

COLD EXPOSURE AND MUSCULO-SKELETAL DISORDERS AND DISEASES

A review

ABSTRACT

The aim of this study was to investigate how cold exposure may be associated with musculoskeletal problems either on symptomatic or disease level based on available relevant scientific literature. The data collection resulted in ten scientific articles, from which nine were epidemiological and one a case report consisting of three cases. The results indicated that musculoskeletal symptoms are more frequent in cold store work and in related conditions than in normal temperature work and symptoms seems to be increased when the working time in cold environment increases. In cold store work low back pain and knee pain are more frequent problems than in normal temperature working environment. The association between cold exposure and shoulder pain is still unclear and has been poorly studied. Meteorological conditions, principally low ambient temperature may have an effect of reported low back pain in a remarkable part of population. In the etiology of tenosynovitis cold exposure has a specific role either as a causative or a contributing factor. The risk for carpal tunnel disease is 2.2-fold in repetitive wrist movements compared with no repetition and 9.4-fold when cold exposure added. Cold exposure in work seems to be associated with a little increased risk (Odds ratio 2.2) for degenerative discopathies of lower back in men. However, this risk is small and seems to be associated with other physical factors in the background. In conclusion, the associations between cold exposure and musculoskeletal complaints or diseases are shown in some studies and the need of further research is apparent. (*Int J Circumpolar Health* 2002; 61: 173-182)

Key words: tenosynovitis, carpal tunnel syndrome, disc degeneration, low back pain, shoulder pain, joint pain

The entity "musculoskeletal disorders" represents all complaints of muscles, joints, tendons, ligaments and bones. The symptoms may be painful conditions or show restricted range of motion or movement, fatigue or functional loss felt in joints, neck, back, arm, muscles, tendons or bursae. In his monograph Kelsey (10) classifies the diseases of the musculoskeletal system as systemic, such as rheumatoid arthritis or as regional, such as diseases of 1) joints and intervertebral discs, such as arthritis, osteoarthritis and disc degeneration, 2) enthesopathies such as tendinitis, peritendinitis, tenosynovitis and epicondylitis, 3) diseases of bursae such

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as bursitis or degenerative processes, 4) endocrine and metabolic bone diseases, 5) osteochondroses and aseptic bone necroses 6) radiculopathies, 7) neurovascular compression syndromes such as thoracic outlet syndrome and 8) chronic musculoskeletal syndromes consisting of primary fibromyalgia syndrome, myofascial pain syndrome and temporomandibular pain and dysfunction syndrome. In general we are speaking about pain in a specific region of the body, for example in neck, back and shoulder pain. These all represent musculoskeletal pain or disorder.

Cold exposure in musculoskeletal system may be caused from environment by low ambient air or water temperature, or from wind-chill effect. It may also be mediated in contact with cooled or frozen food products, in cold stores, in meat-processing industry and in related conditions. Special interest has been directed in occupational and military working conditions to evaluate the exposure and also to develop protective clothing.

The aim of this presentation is to evaluate how cold exposure may be associated with musculoskeletal problems either on symptomatic or disease level according to available relevant scientific literature. The individual "primary" physiological or pathological responses to cold have been principally excluded from the presentation.

METHODS

This presentation was based on available scientific literature, where cold exposure and musculoskeletal symptoms or diseases have been studied. Principally the PubMed and Embase databases and the library of Finnish Institute of Occupational Health were used. The data collection included the following key words: cold exposure, cooling, hypothermia, musculoskeletal, musculoskeletal disorders, musculoskeletal pain, low back pain (LBP), neck pain (NP), shoulder pain (SP), carpal tunnel syndrome (CTS), tenosynovitis, tendinitis, tennis elbow, fibromyalgia, rheumatic disorder. The analysis was concentrated in regional musculoskeletal disorders and diseases.

RESULTS

Using the key and text words taken, the collection of litera-

ture resulted in ten scientific articles, which were considered to be applicable for the purpose of this analysis. A lot of articles have been published using key words cold, cooling, hypothermia but the study plan was either basic scientific or therapeutic and major of the works were not suitable for this study. From the ten papers three were based on questionnaires and clinical examination, three on questionnaires, three were clinical studies and one was a case report of three cases. The exposure for cold was caused by low indoor ambient temperature such as in factories or in cold storages in six studies, by weather in two and by both in two studies.

Musculoskeletal symptoms

Without any diagnosed pathology, several studies have used questionnaires to define prevalent musculoskeletal symptoms in low ambient temperatures principally for occupational purposes. The symptoms of the musculoskeletal

Table 1. A collection of studies on musculoskeletal symptoms associated with cold exposure

<i>Author(s), year</i>	<i>Study design and exposure</i>	<i>N</i>	<i>Results and conclusions</i>
Chen et al. 1991	Musculoskeletal pain in cold store workers, examin. and questionnaire, lower temperature store (LTS) -10 – -25°C, ice store (IS) -5 - + 5°C vs normal temperature store (NTS) +20 - +30°C, working time 4-6 hours/day in cold	463 men vs 152 men	LBP and KP complaints significantly higher in LTS and IS groups than in NTS group, SP significantly higher in IS group, LB and knee symptoms will increase after 5 years of working time. Knee pain in cold stores is not only caused by heavy work
Wang et al. 1991	BP in physical examination in 41 LTS, 109 IS and in 67 workers exposed to cold water (CW) vs 73 NT workers	290	LBP in physical examin. in: 46 % of LTS, 24 % of CW, 19 % of IS and 3 % of NT workers
Ding et al. 1994	physical examination. 165 workers in LTS, work. Daily workload 5-10 tons/person	220	LBP in physical examin. in: 26 % of LTS, 4 % of IS and 10 % of NT workers
Pope et al. 1997	Occupational factors related to shoulder pain (SP) and disability, posted questionnaire, case control, SP >24 hrs during 1 month before the interview	232	Men working in cold conditions had increased risk of SP, OR 6.4
McGorry et al. 1998	Self-report of LBP and meteorological conditions, questionnaire, 6 months, perceived weather sensitivity in 33 (45,8%) of the 73 responders	94	Cold temperature and low vapour pressure were associated with higher LBP scores in sensitive persons
Niedhammer et al. 1998	Shoulder disorders in female supermarket cashiers. Questionnaire and clinical examination	210	Cold exposed 116 (55.2%), left shoulder disorders 40,5 % vs 29.8 % in cold vs non-exposed. OD 1,92 (CI 0.96 – 3.82) for left shoulder disorders in cold exposure.

N= number of patients or study sample, LTS=lower temperature stores, IS=ice stores, NTS, NT= normal temperature (stores), CW=cold water exposure, LBP=low back pain, KP=knee pain, SP=shoulder pain.

system may be variable, local or generalised feelings of pain, and fatigue of muscles or joints. Table I show relevant studies, where musculoskeletal symptoms associated with cold exposure have been studied.

The study by Chen et al. (1) has studied musculoskeletal complaints (low back pain, LBP, knee pain, KP and shoulder pain, SP) and also other symptoms in 463 male cold store workers in 40 different stores in China. The employees were working in low temperature stores (LTS, n=296) where the ambient temperature was between -15 and -25 °C and in ice stores (IS, n=167), where the temperature varied between -5 and $+5$ °C. The control group consisted of 152 workers in the location working in normal temperature conditions (NTS). The subjects were aged from 21 to 45 years, having a cold store working history between 1 and 20 years. According to the protective clothing there were no differences between LTS and IS groups. The complaints were registered using questionnaires and if the workers felt pain, the location of pain was asked. The results showed no special occupational diseases. The percentage of musculoskeletal complaints was significantly higher in cold store workers than in controls. The cold store workers reported an average of 52.7 % of LBP, 50.8 % of KP and 15 % SP, which were significantly higher ($p < 0.01$) than in workers in NTS. The complaints were associated with the duration of the working history in cold stores. The fatigue of lower back was associated with working in cold stores more frequently than in normal temperature stores ($p < 0.01$).

LBP in cold store work was studied by Wang et al. (17) and by Ding et al. (3) and the review of these two works is presented by Jin et al. (9). The study by Wang et al. (16) was performed in 150 cold store and in 73 normal temperature (NT) storage workers in an ocean-fishing company. Back pain diagnosed by physical examination was the method to evaluate the prevalence of symptoms. From the 150 cold store workers 41 were working in LTSs (-15 - -20 °C) and 109 in ISs (-10 °C). The study investigated also 67 workers who were exposed to cold water (CW). The NT workers had an ambient temperature of $+3$ - $+10$ °C. The results according to the physical examination showed LBP in 46 % of LTS, in 24 % of CW and in 19 % of IS and in 3 % of NT group workers.

The study by Ding et al. (3) used also physical examination to evaluate the prevalence of LBP in cold store work. The study population consisted of 165 workers in LTS (-10

-25 °C), 24 workers in IS and 31 workers in NT stores. The cold storage study was performed in 4 meatpacking factories. The average workload was 5-10 tons/day/person. The results indicated that LBP was noted in 26 % of LTS, in 4 % of IS and in 10 % of NT workers.

Occupational factors related to shoulder pain and disability were investigated by Pope et al (15) in 500 people randomly selected from the register of one general practice using posted questionnaire. The aim of the study was to resolve the shoulder pain during the past month. The data was also collected from the present and past job and working conditions using a 4-fold scale. Finally 312 people responded. Totally 39 people had shoulder pain. The results showed that cold exposure always associated with work in men presented a 6,4-fold risk (CI 1.5 – 27) for shoulder pain and disability. This was not noted in women. The results were based on three cases exposed to cold versus one control (non-exposed) case.

Niedhammer et al. (14) studied shoulder disorders related to work organisation and other occupational factors finally in 210 supermarket cashiers. 116 cashiers (55.2%) were exposed to cold. From the cold exposed cashiers 40.5 % had shoulder symptoms on left side compared with 29.8 % of those who were not cold-exposed ($p < 0.15$). A logistic regression analysis showed an OD of 1.92 (CI 0.96 – 3.82, $p = 0.06$) for left side shoulder disorders in cashiers exposed to cold.

Meteorological conditions and self-report of LBP were studied by McGorry et al. (13) in 94 individuals. Eight weather variables reported to influence musculoskeletal pain were evaluated using daily pain ratings during a six-months' period. After the rating collection period the individuals were classified into groups based on perceived weather sensitivity and the differences between the two groups were tested in 74 individuals who responded the weather sensitivity question.

The results showed significant effects on pain scores for temperature and vapour pressure. The differences were significant between the individuals who were insensitive or those who had perceived weather sensitivity. The effects were small in magnitude but the main conclusion was, that weather conditions may influence subjective reporting of LBP significantly in individuals perceiving sensitivity to those conditions.

Table II. A collection of studies on musculoskeletal diseases and cold exposure

Author(s), year	Study design and exposure	N	Results and conclusions
Georgitis 1978	3 case reports of extensor tenosynovitis of the hand, riding in a open-top jeeps, ambient temperature -25 - 0°C, 10-16 hours	3	Acute diagnosed crepitating extensor tenosynovitis of the II-III fingers caused from cold air and wind-chill exposure
Chiang and Chen 1990	Occurrence of carpal tunnel syndrome (CTS) in frozen food factory employees, evaluation of task movement repetitiveness and local cold exposure of the hands	207	Local cold exposure of hands and high repetitiveness of hand movements were contributing factors leading to CTS, risk for CTS 14.39 fold compared with those with low exposure
Kurppa et al. 1991	Incidence of tenosynovitis and peritendinitis in meat-processing industry. The female packers worked in an ambient temperature of +8-+10°C and female sausage makers in +20°C	377	Female packers had higher incidence of tenosynovitis/peritendinitis than female sausage makers, 16.8 vs 25.3 cases/100 person years.
Elsner et al. 1997	Case-control, degenerative discopathies in the area of lumbar spine and working conditions, questionnaire	188M 160F	Men working in a humid or cold environment had an increased risk for degenerative discopathy of the lumbar spine, OR 2.2, OR of women 1.6

N= number of patients or study sample

Specific musculoskeletal diseases

A musculoskeletal disease presupposes a special diagnosed pathologic condition of the musculoskeletal system. The pathology is principally local and may be diagnosed clinically or using special imaging or laboratory techniques. The results of the reviewed papers are summarized in Table II.

Georgitis (6) reported 3 cases of hand extensor tenosynovitis all caused by a similar-type cold exposure. The individuals were exposed 10-16 hours to cold and wind-chill when riding open-top jeeps in an ambient temperature between -25 and 0 °C. The diagnosis of extensor tendinitis of the hand was made based on local crepitation, tenderness, swelling and erythema. The cases seem to represent typical acute cases of extensor tenosynovitis.

Chiang et al. (2) studied cross-sectionally among 207 workers in frozen food factories the occurrence of carpal tunnel syndrome (CTS) associated with workload and local cold exposure. They founded that CTS had a 14.39-fold risk when the work had high repetition for hands and local cold exposure compared with controls. High repetition of wrists only had 2.2-fold risk for CTS compared with no repetition and after adjustment for sex, age and duration of employment the risk for CTS associated with high repetitiveness and local cold exposure was 9.4-fold compared with no

cold exposure and no repetition in work and significantly higher than in case of high repetition only.

Kurppa et al. (11) showed that in meat-processing industry the incidence of tenosynovitis or tendinitis was greater in female packers than in female sausage makers, 25.3 vs 16.8 cases/100 person years. The only difference between these two groups was the ambient temperature, which was +8- +10 °C for female packers and +20 °C for sausage makers. Although the specific effect of cold exposure for the symptoms was not studied, the authors, according to the data on working conditions, concluded that the increased incidence of tenosynovitis in female packers might be associated with the low ambient temperature.

Work-related degenerative discopathies in the area of the lumbar spine were studied by Elsner et al. (4) using a case-control method in 346 patients of an orthopaedic clinic and in 239 controls, which were free from musculoskeletal symptoms. The aim of the study was to determine occupational risk factors for osteochondrosis, spondylosis and spondylarthrosis. The ORs for different working conditions, loading, postures etc. were calculated and also cold exposure and humidity of the working environment was analysed. The results showed, that working in a humid or cold environment resulted in men in an elevated risk of OR 2.2 (95% CI 1.30-3.72) and in women of OR 1.6 (CI 0.78-3.31) for degenerative discopathies of the lumbar spine. The risk for men was significantly higher than in controls and was the same as some other usual risk factors, for example bending of the back (OR 2.2) kneeling (2.4), squatting down (2.1) upper extremity vibration (2.3), whole body vibration (2.1) for low back pain. In women working in a cold or humid environment showed only an OR of 1.6 for disk degeneration. The authors considered that men working in a humid or cold environment have an elevated risk for degenerative discopathies of the lumbar spine.

DISCUSSION

According to the reviewed literature, the documentation of cold exposure as a causative factor for musculoskeletal symptoms or diseases is incomplete and there is a lack of controlled studies in this field. Multi-factorial origin and high prevalence of musculoskeletal complaints and diseases in population makes it difficult to ascertain the possible sole

effect of cold exposure as a causative factor for any musculoskeletal disease or symptom. Several separate factors may have a role and to ascertain the most precipitating or causative factor may be very difficult. According to the relevant data, major causes for work-related musculoskeletal complaints and diseases are workload and also psychosocial factors (16). Some associations, however, can be seen between cold exposure and musculoskeletal disorders and diseases.

Without doubt it is clear, that in cold store work there is a higher prevalence of musculoskeletal complaints and the symptoms have a trend to increase according to the duration of working history in cold environment (1) In several studies (1, 3, 9) the increased prevalence of LBP in cold store work has been showed and the results favour that the low ambient temperature is associated with the increased prevalence of LBP symptoms. Shoulder pain seems to associate with cold or humid working conditions in men. Because the sample of shoulder pain patients of the study reviewed (15) was small (n=39), the conclusions must take with care, and further research is needed to strengthen this finding of an increased risk. The other reviewed study (14) shows that left shoulder pain is associated with cold exposure, but the association was not statistically significant. This rather shows a trend and probably represents the effects of workload. Self-reported LBP seems to be associated with ambient weather temperature in persons with subjective sensitivity to weather (13). Because over 45 % of the responders in the study by McGorry et al. (13) were weather-sensitive, the weather conditions as a contributing factor in LBP pain reports must be kept in mind, because of a great proportion of people report low back pain associated with low temperature conditions. This must also consider in pain-based population studies. In a study by Lapossy et al. (12) cold-induced vasospasm has been reported to be more frequent (38%) in patients with fibromyalgia and in LBP patients (20%) than in healthy controls (8%), which shows that the effect of cold may be different in different conditions. It is still obscure is the reason for higher pain scores in sensitive patients primary or a consequence from cold exposure? This needs further longitudinal and dose-response studies. Research is also needed to specify "primary" and "secondary" effects caused by cold exposure.

There are a few studies focused on cold exposure and musculoskeletal disorders or diseases although the possible

association or contributing role of cold exposure has been proposed in many studies.

According to the reviewed articles, the best documentation is that of tenosynovitis as a clinical entity (6, 11). The case report study by Georgitis (6) represents extreme conditions as an etiologic factor for extensor tenosynovitis of the hand and the results can be considered relevant and cold exposure and wind-chill can be considered as a causative factors for tenosynovitis. In these cases also static work of wrists may be a contributing factor. The study by Kurppa et al. (11) shows the association of increased incidence for tenosynovitis in a colder (8-10 °C) than in normal working temperature. The carpal tunnel syndrome seems to be associated with cold exposure (2) in connection with the simultaneous high repetitive wrist movements. This combination makes it difficult to show the single causative proportion and the principal mechanism of cold exposure in the development of CTS.

Degenerative back diseases are a troublesome and expensive problem in work life in western countries. Degenerative disc diseases of the low back seem to associate with cold exposure in work as an elevated risk in population (4), but the risk is not very high and according to the relevant data the association can be questioned. The risk seems to be the same as usual posture-related risk factors for disc diseases of the low back. Degenerative back disorders are very common and may have also many genetic and traumatic etiologic causes. Heavy work is associated with back pain and degenerative processes and it is possible that heavy work in many cases includes also working in difficult conditions as in cold environment. This kind of problem needs further and greater population-based, prospective and clinical studies to specify the possible association between cold exposure and back problems in work. The relationship is possible because cold exposure may increase the risk for back injuries such as intervertebral disc lesions or soft tissue sprains. This can be caused by declined motor and musculoskeletal performance in cold environment. However, according to the available scientific data, the weakest association is still between cold exposure and back diseases including also discopathies. Cold exposure may be a contributing factor for injuries in different parts of the whole musculoskeletal system as proposed in many studies (8). How important the "cold exposure-musculoskeletal injury-mechanism" is in developing musculoskeletal diseases, is

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still obscure.

The following conclusions are to be drawn from the reviewed literature. Musculoskeletal symptoms are more frequent in cold store work and in related conditions than in normal temperature work. Cold exposure has an increasing effect on symptoms, which seem to be increased according to the duration of exposure time (years). In cold working environment low back pain is a frequent problem. The association between cold exposure and shoulder pain is still unclear and has been poorly studied. Meteorological conditions, principally low ambient temperature may have an effect of reported low back pain in population. In the etiology of tenosynovitis cold exposure has a specific role either as a causative or a contributing factor. Cold exposure in association with repetitive wrist movements seems to increase the risk for carpal tunnel disease. Cold exposure in work seems to be associated with a little increased risk for degenerative discopathies of lower back. However, this association is weak. The associations between cold exposure and musculoskeletal complaints or diseases can slightly be seen, but the need of further research is apparent.

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