repetitive work, forceful exertions, high level of static contractions, prolonged static loads and extreme postures, as well as combinations of these factors. There was insufficient evidence for vibration as a risk factor for neck disorder.

**Literature search, 2000–2006**

In the present review it was decided to follow up on this earlier review with a systematic search of the newest epidemiological literature to reveal whether new evidence had emerged regarding risk factors for upper-extremity disorders. The search was performed in OSHROM, MEDLINE, EMBASE and Cochrane (CDSR). For details see Appendix 1.

The search was conducted as a combination of four sets of keywords, and results were restricted to review papers published from 2000 to 2006 in the English language. This resulted in 156 review papers that were scrutinized to include only systematic reviews with a reproducible search method, a quality estimation and objective criteria for defining sufficient evidence for a risk factor. This procedure resulted in ten reviews primarily based on epidemiological evidence and considering both disorders confirmed by clinical examinations as well as symptoms described as disorders, pain, decreased work ability or performance, etc. Conclusions on the major risk factors are presented as follows.

**Identified risk factors**

**Gender**

Individual factors are not considered in this review, with just one exception; gender seems to play a prominent role, since the prevalence of pain in the upper extremity is much higher among women than men. This is the case even when adjusting for confounders such as age and seniority. The difference may be explained by many factors, but one explanation could be that women’s jobs, more often than men’s,
involve work tasks with static load on the neck muscles, high repetitiveness, low control and high mental demands that are possible risk factors for neck–shoulder pain.

**Repetitive movements**

Malchaire et al found that 75% of the studies reviewed demonstrated a significant relationship between repeated movements and upper extremity disorders in general, whereas van der Windt et al found a consistent relationship specifically between neck–shoulder pain and repeated movements. However, it was not possible to find evidence of a detailed dose–response relation between specific work tasks and the development of specific disorders. All in all the most recent literature reviews confirm the strong evidence found in the National Research Council (NRC) survey for repetitive movements.

**High force demands**

Very few work situations demand high force performed directly by neck–shoulder muscles. However, forceful manipulation with the hands often requires a high degree of stabilization in the neck–shoulder area. Ariens et al found some evidence for a correlation between the work-related force requirements in the arms and neck–shoulder pain, as well as between heavy lifting and neck–shoulder pain. Malchaire et al further found sufficient evidence for a linkage between forceful hand work and both hand/wrist and neck–shoulder disorders.

**Work posture**

Work posture as a risk factor for neck disorders involves both duration of constrained postures, as well as awkward or extreme postures involving both neck and arm. Malchaire et al found evidence for awkward posture as a risk factor for neck–shoulder disorder. Likewise, Ariens et al found some evidence for a causal relation between neck disorders and sedentary work for more than 5 hours a day, as well as work demanding bending and twisting of the upper spine. Both Ariens et al and Walker-Bone et al found that working with the arms lifted above shoulder level was a well-documented risk factor for neck–shoulder disorder.

**Vibration**

Vibration is typically found in work with hand tools or machines. In the NRC report evidence was found for vibration as a risk factor for muscle disorders in general. The recent literature survey does not support this clear picture. While Malchaire et al found no relationship between vibration and shoulder or hand disorders, van der Windt et al reported a consistent association with shoulder disorder, while Ariens concluded that there was some evidence.

**Computer work**

The NRC review concluded that there was evidence for an increased risk for development of upper-extremity disorders among computer users. It was suggested that this could be due to constrained postures, constant force and highly repetitive movements as well as psychosocial factors such as time constraints and high quantitative demands. This conclusion is supported by the prevailing literature on sustained
activity of low-threshold motor units during low-force static or repetitive muscle tension in trapezius as well as the forearm muscle.\textsuperscript{21–25}

Only a few reviews have been done since 2000 regarding the documentation for computer work and symptoms from the upper extremities. A single review has focused on temperature and disorders, since cold hands and forearms are often reported symptoms among computer users.\textsuperscript{26} However, no support was found for a connection between temperature changes and disorders among computer users.

Gerr et al focused on the association between neck disorders and work postures and duration of computer use measured as hours per day or week.\textsuperscript{27} The review concluded that there is evidence for work posture as a risk factor for the development of disorders. Specifically, the keyboard position below elbow height and support under the forearms were associated with a reduced risk of developing neck–shoulder disorders. Even though it was not possible to specify a dose–response relationship, evidence was found for duration of computer work as a risk factor for neck–shoulder disorder, as has also been confirmed in recent studies.\textsuperscript{27,28}

Veiersted et al focused on a possible connection between computer use and clinically diagnosed disorders in neck, shoulder and arms, and is thus narrower in scope than the reviews on symptoms in general.\textsuperscript{29} They found that there was limited evidence for a causal relationship between computer work, mouse use or keyboard use, and this rather strict definition of neck disorders that does not consider diagnoses such as, for instance, trapezius myalgia.\textsuperscript{29}

\textit{Psychosocial factors}

The NRC report showed documentation for a causal relationship between work-related stress and high demands, and disorders in the upper extremity.\textsuperscript{16} Only a few newer overviews add to this. There is some evidence for a relationship between disorders and high quantitative demands, lack of support from colleagues, low job control and low influence.\textsuperscript{30} In two other reviews, evidence for a relation between mental stress at work and disorders was also demonstrated.\textsuperscript{18,31} In addition, a relationship between high quantitative and qualitative demands at work and disorders was evident. However, there was insufficient evidence to evaluate the relationship between disorders and low control, influence on own job situation, lack of support from colleagues and superiors, general unsatisfactory job content. All in all, the limited amount of literature focusing on causal relationships between psychosocial factors and disorders makes it difficult to estimate the influence of these factors and how they may interact with the biomechanical and individual factors.

\textbf{MUSCLE NOCICEPTION}

Neurophysiological studies have indicated that small-diameter, slowly conducting afferent nerve fibres from skeletal muscle have to be excited in order to elicit pain. A high proportion of these fibres terminate in free nerve endings with nociceptive properties.\textsuperscript{32} Nociceptors are sensitive to chemical substances released from damaged or overloaded cells and excessive tissue deformation.\textsuperscript{33} Nociceptors have been shown to respond to several algesic substances such as bradykinin, serotonin, and prostaglandin, to name a few.\textsuperscript{34} Administration of any of these substances, alone or in combination, results in excitation of nociceptors and/or peripheral sensitization. A sensitized nociceptor has a lowered threshold for activation and can thus be activated by stimuli
which are normally innocuous. Sensitization is often accompanied by an increase in the sensitive area. Different sensitization processes can occur in the central nervous system. Central sensitization and spreading of pain is widely discussed, and is very likely to influence the clinical symptoms and the course of neck myalgia, but is beyond the aim of this chapter to review. Most research on muscle pain has been conducted on animals; however, this review will primarily focus on human studies of neck and shoulder myalgia, for which the frequently affected trapezius muscle often serves as a model muscle.

MORPHOLOGICAL AND BIOCHEMICAL STUDIES OF MYALGIA

During recent years, several studies on biochemical and morphological processes in myalgic human muscle have been published and will be the focus in this section.

Literature search

A systematic literature search was made in MedLine, Science Citation Index and EMBASE. The following combinations of search words were used: (1) trapezius, biopsy, (2) neck, muscle, pain, pathophysiology, (3) muscle, pain, microdialysis, (4) muscle, pain, induced. The searches were limited to papers in English and resulted in 89 articles after duplicates were removed. Firstly, the abstracts of these articles were read, and when abstracts were found to be relevant for this review the full papers were scrutinized.

Muscle biopsy studies

The muscle biopsy technique provides a snap-shot approach. The biopsy includes muscle fibres, connective tissue and extracellular space, and is useful for detection of possible structural alterations in painful conditions. Nine studies addressing trapezius muscle fibre abnormalities have been published. Eight of them have previously been reviewed. Standard histological methods were made with some variations. Major findings in myalgic and non-myalgic subjects exposed to demanding neck and arm work tasks were increased fibre cross-sectional areas and reduced capillarization per fibre area, the latter only in women, possibly indicating disturbances of oxidative metabolism. Furthermore, various mitochondrial disturbances of type I fibres, named moth-eaten fibres and ragged red fibres, were found to be more frequent in subjects with pain.

The microdialysis technique

Microdialysis is a technique for studying the local biochemistry of individual tissues in the body. The technique has been extensively used in neuroscience to monitor neurotransmitter release, but has also found application in monitoring the biochemistry of peripheral tissues in both animals and humans. The basic principle is to mimic the function of a capillary blood vessel by perfusing a thin dialysis tube implanted into the tissue with a physiological saline solution. Substances can pass, by simple diffusion, across the dialysis membrane along the concentration gradient. The dialysate is analysed chemically and reflects the composition of the extracellular fluid. Microdialysis
thus allows for continuous sampling of compounds in the muscle interstitial space, where nociceptor free nerve endings terminate, and in close proximity to the muscle fibres, providing accurate information on regional biochemical changes before such compounds are diluted and cleared by the circulatory system.

Biochemical studies of non-myalgic and myalgic muscles in human subjects

Metabolites

In a study on six healthy men, Rosendal et al found marked changes in muscle interstitial lactate, pyruvate and potassium in response to repetitive low-force contractions of the trapezius muscle, which were not reflected in plasma. The findings were interpreted to be due to inhomogeneous activation rather than insufficient blood flow. Likewise, a fast and marked increase in interleukin 6 (IL-6) was found during exercise. It was speculated that the high IL-6 level could be partly attributable to local changes in metabolic demands during exercise, but this could not be confirmed in a study of women with and without long-standing trapezius myalgia. Although the myalgic women were found to have increased levels of pyruvate and lactate at rest and during exercise, indicating hyper-metabolism, uniform levels of local blood flow were found in the groups during rest and exercise. In support of these findings, in another study on 20 healthy women who performed either 30 or 60 minutes of repetitive low-force arm work, Flodgren et al found that interstitial trapezius muscle glutamate and lactate increased significantly in response to repetitive low-force work. However, no further increase with increasing work duration was found. Neither were alterations in prostaglandin E$_2$ (PGE$_2$) or local muscle oxygenation, assessed by near-infrared spectroscopy, affected by the duration of work.

Recently, McIver et al found that eight women with chronic widespread myalgia and hyperalgesia – i.e. fibromyalgia (FM) patients – responded during exercise to nitric oxide with higher muscle interstitial lactate levels compared to controls; nitric oxide is known to have many physiological actions, including vasodilatation.

Pain-related substances

In a myalgic group of women, the algesic substances serotonin and glutamate were increased and correlated to pain intensity and decreased pain pressure thresholds respectively. Glutamate is a well-known pain modulator in the human central nervous system, acting via the N-methyl-D-aspartate (NMDA) receptor. Direct and indirect evidence in animals has shown that excitatory amino acid receptors – i.e. glutamate receptors – are present on the peripheral ends of small-diameter primary afferents in several tissues such as muscle. The role of glutamate in peripheral nociception in humans is unclear. Tension-type headache is not associated with increased peripheral glutamate, whereas increased glutamate levels and NMDA receptors have been demonstrated in painful tendon tissue. Several studies have demonstrated that injections of glutamate increase pain intensity, but it is difficult to compare these findings with Rosendal's studies because higher doses are used in the injection studies. Although high interstitial glutamate levels were demonstrated in a study of myalgic and non-myalgic women, no differences in interstitial glutamate and PGE$_2$ levels between the groups were found. A possible difference between subjects of these studies may contribute to the inconsistent glutamate finding. The pain history, the present pain, and clinical muscular neck status of the subjects are
sparsely presented in the Flodgren study. The myalgic subjects studied by Rosendal et al comprised subjects reporting considerable long-standing pain, distinct current muscular signs confirmed at clinical examination, and most were on disability leave. Shah et al examined the local biochemical milieu in the trapezius muscle of healthy subjects and subjects with neck pain before, during, and after stimulation of the hypersensitive nodule. Bradykinin, calcitonin gene-related peptide, substance P, tumor necrosis factor α, interleukin 1β, serotonin and norepinephrine were found to be significantly higher in the myalgic group and related to external stimulation rather than the hypersensitive nodule. Also Boix et al studied the potent algogen, and key mediator of inflammatory hyperalgesia, bradykinin. It was found that during bilateral shoulder abduction sustained until exhaustion, healthy women liberated intramuscular bradykinin which correlated positively with pain intensity. Ashina and co-workers have investigated local tenderness in trapezius muscle of patients with chronic tension-type headache. The subjects performed static exercises (10% of maximal force), and it was found that the exercise-related increase in blood flow was lower in patients than in controls. This increase was interpreted as related to increased sympathetic activity in the chronic painful state. No signs of altered metabolism or inflammation were found in the tender trapezius muscle of patients with tension-type headache.

In animal experiments, serotonin (5-HT) has been found to mediate pain and hyperalgesia. Single injections of a combination of bradykinin and 5-HT in concentrations similar to the findings of 5HT in resting painful muscle results in muscle pain and hyperalgesia. The deep craniofacial tissues such as the masseter muscle represent common sites for acute and chronic pain, and masseter myalgia is often associated with pain in neck–shoulder muscle. Intramuscular administration of 5-HT into the human masseter muscle has been demonstrated to induce pain. A positive correlation between pain intensity during the last week, allodynia, and the level of interstitial 5-HT in the masseter muscle in patients with fibromyalgia (FM) and patients with localized myalgia compared to controls has been reported. Furthermore, FM patients also seem to have a higher fraction of 5-HT in the masseter muscle compared to the level in blood serum.

The effects of intramuscular glucocorticoid (GC) on the level of 5-HT and associated changes in pain and tenderness of the masseter muscle in subjects with local masseter muscle pain has been examined. A negative correlation regarding 5-HT and pressure pain threshold and pressure pain tolerance was found after GC injections in this study. PGE2 levels were also found to be related to muscular pain in FM patients, and intramuscular administration of GC in the masseter muscle of FM patients and subjects with masseter myalgia resulted in a decrease in muscle PGE2 and a decrease in resting pain in FM patients. Thus masseter muscle pain was interpreted to be partly due to peripheral inflammation in FM. Peripheral inflammation as a cause of pain is disputed by other studies. Studies on painful conditions found no indication of PGE2 being associated with trapezius myalgia, or tendon pain, as well as finding similar levels of the pro-inflammatory cytokine IL-6 in myalgic and non-myalgic subjects.

Increased potassium levels have also been speculated to be related to muscle pain. Graven-Nielsen et al have presented an in-vivo muscle model of muscle pain, and suggested that pain activation and cessation were related to increased intramuscular sodium and potassium respectively. However, Green et al did not find potassium related to ischaemic myalgia in healthy subjects. Despite this, increased potassium
levels have been shown in response to repetitive work and in subjects with trapezius myalgia.

**CLINICAL DIAGNOSIS OF NECK AND SHOULDER MYALGIA**

The basis for the diagnostic criteria of neck and shoulder myalgia is relatively vague, and the diagnostic terminology and methods for assessment of neck and upper-limb musculoskeletal disorders are variable. This implies that several more or less specific and partly overlapping diagnoses exist in clinical practice and epidemiological research. A typical anamnesis with progressing neck and shoulder pain and no other symptoms or signs does not require investigations such as radiography, magnetic resonance imaging, electromyography or nerve conductance velocity testing. The patients’ complaints and the manual clinical examination are the most important instruments in the process of diagnosis. A standardized clinical examination protocol leading up to diagnoses of the neck and upper extremity based on carefully defined criteria (Table 1) was developed and has recently been modified. In short, the standardized clinical examination included questions on pain, tiredness and stiffness on the day of examination, as well as physical tests including range of motion and tightness of muscles, pain threshold and sensitivity, muscle strength, and palpation of tender points. The protocol has been widely used in epidemiological research and may also be appropriate in clinical practise. Sluiter et al reviewed the literature on upper-extremity musculoskeletal disorders and proposed criteria for signs and symptoms for the most common work-related disorders. When criteria for assessing pain and non-articular soft-tissue disorders of neck and upper limb were reviewed, it was concluded that the diagnosis relies heavily on the clinical opinions of the investigators. Furthermore, data were found to be insufficient to indicate that the criteria are repeatable, sensitive or specific; 27 classifications systems for upper-limb musculoskeletal disorders were reviewed, and only slight agreement was found between the systems.

**PREVENTIVE INTERVENTIONS**

The first recommendations given by the NRC report is that a broad comprehensive effort to promote ergonomic as well as other preventive strategies is highly justified. This is based on the consequences of musculoskeletal disorders for both the individual and society, in combination with the evidence that these problems are at least to some degree preventable. The broad consensus of the multifactorial element in the development of musculoskeletal neck–shoulder disorders indicates the need for a combined physical, psychosocial and organizational approach to prevention. This view is supported by a number of newer reviews that also stress the participatory element as important for successful intervention. However, only a few reviews of effect-evaluated interventions are available. In 2006 a Cochrane review was performed evaluating randomized controlled studies until year 2000 on the effect of physical activity compared to organizational changes on disorders in the low back and neck regions. However, there were not found any randomised controlled trials focusing on the neck. Apart from this Cochrane review, there are several more general but systematic reviews on preventive interventions. Silverstein and Clark reviewed 73 studies and concluded that the largest body of evidence for the prevention of neck–shoulder disorders stems from multicomponent interventions, and that subject-oriented interventions are the
Table 1. Criteria for diagnosis of disorders of the neck and upper limbs. All findings were required.

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Criteria</th>
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<tr>
<td>Tension neck syndrome</td>
<td>Neck pain; sense of fatigue or stiffness in the neck; pain radiating from the neck to the back of the head; tightness of muscles; tender spots in the muscles</td>
</tr>
<tr>
<td>Cervical syndrome</td>
<td>Pain radiating from the neck to the upper extremity; limited neck movement; radiating pain provoked by test movements; decreased sensibility in hands/fingers; muscle weakness of the upper limb</td>
</tr>
<tr>
<td>Cervicalgia(^a)</td>
<td>Neck pain, limited neck movement in at least four of six directions. Diagnosis only if tension neck syndrome or cervical syndrome is not present</td>
</tr>
<tr>
<td>Trapezius myalgia(^a)</td>
<td>Neck pain, tightness of muscles, tender points in the muscles. Diagnosis only if tension neck syndrome or cervical syndrome is not present</td>
</tr>
<tr>
<td>Thoracic outlet syndrome</td>
<td>Pain radiating to upper extremity, in the distribution of the ulnar nerve; paresthesia in the distribution of the ulnar nerve; positive Roos' test (increase of the subjective symptom, not only fatigue); intense tenderness over the brachial plexus. Diagnosis only if tension neck syndrome or cervical syndrome is not present</td>
</tr>
<tr>
<td>Frozen shoulder</td>
<td>Shoulder pain; progressive stiffness of the shoulder during the last 3–4 months; limited outward rotation, and abduction</td>
</tr>
<tr>
<td>Supraspinatus tendinitis ((n=18))</td>
<td>Shoulder pain: local tenderness over the tendon insertion; pain at resisted isometric abduction</td>
</tr>
<tr>
<td>Infraspinatus tendinitis</td>
<td>Shoulder pain; local tenderness over the tendon insertion; pain at resisted isometric outward rotation</td>
</tr>
<tr>
<td>Bicipital tendinitis</td>
<td>Shoulder pain; local tenderness over the tendon(s); pain at resisted isometric elevation of the arm (straight and elevated 90°) and/or resisted isometric flexion of the elbow (flexed 90° hand supinated)</td>
</tr>
<tr>
<td>Acromioclavicular syndrome</td>
<td>Shoulder (epaulet pain); palpable tenderness of the joint; pain provoked by horizontal adduction and/or by outward rotation of the arm (90° abducted, with flexed elbow)</td>
</tr>
<tr>
<td>Lateral and medial epicondylitis</td>
<td>Elbow pain; palpable tenderness of the lateral and/or medial epicondyle; pain at resisted isometric extension or flexion of the wrist; for the diagnosis lateral epicondylitis, pain and/or weakness in gripping</td>
</tr>
<tr>
<td>De Quervain's tendinitis(^a)</td>
<td>Pain at the wrist; tenderness at palpation of tendons the thumb side of the wrist. Localized swelling, redness and heat</td>
</tr>
<tr>
<td>Overused hand syndrome(^a)</td>
<td>Wrist pain; palpable tenderness of the wrist capsule of the thenar- and hypothenar muscles and of the intrinsic muscles of the hand</td>
</tr>
<tr>
<td>Peritendinitis/tenosynovitis</td>
<td>Wrist pain; palpable tenderness of the tendon(s); local swelling; redness, or heat</td>
</tr>
<tr>
<td>Carpal tunnel syndrome</td>
<td>Nocturnal numbness of the hand; paraesthesia in the distribution of the median nerve; positive Tinel’s sign over the carpal tunnel; positive Phalen’s test; decreased sensibility in the distribution of the median nerve: decreased strength in opposition of the thumb</td>
</tr>
<tr>
<td>Pronator syndrome</td>
<td>Pain of the medial/proximal part of the forearm; local tenderness over the edge of m. pronator teres; pain and decreased strength in pronation; decreased flexion strength in pronation; decreased flexion strength of the wrist and/or of the distal phalanxes of the fingers I–II</td>
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least efficient. Lötters and Burdof reviewed 40 studies and concluded that although many different interventions all showed some effect, the greatest effect resulted from primary prevention in the physically heavy jobs. Buckle and Devereux evaluated the reduction in biomechanical risk factors by organizational changes and work-place adjustments, and found that exposure could be reduced which could potentially reduce neck–shoulder disorder. Likewise Leonard focused on education, and concluded that this could also potentially reduce risk factors by changing the behaviour of employees. Brewer et al included 31 studies in a review on interventions in office work. Overall it was concluded that, due to the limited number of studies, there was only moderate evidence for an effect by any form of intervention in office work. However, there probably could be a positive effect of interchanging the input device in computer work, and here it should be remembered that ‘absence of evidence is not the same as evidence of absence’.

Two reviews have looked at physical activity. Hildebrandt et al focused on 39 studies on leisure-time activity, and Proper et al included 26 studies on work-place activities. Physical activity in leisure time was not associated with neck–shoulder disorders, but sedentary workers with low levels of leisure-time activity had a higher prevalence of neck disorders. Proper et al found strong evidence for a positive effect of physical activity at work on neck–shoulder disorders. However, the evidence for a similar positive effect on sickness absence was rather limited due to a lack of high-quality studies. Since these reviews were published, a number of intervention studies have focused on systematic strength training as an intervention among women with chronic disorders. While less intensive training, stretching, and aerobic training generally showed no effect, a follow-up design could even document a long-term effect of strength training. In one study light resistance training has also been found to decrease the intensity of neck pain among office workers, while Brox and Frøystein found no evidence for decrease in sickness absence with low-intensity physical activity interventions.

<table>
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<tr>
<th>Diagnosis</th>
<th>Criteria</th>
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<td>Radial tunnel syndrome</td>
<td>Pain in the elbow during rest; tenderness about 2—3 inches distally of the lateral epicondyle; pain of the proximal, lateral part of the forearm and pain and decreased strength in supination; decreased strength in ulnar deviation</td>
</tr>
<tr>
<td>Ulnar nerve entrapment at the elbow</td>
<td>Pain and paresthesia of numbness in the distribution of the ulnar nerve; decreased sensibility of the fingers IV—V and of the ulnar part of the back of the hand; positive Tinel’s sign over the cubital tunnel; decreased strength in spreading the fingers and in flexion of the distal phalanx of finger V</td>
</tr>
<tr>
<td>Ulnar nerve entrapment at the wrist</td>
<td>Pain and paresthesia or numbness in the distribution of the ulnar nerve: decreased sensibility of the fingers IV—V; positive Tinel’s sign over Guyon’s tunnel (volar/ulnar at the wrist); decreased strength in spreading the fingers</td>
</tr>
</tbody>
</table>

Modified from Ohlsson et al (Ergonomics 1994; 37: 891–897) with permission from Kerstina Ohlsson. * Diagnosis added by personal communication with Kerstina Ohlsson since the table was originally published by Ohlsson et al (1994); and these have been added in 2006.
SUMMARY

This review has focused on the physiology of neck–shoulder pain and trapezius myalgia, its possible relationship to work, risk factors for its development, the latest knowledge on changes in structure and biochemical milieu in painful muscles, and the most-used standards for diagnosing neck–shoulder disorders as well as the state of the art in rehabilitation.

The review confirms earlier findings of evidence for a causal relationship between neck and shoulder disorders and highly repetitive work, forceful exertions, high level of static contractions, prolonged static loads, and extreme postures, as well as combinations of these factors.

Whether local muscular processes can explain chronic neck–shoulder pain is often questioned, and this has turned the focus towards central processing as the primary...
explanation for pain. However, new methodology and many recent publications have indicated a role for local muscular processes as being causally related to pain. Several studies have reported altered metabolism and increased intramuscular levels of algesic substances in subjects with chronic neck and shoulder myalgia. Furthermore, there are some indications of structural abnormalities in biopsies from painful muscles. Despite this, criteria for neck–shoulder disorders are not sufficiently repeatable, sensitive or specific, and there is little agreement between the different classification systems.

A single, universal, simple classification system would probably advance the management of these disorders, but at present no such classification system exists. A step towards reducing these disorders may be a consensus on the key elements of a classification system.

Evidence for physical activity for rehabilitation of neck–shoulder pain is slowly emerging, and promising results are appearing on the effect of strength training. Still, because the pathophysiology of neck–shoulder pain seems to be multifactorial, interventional models including physical, psychosocial and organizational elements will probably have the greatest effect on pain in the long run.

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CONFLICT OF INTEREST STATEMENT

There are no conflicts of interest. No financial or personal relationship has inappropriately influenced this work.

Appendix 1. Literature search on risk factors for work-related neck–shoulder pain

As described under ‘Literature search, 2000–2006’, a systematic search for the newest epidemiological literature on risk factors for neck–shoulder was performed. The search was performed in OSHROM, MEDLINE, EMBASE and Cochrane (CDSR) as combinations of the four sets of keywords listed below. The results were restricted to review papers published from 2000 to 2006 in the English language. The search terminology was arranged as sets of search keywords:

1. shoulder, neck, arm, upper extremity, forearm, head, musculoskeletal, upper limb, cervical, muscle
2. pain, discomfort, illness, nociception, fatigue, tired, stress, injury, strain, unpleasantness, disorder, myalgia
3. work, workplace, job, occupational, work-related
4. risk factors, static load, repetitiveness, force, monotonous, office work, computer, industry, psycho social, psychosocial, psychosocial factors at work, emotional demands, bottling up emotions, job insecurity, job strain, job control, social support, management quality, reward, meaning, predictability, conflicts at work, perceived stress, stress at work, high job demands, effort reward imbalance, social support, social network, job demands, role conflicts, role clarity, burnout, job satisfaction, family-work.

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