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Subjective Symptoms of Female Workers Sorting Goods in Summer

Ryoichi INABA[1]*, Mayumi OKUMURA[1] and Seyed Mohammad MIRBOD[1]

[1]Deparatment of Occupational Health, Gifu University Graduate School of Medicine, 1–1 Yanagido, Gifu 501-1194, Japan

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Abstract: Subjective musculoskeletal symptoms are more frequently complained about in cold store work and in related conditions than those experienced in normal temperature work. This cross sectional study was undertaken to evaluate the effects of indoor cooling and cold storage goods on the prevalence of subjective symptoms in summer. Female workers sorting cold storage goods (exposed group) were the main subjects of this study (n=47). We also included a group of female workers engaged sorting dry goods as the unexposed to cold group (n=86). Work load for the two groups were estimated according to the recommended criteria. A self-administered questionnaire covering age, occupational career, smoking, alcohol drinking and physical exercise, present or past history of diseases, individual protective measures against cold or heat, and subjective symptoms (60 items) was used. The air temperature of the site at the start of working time for the workers sorting cold storage goods was 22.2°C which was significantly lower than those measured for the other two work places (25.4°C and 25.4°C) of the unexposed to cold group. Environmental temperatures at the foot level at the sorting workshop of cold storage goods and dry goods were ca.16°C and 26°C all day, respectively. The surface temperatures of cold storage goods were between –2.8°C and 9.4°C. The surface temperature of dry goods was 26.5°C. Among the working characteristic items, only daily working hours in the exposed group (5.6 ± 0.6 h) were significantly longer than those in the unexposed to cold group (4.6 ± 0.9 h) (*p*<0.01). The prevalence rates of finger cold sensation, stiffness in the fingers, pain in the wrist, pain in the elbow, back dullness, back pain, low-back cold sensation, foot cold sensation and pain in the foot in the exposed group were significantly higher than those in the unexposed to cold group (*p*<0.05 or *p*<0.01). Pain in the fingers, numbness in the fingers, pain in the foot and foot numbness due to the cold in the exposed group were significantly higher than those in the unexposed to cold group (*p*<0.05 or *p*<0.01). These results suggest that indoor cooling and/or job activities related to cold storage goods could, to some extent, affect peripheral circulatory disturbances; and it could be regarded as a factor related to musculoskeletal symptoms among the exposed workers.

Key words: Air-conditioning, Subjective symptoms, Female workers, Warm clothes, Physical activity

Introduction

In Japan, consideration of comfortable thermal working conditions is advised as a duty having been adopted by the revision of the Health and Safety at Work Act in 1992[1]. A relationship between indoor cold exposure and the development of subjective complaints particularly those related to the musculoskeletal system have been the subject of a few researches. The associations between indoor cold exposure and some musculoskeletal disorders such as low back pain, knee pain and shoulder pain[2], carpal tunnel syndrome[3], and neck and shoulders[4] have been reported.

*To whom correspondence should be addressed.
E-mail: rinaba@gifu-u.ac.jp

In a recent study, Bang *et al*.[5] investigated the relation between feeling cold at work and the risk of symptoms from muscles, skin, and airways among 1,767 seafood industry workers. They showed that moderate cooling, caused by a cold indoor working environment, may increase muscle, airway, and skin symptoms. However, still little is known about the effects of daily exposure to a moderate cold environment (–5 to 15°C)[6]. In addition, a large number of workers in the work places are females who are more sensitive to the cold[6–8]. Thus, it can be anticipated that among female workers whose jobs require exposure to cold, subjective symptoms related to the chilliness such as finger or foot cold sensation, Raynaud's phenomenon, and gastrointestinal disturbances might be complained about in higher percentages[6].

Watanabe[1] reported that many workers complained of chilliness and general tiredness when cooled air was ventilated in summer. Among male workers, the complaints tended to center around chilliness in offices with a room temperature of less than 25–26°C and tiredness in offices with a room temperature above 25–26°C. The first author has carried out activities as an occupational physician in a consumer cooperative for the past several years in a certain city located in the central part of Japan. The consumer cooperative has one work site for sorting cold storage goods. The environmental temperature in this work site is regulated at 0–18°C throughout the year. Pienimaki[9] showed that musculoskeletal symptoms are more frequent in cold store work and in related conditions than in neutral temperature work and symptoms seems to increase when the working time in the cold environment increases. We reported high prevalence rates of subjective complaints related to cooling disorder in various body parts in the summer and the winter among the female sorting workers in the consumer cooperative[10, 11]. Griefahn *et al*.[6] stated that pains in the shoulders and in the extremities complained of by workers were caused by repetitive physical activities rather than by cold. Their conclusions were on the basis of the evidence gained from a questionnaire survey performed among workers in the food industry, mainly from distributors, meat productions and from breweries, whose main occupational activities were manual material handling and heavy lifting, in moderately cold environments. Thus, a causal relation between indoor cooling and subjective musculoskeletal complaints in the summer among the female sorting workers is questionable.

The purpose of this cross-sectional study was to explore the effects of indoor cooling and cold storage goods on subjective symptoms experienced in summer. We compared the prevalence of subjective symptoms in female workers sorting cold storage goods to those symptoms reported by workers sorting dry goods.

Materials and Methods

Subjects and questionnaire

This study was conducted among 61 female workers (exposed group) sorting cold storage goods for door to door delivery in A consumer cooperative located in G city. A group of 171 female workers sorting dry goods (unexposed to cold group) for door to door delivery in B consumer cooperative located in K city was also included. Both G city and K city locates in the central part of Japan and have the same environmental temperature. The work tasks of the two types of sorting workers were very similar. Their main tasks included manual material handling and heavy lifting. Work loads of the two types of sorting workers were estimated to be at rates of RMR 1-3[10–12].

The surface temperatures of cold storage goods were between –2.8°C and 9.4°C. On the other hand, the surface temperature of dry goods was 26.5°C, measured using a infrared thermometer (RAYST20XXJP, RAYTEK Japan Co.).

There were not any cold or hot surfaces except cold storage goods near to the workers. There were not any strong air movements or drafts a) generally in the facilities and/or b) at foot level, except air conditioning outlets.

Through the headquarters of the consumer cooperative, a self-administered questionnaire, not requiring a signature, covering age, body dimensions, occupational career, working days in a week as well as daily working hours, lifestyles (Morimoto's 8 items[13] such as smoking, alcohol drinking and physical exercise), present illness, past history of diseases, individual protective measures to the cold, and subjective symptoms (60 items) was distributed and then collected. The questionnaire was almost the same as we used in our previous study[10, 11]. The participants were questioned as to whether they had any of the investigated symptoms in summer. The subjective symptoms were classified into three categories of frequency: frequently, sometimes, or almost none. In order to be able to present and to discuss the results obtained, selection of "frequently" or "sometimes" was taken to indicate the presence of the symptom. The survey was carried out at the end of August 2006. 90.2% of the subjects sorting cold storage goods and 53.8% of the subjects sorting dry goods replied to the questionnaire.

The study was approved by the Ethical Committee of Gifu University Graduate School of Medicine.

Measurement of thermal condition in the workshops

Temperature (T) (°C) and relative humidity (H) (%) were measured at 150 cm height from the ground at the picking line in the sorting workshop of cold storage goods located in the first floor of the building of the "A" enterprise and the two picking lines in the sorting workshop of dry goods located in the first floor and the second floor of the building of the "B" enterprise. The measurement time was at the work beginning time (9:00), noon and at the closing time (16:00) for 6 days (from August 31th (Thursday) to September 6th (Wednesday), 2006). Discomfort index (temperature−humidity index) was calculated according to the following equation[14]; 0.81T+0.01H(0.99T−14.3)+46.3.

Statistics

The significance of differences among values was tested using χ^2 test, *t*-test, Student's paired *t*-test and one way analysis of variance (ANOVA) followed by Scheffe's multiple comparison. When the frequency was low (below 5), Fisher's exact test was used. The significance level was set at $p<0.05$. Statistical analysis was conducted with the SPSS software, version 12 (SPSS, Inc., Chicago, IL).

Results

Table 1 shows the characteristics of the subjects. Among working characteristics of the two groups, only daily working hours in the exposed group were significantly longer than those in the unexposed to cold group (5.6 ± 0.6 and 4.6 ± 0.9 h, respectively; $p<0.01$).

From the questionnaire, hypertension was found in 3 (6.4%) workers in the exposed group and in 12 (14.0%) workers in the unexposed to cold group. Percentages of the workers in the exposed group who had lumbago under treatment (23.4%, 11 subjects) were significantly higher than those in the unexposed to cold group (10.5%, 9 subjects) ($p<0.05$). Two (4.3%) workers in the exposed group and 2 (2.3%) workers in the unexposed to cold group had a poor blood circulation (*hiesyou*).

The individual protective measures being used by the workers in the exposed group are listed in Table 2. In order to work comfortably in summer, the exposed workers used these countermeasures against the indoor cool environment. The proportion of the subjects who used at least one protective measure of the described items against the cold environment was 95.7%. The three main protective measure used among workers were thermal trousers (76.6%), gloves made of cotton (53.2%) and thermal clothes (46.8%).

Table 3 shows the individual protective measures against the hot environment to work comfortably in summer in the unexposed to cold group. The proportion of the subjects who used at least one protective measure of the described items against the hot environment was 97.7%. The main protective measures used among workers were drinking water at short intervals (77.9%) and wearing the high hygroscopicity clothes (75.6%).

Figures 1-1 and 1-2 show the prevalence of subjective musculoskeletal symptoms in summer among the two groups. The five main subjective musculoskeletal symptoms in the exposed group were shoulder stiffness

Table 1. Characteristics of the two groups of female subjects

	Workers sorting cold storage goods (N=47)		Workers sorting dry goods (N=86)	
	Mean ± SD	(Minimum – Maximum)	Mean ± SD	(Minimum – Maximum)
Age (yr)	49.6 ± 9.3	(27 – 68)	51.4 ± 5.8	(25 – 59)
Height (cm)	156.4 ± 5.2	(148 – 175)	155.6 ± 4.8	(135.5 – 166)
Body weight (kg)	51.5 ± 6.9	(40 – 73)	52.9 ± 7.1	(35 – 75)
BMI	21.0 ± 2.2	(17.8 – 26.3)	21.9 ± 2.8	(16.9 – 30.3)
Occupational career (yr)	7.4 ± 5.7	(0.3 – 16.6)	9.2 ± 4.2	(0.8 – 14.3)
Monthly working days	19.9 ± 1.5	(14 – 25)	19.9 ± 1.5	(16 – 27)
Daily working hours **	5.6 ± 0.6	(5 – 8)	4.6 ± 0.9	(3.8 – 6)
One way communicating hours	0.3 ± 0.1	(0.1 – 1)	0.3 ± 0.1	(0.1 – 0.8)
Daily sleeping hours	6.4 ± 0.7	(4.8 – 8)	6.3 ± 0.7	(5 – 8)
Smoking history (yr)	0.9 ± 3.7	(0 – 17)	0.0 ± 0.0	(0 – 0)
Daily smoking numbers	2.0 ± 9.4	(0 – 60)	0.0 ± 0.0	(0 – 0)
Daily drinking volume (Japanese Sake, gou)$	0.4 ± 1.8	(0 – 11)	0.1 ± 0.4	(0 – 2.3)
Daily ethanol intake (g)	11.6 ± 49.1	(0 – 297)	3.5 ± 10.4	(0 – 62.1)
Score of life style (Morimoto's 8 items)	5.8 ± 1.3	(3 – 8)	5.9 ± 0.8	(4 – 8)

Significant differences between the two groups; **$p<0.01$. $; one "gou" is about 180 ml.

Table 2. The subjects' individual protective measures against the indoor cool environment to work comfortably in summer among workers sorting cold storage goods (N=47)

	N	(%)
☆	45	(95.7)
Thermal clothes	22	(46.8)
Thermal underwear	5	(10.6)
Body warmer	3	(6.4)
Thermal trousers	36	(76.6)
Underpants	0	(0.0)
Thermal tights	3	(6.4)
Thermal socks	4	(8.5)
Thermal shoes	18	(38.3)
Shoe warmer	0	(0.0)
Thermal earmuff	0	(0.0)
Muffler	7	(14.9)
Gloves made of cotton	25	(53.2)
Gloves made of rubber	9	(19.1)
Gloves made of leather	1	(2.1)
Gloves made of synthetic fiber	6	(12.8)
Wiping the body sweat off during work and rest	5	(10.6)
Changing underwears after sweating	0	(0.0)
Others	0	(0.0)

☆, subjects who had at least one protective measure of the descrived items.

Table 3. The subjects' individual protective measures against the hot environment to work comfortably in summer among workers sorting dry goods (N=86)

	N	(%)
☆	84	(97.7)
Wearing the high hygroscospity clothes	65	(75.6)
Wearing cooling fiber made underwear	2	(2.3)
Changing clothes frequently	11	(12.8)
Drinking water at short intervals	67	(77.9)
Taking salt directly or by drinking sport drink	11	(12.8)
Wearing something cool round the neck	8	(9.3)
Reducing the amount of drinking	0	(0.0)
Others	1	(1.2)

☆, subjects who had at least one protective measure of the descrived items.

(80.9%), neck stiffness (76.6%), lumbago (74.5%), low back dullness (72.3%) and foot cold sensation (70.2%). The five main subjective musculoskeletal symptoms in the unexposed to cold group were shoulder stiffness (81.4%), neck stiffness (70.9%), lumbago (69.8%), low back dullness (64.0%) and pain in the shoulders (58.1%). The prevalence rates of finger cold sensation, stiffness in the fingers, pain in the wrist, pain in the elbow, back dullness, back pain, low-back cold sensation, foot cold sensation and pain in the foot in the exposed group were significantly higher than those in the unexposed to cold group (p<0.05 or p<0.01).

Figures 2-1 and 2-2 show the prevalence of subjective general symptoms in summer among the two groups. The five main subjective general symptoms in the exposed group were easily fatigued (87.2%), general fatigue (83.0%), sweating (63.8%), rough skin (53.2%), diarrhea (51.1%) and initial insomnia (51.1%). The five main subjective general symptoms in the unexposed to cold group were easily fatigued (89.5%), general fatigue (81.4%), sweating (81.4%), weak resistance to heat (61.6%) and dull head (51.2%). Prevalence rates of sweating and weak resistance to heat in the exposed group were significantly lower than that in the unex-

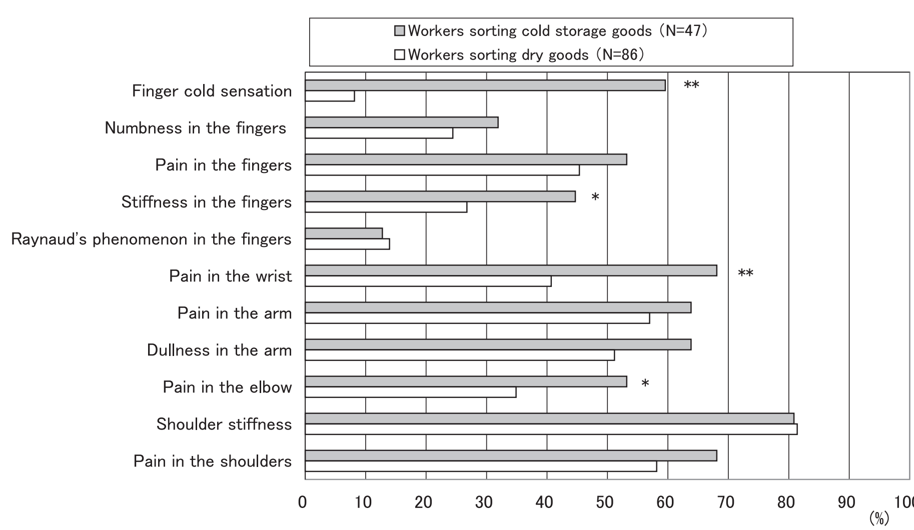

Fig. 1-1. Prevalence of musculoskeletal symptoms in summer season among the two groups of subjects.
Significant differences between the two groups; **p<0.01, *p<0.05.

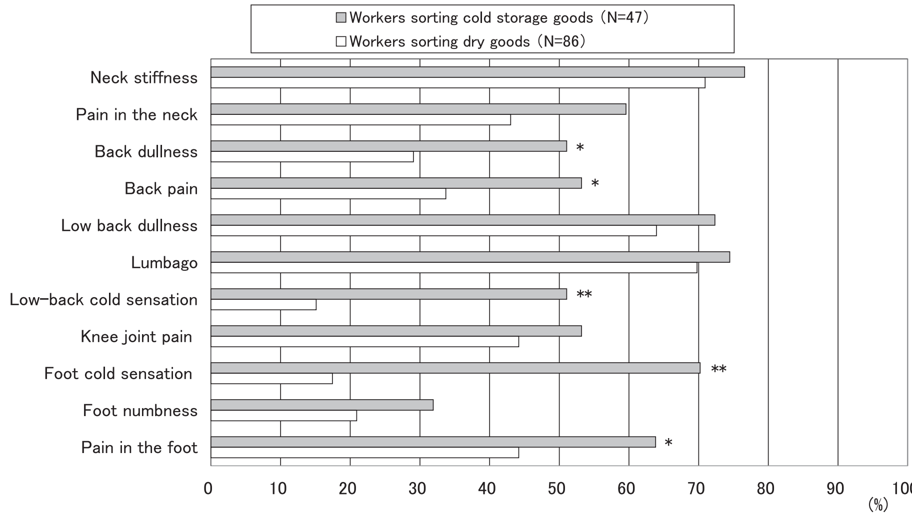

Fig. 1-2. Prevalence of musculoskeletal symptoms in summer season among the two groups of subjects.
Significant differences between the two groups; $^{**}p<0.01$, $^{*}p<0.05$.

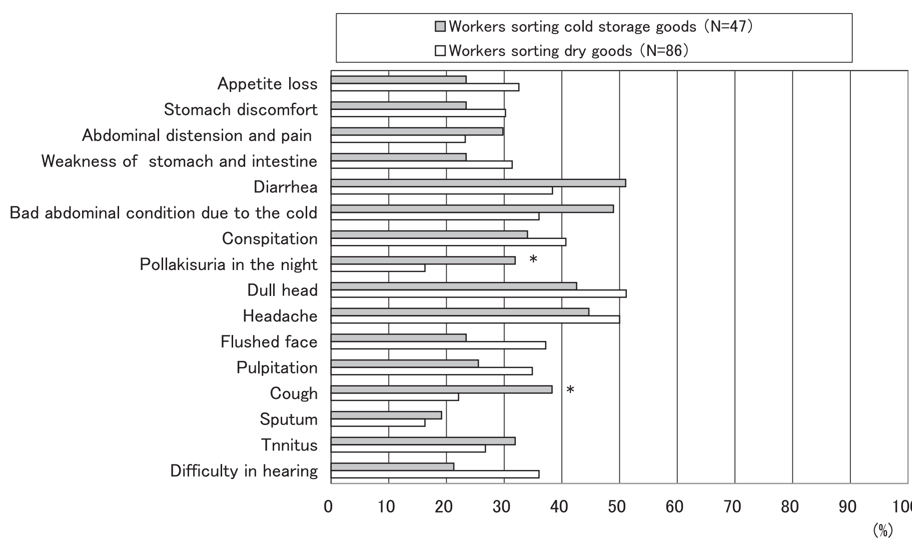

Fig. 2-1. Prevalence of general symptoms in summer season among the two groups of subjects.
Significant differences between the two groups; $^{*}p<0.05$.

posed to cold group ($p<0.05$). Prevalence rates of pollakisuria and cough in the exposed group were significantly higher than those in the unexposed to cold group ($p<0.05$).

Figure 3 shows the prevalence of subjective symptoms during work in the summer season among two groups of subjects. Prevalence of sweating in the exposed group was significantly lower than that in the unexposed to cold group ($p<0.05$). Prevalence rates of pain in the fingers, numbness in the fingers, pain in the foot and foot numbness due to the cold exposure in the exposed group were significantly higher than those in the unexposed to cold group ($p<0.05$ or $p<0.01$).

In the unexposed to cold group, the prevalence of work difficulty due to hot weather during work was 88.4%.

Figure 4 shows the environmental temperature in the workshops. The results clearly depict that environmental temperatures at the sorting workshop of cold storage goods of the "A" enterprise (22.2 ± 0.4°C~23.0 ± 1.3°C) were significantly lower than those at the two sorting workshops of dry goods of the "B" enterprise (25.4 ± 0.5°C~26.1 ± 1.7°C, $p<0.01$). In the sorting workshops of dry goods of the "B" enterprise, there were no significant differences in the environmental temperatures between the data obtained for the first floor compared to the second floor. There were no significant differences in the environmental temperatures

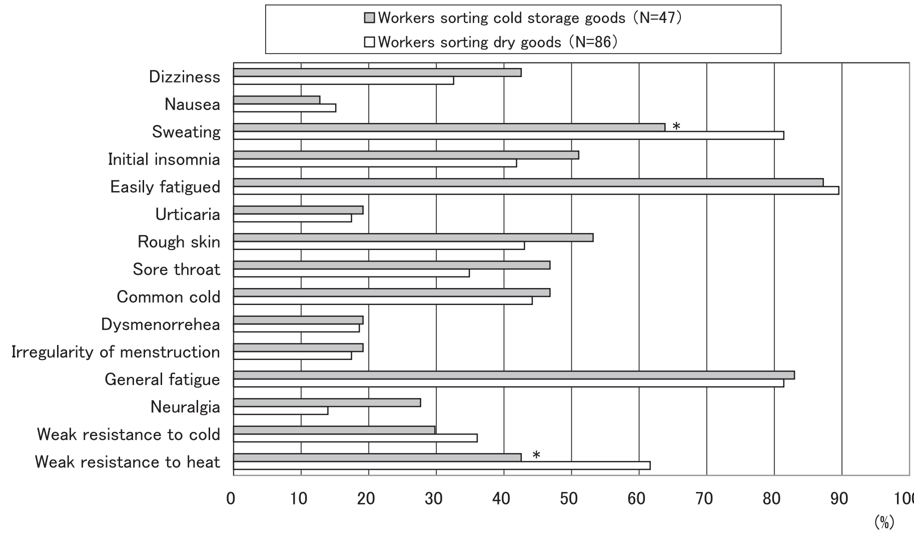

Fig. 2-2. Prevalence of general symptoms in summer season among the two groups of subjects.
Significant differences between the two groups; *$p<0.05$.

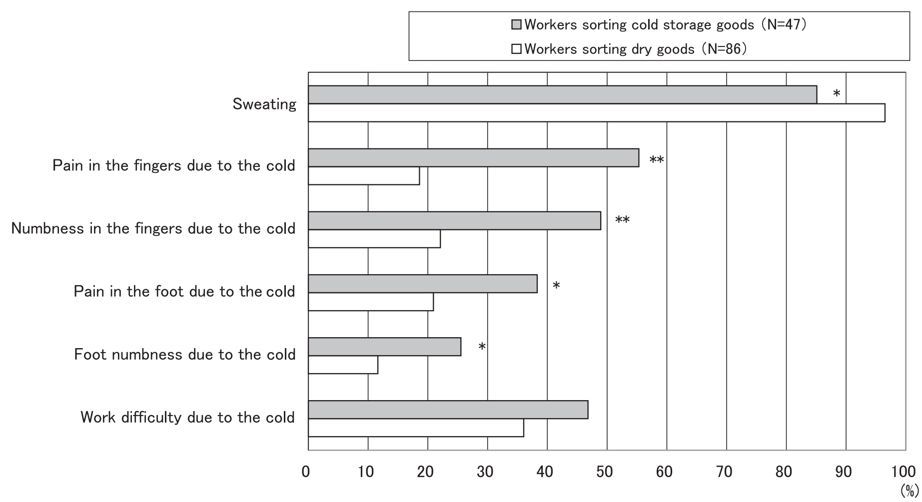

Fig. 3. Prevalence of subjective symptoms during work in the summer season among two groups of subjects.
Significant differences between the two groups; **$p<0.01$, *$p<0.05$.

data recorded at 9:00 (work starting time), 12:00 and 16:00 (closing time) in all workshops.

At the sorting workshop of cold storage goods and dry goods, environmental temperatures at the foot level were ca.16°C and 26°C all day, respectively.

Figure 5 shows the relative humidity in the workshops. At each measured point, relative humidity at the sorting workshop of cold storage goods of the "A" enterprise (39.5 ± 4.2%~41.7 ± 5.1%) was significantly lower than the corresponding data recorded for sorting workshops of dry goods of the "B" enterprise (58.1 ± 3.9%~68.9 ± 0.9%, $p<0.01$). As shown, relative humidity at the sorting workshops of dry goods in the first floor of the "B" enterprise was significantly higher than that in the first floor of the "B" enterprise ($p<0.05$ or $p<0.01$). There were no significant differences in the relative humidity recorded at 9:00, 12:00 and 16:00 in all workshops.

Figure 6 shows the discomfort index in the workshops. At each measured point, discomfort index at the sorting workshop of cold storage goods of the "A" enterprise (67.3 ± 0.8~68.4 ± 1.5) was significantly lower than the corresponding data recorded for sorting workshops of dry goods of the "B" enterprise (73.7 ± 1.8~75.2 ± 0.1, $p<0.01$). In the sorting workshops of dry goods of the "B" enterprise, there were no significant differences in the discomfort index between the data obtained for the first floor compared to the sec-

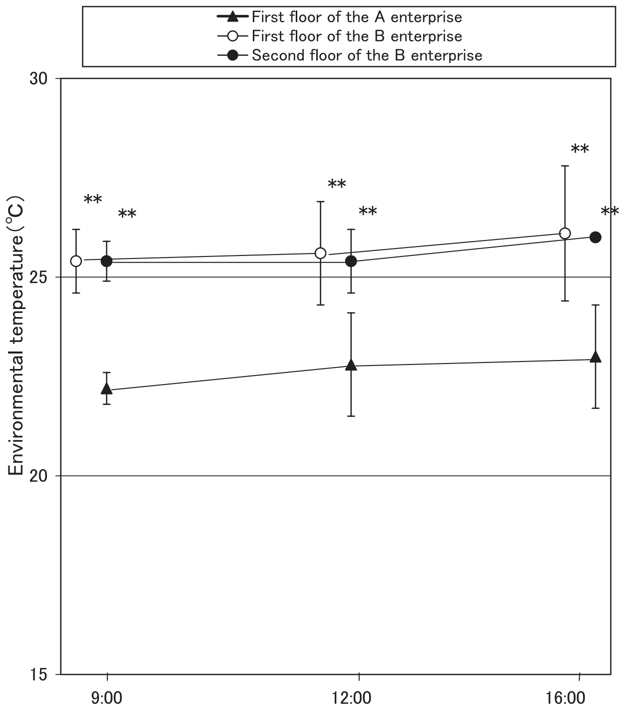

Fig. 4. Environmental temperature in the workshops in summer.
Each value represents the mean ± SE. $**p<0.01$, compared with the temperature at the first floor of the A enterprise (ANOVA followed by Scheffe's multiple comparison).

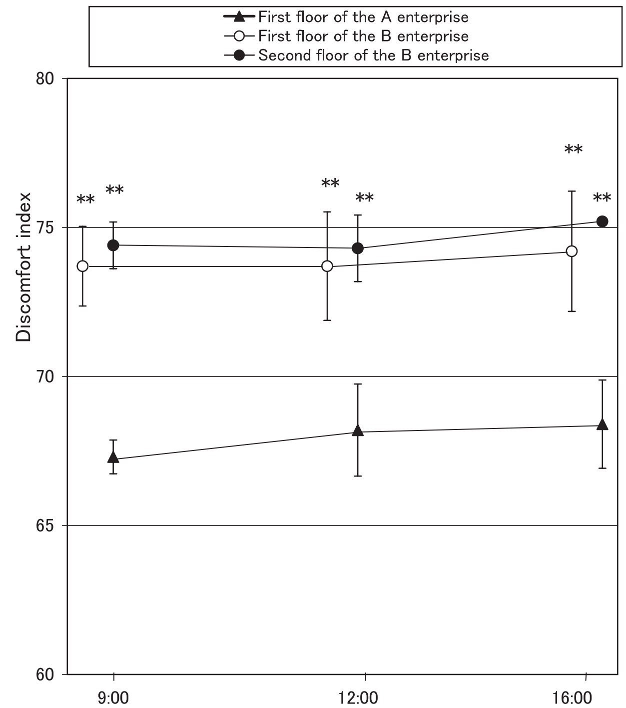

Fig. 6. Discomfort index in the workshops in summer.
Each value represents the mean ± SE. $**p<0.01$, compared with the temperature at the first floor of the A enterprise (ANOVA followed by Scheffe's multiple comparison).

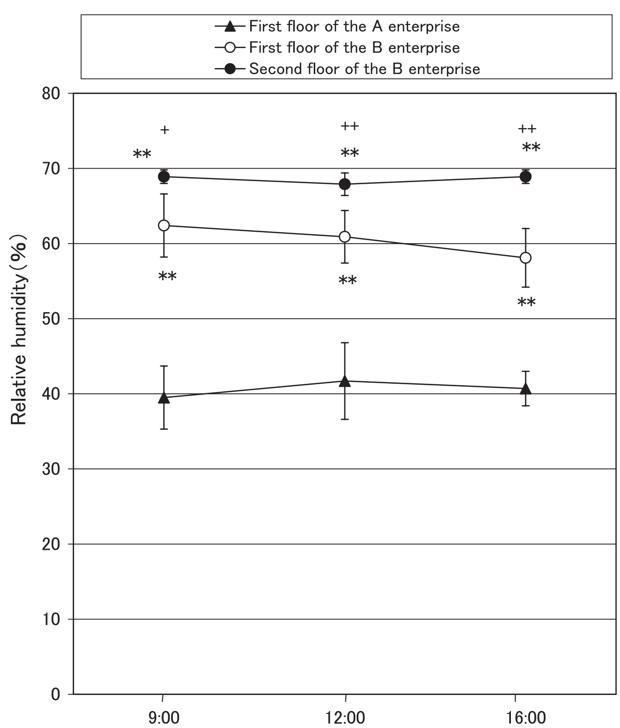

Fig. 5. Relative humidity in the workshops in summer.
Each value represents the mean ± SE. $**p<0.01$, compared with the relative humidity at the first floor of the A enterprise. $^{++}p<0.01$, compared with the relative humidity at the first floor of the B enterprise (ANOVA followed by Scheffe's multiple comparison).

ond floor. There were no significant differences in the discomfort index recorded at 9:00, 12:00 and 16:00 in all workshops.

Thermal conditions of the rooms in which the two groups of workers spent their pauses were almost same as the workshops (ca. 22°C and 26°C).

Discussion

Anatomically, women are potentially at a disadvantage to cold stress because of their smaller total and lean body mass and larger body surface area/mass; however, they also have a potential advantage due to greater body fat[15]. Walsh and Graham[16] reported that comparing the response of men and women to cold stress (–10, –3.5, 3.5 and 10°C) during intermittent exercise (20 min exercise (60 W), 10 min rest) for 3 h, women had a lower mean skin temperature. Meese *et al.*[17] reported by a laboratory study simulating factory work for 1 day that by fixing clothing levels, skin temperature during work in the cold (6 and 12°C) was decreased more in women than in men. We reported the high prevalence of subjective complaints related to cooling disorder in various body parts in the summer among the female workers sorting cold storage goods[10]. Thus, the present cross-sectional study was undertaken to investigate the effects of indoor cooling environment on individual subjective complaints in summer in female workers sorting cold storage goods and those sorting dry goods.

In the present study, concerning the working conditions, we observed that at each measured point, environmental temperatures, relative humidity and discomfort index at the sorting workshop of cold storage goods (22.2~23.0°C, 39.5~41.7% and 67.3~68.4) were significantly lower than those at the two sorting workshops of dry goods (25.4~26.1°C, 58.1~62.4% and 73.2~74.2 in the first floor; 25.4~26.0°C, 67.9~68.9% and 74.7~75.2 in the second floor). The environmental temperatures, relative humidity and discomfort index were almost stable during working time. Although we did not measure wind velocity in the workshops, the values of wind velocity seem to be about 1 m/s.

The surface temperatures of cold storage goods were between –2.8°C and 9.4°C. The surface of cold storage goods becomes wet when they are taken to room temperature. So, the cold storage goods should preferably be called "cold and wet goods". At the sorting workshop of cold storage goods, environmental temperatures at the foot level were ca.16°C all day. On the other hand, at the sorting workshop of dry goods, the surface temperature of dry goods and environmental temperatures at the foot level were almost same as room temperature.

Thermal conditions of the rooms in which the workers spent their pauses were almost same as the workshops.

In this study, exposed group gave very high response to the questionnaire while the unexposed to cold group gave much lower response. It is considered to be one of the factors that the first author carried out activities as an occupational physician in A consumer cooperative having a sorting workshop of cold storage goods. This could have some influence on the statistical comparison between these two circumstances.

The four main subjective symptoms (shoulder stiffness, neck stiffness, lumbago, low back dullness) in summer among two groups of sorting workers were reported at the same rate. In addition, there were no significant differences in the prevalence rates of these symptoms between the two groups. The four main subjective symptoms in the exposed group were almost similar compared to those reported before[10].

Prevalence rates of finger cold sensation, low-back cold sensation, foot cold sensation, stiffness in the fingers, pain in the wrist, pain in the elbow, back dullness, back pain, and pain in the feet, which are considered to be related both to peripheral circulatory disturbance and musculoskeletal fatigue[15], in the exposed group, were significantly higher than those in the unexposed to cold group. In addition, prevalence rates of pain in the fingers, numbness in the fingers, pain in the foot and foot numbness due to the cold during work in the exposed group were significantly higher than that in the unexposed to cold group. On the other hand, prevalence of sweating in the exposed group was significantly lower than that in the unexposed to cold group. These results suggest that indoor cooling (22.2–23.0°C) and/or job activities related to cold storage goods affect peripheral circulatory and musculoskeletal symptoms among sorting workers, as discussed after in detail.

In summer, in those female workers who had to work in cooled indoor working environment and/or their job activities were related to cold storage goods, showed an increase in the prevalence of peripheral circulatory disturbances such as finger cold sensation and foot cold sensation. Obviously, these workers were aware of their working environment and they used various individual measures, or at least used one item (95.7%), to protect themselves against the indoor cool environment. The three main protective measures used among workers were thermal trousers, gloves made of cotton and thermal clothes. We[8, 18] suggested that female workers working in moderate cold environment should wear thermal shoes. This protective measure might be effective at preventing cold sensation in the fingers and feet. In the present study, in summer, prevalence rates of finger cold sensation and foot cold sensation in the exposed group were 59.6% and 70.2%, respectively. However, only about 40% of the workers in the exposed group used thermal shoes. We previously reported that 77.8% of the workers sorting cold storage goods used thermal shoes[11]. Thus, it is recommended that workers sorting cold storage goods should be advised to use thermal shoes both in summer and in winter.

Concerning the prevalence of lumbago, the results reported here in the exposed group (74.5%) is somewhat higher than those reported by Chen *et al*.[2] who found lumbago in 42.3% of workers in a low temperature store (–10 to 25°C) and in 9.2% of workers in a normal temperature store (20 to 30°C). They concluded that cold exposure might be a co-factor in development of chronic problems of the muscles and joints. Lundqvist *et al*[4], also indicated the same conclusion for those exposed to moderate cold exposure (5–19°C). We[19] also reported that heat and steam generator (38–40°C continuing for 5 h) improved lumbago among supermarket checkers working in air-conditioning room (18–22°C) during summer.

In the present study, percentages of the workers in the exposed group who had lumbago under treatment were significantly higher than those in the unexposed to cold group. As the exposed subjects of the present study worked in a nearly moderate cold environment, regarding their musculoskeletal complaints, we also assume that besides the nature of the job and individual susceptibility, indoor cooling could be considered as an important co-factor in the development of the investigated musculoskeletal symptoms.

Complaints of lumbago are usually more frequent with advancing age and it is often provoked by more or less vehement motions[8]. Griefahn *et al*.[8] reported that lumbago was associated with changes in temperature or frequently interrupted exposures to cold by moving frequently between different rooms. However, frequent changes in temperature in the sorting work place were not observed. In addition, as sorting workers did not move to other rooms except at rest times, they were exposed to cold uninterruptedly. In this study, there were no significant differences in the prevalence of lumbago between the two groups of sorting workers, although averaged working hours of the workers in the exposed group was significantly longer (1.0 h) than those in the unexposed to cold group. It should be noted that, in general, lumbago is a common subjective complaint among working population. In addition to cold exposure, a number of co-factors such as gender, aging, work experience, body movements during working activities, job adaptation, etc should have been studied more in details. On the basis of a few walk-through observations made to the working sites and the results presented here, the high prevalence (about 70 and 75%) of lumbago among sorting workers might be caused by aging as well as frequent movements of upper limbs and vehement motions in the sorting work.

Concerning the other musculoskeletal symptoms, Niedhammer *et al*.[20] applied multiple logistic regression analysis to their data and observed a relation (Odds ratio 1.92, p=0.06) between exposure to cold and left shoulder pain among supermarket checkers. A causal relation is nevertheless questionable. Griefahn *et al*.[8] stated that pains in the shoulders and in the extremities complained of by workers were caused by repetitive physical activities rather than by cold. Their conclusions were on the basis of the evidence gained from a questionnaire survey performed among workers in the food industry, mainly from distributors, meat productions and from breweries, whose main occupational activities were manual material handling and heavy lifting, in moderately cold environments (–5 to 15°C). We also observed in the present study that there were no significant differences in the prevalence of pain in the shoulder, arm, fingers or knee joint between the two groups of sorting workers whose tasks were very similar. On the other hand, prevalence of pain in the wrist and elbow in the exposed group was significant higher than that in the unexposed to cold group. It is seemed that these results were also caused by the occupational activities rather than by just one factor– the indoor cool exposure–as evidenced by the results of the present study. In brief, workers in the exposed group with significantly higher working hours showed higher prevalence for the mentioned symptoms than in the unexposed to cold group. However, the factor of working air temperature should not be disregarded, as we[19] previously found that the heat and steam generator improved shoulder pain and low-back cold sensation among supermarket checkers working in air-conditioning room during summer. Thus, the effect of air-conditioning on the musculoskeletal symptoms should be taken into consideration.

Interestingly, we observed in the present study that prevalence rate of subjectively weak resistance to heat in the exposed group was significantly lower than that in the unexposed to cold group. It is possible that the result was due to healthy workers effects concerning the workers sorting cold storage goods.

There have been some reports[21, 22] that irregularity of menstruation and dysmenorrhea in female workers are significantly related to work conditions such as cold exposure as well as ageing. We[11] reported that workers sorting cold storage goods had significantly higher prevalence rates of irregularity of menstruation, compared with the office workers, and prevalence rates of dysmenorrhea in the checkers were significantly higher than those in the office workers. However, in the present study, there were no significant differences in the mean of the age or the prevalence rates of irregularity of menstruation or dysmenorrhea, or between the two groups of sorting workers. Thus, it is considered that effect of indoor cooling (22.2~23.0°C) and/or cold storage goods on menstruation is not a matter of concern.

The prevalence rate of pollakisuria and cough in the exposed group were significantly higher than those in the unexposed to cold group. It was reported that cold stress causes an osmolal diuretis[23]. Some researchers[6, 24] reported that a cold workplace environment contributes to the genesis of bronchitis or aggravates the process. Thus, it might be supposed that the results were mainly caused by the differences of working conditions between the two groups of sorting workers.

The prevalence of Raynaud's phenomenon in the fingers in the exposed group and the unexposed to cold group were 14.0% and 12.8%, respectively. These prevalence rates were higher than in the female general population in Japan (1–4%)[25]. Griefahn *et al*.[6] reported that exerted grip force may be one of the important factors in the pathogenesis of secondary Raynaud's phenomenon in workers who are at least temporarily exposed to low temperature. Taking this fact into consideration, the high prevalence of Raynaud's phenomenon in the exposed group could be due to the inadequate protective clothing against cooling and repetition of exerted grip force (e.g. while lifting and carrying heavy weights or while handling manually cold material) as well as direct exposure to cooled air. However, concerning the high prevalence of Raynaud's phenomenon in the unexposed to cold group shows that further research is apparent.

In the exposed group, prevalence of sweating during work was 85.1%. Prevalence of work difficulty due to the cold during work was 46.8% although only 4.3% of workers had a poor blood circulation (*hiesyou*). We tried to estimate the thermal insulation in the exposed group from the clothing items used as individual protective measures against the indoor cool environment (Table 2) referring to the ISO 9920[26] although we did not get information about all clothes which the workers wore during work. As a result, thermal insulation in the exposed group was estimated at 1.21 ± 0.17 (0.87~1.64) clo. Insufficient protective clothing and having a long time work activity inside the cold store have been cited[2] as key factors causing musculoskeletal symptoms and health problems among cold store workers. Sweating causes decrease of the body temperature afterward[27]. However, only 10.6% of the workers in the exposed group wiped the body sweat off during work and rest. In addition, there were no workers changing underwear after sweating in the exposed group. Thus, it is recommended to the workers sorting storage goods to change wet clothes to dry ones in an appropriate resting room when heavy sweating occurs during working activities.

On the other hand, in the unexposed to cold group, prevalence of sweating during work was 96.5%. Prevalence of work difficulty due to hot weather during work was 88.4%. Thus, the result is considered to be caused by physical work in the hot environment[31]. We observed high prevalence of individual protective measures against hot environment to work comfortably in summer[28, 29] in the unexposed to cold group. The most individual measures were drinking water at short intervals (77.9%) and wearing the high hygroscopicity clothes (75.6%). These values were higher compared to the workers (48.5% and 54.5%) in the kitchen of a university in summer (temperature, 29.8 ± 0.4°C; relative humidity, 63.8 ± 6.8)[30].

Interestingly, there were no significant differences in the percentages of subjects who complained of work difficulty due to the cold between the two groups of sorting workers. The result suggests that work difficulty due to the indoor cooling in the workers sorting cold storage goods was reduced by physical activity as well as by clothes. In the unexposed to cold group, we observed that prevalence rates of pain in the fingers, numbness in the fingers, pain in the foot and foot numbness due to the cold during work were 11.6%~22.1%. These results are considered to be caused by the exposure to cool air current from air conditioning outlets near to the workers sorting dry goods, which could explain the simultaneous experiences of cold and heat strain.

Consequently, it seems that both cold problems (cold extremities etc.) and heat problems (sweating) appear in both thermal conditions during almost same phases of work.

In conclusion, indoor cooling (22.2°C~23.0°C) and/or job activities related to cold storage goods could, to some extent, affect peripheral circulatory disturbances; and it could be regarded as a factor related to musculoskeletal symptoms among the exposed workers.

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