

Prevention of Heat Stress Disorders in the Workplace

JMAJ 56(3): 186–192, 2013

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Abstract

The intensive summer heat in Japan led to the death of 47 workers due to incidence of heat stroke in 2010. A notable cluster was observed during the first three days after the start of working in a hot environment. The construction industry accounted for 64% of all lethal cases, and the Wet Bulb Globe Temperature (WBGT) of 28°C or higher demonstrated an increasing tendency for lost workdays due to heat stress disorders. Lack of specific symptoms and signs strengthens the importance of prevention. Obedience to orders from employers in uncontrollable hot, humid environments requires thermoregulation dependent on sweating. Loss of low-concentrated sodium in sweat causes temporary hypernatremia, followed by a shift in interstitial fluid to serum and secretion of arginine-vasopressin to adjust osmolarity; however, massive water intake sometimes leads to excessive serum dilution causing temporary hyponatremia, expressed as heat cramps. The complex risk of heat stroke in the workplace can be categorized into four principal causes: physical labor, hot and humid environment, long hours of work and short break times, and protective clothing. The Labour Standards Bureau, Ministry of Health, Labour and Welfare of Japan, noticed WBGT standard values based on ISO 7243 and ACGIH TLVs[®] and recommended the multifaceted measures of frequent breaks, breathable and porous clothing, sunscreen, sodium-containing palatable water, and education in emergency care.

Key words Heat stroke, Occupational health, Industrial physician, Wet Bulb Globe Temperature (WBGT)

Introduction

According to *Vital Statistics in Japan*, the number of fatalities classified as T67 (effects of heat and light) of the ICD-10 Code peaks in the 50s, which is the tendency observed in males only. This category supposedly includes many cases of heat stroke in the workplace. In recent years, global-scale climate change might raise the average temperature in Japan. In urban areas, hot work environments that significantly exceed the temperature observed by Japan Meteorological Agency and weather stations are produced by the effect of anthropogenic heat from automobiles and air conditioners, heat absorption by paved roads and concrete structures, the green-

house effect from air pollution, and the blocking of winds by high-rise buildings in oceanfront areas. In 2011, it became more difficult to maintain comfortable temperatures in rooms after requests to save power due to power supply shortage resulting from the nuclear power accident caused by the Great East Japan Earthquake. Uncomfortable temperatures cause errors in work, deterioration of productivity and the quality of operations, and an increase in the risk of accidents.

Heat Stroke in the Workplace

In 2010, extreme heat continued after the end of the rainy season from middle June to middle

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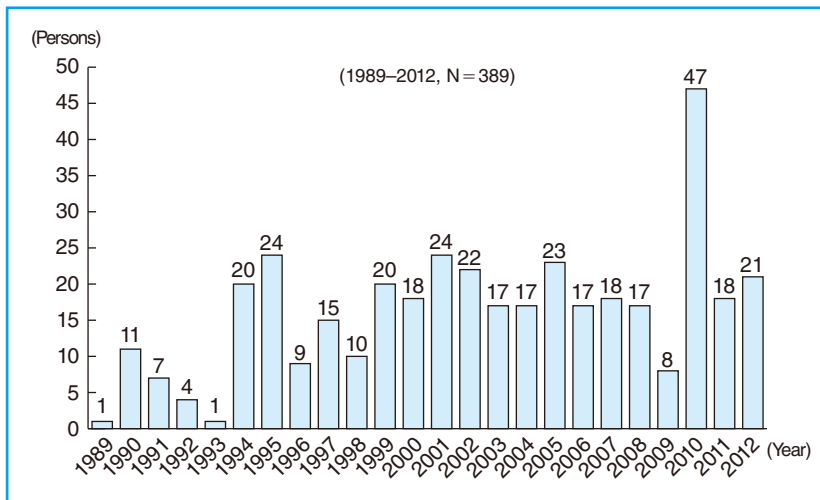


Fig. 1 Number of fatalities due to heat stroke reported as industrial accidents by year

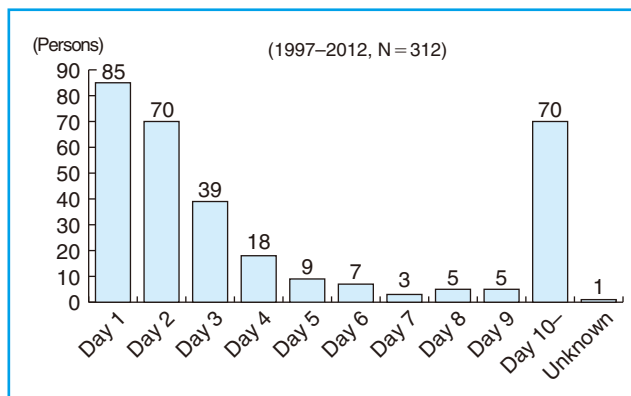


Fig. 2 Number of fatalities due to heat stroke reported as industrial accidents in hot environments by the number of days elapsed after the start of the work

July in Japan. The number of deaths due to heat stroke, which was reported as industrial accident, totaled 47, which was the greatest number on record (Fig. 1).

As for the 389 deaths due to heat stroke from 1989 to 2012 reported as industrial accidents, the time and place of the accident and the victim’s age, category of business, work description and environment, subjective symptoms, and objective opinion were analyzed and the following findings were reported.

Heat stroke occurred during the period from May to September with a peak in July. The largest

number of people died on the first day of work in a hot environment and about two-thirds of the deaths occurred during the first three days (Fig. 2). A total of 54% of all deaths occurred between 2 to 4 PM. Most cases were observed in Tokyo, followed by Aichi, Hyogo, and Saitama in that order, although heat stroke occurred in almost all prefectures in Japan.

All victims were male. Those in their 30s to 50s accounted for 75% of the deaths. Approximately two-thirds occurred outdoors. The most frequent category of business was construction (62%), followed by manufacturing (13%), secu-

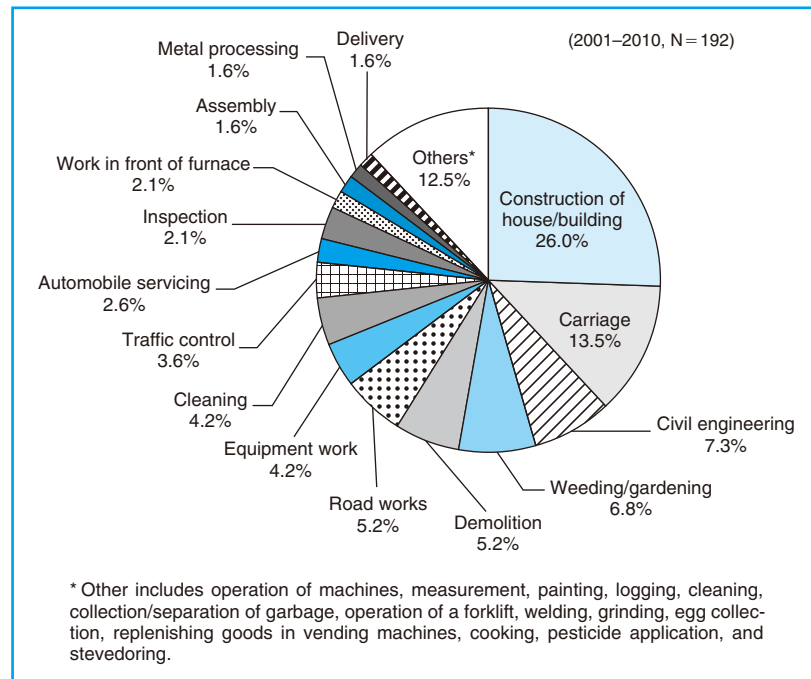


Fig. 3 Percentage of fatalities due to heat stroke reported as industrial accidents by type of work

rity service (5%), and forestry (4%). The annual mortality rate per one hundred thousand workers was estimated at 0.24 in construction, 0.13 in security service, 0.04 in agriculture and forestry, 0.03 in manufacturing, and 0.02 in transportation. The most frequent type of work at the onset of heat stroke was construction of a house or building, followed by carriage, civil engineering, weeding/gardening/bush cutting, demolition, and roadwork in that order (Fig. 3).

From the records of temperature and humidity in the workplaces, the Wet Bulb Globe Temperature (WBGT) was estimated from the table shown in the *Guidelines on Heat Disorders: Prevention in Daily Life* prepared by the Japanese Society of Biometeorology. The cases were classified according to the WBGT values, and the tendency was for the number of occurrences to increase from 28°C. Fewer victims were aware of subjective symptoms. About two-thirds were unknown, and 31% were unspecified ill health. Those who had the records of headache, dizziness, and nausea accounted for less than 5% in total. Objective signs were nonspecific, and 32% were sudden impaired consciousness, 17% staggering, and 8% convulsions.

Risk of Developing Heat Stroke in the Workplace

Workplaces present the risk of developing heat stroke, and the characteristics are different from sports or daily life. Workers must obey employers during working hours, which inhibits an escape from the hot environment or a discontinuance of their works at their discretion. Working hours are as long as eight hours a day. Many workers only have a break in the morning and in the afternoon, except for lunchtime. They sometimes work in a hot environment for two consecutive hours, which is almost equivalent to the conditions of a full marathon. If a worker concentrates on the work and tolerates the hot ambient temperature, the body temperature rises before the person is aware of it. As a result, the worker cannot make the correct decision and may suddenly lose consciousness. In addition, many workers wear protective clothing to prevent contact with ignition sources or chemicals. Some workers cover the head with protective respiratory devices like dust masks or heavy safety helmets, depending on the type of work, instead of wearing clothes suitable for the environment. Protective gear pre-

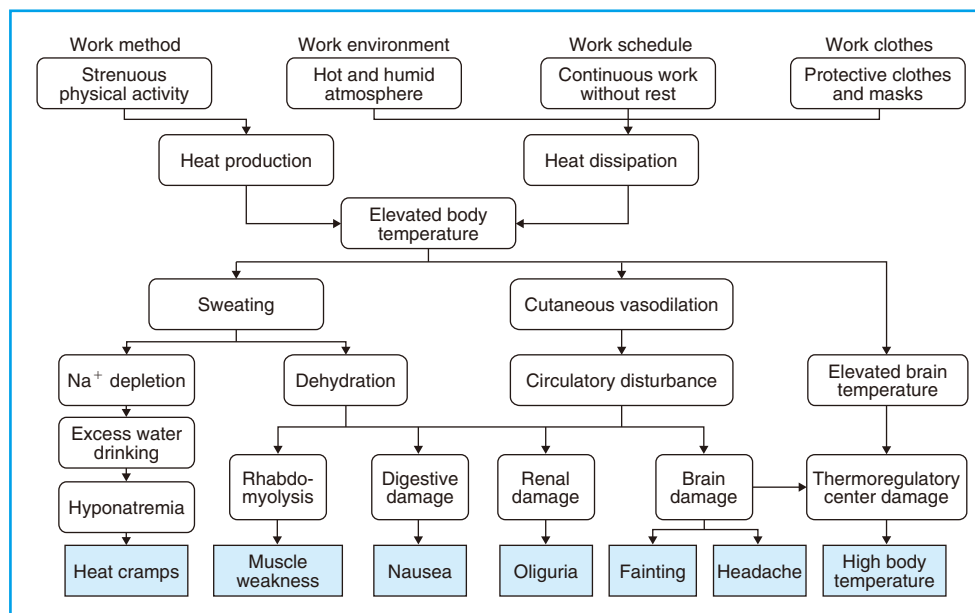


Fig. 4 Mechanism of heat stroke occurrence in the workplace

vents sweat from evaporating and ineffective sweating often causes dehydration.

The sodium concentration in sweat is one-fourth to one-eighth of blood serum in most cases. When sweating heavily, however, sweat glands cannot reabsorb enough sodium and thus the concentration increases. Immediately after sweating, it causes temporary hypernatremia and high osmotic pressure. However, interstitial fluid shifts to serum as an adjustment, and secretion of arginine-vasopressin (AVP) reduces in urine output and increases a sense of thirst and drinking behavior. Massive water intake sometimes gradually leads to hyponatremia, which causes muscular spasms in the legs and arms used for work and deterioration of muscular strength and digestion by slight dehydration.¹

Heat stroke in the workplace likely occurs under four principal conditions: 1) hot and humid environment, 2) clothes with less moisture and air permeability, 3) labor with a heavy physical load, and 4) insufficient break times (Fig. 4).

The risk of developing heat stroke is largely dependent on personal constitution. Persons who are not acclimatized to or stayed away from hot environment for about a week have experience an impaired sweating and vasodilation function and thus tend to have higher body temperatures.

The autonomic nervous response slows down gradually in people in their 50s, resulting in a delayed start of sweating and reduced sweating rate, deteriorated sensory and motor nerve response, insensitivity to heat and thirst, and the inability to take the precautions to avoid heat, such as removing clothing. If persons with the risk of cardiovascular disease or advanced arteriosclerosis have cardiovascular drift and dehydration due to sweating, the heart rate increases from even light exercise, resulting in an excessive load on the circulatory function and the higher risk of complications, such as myocardial and cerebral infarction. A thick layer of subcutaneous fat obstructs the dissipation of body heat. Drugs that act on autonomic nerves impede the functioning of the sweat glands under sympathetic innervation. In addition, chronic diseases of the brain, heart, lung, kidney and thyroid gland, as well as fever, diarrhea, and dehydration, can be risks of developing heat stroke.

Recommendation by Academic Societies for a Heat Environment

Environmental conditions that prevent heat stroke in the workplace are represented by WBGT values, while taking into consideration

of work intensity, frequency of breaks, and type of clothing. The Japan Society for Occupational Health defines and advises that the permissible level for the most intensive work that may continue for an hour (relative metabolic rate (RMR) ≤ 5.0) is 26.5°C .² The Society also publicized the precautions to prevent heat stroke in the work to reconstruct areas hit by the Great East Japan Earthquake, to restore nuclear power plants, and clerical work during the electricity conservation period.³

According to the threshold limited values (TLVs) recommended by the American Conference of Governmental Industrial Hygienists, the upper limit is 27.5°C for heavy physical work, including hand drilling and sawing, even if more than 25% of the total working hours is allocated to rest. Furthermore, the action limit meaning the value when you should start discussions to improve the work environment is 24.0°C .⁴ The international standard ISO 7243 (JIS Z 8504) recommends that the upper limit is 30°C if a worker acclimatized to a hot environment uses the hands and upper arms and 28°C if the person uses the whole body as in assembly work. If we follow the recommendations, in the environment where WBGT exceeds 28°C , physical work involving the whole body must be limited to one hour.

Preventive Measures Based on Laws, Regulations, and Guidelines

The Labor Standards Act, the Industrial Safety and Health Act, and relevant laws and regulations provide precautions that companies and other business operators must take to prevent heat stroke. For example, overtime beyond the statutory working hours must be within two hours, and minors and pregnant women must not work in an extremely hot environment; temperature, humidity, and radiant heat must be measured twice a month in a hot or humid indoor environment; and room temperature, outdoor temperature, and humidity must be measured bimonthly, and efforts must be made to keep temperature between 17 and 28°C and humidity between 40% and 70% in an air-conditioned office.

The Ministry of Health, Labour and Welfare (MHLW) of Japan issued administrative instructions to prevent heat stroke. Among them,

“Prevention of Heat Stroke in the Workplace” (Notice from the Director of the Labour Standard Bureau, MHLW, issued on June 19, 2009, document number 0619001)⁵ specifies that the WBGT must be measured in the workplace and multifaceted preventive measures for heat stroke must be taken (**Table 1**) if it exceeds the standard values defined by ISO 7243 and ACGIH TLVs. The notice also states that if a worker cannot drink water without assistance, the person should be transported to a hospital. The Ministry of the Environment of Japan calls the WBGT a heat index and publishes numerical forecasts and quick reports nationwide during the period from May to September.⁶ In addition, administrative information useful for preventing heat stroke is publicized.⁷⁻⁹

Practical Preventive Measures

When measuring indoor temperature, the employer should not observe the preset temperature of air conditioner, but gauge the actual temperature of an area where the people work. The temperature of resting rooms for field-workers must be set between 24 to 26°C , where water chillers, refrigerators, couches, and towels should be prepared.¹⁰ Cooled air is circulated with electric fans and windows are covered with blinds, shading films, reed screens, and the shade of trees. Even if the indoor temperature is as high as body temperature, air currents promote evaporation from the surface of the skin or clothes and can lower the skin temperature. If possible, it is also effective to pour water over the head, arms, and legs of a worker to help evaporation from the body surface and lower the body temperature. It is a good idea to remove work clothes and socks.

The employer should consider the elimination, sealing, or separation of the source of heat and vapor. The radiated heat and heated air are kept out with a screen, vapor or heated air are discharged from up above, and the area for workers is ventilated with portable spot coolers or large electric fans. In the open air, the employer should consider preparation of quick-built roofs, eaves, tents, and mist cooling systems and the application of heat exchange paint on the outer wall of a building. Sprinkling is more effective in the morning when it is less hot and humid.

Table 1 Preventive measures for heat stroke shown in the “Prevention of Heat Stroke in the Workplace” a notice from the Ministry of Health, Labour and Welfare of Japan (outline)

<p>1. Work environment control</p> <ul style="list-style-type: none"> i) Reduction of the WBGT value: Construct roofs to block heat, direct sunlight, and reflections and install ventilation, cooling, and dehumidification equipment ii) Preparation of rest areas: Prepare cool rest areas in the shade. Prepare ice, cold wet towels, and drinking water. <p>2. Work control</p> <ul style="list-style-type: none"> i) Shortened work hours: Secure break time, shorten the length of continuous work, avoid heavy physical labor, and change the work areas. ii) Acclimatization to heat: Set a period for acclimatization to heat (seven days or longer) iii) Intake of water and salt: Regular intake before, during, and after work; create an intake checklist, and confirm intake by a tour of inspection. Intake one or two cups of 0.1 to 0.2% salt water, sports drink containing 40 to 80 mg sodium per 100 mL, or oral rehydration solutions every 20 to 30 minutes. iv) Clothes: Avoid clothing made of endothermic and thermal fabrics and wear clothes with moisture and air permeability, cool garments, and a hat with air permeability v) Tour of inspection during work: Check the health conditions of workers <p>3. Health management</p> <ul style="list-style-type: none"> i) Response to the result of health examination: Implement measures during work following the opinion of physicians based on the result of regular health examination. Seek the opinions of industrial physicians and family physicians regarding whether or not workers who have diseases increasing the susceptibility to heat stroke (diabetes, hypertension, heart diseases, renal insufficiency, mental and nerve disease, widespread skin disease, etc.) can work in hot, humid environment and implement measures based on the suggestions and opinions. ii) Daily health management: Provide guidance on a lifestyle to avoid lack of sleep and ill health, alcohol drinking on the previous day, and skip breakfast. Health management of workers with a disease increasing the susceptibility to heat stroke and encouraging them to report it to the employer. iii) Checking the health condition of workers: Check the condition by talking to workers before and during work. iv) Condition of workers who should stop working: The heart rate per minute continuously exceeds the value obtained by subtracting the age from 180 for several minutes. The heart rate exceeds 120 one minute after the peak of work intensity. The body temperature during a break does not return to the level before the start of the work. Body weight decreases by 1.5% or more after work. Such symptoms as acute and intense fatigue, vomituration, dizziness, and unconsciousness occurred. v) Checking physical conditions: Check the body temperature and weight during the break. <p>4. Occupational health education</p> <p>Educating managers and workers in hot and humid environments (about the symptoms, preventive measures, first aid in an emergency, and cases of heat stroke)</p> <p>5. First aid</p> <ul style="list-style-type: none"> i) Creation of an emergency communication list and making it known to workers: know the locations of hospitals and clinics. Create an emergency communication list and make it known to workers ii) First aid: Cool the body in a cool place. Consume water and salt. Request emergency services and consult a physician.
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(Extracted and partly modified from MHLW.⁵⁾

Work where workers are exposed to heat, for example in front of a furnace, must be shared by more than one person to reduce the work hours and work volume per person. The workers are allocated other types of work from 2 to 4 PM. Workers should take 5- to 10-minute breaks every hour. The type and volume of work for

individual workers are adjusted considering each individual's acclimatization to heat, physical condition, and fatigue. Assuming that workers will be lightly dehydrated, the employer urges them to drink water before work and prepare jugs of water and cold water bottles so they can drink 150 to 250 mL water every 20 to 30

minutes. When heavily sweating, it is recommended to consume drinks containing sodium, oral rehydration solutions, sesame and salt, salt tablets, salt candy, soybean paste, pickled plums, or seasoned tangle.

It is also important to choose clothing that is made of breathable cloth in white or a similar color, that will easily absorb sweat, and that is not tight on the body. For office workers, open-collar Cool Biz clothing is recommended. Depending on the type of work, workers should use parasols, awnings, protective devices with an electric fan, vests containing refrigerant such as phase-change material, sun shade cover, towels designed to absorb and evaporate sweat from the forehead

and neck, protective clothing with cool water circulated on the body surface, or clothes cooled by adiabatic expansion of compressed air.

Conclusion

Heat stroke in the workplace is caused by a hot and humid environment, clothing with less moisture and air permeability, and heavy physical labor. It can be prevented by improving the work environment and methods, intake of water and sodium, etc. It is necessary to promote the measurement of WBGT and implement measures based on the guidelines of the MHLW of Japan.

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