Factors Associated with Self-estimated Work Ability and Musculoskeletal Symptoms among Male and Female Workers in Cooled Food-processing Facilities

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Abstract: This questionnaire study evaluates how work ability and musculoskeletal symptoms associate with physical work factors and individual characteristics of the workers in cooled food-processing facilities. A total of 1,117 workers (response rate 85%) responded to the study. Poor work ability was significantly associated with longer work duration, experience of draught at the workplace, absence from work due to health reasons, and physical inactivity during free time. The amount of local cooling experienced was significantly associated with the risk for musculoskeletal symptoms in the neck-shoulder region, shoulders, wrists and lower back. Additionally, female gender, longer work duration and poor work ability were associated with the increased prevalence of the symptoms. The prevalence of musculoskeletal symptoms was significantly higher among older employees (40 to 64 yr) than among younger employees (18 to 39 yr) for all regions except wrists. Cold discomfort and unpleasant sensations due to the physical factors of work were significantly more common among females than males. The results showed that, in addition to individual characteristics of workers, factors related to work in a cool environment (experience of draught and cooling and long exposure to cold) are associated with poor work ability and musculoskeletal symptoms.

Key words: Food-processing industry, Cold ambient temperature, Gender, Work ability, Musculoskeletal symptom

Introduction

The food-processing industry, employing ca. 35,000 workers, comprises the fourth largest field of industry in Finland and has the highest risk for the incidence of occupational diseases compared to other industries. Of all occupational diseases, the number of repetitive strain injuries is the highest, and for instance in 2002, the incidence of repetitive strain injuries in the food-processing industry was 14-fold compared with the average of all fields in Finland. Besides, the incidence of both occupational respiratory diseases and skin diseases were most frequent in food-processing work1).

The present study mainly describes one of the largest sectors of food-processing industry, the meat-processing industry, where highly repetitive monotonous manual work and fast working pace on assembly lines are typical elements of the work. Because of hygienic reasons, great parts of the production facilities are cooled to 0 to 10°C. Due to the above mentioned work constraints, workers in the meat-processing industry face many health hazards. Complaints of unpleasant work environment,
cold-induced discomfort, and sensations of fatigue and pain at work have been found to be common among workers at low ambient temperature in the meat-processing industry\textsuperscript{2, 3}. Moreover, health problems, e.g. abdominal and intestinal problems and headache, have been found to be more common among workers at low ambient temperatures in cold stores (\textasciitilde{}5 to +5°C) compared to their controls at normal environmental temperatures (20 to 30°C)\textsuperscript{4}).

In a review by Hildebrandt \textit{et al.}\textsuperscript{5}, epidemiological evidence about the relationship between climatic factors, such as cold, draughts and changes of temperature, and musculoskeletal symptoms was concluded to be weak, even though the association was considered plausible by the researchers and the patients themselves. However, in the empirical study conducted by Hildebrandt \textit{et al.}\textsuperscript{5} themselves, poor climatic factors, i.e. a climate index consisting of cold, draught, dampness and changes of temperature, were found to be related, as a causal or aggravating factor, to the incidence of low back (15 to 21% of the respondents) and neck-shoulder symptoms (22 to 27% of the respondents). Of single climatic factors, only draughts showed a significant association between the occurrence of neck-shoulder symptoms (OR 1.45) and sick leaves due to these symptoms (OR 1.46)\textsuperscript{5}).

Furthermore, several cross-sectional studies have revealed that low ambient temperature and a damp work environment may increase the risk of low back\textsuperscript{4, 6, 7), shoulder\textsuperscript{8, 9) and knee\textsuperscript{4) pain. Manual repetitive work in association with local exposure to cold increased the occurrence of nerve entrapment at the wrist (carpal tunnel syndrome, CTS) to 9.4-fold, whereas the occurrence in repetitive work alone, without cold exposure, was 2.2-fold\textsuperscript{10}). In a cohort study by Kurppa \textit{et al.}\textsuperscript{11}, the incidence of wrist and forearm tendinitis was higher among female sausage packers (25.3%) at a temperature of 8 to 10°C compared to female sausage makers (16.8%) who worked at a temperature of 20°C. The studies of Chiang \textit{et al.}\textsuperscript{10} and Kurppa \textit{et al.}\textsuperscript{11} are confirmed by Kim \textit{et al.}\textsuperscript{12}, who considered meat- and fish-processing work as a high-risk industry for CTS. Moreover, the prevalence of rheumatic complaints, e.g. fibromyalgia, has been found to be higher among workers in the meat-processing industry compared with those working in a satisfactory microclimate\textsuperscript{21}.

The concept of work ability can be related to the interactions between 1. the worker’s health and functional capacity, 2. work demands and the environment, 3. work organization and the work community and 4. the worker’s professional competence\textsuperscript{13, 14}. Exposure to cold at work may be a risk for worker’s health and cause cold-related health and performance degradations, illness and cold-induced injuries\textsuperscript{15}). Moreover, physical\textsuperscript{16, 17} and cognitive performance\textsuperscript{18}), both of which are composed of several different factors, have been shown to be impaired due to cold exposure.

This questionnaire study aims to evaluate factors associated with self-estimated work ability and musculoskeletal symptoms causing disadvantage in daily activities among workers in Finnish food-processing industry.

**Subjects and Methods**

**Study population and setting**

The questionnaire was carried out in five meat processing factories and two dairies, and a total of 1,117 workers (54% males and 46% females) responded to the study. The response rate was 85%. The study was performed in co-operation with Finnish Institute of Occupational Health, Oulu and the Centre for Occupational Safety.

The workers were informed about the purpose of the study, and the questionnaires were delivered by occupational safety personnel in each factory and dairy in 1997. Participation in the study was voluntary and personal data of the respondents were not disclosed. The questions were answered by choosing the appropriate alternative. Some questions also included the option of open-ended responses. The questionnaires were completed during working hours and then sent in reply-paid envelopes to the researcher.

**Measurements and classifications of body mass index, work ability and musculoskeletal symptoms**

The questionnaire included questions on personal data, lifestyle, length of employment, characteristics of working at cold environment (ambient temperature, exposure time and thermal sensations), clothing and cold protection, work ability, general health status, and complaints in the musculoskeletal system. \textit{Body mass index (BMI, kg/m\textsuperscript{2})} was classified as follows, modified from WHO\textsuperscript{19}: normal weight (\textasciitilde{}25 kg/m\textsuperscript{2}), overweight (25 to 29.9 kg/m\textsuperscript{2}), and obese (\textasciitilde{}30 kg/m\textsuperscript{2}). Because of the small proportion of subjects (1.5%) in the underweight-class (<18.5 kg/m\textsuperscript{2}), two classes (underweight and normal weight) were compound and categorized as normal weight. \textit{Work ability} was assessed by an estimated comparison of current work ability with lifetime best (0–10 points, from unable to work to lifetime best work ability). The variable was then categorized in two classes. Points 1 to 6 represented the lowest 11% of the respondents and were categorized as poor \textit{work ability} (see Kujala \textit{et al.}\textsuperscript{20}). Points 7 to 10 represented 89% of the respondents and were categorized as \textit{good work ability}. The variable “disadvantage in daily activities due to musculoskeletal symptoms” was coded into a two-class...
model: “disadvantage due to symptoms” or “no disad-
vantage due to symptoms”, whereas in the original ques-
tionnaire the classification for disadvantage due to mus-
culoskeletal symptoms entailed four classes.

Statistics

Descriptive statistics was used to evaluate the back-
ground information. Cross-tabulation with Person \( \chi^2 \) and
binary logistic regression analyses were used to evaluate
the associations between the explanatory variables and
poor work ability, and musculoskeletal symptoms. Odds
ratios (OR) and their 95% confidence intervals (95% CI)
were calculated for the explanatory variables. If the con-
fidence intervals were lower or higher than 1, it was con-
cluded that the explanatory variable had a significant
impact for the dependent variable \(^{21}\). The criterion for
statistical significance in Person \( \chi^2 \) tests was
\( p < 0.05 \). The analyses were performed using SPSS software for
Windows (version 14.0, SPSS Inc., Chicago, IL, USA).
The term risk factor has been used as a synonym for the
term explanatory variable in the results and discussion
sections.

The binary logistic regression analyses were performed
for the whole study population. In order to analyze the
impact of age on the prevalence of musculoskeletal symp-
toms, the subjects were divided into two age groups:
younger employees of 18 to 39 yr (68.5%) and older
employees of 40 to 64 yr (31.5%).

Results

Characteristics of work and working conditions

The average age for the male respondents was
33 ± 10 yr and for the female respondents 35 ± 11 yr. On
average, one third of the respondents (32%) had worked
in their present job for 1 to 3 yr, and 12% of the work-
ers had more than 15 yr of work duration in cold condi-
tions.

Most of the respondents (85%) worked at ambient tem-
perature of 1 to 10°C. On average 4% of the subjects
were exposed to temperature below 0°C, up to –25°C.
The average daily exposure time in cooled conditions was
6 to 8 h and a single work period generally varied between
30 and 60 min. The most important environmental prob-
lem was the cold ambient temperature, which was rated
to cause harm by 96% of the respondents. Both draught
and noisy work environment were rated to be harmful by
92% of the respondents. The corresponding value for
moisture was 74%. Female workers experienced these
environmental factors as significantly (\( p < 0.01 \) to 0.001)
more harmful than their male counterparts.

Majority of the work consisted of sorting and packing
the products and supervising the functionality of the
assembly lines and the fluency of the sorting phases. The
majority of the work was performed standing (84% of the
respondents). The work was considered to be highly
repetitive (74% of the respondents), and every other
(49%) respondent reported that their work often contained
awkward working postures (stooped or rotated postures)
and carrying and lifting (48% of the respondents). Males
stated having significantly more physically heavy work
(\( p < 0.05 \)), continuous moving from place to place
(\( p < 0.001 \)), and less repetitive work (\( p < 0.001 \)) compared
to females.

A cool work environment caused cold discomfort and
body cooling. Cooling, either “some” or “extensive”, was
felt mostly in hands, wrists and fingers, neck and the
shoulder region, feet and toes (Fig. 1). Females experi-
enced significantly (\( p < 0.001 \)) more cold discomfort and
body cooling compared to males.

Poor work ability and associated risk factors

Table 1 presents six explanatory variables associated
with poor work ability. The risk for poor work ability
had a significant association with the length of employ-
ment, as it more than doubled (OR 2.24, CI 1.03 to 4.86)
after 15 yr in the same job compared to the beginning of
a person’s work career. In the unadjusted analysis, poor
work ability was significantly associated with the length
of employment already after four years of working in the
cold (Table 1).

Of the work environmental variables, only the experi-
ence of draught (OR 1.55, CI 1.00 to 2.40) was associ-
ated with poor work ability. Unexpectedly, a cold work
environment was not significantly associated with poor
work ability (OR 1.40, CI 0.91 to 2.15). The risk of poor
work ability was more than six times higher (OR 6.37, CI 3.24 to 12.53) among workers who had 25 to 60 sick leave days per year compared to those who had no absences from work in the same period of time. Meanwhile, the risk was lower (OR 3.77, CI 1.35 to 10.54) among those who had more than 60 sick leave days compared to those with 25 to 60 d of absence from work. Moreover, a physically inactive lifestyle was associated with poor work ability, and the risk was almost twice as high (OR 1.84, CI 1.02 to 3.32) for those not engaging in physical activity during leisure time compared to those who exercised at least twice a week (Table 1). As the single independent variable, age of more than 35 yr was also significantly associated with poor work ability (OR 2.23, CI 1.14 to 4.34). This variable is not shown in the final model, because of its high multicollinearity with number of years on the job.

Musculoskeletal symptoms and associated risk factors

Pain in the musculoskeletal system causing disadvantage in daily activities, pain intensity ranging from “some” to “much”. The proportion of respondents reporting respective pain in both wrists and shoulders was 36% and the corresponding figure for lower back was 41%. Tables 2 to 5 present six explanatory variables associated with disadvantage in daily activities due to musculoskeletal symptoms in the last 12 month.

Neck-shoulder region

The prevalence of neck-shoulder region pain was highest among those who experienced “extensive neck-shoul-
der cooling” (OR 6.47, CI 2.79 to 14.99). This association remained significant both among younger (OR 5.88, CI 2.20 to 15.72) and older (OR 3.87, CI 1.25 to 55.95) employees. Females reported pain in the neck-shoulder region almost twice as often as males (OR 1.85, CI 1.26 to 2.81). The association was emphasized especially among younger employees: young female workers had over two-fold risk (OR 2.55, CI 1.58 to 4.11) of neck-shoulder region pain compared to young male workers.

In the whole study population, those who experienced their work ability as poor had a higher prevalence of neck-shoulder pain (OR 2.86, CI 1.19 to 6.89) compared to those with better work ability. This association remained

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>% (n)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>11 (62)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>female</td>
<td>12 (58)</td>
<td>1.14 (0.78–1.67)</td>
<td>0.92 (0.61–1.4)</td>
</tr>
<tr>
<td>Length of employment (in years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 yr</td>
<td>6 (12)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1–3 yr</td>
<td>8 (27)</td>
<td>1.26 (0.62–2.54)</td>
<td>0.77 (0.37–1.62)</td>
</tr>
<tr>
<td>4–7 yr</td>
<td>12 (27)</td>
<td>2.17 (1.07–4.41)</td>
<td>1.27 (0.60–2.71)</td>
</tr>
<tr>
<td>8–15 yr</td>
<td>14 (27)</td>
<td>2.54 (1.25–5.18)</td>
<td>1.51 (0.70–3.25)</td>
</tr>
<tr>
<td>&gt; 15 yr</td>
<td>20 (26)</td>
<td>3.78 (1.83–7.80)</td>
<td>2.24 (1.03–4.86)</td>
</tr>
<tr>
<td>Cold work environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>9 (42)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Yes</td>
<td>13 (78)</td>
<td>1.46 (0.98–2.17)</td>
<td>1.40 (0.91–2.15)</td>
</tr>
<tr>
<td>Feeling of draught</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>8 (39)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Yes</td>
<td>13 (81)</td>
<td>1.78 (1.19–2.65)</td>
<td>1.55 (1.00–2.40)</td>
</tr>
<tr>
<td>Absence from work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>6 (15)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>9–24 d</td>
<td>9 (57)</td>
<td>1.51 (0.84–2.72)</td>
<td>1.30 (0.71–2.38)</td>
</tr>
<tr>
<td>&gt; 60 d</td>
<td>23 (7)</td>
<td>4.71 (1.75–12.67)</td>
<td>3.77 (1.35–10.54)</td>
</tr>
<tr>
<td>Physical activity at leisure time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>12 (31)</td>
<td>1.74 (1.00–3.03)</td>
<td>1.43 (1.02–3.32)</td>
</tr>
<tr>
<td>1–2 times a week</td>
<td>13 (64)</td>
<td>1.89 (1.16–3.07)</td>
<td>1.86 (1.11–3.11)</td>
</tr>
<tr>
<td>&gt; 2 times a week</td>
<td>7 (25)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Odds ratios, OR (adjusted for all variables in the table) and their 95% confidence interval (95% CI). Statistically significant odds ratios are underlined.
significant among older employees (OR 8.69, CI 1.08 to 70.11), whereas the association was not significant among younger employees (OR 1.73, CI 0.64 to 4.70, Table 2). The prevalence of neck-shoulder region pain was higher among older employees (86%) compared to younger employees (81%, p<0.05)

Furthermore, in the unadjusted analysis, those who exercised 1 to 2 times a week in their leisure time were 1.6 times more likely to report pain in the neck-shoulder region compared to inactive persons, however the significance disappeared when the frequency of physical exercises increased over 2 times a week. Similarly, in the unadjusted analysis the association between neck-shoulder pain and the length of employment became significant after four years in the job (OR 1.77, CI 1.08 to 2.88), but the statistical significance disappeared after adjustment for the other risk factors (Table 2).

Shoulder

Local shoulder cooling, even slight cooling (OR 2.44, CI 1.73 to 3.43), was associated with the increased prevalence of shoulder pain, and the association remained significant both among younger (OR 2.71, CI 1.85 to 3.97) and older (OR 5.37, CI 1.91 to 15.10) employees. Instead, exposure to the same work for over four years (OR 1.60, CI 1.00 to 2.56) and self-estimated poor work ability (OR 1.77, CI 1.00 to 3.13) were associated with the increased prevalence of shoulder pain only in the pooled data of young and old employees (Table 3).

In contrast to the results for neck-shoulder pain, gender was not significantly associated with the experience of shoulder pain. Among the older employees, after adjustment for the risk factors, leisure time physical activity 1 to 2 times a week was associated with increased prevalence (OR 3.03, CI 1.13 to 8.16) of shoulder pain, however the significance disappeared when the frequency of physical exercises increased over 2 times a week.
(Table 3). The prevalence of shoulder pain was more common among older employees (78%) compared to younger employees (54%, \( p<0.001 \)).

**Wrist**

Within the whole study population, experience of wrist cooling was associated with the higher prevalence of wrist pain, especially among those who reported “extensive cooling” (OR 21.65, CI 11.58 to 40.46). This association remained significant both among younger (OR 25.82, CI 11.94 to 55.85) and older (OR 17.96, CI 5.18 to 62.31) employees. The occurrence of wrist pain was higher among female workers (OR 1.72, CI 1.18 to 2.52) compared with male workers only in the younger age group. In the unadjusted analysis, both history of more than 15 yr of cold work (OR 1.88, CI 1.10 to 3.22) and poor self-estimated work ability (OR 2.08, CI 1.30 to 3.31) were associated with the increased prevalence of wrist pain, but these associations did not remain significant after adjustment for other factors (Table 4).

There were no statistically significant differences in the prevalence of wrist pain between the younger and the older employees. In addition, further analyses (data not shown) revealed the significant association between low body mass index (BMI) and the increased occurrence of wrist pain. The prevalence of pain was higher among those with a BMI under 20 kg/m\(^2\) compared to those with a BMI of 20 to 25 kg/m\(^2\) (all employees: OR 2.10, CI 1.06 to 4.12 and among younger employees: OR 2.21, CI 1.08 to 4.49).

**Low back**

The occurrence of low back pain was the highest among those who experienced “extensive low back cooling”, being significant both among younger (OR 3.88, CI 1.82 to 8.25) and older (OR 38.09, CI 6.99 to 207.64) employees. Self-assessed poor work ability was significantly associated with the increased occurrence of low back pain.
back pain only among younger employees (OR 2.86, CI 1.28 to 6.43). Similarly to shoulder region pain, among the older employees and after the adjustment made for the explanatory variables, physical activity 1 to 2 times a week during leisure time was associated with increased prevalence of low back pain (OR 4.25, CI 1.57 to 11.54) compared to having no physical activity. The significance disappeared when the frequency of physical exercises increased more than 2 times a week (Table 5). The prevalence of low back pain was significantly higher among older employees (73%) compared to their younger counterparts (62%, p < 0.05).

In the crude analyses, obesity (OR 1.73; CI 1.02 to 2.96) and length of employment, after four years of working (OR 2.20, CI 1.45 to 3.33), were significantly associated with increased the prevalence of low back pain. After adjustment for other explanatory variables, the association with the prevalence of low back pain remained significant only for employees who had worked in the same job for 8 to 15 yr (OR 2.00, CI 1.17 to 3.40, Table 5).

### Relationship between work ability and musculoskeletal symptoms

Figure 2 presents the relationship between disadvantages in daily activities due to musculoskeletal symptoms and self-estimated work ability. Those who rated their work ability as poor reported significantly more often disadvantage in daily routines due to neck-shoulder (p < 0.001), shoulder- (p < 0.001), wrist- (p < 0.01), and low back pain (p < 0.001) compared to those with good work ability.

### Discussion

The results of this questionnaire study indicate that longer work duration, experience of draught at work, physical inactivity at leisure time and absence from work due to health reasons were significantly associated with

### Table 4. Logistic regression analysis and percentages of the prevalence of wrist pain causing disadvantage in daily routines during the last 12 months among whole study population

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% (n)</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>male</td>
<td>58 (311)</td>
<td>1.00</td>
</tr>
<tr>
<td>female</td>
<td>71 (318)</td>
<td>1.77 (1.36–2.31)</td>
</tr>
<tr>
<td>Body mass index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal weight</td>
<td>65 (391)</td>
<td>1.00</td>
</tr>
<tr>
<td>overweight</td>
<td>59 (175)</td>
<td>0.76 (0.57–1.01)</td>
</tr>
<tr>
<td>obese</td>
<td>69 (55)</td>
<td>1.17 (0.71–1.92)</td>
</tr>
<tr>
<td>Length of employment (in years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 yr</td>
<td>61 (115)</td>
<td>1.00</td>
</tr>
<tr>
<td>1–3 yr</td>
<td>60 (204)</td>
<td>0.95 (0.66–1.36)</td>
</tr>
<tr>
<td>4–7 yr</td>
<td>64 (127)</td>
<td>1.10 (0.73–1.67)</td>
</tr>
<tr>
<td>8–15 yr</td>
<td>67 (109)</td>
<td>1.28 (0.83–1.99)</td>
</tr>
<tr>
<td>&gt; 15 yr</td>
<td>75 (74)</td>
<td>1.88 (1.10–3.22)</td>
</tr>
<tr>
<td>Work ability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>good (7–10)</td>
<td>62 (537)</td>
<td>1.00</td>
</tr>
<tr>
<td>poor (0–6)</td>
<td>77 (84)</td>
<td>2.08 (1.30–3.31)</td>
</tr>
<tr>
<td>Wrist cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>30 (46)</td>
<td>1.00</td>
</tr>
<tr>
<td>slight</td>
<td>54 (125)</td>
<td>2.74 (1.78–4.22)</td>
</tr>
<tr>
<td>some</td>
<td>72 (239)</td>
<td>6.11 (4.01–9.31)</td>
</tr>
<tr>
<td>extensive</td>
<td>90 (173)</td>
<td>20.12 (11.29–35.85)</td>
</tr>
<tr>
<td>Physical activity at leisure time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>60 (143)</td>
<td>1.00</td>
</tr>
<tr>
<td>1–2 times a week</td>
<td>66 (296)</td>
<td>1.30 (0.94–1.80)</td>
</tr>
<tr>
<td>&gt; 2 times a week</td>
<td>63 (192)</td>
<td>1.11 (0.78–1.57)</td>
</tr>
</tbody>
</table>

(all, age 18 to 64 yr, unadjusted OR and adjusted OR), among employees aged 18 to 39 yr (adjusted OR1) and among employees aged 40 to 64 yr (adjusted OR2). Odds ratio, OR (adjusted for all variables in the table) and their 95% confidence interval, 95% CI. Statistically significant odds ratios are underlined.)
Poor work ability. Musculoskeletal symptoms causing disadvantage in daily activities in the past 12 months were the most common in the neck-shoulder region, shoulders, wrists and lower back. The prevalence of these symptoms was significantly associated with the experience of local cooling. In addition, longer work duration, female gender, increasing age and self-estimated poor work ability were associated with the increased prevalence of musculoskeletal symptoms causing disadvantage in daily activities.

**Work ability**

The present results indicate that long-term exposure to cold working conditions may constitute a risk for work ability impairment. This contradicts the statement that utilization of work experience is related to good work ability among aging workers in Finland\(^\text{14)}\). Our findings emphasize the significance of preventive measures, e.g. recovery phases in warm conditions, ergonomic interven-

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### Table 5. Logistic regression analysis and percentages of the prevalence of low back pain causing disadvantage in daily routines during the last 12 months among whole study population

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>All, age 18–64 yr</th>
<th>Age 18–39 yr</th>
<th>Age 40–64 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>% (n)</td>
<td>Unadjusted OR (95% CI)</td>
<td>Adjusted OR (95% CI)</td>
</tr>
<tr>
<td>male</td>
<td>64 (347)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>female</td>
<td>68 (303)</td>
<td>1.18 (0.91–1.53)</td>
<td>1.09 (0.80–1.51)</td>
</tr>
<tr>
<td>Body mass index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal weight</td>
<td>63 (378)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>overweight</td>
<td>69 (203)</td>
<td>1.32 (0.98–1.77)</td>
<td>1.20 (0.84–1.71)</td>
</tr>
<tr>
<td>obese</td>
<td>74 (58)</td>
<td>1.73 (1.02–2.96)</td>
<td>1.34 (0.72–2.48)</td>
</tr>
<tr>
<td>Length of employment (in years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 yr</td>
<td>52 (98)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>1–3 yr</td>
<td>61 (202)</td>
<td>1.42 (0.99–2.04)</td>
<td>1.29 (0.85–1.96)</td>
</tr>
<tr>
<td>4–7 yr</td>
<td>70 (142)</td>
<td>2.20 (1.45–3.33)</td>
<td>1.40 (0.87–2.27)</td>
</tr>
<tr>
<td>8–15 yr</td>
<td>76 (128)</td>
<td>2.97 (1.88–4.69)</td>
<td>2.00 (1.17–3.40)</td>
</tr>
<tr>
<td>&gt; 15 yr</td>
<td>78 (81)</td>
<td>3.27 (1.90–5.65)</td>
<td>1.46 (0.76–2.82)</td>
</tr>
<tr>
<td>Work ability</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>good (7–10)</td>
<td>63 (553)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>poor (0–6)</td>
<td>84 (91)</td>
<td>2.94 (1.74–4.97)</td>
<td>2.12 (1.16–3.85)</td>
</tr>
<tr>
<td>Low back cooling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>43 (131)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>slight</td>
<td>71 (195)</td>
<td>3.22 (2.28–4.55)</td>
<td>2.79 (1.94–3.99)</td>
</tr>
<tr>
<td>some</td>
<td>82 (175)</td>
<td>6.08 (4.01–9.24)</td>
<td>5.00 (3.21–7.80)</td>
</tr>
<tr>
<td>extensive</td>
<td>85 (78)</td>
<td>7.36 (3.99–13.58)</td>
<td>5.76 (2.93–11.31)</td>
</tr>
<tr>
<td>Physical activity at leisure time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>62 (149)</td>
<td>1.00 (1.00–1.00)</td>
<td>1.00 (1.00–1.00)</td>
</tr>
<tr>
<td>1–2 times a week</td>
<td>70 (313)</td>
<td>1.41 (1.01–1.95)</td>
<td>1.25 (0.85–1.83)</td>
</tr>
<tr>
<td>&gt; 2 times a week</td>
<td>61 (189)</td>
<td>0.97 (0.69–1.37)</td>
<td>1.04 (0.69–1.57)</td>
</tr>
</tbody>
</table>

(all, age 18 to 64 yr, unadjusted OR and adjusted OR), among employees aged 18 to 39 yr (adjusted OR\(_1\)) and among employees aged 40 to 64 yr (adjusted OR\(_2\)). Odds ratio, OR (adjusted for all variables in the table), and their 95% confidence interval, 95% CI. Statistically significant odd ratios are underlined.

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Fig. 2. Disadvantage in daily activities (% of the respondents) due to neck-shoulder-, shoulder-, wrist- and low back symptoms among workers with good work ability and workers with poor work ability.

\(*p<0.01, **p<0.001\) in relation to good work ability.
tions during repetitive work, and individual guidance in the use of personal protective clothing, early in the work career to maintaining and improving work ability in a cold environment. Self-estimated poor work ability was associated with a longer period of absence from work due to health reasons. Differences in coping strategies have been associated with the frequency and duration of sickness absence. We could only postulate that workers with more sickness absences (more than 60 d) may have developed coping strategies in order to maintain better self-estimated work ability compared to workers with less sickness absences (25 to 60 d). However, previous research has indicated that work ability is assessed lower for those with a longer duration of sickness absence compared to workers with less sickness absence.

In the meat-processing industry, cold exposure consists of cold ambient temperature, air movements, draught, dampness, and handling of cold products. In this study, the experience of draught was a stronger risk factor for poor work ability than cold work environment. Women and fatigued persons have been shown to have uncomfortable and cool sensations when exposed to draughts more often than men and alert persons. This is parallel with the result of the present study on gender differences in the experience of unpleasant working conditions and cold discomfort. Anttonen and Virokannas assessed cold stress in outdoor occupations using body cooling in relation to the recommended temperature limits for degradation of performance by Lotens. They examined body cooling as changes in mean skin temperature (Tsk) and concluded that work ability may be reduced, at least temporarily, because of lowered mean skin temperature during the work day. Because of the adverse effects in cold exposure, cold stress should be acknowledged in occupational health and safety with health examinations, and new means should be developed to prevent performance deterioration and impairment in occupational safety.

Follow-up studies by Seitsamo and Ilmarinen and Tuomi et al. in thermoneutral conditions concur with the findings of the present study that physical inactivity during leisure time was significantly associated with increased risk of poor work ability. They found that work ability remained good or was improved if the amount of leisure time physical activities was increased. Similarly, those whose work ability was lowered at the follow-up had decreased their physical activity. Furthermore, it can be concluded that physically active lifestyle promotes better physical functioning among working population and better cold tolerance. Thus, encouraging physical activity during leisure time can be considered as a beneficial measure to maintain and enhance good work ability in low ambient working temperatures. Promotion of good work ability is also an important factor in the prevention of premature retirement. In an 11-yr follow-up study among food-processing industry workers, Salonen et al. found that poor subjective work ability was significantly associated with early exit from work life.

Musculoskeletal symptoms

In our study, the prevalence of musculoskeletal pain causing disadvantage in daily activities was more frequent than in the questionnaire study of Koskinen et al., where the study population worked mainly in warm conditions in the baking industry. It can be concluded that low ambient temperature constitutes a higher risk for musculoskeletal pain in the upper extremities and upper torso compared to warm conditions. This conclusion is consistent with the findings that low ambient temperature may increase the prevalence of shoulder, lower back, and knee symptoms. Moreover, several studies have shown increased risk for upper extremity symptoms and disorders among workers in the meat- and fish-processing industry compared with workers in control conditions.

Our results confirm the findings by Bang et al. who found that pain in neck/shoulders, wrists/hands, back, and legs was significantly more frequent among workers who often felt cold at work compared with workers who never felt cold at work. Furthermore, in a study by Hildebrandt et al., poor climatic factors (cold, draughts, dampness and changes of temperature) were significantly associated with musculoskeletal symptoms in the low back and neck-shoulder region. There is still uncertainty about the underlying pathophysiological mechanisms for correlations found between musculoskeletal disorders and climatic factors. The question remains: “Is there any influence of climatic factors on the disease process itself (tissue damage) or is there rather a secondary effect: activation of an already existing disease or a lowering of the pain threshold?”

The prevalence for neck-shoulder and wrist pain was significantly higher in women compared with men. These associations were emphasized among younger employees compared to their older colleagues. Gender differences in the prevalence of musculoskeletal pain were also detected in a study by Nordander et al. in fish-processing work where the prevalence of neck, shoulder, elbow and hand complaints were almost three times higher among female workers than among males. Furthermore, Chiang et al. found the prevalence of CTS to be more common among female frozen food packers (42%) compared to their male colleagues (30%). In the review article, Hooftman et al. list explanations for the gender difference in the prevalence of musculoskeletal complaints: 1. different exposure to the risk factors at
work between genders, 2. females are more prone to express pain symptoms, 3. same risk factors may have different effects depending on gender and 4. men and women use different coping strategies in dealing with occupational stressors, and this results in different outcomes. In line with the study by Nordander et al.30, the present results support the first explanation: women in our study were more frequently exposed to assembly line work. Their work contained more highly repetitive manual upper extremity work and involved more static muscular strain in the shoulder region compared with men who performed more physical work with varying muscular loading.

We found the factor of length of employment to be significantly related to the occurrence of shoulder and low back pain. The results are supported by a study by Chen et al.41 about the influence of cumulative exposure to a cold work environment on musculoskeletal pain. Chen et al.41 found a significant increase in symptoms in low back, shoulders and knees after five years of working in cold stores. In a study by Frost et al.38, performed at a slaughterhouse and a chemical factory, the risk for shoulder impingement syndrome increased during the first 5 to 8 yr of cumulative exposure and then tended to level off until a new increase of the prevalence ratio after 25 yr of cumulative exposure. On the other hand, inexperience and being unaccustomed to work may also increase the risk of musculoskeletal disorders39. Our finding that the experience of wrist pain was equally common among younger and older workers and not associated with the length of work history was in accordance with the results gained by Chiang et al.10 in a frozen food factory. This indicates the importance of preventive action at an early stage of the work career for the incidence of wrist pain.

A significant association was found between poor work ability and musculoskeletal symptoms, being especially strong among older employees with neck-shoulder pain. A cross-sectional study such as this one does not allow for conclusions regarding the causal relationships between the risk factors and the prevalence of musculoskeletal symptoms, and it remains uncertain whether poor work ability increases complaints of musculoskeletal symptoms or whether the relationship is in fact reversed. Similarly, the healthy workers effect should be taken into account when interpreting the prevalence of musculoskeletal symptoms and work ability. Blyth et al.40 concluded that among chronic pain employees working with pain was more common than being on sick leave due to pain symptoms. They found that on average 60% of those who worked with pain reported reduced work effectiveness.

In an unadjusted analysis, low BMI was associated with wrist pain causing disadvantage in daily activities. One possible explanation for this may be that smaller total body and muscle mass and larger body surface to mass-ratio expose to stronger body cooling41) thus increasing the experience of musculoskeletal symptoms35. There are several epidemiological studies in thermoneutral conditions42–44 about the effect of e.g. body weight on increased risk of CTS, but the relationship has been found to be controversial to our finding, although we did not control wrist pain for the prevalence of CTS. Our finding that obesity was associated with the increased occurrence of back pain existed only in unadjusted analysis, but confirmed findings by Kostova and Koleva45) that being overweight is a risk factor for back disorders, especially with respect to low back pain. Interestingly, after the adjustment made in the present risk factors, the prevalence of low back pain was higher among those exercising one to two times a week compared to those with no physical activity. Unfortunately, there were several factors that we did not control for in the present analyses (e.g. smoking, detailed description of the work tasks and possible rehabilitation for the existing pain) that may have an effect on low back pain. However, our findings about the relationship between both body mass and the level of physical activity at leisure time and musculoskeletal symptoms confirm the importance of health promotion as a preventive measure for musculoskeletal disorders.

In conclusion, the results confirm the multifactorial feature of musculoskeletal symptoms46 and work ability. In addition to individual characteristics of workers (the state of health, female gender, age and physical inactivity at the leisure time), factors related to work in a cool environment, such as the experience of draught and cooling, and longer work duration, are associated with poor work ability and prevalence of musculoskeletal symptoms causing disadvantage in daily activities. Identification of these work environmental factors and individual risk factors is important when developing measures to preserve work ability and to reduce the prevalence of musculoskeletal symptoms in cooled food-processing facilities.

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References


