The relieving effects of shelter modes on physiological stress of traffic police in summer

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Abstract. In summer, high temperature and strong sun radiation last for a long time. However, traffic police still stick to their positions to ensure normal traffic order. Therefore, the health and safety of traffic police are challenged by the high temperature weather. To protect the safety of the traffic police in the outdoor high temperature environment, some shelter modes, such as sun hat and sun umbrella are selected for duty traffic police. The relieving effects on the physiological stress of the shelter modes are analyzed by comparison of the physiological parameters in these shelter modes. The results show that sun umbrella has a good effect on relieving physiological stress. And sun hat has no effect on relieving physiological stress, although it avoids the direct sunlight on the face. However, it causes the increase of the thermal sensation. This study can provide important methods for health protecting of traffic police in the outdoor high temperature environment. It also provides a theoretical support for the revision of the outdoor high temperature labour protection standard.

1. Introduction

In summer, high temperature weather last for a long time. The health and safety of outdoor workers are challenged by the high temperature weather. Living environment higher than 35℃ and the production environment higher than 32℃ are generally regarded as the high temperature environment [1]. Under the high temperature environment, people become whiny and anxious. Thus the work efficiency becomes low. In addition, people are easily suffered from dehydration, heat stroke, and even suffocation. Sometimes brain blood supply declines, people will feel dizzy and heat exhaustion will be caused [2, 3].

Scientific research on physiological responses in outdoor high temperature environment can be traced back to World War II. The initial purpose is mainly to improve the combat capability of the army in high temperature environment. Up to now, studies on physiological response in the outdoor high temperature environment mainly focused on the heat stress and heat tolerance of human body in the outdoor high temperature environment [4-8]. And studies on relieving measures for physiological response and their relieving effects are rare. In this paper, the traffic police were selected as the study objects, the physiological responses under sun hat, sun umbrella and no shade condition were compared. Then the better relief measure for the traffic police in summer can be obtained. The results can be referenced to obtain scientific relieving measures of physiological response and provide a theoretical basis for protecting the physiological safety of workers in outdoor high temperature environments.

2. Materials and methods

2.1. Experiment site

The experiment was carried out in an open area in a campus in Baoding. The surface of the open area was tar coated. The experiment was carried out in sunny summer, and the experiment site met the requirements of the measurement.

2.2. Parameters and instruments

In order to study the physiological stress of traffic police, the environmental and physiological parameters were mainly measured, such as solar radiation intensity, air temperature, black globe temperature, wet bulb globe temperature (WBGT), relative humidity, heart rate, sweating rate, rectal temperature, skin temperature and thermal sensation questionnaire. The measurement parameters and instruments are shown in table 1.

The thermal sensation in the questionnaire is very cold (-4), cold (-3), cool (-2), minute cool (-1), middle (0), minute warm (1), warm (2), hot (3), very hot (4) [9].

Table 1. Experimental parameters and instruments.

Parameters	Instruments	Model	Accuracy
Air temperature	Solar power meter	AZ8778	±0.6℃
Black globe temperature	Solar power meter	AZ8778	±0.6℃
WBGT	Solar power meter	AZ8778	±0.6℃
Relative humidity	Solar power meter	AZ8778	±3%
Heart rate	Electronic sphygmomanometer	OMRON HEM-7051	±5%
Nude weight	Electronic body weight meter	Yousheng XH3100	±5g
Water supplement	Electronic body weight meter	Yousheng XH3100	±5g
Rectal temperature	Electronic thermometer	OMRON MC-347	±0.1℃
Skin temperature	Infrared radiation thermometer	DT806	±0.3℃

The mean skin temperature [10, 11] is a weighted mean value of skin temperature in different body parts. It can be calculated by equation (1) [12] :

$$MT_{skin} = 0.3T_{chest} + 0.3T_{upperarm} + 0.2T_{thigh} + 0.2T_{shank} \quad (1)$$

where MT_{skin} is the mean skin temperature, ℃; T_{chest} is the temperature of the chest, ℃; $T_{upperarm}$ is the temperature of the upper arm, ℃; T_{thight} is the temperature of the thigh, ℃; T_{shank} is the temperature of shank, ℃. In normal conditions, the mean skin temperature is 33.5℃.

Sweating quantity can be calculated by the nude body weight difference before and after each measurement subtracting the amount of water supplemented by the subjects during the test. Based on sweating quantity, sweating rate can be calculated by equation (2):

$$SR = \frac{(mn_a - mn_b) + (mw_a - mw_b)}{15} \quad (2)$$

where SR is the sweating rate, g/min; mn_a is the nude weight of subject at a moment, g; mn_b is the nude weight of subject at b moment, g; mw_a is the weight of residual water at a moment, g; mw_b is the weight of residual water at b moment, g; a, b are any two adjacent measurement moments of the experiment, and a is earlier than b.

2.3. Experiment process

In the experiment, the subjects were requested to stand to simulate the labour condition of duty traffic police. The shelter modes consisted of three conditions: no shelter, sun hat and sun umbrella.

For above three shelter modes, the experiment was conducted on sunny day, and the outdoor air temperature was 36℃. In each experiment condition, the subjects were asked to have a rest for 30min

to stabilize their physiological parameters before the experiment. When the subjects entered the outdoor experiment site, the testers immediately measured the environmental parameters, the physiological parameters and subjective evaluation of the subjects at 0min. Then the subjects began to stand. During the experiment, the environmental parameters, physiological parameters and subjective evaluation are measured every 15 minutes.

The testers should learn the basic knowledge of the first aid before the experiment, especially the emergency treatment of heat stroke and dehydration. In the process of experiment, urgent drugs such as Patchouli water, sunscreen cream and so on were available in the experiment site.

2.4. Subjects

In each experiment condition, ten subjects were selected. The average age, height and weight of subjects are shown in table 2.

Table 2. The basic information of subjects.

Conditions	Age	Height (cm)	Weight (kg)	Male	Female
No shelter	21.5±2.5[a]	169.6±6.8	63.3±9.45	9	1
Sun umbrella	20.8±1.8	169.2±6.2	59.9±11.23	9	1
Sun hat	21.8±2.6	167.9±7.1	62.0±8.5	10	1

Note: [a] mean ± standard deviation.

3. The relieving effects of sun umbrella and sun hat

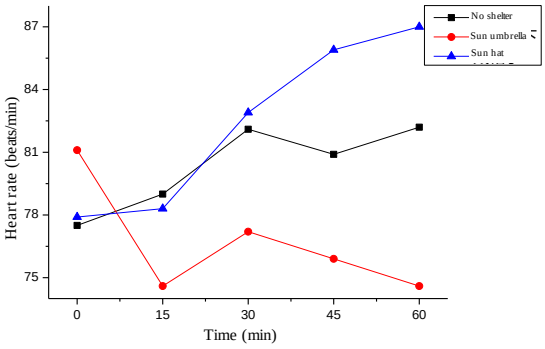

Figure 1. The change of heart rate.

The comparisons of the physiological responses in the no shelter condition, sun umbrella condition and sun hat condition are shown in figures 1-5.

As shown in figure 1, in no shelter condition, the average heart rates at each measure time are 77.5, 79.0, 82.1, 80.9 and 82.2 beats/min individually, and the trend is stable rising. In sun umbrella condition, the average heart rates at each measure time are 81.1, 74.6, 77.2, 75.9 and 74.6 beats/min individually. The total trend is declining. The reason for the declining is that the micro environment under the sun umbrella is more comfortable, and the body under the sun umbrella is more easily to establish a new thermal balance. In the sun hat condition, the average heart rates at each measure time are 77.9, 78.3, 82.9, 85.9 and 87 beats/min individually. The trend is stable increasing. It indicates that, sun umbrella shows significant effects in relieving the stress in heart rate while the sun hat does not show significant effects in relieving the stress in heart rate.

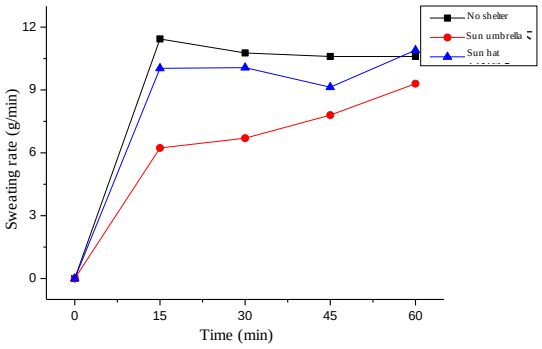

Figure 2. The change of sweating rate.

As shown in figure 2, in no shelter condition, the average sweating rates at 15th, 30th, 45th and 60th min are 11.4, 10.8, 10.6 and 10.6 g/min individually, and the sweating rate in the whole experiment process is 10.85 g/min and the trend is basically stable. In sun umbrella condition, the average sweating rates at 15th, 30th, 45th and 60th min are 6.2, 6.7, 7.8 and 9.3 g/min individually, and the sweating rate in the whole experiment process is 7.5 g/min. Due to the micro environment under the sun umbrella, the sweating rates in the sun umbrella condition is lower than those in the no shelter condition. In the sun hat condition, the average sweating rates at 15th, 30th, 45th and 60th min are 10.0, 10.1, 9.1 and 10.9 g/min individually, and the sweating rate in the whole experiment process is 10.0 g/min. The change trend of the sweating rate in the sun hat condition is similar with that in the no shelter condition. It indicates that, sun umbrella shows significant effects in relieving the stress in sweating rate while the sun hat does not show significant effects in relieving the stress in sweating rate.

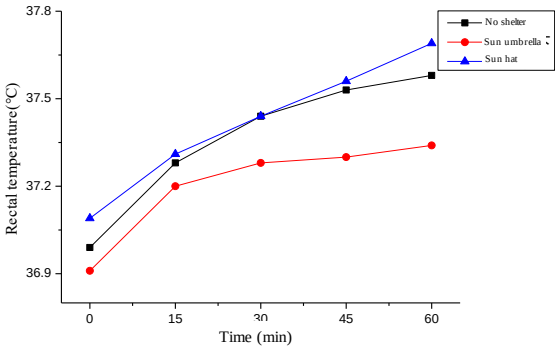

Figure 3. The change of rectal temperature.

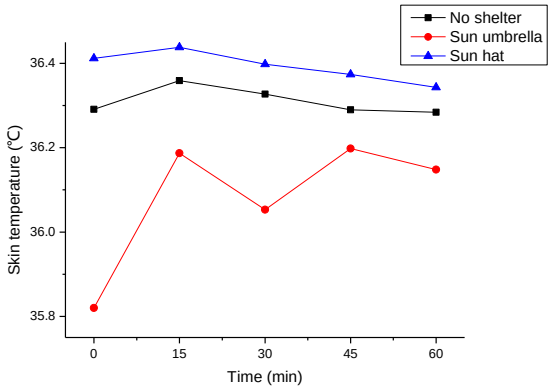

Figure 4. The change of skin temperature.

As shown in figure 3, in no shelter condition, the average rectal temperatures at each measure time are 36.99, 37.28, 37.44, 37.53 and 37.58℃ individually. Similar with the heart rates in the no shelter condition, the trend is stable rising. In sun umbrella condition, the average rectal temperatures at each measure time are 36.91, 37.2, 37.28, 37.3 and 37.34℃ individually. In the sun hat condition, the average rectal temperatures at each measure time are 37.09, 37.31, 37.44, 37.56 and 37.69℃ individually. Thus, the rectal temperatures in the sun umbrella condition and sun hat condition are similar with those in the no shelter condition. It indicates that, the sun umbrella and sun hat do not show significant effects in relieving the stress in rectal temperature.

As show in figure 4, in no shelter condition, the average skin temperatures at each measure time are 36.29, 36.36, 36.32, 36.29 and 36.28℃ individually, and the trend is rising and then falling. The reason is that when people enter the thermal environment, sweating mechanism begins to respond, and as a result of sweat evaporation on the skin surface, the skin temperature will decline. In the sun umbrella condition, the average skin temperatures are 35.82, 36.18, 36.05, 36.19 and 36.15℃ individually. The trend is rough increasing. In the sun umbrella condition, the average sweating rate is less than that in no shelter condition, thus it indicates that the micro environment under the sun umbrella is more comfortable. In the sun hat condition, the average skin temperatures are 36.41, 36.43, 36.40, 36.37 and 36.34℃ individually. It can be seen that the skin temperature of the subjects wearing sun hat is higher than that of the other two conditions during the whole experiment.

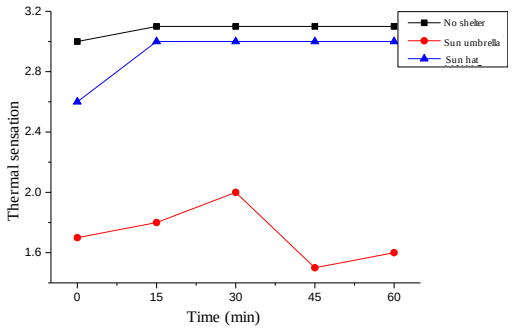

Figure 5. The change of thermal sensation.

As shown in figure 5, in the no shelter condition, the average thermal sensation scores at each measure time are 0.0, 3.1, 3.1, 3.1 and 3.1 individually. In the sun umbrella condition, the average thermal sensation scores are 1.7, 1.8, 2.0, 1.5 and 1.6 individually. In the sun hat condition, the average thermal sensation scores are 2.6, 3.0, 3.0, 3.0 and 3.0 individually. To sum up, the thermal sensation scores between sun hat condition and no shelter condition are similar, while the score in sun umbrella condition is lowest. The reason is that, the sun umbrella blocks the direct sunlight, and the subjects are exposed in a low solar radiation environment. Thus people feel more comfortable and the thermal sensation scores decrease. The comparison of solar radiation intensities between the no shelter condition and the sun umbrella condition is shown in table 3, which verifies above analysis.

Table 3. Comparison of solar radiation intensity.

	Maximum (W/m^2)	Minimum (W/m^2)	Average ± standard deviation (W/m^2)
No shelter	1083	818	987.5±78.9
Under sun umbrella	458	238	360.1±44.5

4. Conclusions

In this study, the relief measures such as sun hat and sun umbrella are selected for duty traffic police. The relieving effects of the shelter modes are analyzed by comparison of the physiological parameters in these shelter modes. Conclusions are as follows:

(1) By comparing the physiological parameters in different shelter conditions, it can be seen that sun umbrella show good effects on relieving heart rate, sweating rate, skin temperature and thermal sensation. It indicates that, sun umbrella has a good effect on alleviating physiological stress.

(2) Sun hat can avoid the direct sunlight on face, however it has no effect on alleviating physiological stress. In opposite, it aggravates the thermal sensation.

(3) In the paper, the relieving effects of the shelter modes on the physiological stress are discussed by comparison of the physiological parameters under different shelter modes. It can provide important methods for health protecting of workers in the outdoor high temperature environment. It also provides a theoretical support for the revision of the outdoor high temperature labour protection standard.

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