

Comparison of Subjective Symptoms and Hot Prevention Measures in Summer between Traffic Control Workers and Construction Workers in Japan

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Abstract: In the present study, a survey on subjective symptoms and hot prevention measures in summer was conducted in 204 male traffic control workers and 115 male construction workers. Work loads of traffic control workers and construction workers were estimated at RMR 1–2 and RMR 2–4, respectively. A self-administered questionnaire was used to collect information on age, occupational career, working habit, present or past history of diseases, individual preventive measures to the heat, and subjective symptoms in the summer. Daily working hours in the sunshine of the traffic control workers were significantly longer than those of the construction workers. Prevalence rates of changing clothes frequently, avoiding direct exposure of face and neck to sunlight using towel like materials, and wearing sunglasses in the traffic control workers were significantly lower than the construction workers. Prevalence rates of symptoms in the upper extremities in the traffic control workers were significantly lower than those in the construction workers. Prevalence of work difficulty due to hot weather during work in the traffic control workers was significantly lower than the construction workers. On the basis of the results obtained, some preventive countermeasures to improve working environment are presented.

Key words: Heat stress, Construction, WBGT, Summer, Questionnaire, Subjective symptom

Introduction

Heat is a physical hazard that can pose a problem in almost any workplace, especially during the warm months^{1, 2}. Working in hot environments, without being adequately acclimated or cooled increases a worker's heat load or thermal stress³. When this happens, the build up of heat can impair worker performance, increase accident risk and cause illness or even death. Prolonged exposure to high temperature and humidity (without effective cooling) can cause health risks like heat cramps, heat exhaustion and heat stroke⁴. The body tries to maintain a normal core (rectal) temperature through the formation of sweat and evaporation. If unable to keep up with the heat being produced, the body will suffer.

Environmental factors in the workplace will affect the body's ability to properly maintain itself. A humid environment, without air movement will slow heat loss from the body by reducing evaporation. Even a mild form of heat stress can cause irritability, decreased morale, increased anxiety and the inability to concentrate. Heat stress is often ignored hazard in the workplace. In addition to health hazard to workers, working in hot environments also increases safety risks.

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. Accordingly, hot working condition causing heat disorders is one of the fundamental working environmental factors being taken into account⁵. Nevertheless, from 1991 through 2001, an average of 13.8 Japanese workers per year died

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from heat related disorders. In 2001, 194 workers were reported to sick leaves for over 4 days due to heat disorders in summer. Recently, it has been reported that most of workers who suffered from heat disorder in summer are outdoor workers such as construction workers, traffic control workers, etc⁶.

Climate changes associated with global warming have been reported to have a serious impact on human beings^{7,8}. The increase of heat-related deaths during intermittent hot weather, as predicted by WHO⁹, is amongst the potential direct risks that global warming would present to human health. Nakai *et al.*¹⁰ reported by a long-term retrospective study (from 1968 to 1994 in Japan) that mortality due to heat disorder increases markedly during hot summer and even a small rise in atmosphere temperature may lead to a considerable increase in heat-related mortality, indicating the importance of combating global warming. Thus, it could be presumed that the incidence of heat disorders among outdoor workers in Japan may increase with global warming and the predicted worldwide increase in the frequency and intensity of heat waves in the future⁷⁻¹¹.

In our previous research project, in workers engaged in excavating ancient objects, being considered as one of outdoor working sites, we investigated the relationship between summer working environment, and body temperature and subjective symptoms by the field survey¹², and the comfortable clothes in the summer season was evaluated by the applied questionnaire survey¹³. In the present study, to help making comfortable workplaces and to prevent heat disorders in two other groups of outdoor workers, we conducted a survey on subjective symptoms and hot prevention measures in summer between traffic control workers and construction workers. On the basis of the results obtained, preventive countermeasures are presented.

Subjects and Methods

Measurement of thermal condition

Dry bulb temperature, wet bulb temperature and globe temperature in two parts of the considered construction sites (the place where a morning assembly was held and on the 3rd floor of the construction site) were measured at the spot of 120 cm upper from the ground or floor, once per 30 min between 9:00 and 16:30 for 6 d from July 31st to August 9th, 2001, using a Wet Bulb Globe Temperature (WBGT) Meter (WBGT-101, Kyoto Electronics Manufacturing Co. LTD, Kyoto), which can automatically compute WBGT. WBGT was evaluated in accordance with the

Recommendations of the Japan Society for Occupational Health designated for Occupational Exposure Limits to Heat and its index evaluation as Heat Stress¹⁴.

The 3rd floor of the building was half shaded by the nets stringed for occupational safety and injury prevention points of view.

Subjects and questionnaire

This study was conducted among 247 traffic control workers in two security guard companies and 115 male workers engaged in building construction in Gifu city. Their working time started at 8:00. Typical tasks in traffic control work include occasional waving a signal flag at standing and typical duty in construction work is frequently moving upper-arms with a tool at standing position. Work loads of traffic control workers and construction workers were estimated at relative metabolic rate (RMR) 1–2 and RMR 2–4, respectively¹⁴. Workers took a rest each time for 15 min at 10:00 and in the afternoon at 15:00, and for 1 h at 12:00. Only construction workers could take a rest in the provided rest house with air conditioners and ice making machines.

All subjects were asked to complete a self-administered questionnaire without signature, covering age, figure, occupational career, working days in a month and hours in a day, smoking and alcohol drinking habits, present illness, past history of diseases, individual preventive measures to the heat, subjective symptoms in the summer (42 items) and subjective symptoms occurred during the daytime working in the summer (6 items). The participants were questioned as to whether they had any of the investigated symptoms in the summer. The questionnaire was almost the same as that used in our previous study¹². 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 “frequency” or “sometimes” was taken to indicate the presence of the symptom. The survey was carried out in the middle of August 2001. From the traffic control workers 240 (204 males and 36 females) (97.2%) and all construction workers replied to the questionnaire.

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

Statistics

The significance of differences among values was tested using χ^2 test or Student's t-test. When the frequency was low (below 5), Fisher's exact test was used. The significance level was set at $p < 0.05$.

Results

Figure 1 shows the WBGT in the summer measured in the place where a morning assembly was held and on the 3rd floor of the construction site. Mean values of WBGT in the place where a morning assembly was held were between 28.1°C at 9:00 A.M. and 32.0°C at 1:30 P.M. The measured WBGT values on the 3rd floor of the construction site were between 26.5°C at 9:00 A.M. and 29.8°C at 4:00 P.M. The values of WBGT except the one measured at 16:30 in the place where a morning assembly was held were significantly higher than those measured on the 3rd floor of the construction site ($p<0.01$ or $p<0.05$).

Table 1 shows the characteristics of the male subjects. Mean age and BMI of the traffic control workers (42.1 ± 14.9 yr and 23.5 ± 3.9) were significantly higher than the construction workers (37.3 ± 13.2 yr and 22.4 ± 2.9) ($p<0.05$). Occupational career, monthly working days, daily working hours, daily working hours at night and one way commuting hours of the traffic control workers were significantly shorter than the construction workers ($p<0.01$). Daily working hours in the sunshine of the traffic control workers (7.5 ± 1.3 h) were significantly longer than those in the construction workers (5.6 ± 2.7 h) ($p<0.01$).

There were no significant differences in the prevalence of past history of heat disorders between the traffic control workers (2.9%) and the construction workers (3.5%).

There were no significant differences in the prevalence rate of smoking between the traffic control workers (68.6%) and the construction workers (78.3%).

Table 2 shows the frequency of alcohol intake of the subjects. Prevalence rate of alcohol intake everyday in the construction workers (45.2%) was significantly higher than that in the traffic control workers (24.0%) ($p<0.01$).

Table 3 shows the prevalence of individual preventive ideas related to clothing against the hot environment being taken into considered by each worker to work comfortably in the summer season. Prevalence rates of wearing a helmet with small holes, clothes with long sleeves and clothes with half sleeves in the traffic control workers were significantly higher than the construction workers ($p<0.01$ or $p<0.05$). Prevalence of changing clothes frequently, avoiding direct exposure of face and neck to sunlight using towel like materials, and wearing sunglasses in the traffic control workers were significantly lower than the construction workers ($p<0.01$).

Table 4 shows the prevalence of individual preventive ideas except clothing against the hot environment to work comfortably in the summer season. Prevalence of drinking water frequently in the traffic control workers and the construction workers were only 75.0% and 70.4%, respectively. Prevalence of using a protective cosmetic against ultraviolet rays in the traffic control workers was significantly higher than the construction workers ($p<0.01$).

Table 5 shows the prevalence of subjective symptoms in the summer season among all subjects. Prevalence of numbness in the fingers, pain in the fingers, pain in the wrist, pain in the arms, pain in the neck, back pain, low back cold sensation, foot numbness, muscle cramps, snivel, diarrhea, dull head, headache, dizziness and impatience in the traffic

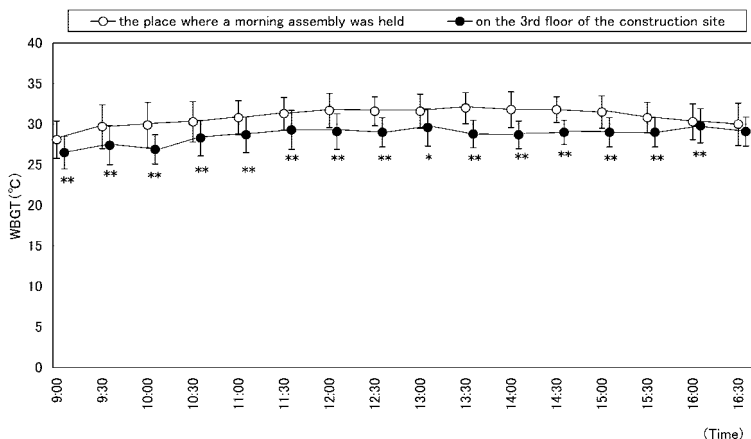


Fig. 1. The WBGT in the summer measured in the place where a morning assembly was held and on the 3rd floor of the construction site.
 Each value represents the mean \pm SD. Significant differences between the two places: * $p<0.05$, ** $p<0.01$.

Table 1. Characteristics of the two groups of male subjects

	Group	
	Traffic control workers (N=204) Mean ± SD	Construction workers (N=115) Mean ± SD
Age(yr)**	42.1 ± 14.9 (18–72)	37.3 ± 13.2 (17–67)
Height (cm)*	167.0 ± 6.8 (148–185)	168.6 ± 6.6 (153–185)
Body weight (kg)	65.5 ± 13.1 (32–135)	63.7 ± 9.3 (45–92)
BMI**	23.5 ± 3.9 (16.8–39.9)	22.4 ± 2.9 (17.6–32.7)
Occupational career (yr)**	3.7 ± 3.7 (0–21)	12.8 ± 11.0 (0.3–45.5)
Monthly working days**	19.9 ± 4.6 (3–28)	24.3 ± 1.8 (20–27)
Daily working hours**	7.9 ± 0.6 (4–10)	8.4 ± 1.0 (6–12)
Daily working hours at daytime	7.5 ± 1.3 (3–10)	7.3 ± 1.9 (1–10)
Daily working hours at night**	0.4 ± 1.2 (0–7)	1.1 ± 1.9 (0–8)
Daily working hours in the sunshine**	7.5 ± 1.3 (3–10)	5.6 ± 2.7 (0–11)
One way commuting hours**	0.4 ± 0.3 (0–1.5)	0.9 ± 0.6 (0.1–2.5)
Daily sleeping hours	6.7 ± 1.1 (3–12)	6.8 ± 1.0 (3.5–9)
Smoking history (yr)	14.9 ± 15.1 (0–53)	13.2 ± 12.3 (0–45)
Daily smoking numbers	15.1 ± 13.8 (0–60)	17.1 ± 11.5 (0–40)

Significant differences between the two groups: * $p < 0.05$, ** $p < 0.01$.

Ranges are shown in the parenthesis.

Table 2. Frequency of alcohol intake of the subjects

Frequency	Group	
	Traffic control workers (N=204) % (N)	Construction workers (N=115) % (N)
Every day	24.0 (49)	45.2 (52)**
Sometimes	41.2 (84)	29.6 (34)
Almost none	34.8 (71)	25.2 (29)
Total	100.0 (204)	100.0 (115)

Significant differences between the two groups: ** $p < 0.01$.

control workers were significantly lower than those in the construction workers ($p < 0.01$ or $p < 0.05$). Prevalence of dropsy of the feet in the traffic control workers was significantly higher than the construction workers ($p < 0.01$). Concerning the prevalence of the other subjective symptoms, there are no significant differences between the traffic control workers and the construction workers.

Figure 2 shows the prevalence of subjective symptoms during work in the summer season among all subjects. There were no significant differences in the prevalence of dizziness, nausea, headache, muscle cramp and hope to lie down during work between traffic control workers and construction workers. Prevalence of work difficulty due to hot weather during work in the traffic control workers was significantly lower than the construction workers ($p < 0.01$).

Discussion

Work in the hot environment can cause individuals to suffer from acute heat disorders, which lead to performance decrements¹⁵. Heat disorder is a preventative illness, but still common^{6, 11, 16–18}. The deleterious effects of heat stress can be improved by acclimatization, work and rest cycle, fluid intake, and altering clothing and gaining access to air conditioning^{16–18}. However, implementing strategies targeted to groups at risk has proved to be difficult¹⁹.

To our knowledge, except a few case reports on heat disorders among traffic control workers, there have been no documented research on heat related occupational health concern among traffic control workers in Japan. Thus, the present study was undertaken to determine and then compared the prevalence of subjective symptoms during work. The hot prevention measures in summer between the traffic control workers and the construction workers were also investigated.

Work environmental conditions in the summer

Mean values of WBGT in the place where a morning assembly was held were between 28.1°C at 9:00 A.M. and 32.0°C at 1:30 P.M. According to the Recommendations of the Japan Society for Occupational Health designated for Occupational Exposure Limits to Heat¹⁴, the mean values between 11:00 and 16:30 were estimated to be over the exposure limit for the traffic control workers of RMR 1–2

Table 3. The subjects' individual preventive ideas related to clothing against the hot environment to work comfortably in the summer season

	Group	
	Traffic control workers (N=204)	Construction workers (N=115)
	% (N)	% (N)
Wearing the high hygroscopicity clothes	34.8 (71)	31.3 (36)
Wearing cooling fiber made underwear*	6.4 (13)	0.9 (1)
Changing clothes frequently**	19.6 (40)	42.6 (49)
Ideas related to hats	2.5 (5)	0.9 (1)
Wearing a helmet with small holes**	13.7 (28)	4.3 (5)
Avoiding direct exposure of face and neck to sunlight by using towel like materials**	16.2 (33)	50.4 (58)
Wearing clothes with long sleeves*	57.4 (117)	45.2 (52)
Wearing a uniform made of protective fiber against ultraviolet rays	2.5 (5)	1.7 (2)
Wearing a arm omission or cover	0.5 (1)	0.9 (1)
Wearing sunglasses**	4.4 (9)	19.1 (22)
Wearing clothes with half sleeves**	25.5 (52)	0.0 (0)
Others	0.0 (0)	0.0 (0)

Significant differences between the two groups: * $p < 0.05$, ** $p < 0.01$.

Table 4. The subjects' individual preventive ideas except clothing against the hot environment to work comfortably in the summer season

	Group	
	Traffic control workers (N=204)	Construction workers (N=115)
	% (N)	% (N)
Drinking water frequently	76.0 (155)	70.4 (81)
Wearing something cool round the neck	5.9 (12)	4.3 (5)
Using a protective cosmetic against ultraviolet rays**	24.5 (50)	0.0 (0)
Others	0.5 (1)	0.9 (1)

Significant differences between the two groups: ** $p < 0.01$.

(30.5°C). In addition, the mean values of WBGT between 9:00 and 16:30 were estimated to be over the exposure limit for the construction workers of RMR 2–4 (27.5°C).

The measured WBGT values on the 3rd floor of the construction site were between 26.5°C at 9:00 A.M. and 29.8°C at 4:00 P.M. Almost the values of WBGT measured at 16:30 in the place where a morning assembly was held were significantly higher than those measured on the 3rd floor of the construction site. However, the mean values of WBGT between 10:30 and 16:30 were estimated to be over the exposure limit for the construction workers.

Subjective symptoms in the summer and prevention measure against heat

Although heat disorder is underdiagnosed¹¹⁾, it has been reported that in recent years, the proportion of construction

workers who died from heat disorders was the biggest among all workers in Japan⁶⁾. In the present study, prevalence of work difficulty due to hot weather while working in the traffic control workers was significantly lower than the construction workers. However, despite of the lower work load described before and shorter daily working hours and one way commuting hours of the traffic control workers, there were no significant differences in the prevalence of past history of heat disorders or in the prevalence of the investigated subjective complaints related to heat disorders during work between the two groups. Semenza *et al.*¹⁹⁾ and Naughton *et al.*²⁰⁾ reported that a working air conditioner is the strongest protective measure against heat-related death during 1995 and 1999 heat waves in Chicago. In the present study, we observed that only at the construction site air conditioned rest house and ice making machines were available during

Table 5. Prevalence of subjective symptoms in the summer season among the two groups of subjects

Subjective symptoms	Group			
	Traffic control workers (N=204)	Construction workers (N=115)		
	% (N)	% (N)		
Musculoskeletal symptoms	Numbness in the fingers**	4.9 (10)	20.9 (24)	
	Pain in the fingers**	2.9 (6)	13.0 (15)	
	Stiffness in the fingers	4.9 (10)	8.7 (10)	
	Pain in the wrist*	5.4 (11)	13.0 (15)	
	Pain in the arm**	5.9 (12)	15.7 (18)	
	Dullness in the arm	16.7 (34)	18.3 (21)	
	Shoulder stiffness	36.3 (74)	47.0 (54)	
	Pain in the shoulders	18.6 (38)	24.3 (28)	
	Neck stiffness	26.5 (54)	33.0 (38)	
	Pain in the neck*	13.2 (27)	23.5 (27)	
	Back dullness	12.3 (25)	17.4 (20)	
	Back pain*	11.3 (23)	20.0 (23)	
	Low back dullness	29.4 (60)	37.4 (43)	
	Lumbago	28.4 (58)	33.9 (39)	
	Low back cold sensation**	3.9 (8)	12.2 (14)	
	Knee joint pain	10.8 (22)	14.8 (17)	
	Foot numbness**	9.3 (19)	20.9 (24)	
	Muscle cramps*	11.8 (24)	22.6 (26)	
	General symptoms	Snivel*	8.3 (17)	16.5 (19)
		Palpitation	7.8 (16)	10.4 (12)
Chest discomfort		11.8 (24)	13.0 (15)	
Appetite loss		41.7 (85)	48.7 (56)	
Thirst		63.7 (130)	57.4 (66)	
Stomach discomfort		15.2 (31)	19.1 (22)	
Diarrhea**		26.5 (54)	41.7 (48)	
Constipation		7.4 (15)	11.3 (13)	
Dropsy of the feet*		27.0 (55)	14.8 (17)	
Difficulty in sleeping		28.4 (58)	27.0 (31)	
Dull head**		10.3 (21)	21.7 (25)	
Headache**		13.2 (27)	26.1 (30)	
Flushed face		8.8 (18)	9.6 (11)	
Foot cold sensation		6.9 (14)	7.8 (9)	
General fatigue		24.5 (50)	32.2 (37)	
Tinnitus		10.8 (22)	17.4 (20)	
Dizziness*		11.8 (24)	22.6 (26)	
Nausea		12.7 (26)	14.8 (17)	
Sweating		55.4 (113)	56.5 (65)	
Easy to get fatigued		42.2 (86)	48.7 (56)	
Waking up due to hot weather	41.2 (84)	40.0 (46)		
Patience loss	27.5 (56)	34.8 (40)		
Impatience*	31.9 (65)	43.5 (50)		
Weak condition of the stomach and intestine	15.2 (31)	19.1 (22)		

Significant differences between the two groups: * $p < 0.05$, ** $p < 0.01$.

daily working time in the summer season. These countermeasures were regarded as efforts making comfortable working places. On the basis of these results, it was assumed that the prevalence of the past history and subjective complaints related to heat disorders during work

in construction workers might be higher than those figures observed in this study. In Japan, to prevent against heat disorders in the construction workplace, the government recommends to provide a rest house blocking out the direct sunshine²¹. We reported that about 80% of the construction

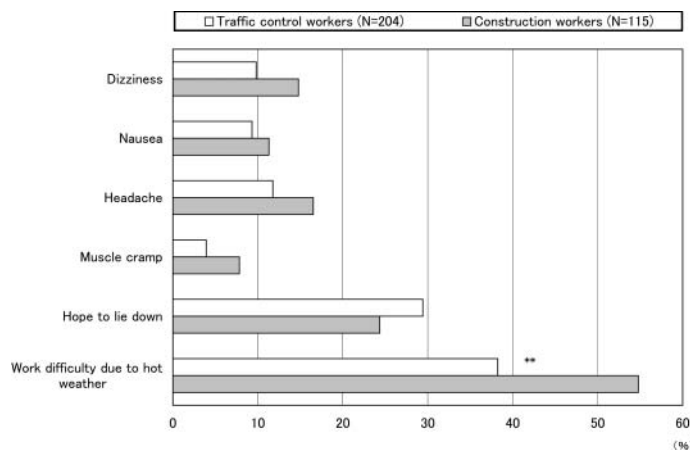


Fig. 2. Prevalence of subjective symptoms during work in the summer season among subjects.

Significant differences between the two groups: $**p < 0.01$.

workplaces had the rest house²¹). Thus, on basis of the presented results and the field investigation, we highly recommend to construct the air conditioned rest house and provide ice making machines in the construction workplace.

Pascoe *et al.*¹⁸) recommended that overall, to keep cool in the heat a worker should wear: 1) thin clothing that allows evaporation; 2) clothing that blocks radiant heat; 3) loose clothing that allows air to circulate next to the skin; 4) materials that keep excess moisture from lying on the skin surface. In the present study, as individual preventive ideas against the hot environment to work comfortably in summer, prevalence of frequently changing clothes in the traffic control workers (19.6%) were significantly lower than the construction workers (42.6%). As already mentioned the later group had access to the rest house freely. There were no significant differences in wearing the high hygroscopicity clothes between the two groups. Recently, in Japan several kinds of cooling fiber made underwear are put into the market and commercially named as comfortable underwear in summer. The percentages in wearing cooling fiber made underwear in the traffic control workers and the construction workers were only 5.4% and 0.9%, respectively. It can be considered that it is valuable to recommend future to outdoor workers to wear the underwear although it is still necessary to examine whether or not the underwear has truly cooling effect and is comfortable for workers to wear them in the summer season.

It is well known that alcohol intake enhances body fluid loss²²⁻²⁴). Saini *et al.*²³) reported that alcohol ingestion increased body fluid loss during exercise conducted in warm condition by suppressing the plasma arginine vasopressin.

Asakura and Yamazaki²⁵) reported that prevalence of every day drinkers and heavy drinkers in the Japanese construction workers was 28.7% and 20.0%, respectively. In the present study, prevalence rate of alcohol intake everyday in the construction workers was significantly higher than that in the traffic control workers. Thus, it is also recommended especially to construction workers to shun alcohol intake for prevention of heat disorder as far as possible.

Prevalence of wearing a helmet with small holes in the traffic control workers was significantly higher than the construction workers, but was only 13.7%. Wearing such a helmet while working in hot environment has been reported²⁶⁻²⁹) to be more comfortable compared with a helmet without vent holes. Obviously, the vent hole has a capacity for stopping the increase of humidity inside the helmet due to sweating. It should be noted that it is still necessary to improve the helmet with vent holes in ventilation capacity, weight and etc²⁹).

In the present study, the traffic control workers' daily working hours in the sunshine (7.5 ± 1.3 h) were about 2 h longer than the construction workers. Solar UV exposure, especially UVB, can have some adverse consequences on human health, notably sunburn, skin cancer, ocular damage and immunosuppression³⁰⁻³²). Hakansson *et al.*³³) reported that among Swedish construction workers there was an increased relative risk in the high sunlight exposure group for myeloid leukemia and lymphocytic leukemia. Thus, it can be considered that adverse effects of solar UV on traffic control workers are severer than those on the construction workers. Prevalence of wearing clothes with long and half sleeves in the traffic control workers were significantly higher

than the construction workers. Prevalence of avoiding direct exposure of face and neck to sunlight using towel like materials in the traffic control workers (16.2%) were significantly lower than the construction workers (50.4%). In addition, only 4.4% in the traffic control workers wore sunglasses, compared with 19.1% in the construction workers. However, prevalence of using a protective cosmetic against UV rays in the traffic control workers (24.5%) was significantly higher than the construction workers (0.0%). These results suggest that it is more difficult for traffic control workers to prevent against UV individually, compared with construction workers since clothes of traffic control workers is regulated as a uniform by employers. It is recommended to employers that they should permit traffic control workers, to wear sunglasses or contact lenses cutting off UV at least since there are no other preventive measures to prevent against ocular damage caused by UV exposure.

In the present study, we observed that prevalence of musculoskeletal symptoms in the summer such as numbness in the fingers, pain in the fingers, pain in the wrist, pain in the arms, low back cold sensation, foot numbness and muscle cramps in the traffic control workers were significantly lower than the construction workers. On the other hand, prevalence of dropsy of the feet in the traffic control workers was significantly higher than the construction workers. It seemed that the results might be mainly due to the difference of work loads and working posture, namely, the lower work load, lower manual and trunk works of the traffic control workers compared with the construction workers, and the continuation of standing position for long time of the traffic control workers.

Occupational career of traffic control workers was significantly shorter than that of the construction workers, though the mean age of the two groups is similar. This difference might be explained that there is a great turn over among the traffic control workers.

In conclusion, despite of some factors including the lower work load of the traffic control workers compared with the construction workers, there were no significant differences in the prevalence of past history of heat disorders, or in the prevalence of subjective complaints related to heat disorders during work between the two groups. In addition, prevention measures against heat disorders and UV exposure among traffic control workers were weaker than those among construction workers. This might be one of the reasons why the occupational career of traffic control workers was shorter than that of construction workers.

References

- 1) Dukes-Dobos FN (1981) Hazards of heat exposure. A review. *Scand J Work Environ Health* **7**, 73–83.
- 2) Roberts DL, Schuman SH, Smith DJ (1987) Heat stress: preventing heat-related hazards important for outdoor workers. *Occup Health Saf* **56**, 20–4, 55.
- 3) Brake DJ, Bates GP (2002) Deep body core temperatures in industrial workers under thermal stress. *J Occup Environ Med* **44**, 125–35.
- 4) Hancock PA, Vasmatazidis I (1998) Human occupational and performance limits under stress: the thermal environment as a prototypical example. *Ergonomics* **41**, 1169–91.
- 5) Watanabe A (1993) Editorial—Necessity of the change of view to the production of comfortable working place from the prevention of heat disorders. *Digest of Science of Labour* **48**, 389 (in Japanese).
- 6) Labor Standards Bureau of Ministry of Health, Labor and Welfare of Japan (2002) Preventive measures against heat disorders. *Occupational Safety & Health* **3**, 546–52 (in Japanese).
- 7) Kalkstein LS, Smoyer KE (1993) The impact of climate change on human health: some international implications. *Experientia* **49**, 969–79.
- 8) Easterling DR, Meehl GA, Parmesan C, Changnon SA, Karl TR, Mearns LO (2000) Climate extremes: observations, modeling, and impacts. *Science* **298**, 2068–74.
- 9) WHO Task Group (1990) Potential health effects of climatic change, 1–100, WHO, Geneva.
- 10) Nakai S, Itoh T, Morimoto T (1999) Death from heat-stroke in Japan: 1968–1994. *Int J Biometeorol* **43**, 124–7.
- 11) Bouchama A, Knochel JP (2002) Heat stroke. *New Engl J Med* **346**, 1978–88.
- 12) Inaba R, Morioka I, Inoue M, Miyashita K, Iwata H (1999) Summer working environment and its relation to body temperature and subjective complaints of workers engaged in excavating ancient objects. *JJOM* **47**, 480–8 (in Japanese with English abstract).
- 13) Inaba R, Morioka I, Inoue M, Miyashita K, Iwata H (2000) Study on the comfortable clothes in summer for workers engaged in excavating ancient objects. *JJOMT* **48**, 431–6 (in Japanese with English abstract).
- 14) Japan Society for Occupational Health (2002) Occupational exposure limits for heat stress. *San Ei Shi* **44**, 153–5 (in Japanese with English abstract).
- 15) Razmjou S, Kjellberg A (1992) Sustained attention and serial responding in heat: mental effort in the control of performance. *Aviat Space Environ Med* **63**, 594–601.
- 16) Kilbourne EM, Choi K, Jones TS, Thacker SB, Field Investigation Team (1982) Risk factors for heatstroke: a case-control study. *JAMA* **247**, 3332–6.
- 17) Rogot E, Sorlie PD, Backlund E (1992) Air-conditioning and mortality in hot weather. *Am J Epidemiol* **136**, 106–16.
- 18) Pascoe DD, Bellinger TA, McCluskey BS (1994) Clothing and exercise II. Influence of clothing during exercise/work

- in environmental extremes. *Spots Med* **18**, 94–108.
- 19) Semenza JC, Rubin Ch, Falter KH, Selanikio JD, Flanders WD, Howe HL, Wilhelm JL (1996) Heat-related deaths during the July 1995 heat wave in Chicago. *N Engl J Med* **335**, 84–90.
 - 20) Naughton MP, Henderson A, Mirabelli MC, Kaiser R, Wilhelm JL, Kieszak SM, Rubin CH, McGeehin MA (2002) Heat-related mortality during a 1999 heat wave in Chicago. *Am J Prev Med* **22**, 221–7.
 - 21) Inaba R, Inoue M, Iwata H (2000) Actual conditions of occupational health program activities in the construction industry. *JJOMT* **48**, 133–9 (in Japanese with English abstract).
 - 22) Eisenhoffer G, Johnson RH (1982) Effect of ethanol ingestion on plasma vasopressin and water balance in humans. *Am J Physiol* **242**, R522–7.
 - 23) Saini J, Boisvert P, Spiegel K, Candas V, Brandenberger G (1995) Influence of alcohol on the hydromineral hormone responses to exercise in a warm environment. *Eur J Appl Physiol* **72**, 32–6.
 - 24) Eichner ER (1998) Treatment of suspected heat illness. *Int J Sport Med* **19**, S150–3.
 - 25) Asakura T, Yamazaki Y (1989) A survey on the life style and health conditions of construction workers. *Sangyou Igaku* **31**, 579 (in Japanese).
 - 26) Reischl UWE (1986) Fire fighter helmet ventilation analysis. *Am Ind Hyg Assoc J* **47**, 546–51.
 - 27) Abeysekera JDA, Shahnavaaz H (1988) Ergonomics evaluation of modified industrial helmets for use in tropical environments. *Ergonomics* **31**, 1317–29.
 - 28) Davis GA, Edmisten ED, Thomas RE, Rummer RB, Pascoe DD (2001) Effects of ventilated safety helmets in a hot environment. *Int J Ind Ergonomics* **27**, 321–9.
 - 29) Ito A, Watanabe A (2002) A study on the ventilation testing of Industrial safety helmets. *J Sci Labour* **78**, 243–53 (in Japanese with English abstract).
 - 30) Armstrong BK, Kricker A (2001) The epidemiology of UV induced skin cancer. *J Photochem Photobiol B* **63**, 8–18.
 - 31) McCarty CA, Taylor HR (2002) A review of the epidemiologic evidence linking ultraviolet radiation and cataracts. *Dev Ophthalmol* **35**, 21–31.
 - 32) Garsen J, Loveren H (2001) Effects of ultraviolet exposure on the immune system. *Crit Rev Immunol* **21**, 359–97.
 - 33) Hakansson N, Floderus B, Gustavsson P, Feychting M, Hallin N (2001) Occupational sunlight exposure and cancer incidence among Swedish construction workers. *Epidemiology* **12**, 552–5.