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Prevalence of Subjective and Musculoskeletal Symptoms Among Cold Store Workers

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Abstract: Exposure to cold in working populations is a relevant risk factor that increases work strain and may induce various health consequences including chronic diseases and local cold injuries. Chronic problems include the association between cold exposure and musculoskeletal symptoms and complaints. A cross-sectional questionnaire study was conducted among workers of a cold store work in Tehran. This study was undertaken to clarify the effects of exposure to cold environments on workers operating a forklift indoor. Workers in this study were 15 workers from a cold storage with the temperature between -27.0$^{\circ C}$ to -30.5$^{\circ C}$ (exposed group) and 20 workers working in an environment with 25$^{\circ C}$ to 27$^{\circ C}$ (unexposed group). Two self-administered questionnaire survey on cold related subjective complaints and musculoskeletal symptoms were performed among workers. The prevalence rates of almost subjective symptoms the highest in the exposed group were significantly higher than those among unexposed group. Prevalence of musculoskeletal symptoms among exposed group was the knee (100.0%), feet (73.3%) and wrist/hands (66.7%). The estimated relative risk for upper back were 16.62(95% CI 1.74-158.08), elbow 12.66(95% CI 1.32-121.46) and neck 10.28 (95% CI 1.73 – 60.90), respectively. The findings in this study showed several adverse health effects of exposure to the cold environment. To control these adverse effects, several possible ways have been proposed in this study.

Key words: Cold store, Subjective symptoms**,** Cold exposure, Musculoskeletal symptoms

INTRODUCTION

The hazards of cold stress include health effects, physiological adjustments, psychological responses and behavioral reactions. The majority of indoor occupational exposures to cold take place in the course of food preparation or storage. Many food preparation exposures take place in the moderately cold range where discomfort is the main problem, although long-term health effects have also been suggested. It has been suggested that some arthritic and musculoskeletal disorders may be more common in those regularly exposed to cold, and a range of symptoms, including those from the gastrointestinal tract; rheumatism and bronchitis have been reported in workers exposed to moderate cold (ISO, 12894 2001). When the body is unable to warm itself, cold related stress may result. This may include tissue damage and possibly death (OSHA, 2005). Cooling of body parts may result in various cold injuries - nonfreezing injuries, freezing injuries and hypothermia which is the most serious. Toes, fingers, ears and nose are at greatest risk because these areas do not have major muscles to produce heat. In addition, the body will preserve heat by favoring the internal organs and thus reducing the flow of blood to the extremities under cold conditions (CCOHS, 2002).

Cold storages facilities are the most common workplaces that produce artificially cold work environments. There are about 4,000 cold storages in Japan, and 85 % of them are kept at a temperature below -20 $^{\circ C}$ (Tanaka and *et al* 1993). Workers in cold storage facilities are frequently exposed to cold environments in all seasons (Tochihara and *et al* 1995). Griefahn and *et al* (1997) have conducted extensive field trials of workers in the cold in German industry. They found that there were many thousands of workers who work in the cold ranging from cold store temperatures (<−20$^{\circ C}$) to chilled environments where food is prepared (<4$^{\circ C}$). Methods used for loading and unloading in cold storage rooms are forklift, manual handling, and automatic machines (Tanaka and *et al* 1993). In Denmark there are more than 20000 people working in cold rooms at temperature between +5 to -25^{oC} (Nielson 1997). The most frequent physical complaints of cold store workers were “lumbago”, “cold”, “neuralgia” and “rheumatism” (Tochihara 2005). Increased prevalence of cold related complaints and symptoms are observed when Ta falls below -15$^{\circ C}$ (Rytkönen and *et al* 2005). The results a study observed high prevalence of subjective symptoms related to cooling disorder among the female workers engaged in cold storage goods in summer (Inaba and *et al* 2002).

According to the reviewed literature, the documentation of cold exposure as a causative factor for musculoskeletal symptoms (Pienimäki 2002). 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

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of working history in cold environment (Chen and *et al* 1991). The epidemiological studies showed the relation between exposure to cold and the development of some musculoskeletal disorders (Chen and *et al* 1991, Griefahn and *et al* 1997, Pope and *et al* 1997, Niedhammer and *et al* 1998). In several studies the increased prevalence of low back pain (LBP) in cold store work has been showed and the results favor 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 (Chen and *et al* 1991, Ding and *et al* 1994, Kelsey 1984). A small-scale questionnaire study (n=24) conducted among workers employed in extremely cold conditions (–43 to –62$^{\circ C}$, exposure ca 60 min/occasion) in a freeze-dried coffee company demonstrated a high prevalence of reported cold-related symptoms (circulatory disturbances, respiratory and musculoskeletal symptoms). In this study repeated musculoskeletal pain was experienced by 12% (Piedrahita and *et al* 2008).

This paper focuses on the possible relationship between subjective symptoms and the prevalence of musculoskeletal symptoms and cold exposure among two groups of workers exposed and unexposed in cold store.

MATERIALS AND METHODS

Subjects:

This was a cross-sectional study that's carried out in a cold-store work in Tehran. The workers in this study were classified into two groups. One group consisted of 15 workers in two cold-storage (air temperature was between -27.0$^{\circ C}$ and -30.5$^{\circ C}$) that was named exposed group, and the second group 20 workers (air temperature was between 25$^{\circ C}$ and 27$^{\circ C}$) that was named unexposed group (control group). Main job of the workers was to carry frozen objects in or out of the cold stores by operating a forklift (forklift work) or by pulling a loaded hand cart (manual work). The forklift workers were frequently exposed to cold stores many times in a working day. Especially the facial cooling seemed to occur frequently in forklift-operating workers because their faces were not covered with any cold protective equipment during work. The finger temperature in some manual workers decreased during work. This appeared to be due to the fact that the manual workers usually loaded and unloaded the frozen objects directly by their hands during work. Cold exposure time per one entrance was shorter for forklift work than for manual work, but frequency of entrance into cold store was higher. The companies supplied both cold protective equipment and work clothes for the workers. The cold protective equipment consisted of insulated jacket, insulated trousers, hat etc. Thermally low-insulated gloves such as cotton gloves were commonly used as a result of giving priority to the workability. Work loads of the workers were used ISO 8996 (1990). This method uses estimates of metabolism from tables by type of activity. In both group the metabolism was (155-255 W/m^2).

Questionnaire survey:

A self-administered questionnaire survey on cold related subjective complaints were performed among workers. Questions consisted about demographic aspects such as age, body dimensions, years on the job, working frequency in mouth, daily working hours, daily sleeping period, and subjective symptoms was (32 items) was distributed and collected. The questions about subjective symptoms were adopted from study Inaba *et al* (2002). The subjective symptoms were classified into three categories of frequency: frequently, sometimes, or none. The questions about musculoskeletal symptoms were adopted from standardized questionnaires Nordic questionnaire (Kourinka and *et al* 1987). The reliability of the questionnaires has been shown to be acceptable (Baron and *et al* 1996, Bjorksten and *et al* 1999, Kaergaard and *et al* 2000). Body mass index (BMI, kg/m^2) was classified as follows, modified from WHO (2000): normal weight (≤25 kg/m^2), overweight (25 to 29.9 kg/m^2), and obese (≥30 kg/m^2).

Statistics:

The analysis was executed using SPSS (ver.11.5) statistical package. Mean of descriptive data were calculated and compared between the two groups using t-test and Mann-Whitney U test. Chi-square test was used in this study to compare between the two groups and subjective complaints. Statistical analysis was performed using odds ratio (OR) 95% confidence intervals (CI) were calculated by logistic regression for associations between musculoskeletal symptoms and two groups. A P-value of 0.05 was defined as the criterion for statistical significance.

Results:

Table 1 depicts the characteristics of the subjects, including age, duration of employment, body dimensions, working frequency, daily working time, sleeping period. All workers (n=35) were male. Some differences were found between both groups. The mean height exposed group workers (171.4± 5.9) were significantly lower than that unexposed group workers (176.6± 4.3) using *t* test and Mann-Whitney test (P> 0.005 and P>0.01, respectively). The mean BMI exposed group workers (26.7± 2.6) were significantly higher than that the

unexposed group workers (24.2± 1.4) using *t* test and Mann-Whitney test (P> 0.001 and P>0.0001, respectively).

Table 2 shows the prevalence of subjective symptoms among the subjects. The prevalence of six subjective symptoms among exposed group were sweating (80.0%), work difficulty due to the cold (66.7%), knee joint pain (66.7%), easily fatigued (53.3%), foot cold sensation (46.7%) and finger cold sensation (46.7%). The prevalence rates of almost subjective symptoms in the exposed group were significantly higher than those among unexposed group (P> 0. 05, P>0.01 and P>0.001). There were no significant differences in the few subjective symptoms among exposed group (low back cold, pain in the foot and appetite loss). Table 3 shows the prevalence of musculoskeletal symptoms in different body regions according to the Nordic Questionnaire. The frequency in exposed group is higher than in unexposed group for all body regions except low back region. The knee was the area with the highest prevalence of musculoskeletal symptoms (100%), followed by the feet (73.3%) and wrist/hands (66.7%) in workers.

Table 4 illustrates estimate of relative risk (RR) 95% the Confidence Interval (CI) of musculoskeletal symptoms between exposed and unexposed group. A significant positive association was found between exposure to the cold condition and the symptoms in neck, shoulder, elbow, wrist/hands, upper back and knees (P> 0.05). The study indicates that workers in cold exposure in different body parts had significant estimated relative risk (RR). Neck symptoms occurred 10.28 times more frequently in exposed workers than in unexposed workers. Shoulders, elbow, wrist/hands upper back and knee symptoms occurred respectively 0.53, 12.66, 11.33 16.62 and 2.22 times more frequently in exposed workers than in unexposed workers.

Discussion:

The study demonstrated that the main cold exposure significantly occurs in the cold stores in the jobs as operating a forklift (forklift work) or when pulling a loaded hand cart (manual work). However, workers in average are exposed to cold for relatively half periods. The self-reported total exposure time, was in average 3.5 hours per day, accounting for 45% of the total weekly time, showed some important cold-related complaints. The duration of indoor cold exposure can be significant with increased prevalence of cold-related symptoms. This is consistent the findings of a preceding study in one occupational group included military personnel (Rintamäki and *et al* 2004), and cold injuries (Hassi and *et al* 2005).

With regard to possible health effects, our study demonstrates that these effects are significantly due to cold exposure among exposed group. The prevalence of various complaints implies that the cold conditions indoor cold store may increase the risk of cold-related health problems. In the present study, we observed that the prevalence of cold sensation in the fingers and feet in exposed group were significantly higher than unexposed group. These results are similar to the study of Inaba and *et al* (2005, 2011). In this study the prevalence of Raynaud's phenomena in the fingers was found significantly associated and it is similar to some previous results regarding the association between cold exposure and Raynaud's phenomena (Griefahn and *et al* 1997, Piedrahita and *et al* 2008, Inaba and *et al* 2005, Inaba and *et al* 2011, JSOH 2003). It is known that several mechanisms are involved in the etiology of Raynaud's phenomenon. Cold exposure is recognized as one factor that may provoke an attack (Belch 1990). Other findings of the present study in cold store workers were sweating, work difficulty due to the cold and rough skin, which they were relatively strong and they were significantly associated with the cold exposure. This pint is also similar to the previous results (Chen and *et al* 1991, Inaba and *et al* 2005). Moreover, health problems, e.g. head cold and head ache, have been found to be more common among workers exposed group compared to the unexposed group, similar to the study by Chen and *et al* (1991).

The results of this cross-sectional study showed that different body regions except low back symptoms were more common among the severely cold-exposed workers than among unexposed workers, because main jobs of workers unexposed were pulling a loaded hand cart that caused an increase in prevalence of low back pain. Symptoms were significantly elevated for the neck, shoulders, elbow, wrist/hands upper back and knee**.** The demographic results cold-exposed workers in this study were similar to the unexposed workers, except mean height and BMI that they had significant differences in two groups. In summary, cold exposure had a clear relationship with the prevalence of musculoskeletal symptoms.

Several epidemiological studies have shown that exposure to cold as a risk factor for the prevalence of musculoskeletal symptoms in different body parts (Griefahn and *et al* 1997, Pienimäki 2002, Chen and *et al* 1991, Pope and *et al* 1997, Niedhammer and *et al* 1998, Piedrahita and *et al* 2008, Inaba and *et al* 2005, Bang and *et al* 2005).

Research on the relationship between musculoskeletal symptoms and cold exposure is limited. The prevalence of shoulder disorders on the body were studied by Niedhammer and *et al* (1998), Pope and *et al* (1997) and Chen and *et al* (1991). Among chronic problems, especially from the viewpoint of epidemiology, an association has been established between cold exposure and musculoskeletal symptoms and complaints, particularly for the neck and upper arm (Chen and *et al* 1991, Pope and *et al* 1997, Niedhammer and *et al* 1998, Kurppa and *et al* 1991, McGorry and *et al* 1998, Hilderbrandt and *et al* 2002). Numerous studies have explored the relationship between cold store work factors and LBP (Chen and *et al* 1991, Ding and *et al* 1994, Massatoshi

and *et al* 1979, Wang and *et al* 1991, Jin and *et al* 2000). In a study performed by Wang from 223 workers under study, 150 of them working in cold stores, including 41 in lower temperature storage (LTS), 109 in ice storage (IS); and 73 workers in normal temperature storage (NT). They found that the prevalence of LBP was 46% for those working in cold stores (LTS), 19% for workers working in ice stores (IS), and only 3% for those working in normal temperature stores (NT) (McGorry and *et al* 1998). Massatoshi and *et al* (1979) reported that the prevalence of low back pain in cold storage workers reached 43% and for shoulder problems 10% [30]. Also Chen and *et al* (1991) found that the prevalence of LPB was 42.3% in LTS, 52.7% in IS and 9.2% in NT. The difference between IS and NT was significant ($p<0.01$).

The limitations of this study are as follows: We used a self-administered questionnaire and did not make any direct observations of the tasks performed at work. Secondly we used a cross-sectional design and had incomplete work place participation, producing possible bias and limited ability to draw any causal inferences.

Table 1: Descriptive data of the study subjects (Mean ± SD)

Parameter	Exposed (n=15)	Unexposed (n=20)	P_{value}*	P_{value}**
Age(yr)	34.2± 7.7	32.1± 7.2	0.41	0.53
Years worked (yr)	11.5± 3.2	10.0± 4.4	0.28	0.20
Height(cm)	171.4± 5.9	176.6± 4.3	0.005	0.01
Weight(kg)	78.8± 11.0	75.7± 7.4	0.33	0.35
BMI(kg/m^2)	26.7± 2.6	24.2± 1.4	0.001	0.0001
Working frequency(d/month)	26.2± 1.0	27.0± 1.7	0.67	0.16
Daily working time(h/d)	10.6± 0.9	10.2± 1.2	0.32	0.41
Sleeping period(h/d)	6.9± 1.4	6.9± 1.0	0.93	0.82
Years of cigarette smoking	1.5± 2.8	2.0± 3.3	0.67	0.75

*P> 0.05, Student's *t*-test analysis; compared between the exposed and unexposed groups
**P> 0.05, Mann-Whitney U test; compared between the exposed and unexposed groups

Table 2: Prevalence of subjective symptoms among workers

subjective symptoms	Exposed group symptoms frequency N (%)			Unexposed group symptoms frequency N (%)		
	frequently	sometimes	None	frequently	sometimes	None
Finger cold sensation[c]	7(46.7)	6(40.0)	2(13.3)	0	1(5.0)	19(95.0)
Numbness in the fingers[c]	5(33.3)	9(60.0)	1(6.7)	0	0	20(100)
Pain in the fingers[c]	2(13.3)	8(53.3)	5(33.3)	0	0	20(100)
Stiffness in the fingers[b]	3(20.0)	3(20.0)	9(60.0)	0	0	20(100)
Raynaud's Phenomena in the fingers[c]	3(20.0)	8(53.3)	4(26.7)	0	0	20(100)
Pain in the wrist[b]	3(20.0)	7(46.7)	5(33.3)	0	3(15.0)	17(85.0)
Pain in the arm[a]	0	6(40.0)	9(60.0)	0	1(5.0)	19(95.0)
Pain in the shoulders[b]	0	7(46.7)	8(53.3)	0	0	20(100)
Pain in the neck[b]	0	8(53.3)	7(46.7)	0	2(10.0)	18(90.0)
Back pain[b]	0	7(46.7)	8(53.3)	0	1(5.0)	19(95.0)
Lumbago	0	9(60.0)	6(40.0)	2(10.0)	13(65.0)	5(25.0)
Low back cold sensation[b]	3(20.0)	5(33.3)	7(46.7)	0	0	20(100)
Knee joint pain[c]	10(66.7)	5(33.3)	0	1(5.0)	8(40.0)	11(55.0)
Foot cold sensation[c]	7(46.7)	8(53.3)	0	0	0	20(100)
Foot numbness[b]	2(13.3)	6(40.0)	7(46.7)	0	1(5.0)	19(95.0)
Pain in the foot	3(20.0)	8(53.3)	4(26.7)	4(20.0)	8(40.0)	8(40.0)
Appetite loss	0	4(26.7)	11(73.3)	2(10.0)	3(15.0)	15(75.0)
Stomach discomfort	0	4(26.7)	11(73.3)	1(5.0)	4(20.0)	15(75.0)
Dull head[a]	0	8(53.3)	7(46.7)	0	4(20.0)	16(80.0)
Head ache[b]	4(26.7)	11(73.3)	0	0	8(40.0)	12(60.0)
Dizziness	1(6.7)	4(26.7)	10(66.7)	0	11(55.0)	9(45.0)
Palpitation	1(6.7)	7(46.7)	7(46.7)	0	9(45.0)	11(55.0)
cough[b]	5(33.3)	7(46.7)	3(20.0)	0	10(50.0)	10(50.0)
Sweating[c]	12(80.0)	3(20.0)	0	2(10.0)	10(50.0)	8(40.0)
Initial insomnia	3(20.0)	9(60.0)	3(20.0)	1(5.0)	10(50.0)	9(45.0)
Easily fatigued[c]	8(53.3)	6(40.0)	1(6.7)	0	9(45.0)	11(55.0)
Rough skin[b]	6(40.0)	3(20.0)	6(40.0)	0	6(30.0)	14(70.0)
Sore throat[c]	2(13.3)	11(73.3)	2(13.3)	0	5(25.0)	15(75.0)
Head cold[c]	2(13.3)	13(86.7)	0	0	9(45.0)	11(55.0)
Body dullness[a]	1(6.7)	11(73.3)	3(20.0)	0	7(35.0)	13(65.0)
Neuralgia[a]	3(20.0)	7(46.7)	5(33.3)	0	2(10.0)	18(90.0)
Work difficulty due to the cold[c]	10(66.7)	5(33.3)	0	0	0	20(100)

[a]P> 0.05, [b]P> 0. 01, [c]P> 0.001, chi-square; significantly different from its corresponding value in the unexposed group

Table 3: Prevalence of musculoskeletal symptoms in different body regions workers

Body regions	Exposed (n=15) N (%)	Unexposed(n=20) N (%)
Neck	8 (53.3)	2 (10.0)
Shoulders	7 (46.7)	0
Elbow	6 (40.0)	1 (5.0)
Wrist/hands	10(66.7)	3(15.0)
Upper back	7 (46.7)	1 (5.0)
Low back	9(60.0)	15 (75.0)
Knee	15 (100.0)	9 (45.0)
Feet	11(73.3)	12(60.0)

N= Number of cases

Table 4: Estimate of Relative Risk (RR) of musculoskeletal symptoms between exposed and unexposed group

Body regions	Musculoskeletal symptoms RR and 95% Confidence Interval CI
Neck	10.28 (1.73-60.90)*
Shoulders	0.53 (0.33-0.85)*
Elbow	12.66 (1.32-121.46)*
Wrist/hands	11.33 (2.21-57.87)*
Upper back	16.62 (1.74-158.08)*
Low back	0.50 (0.11-2.12)
Knee	2.22 (1.36-3.60)*
Feet	1.83 (0.42-7.83)

*P> 0.05

Conclusion:

Cold exposure has an increasing effect on subjective symptoms. Cold work involves several adverse health effects that are observed in indoor work. Musculoskeletal symptoms are more frequent in a cold store work than in a normal a temperature work. With regard to cold exposure, special attention should be given to the prevention of possible adverse cold effects occurring in cold stores. Efforts should be made to minimize the cold exposure of the workers by designing automation processes to avoid the permanent presence of the workers inside the freeze cold stores. In addition, the risk would be reduced by improving the cold-protective clothing as well as work management aspects of occupational facility.

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