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The Response of Blood Pressure of Men at Work to Humid Heat*

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The present paper described the response of blood pressure of men at work to humid heat for the purpose of determining the permissible limit of environmental heat. From the practical viewpoint of industrial health, the upper permissible limit of humid heat seemed to be 30° — 31°C wet bulb temperature and yet around 90°F effective temperature.

It is very important for industrial health to determine the permissible limit of environmental heat in which men can still work effectively. In 1945 and 1946 EICHNA et al[6] and AIZAWA[1] respectively reported that men, exposed to such humid heat as 33°C wet bulb or more, might be subjected to heat stroke.

In the previous papers[2)3)], the authors reported the response of blood pressure with the subjects in the supine position or in the sitting position to humid heat for the purpose of determining the permissible limit of environmental heat. The present paper described the response of blood pressure of men at various levels of wet bulb temperature.

METHODS

The subjects were 2 students in good physical condition, aged 23 and 24 years. The experiments were conducted in August 1964. After 30 minutes' rest in ordinary temperature, the subjects worked for 75 or 120 minutes in the climatic room. The details of the environmental heat for each exposure were shown in Figures 2 — 6 in which the experimental data were described.

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Besides, the experiment in ordinary room temerature, shown in Fig. 1, was conducted as a control experiment.

The work consisted of the putting up and taking down of a bucket weighing 5 kg. on a table, being 80 cm. in height, in the rate of 10 times per minute in time with the rhythm of metronome. This work was middle grade for intensity, being 3.5 of relative metabolic rate.

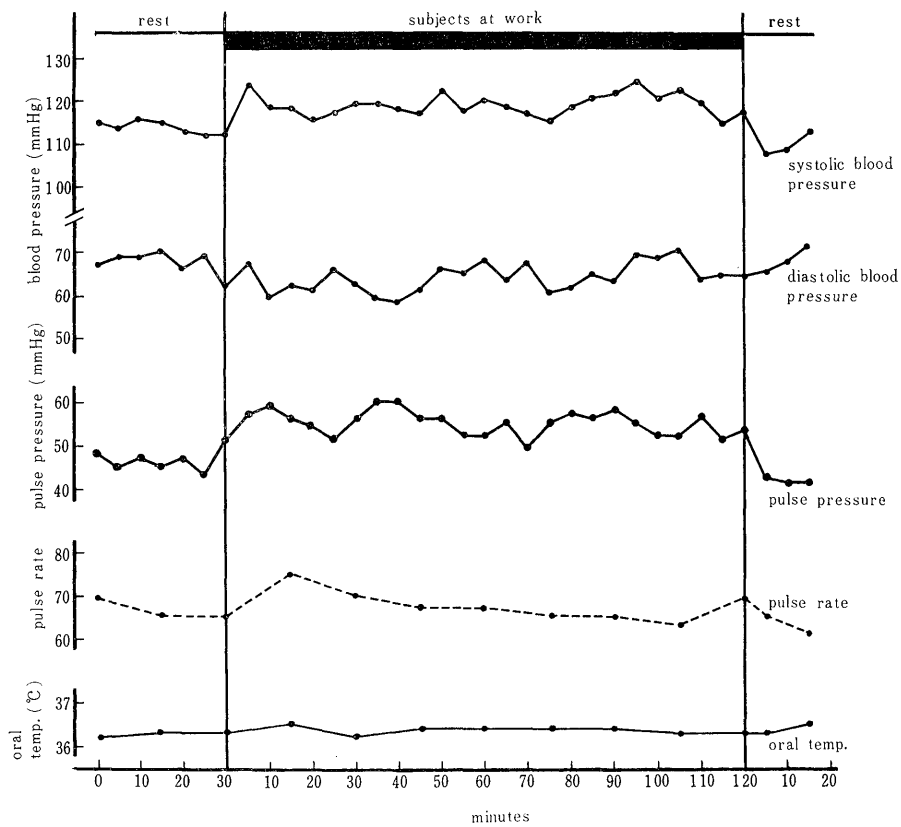
The blood pressure, oral temperature, pulse rate, rate of sweating (represented by the loss of body weight) and general clinical appearance were adopted as the measuring items. The details were described in the previous paper[2].

The blood pressure, oral temperature and pulse rate were measured in the sitting position. The measurement of these items was finished within about 45 seconds. Therefore the above-mentioned work was almost continuously conducted throughout the exposure to humid heat.

RESULTS

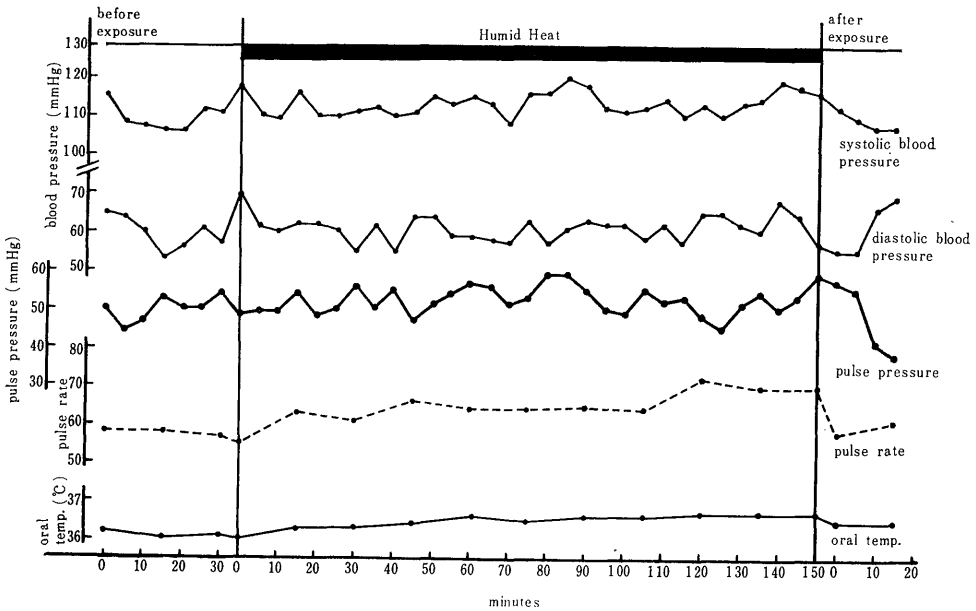
1) Ordinary room temperature, 20°C wet bulb temperature (Fig. 1)

Fig. 1. Influence of Work in Ordinary Room Temperature on Subjects



Note : (1) ordinary room temperature (D.B. 24.9°C, W.B. 20.3°C, E.T. 72°F)
(2) Loss of Body Weight ····· 380gm. (190gm. per hr.)

Fig. 2. Influence of Humid Heat (W.B. 30°–31°C) on Subjects at work



Note : (1) before exposure (D.B. 29.0°C, W.B. 26.0°C, E.T. 81°F)
Humid Heat (D.B. 33.5°C, W.B. 30.1°C, E.T. 88°F)
after exposure (D.B. 29.1°C, W.B. 26.0°C, E.T. 81°F)
(2) Loss of Body Weight ····· 1135gm. (434gm. per hr.)

The physiological reactions maintained a steady state through 120 minutes' work in ordinary room temperature. The subjects continued the work easily and effectively. The loss of body weight was only 190 gm. per hr.

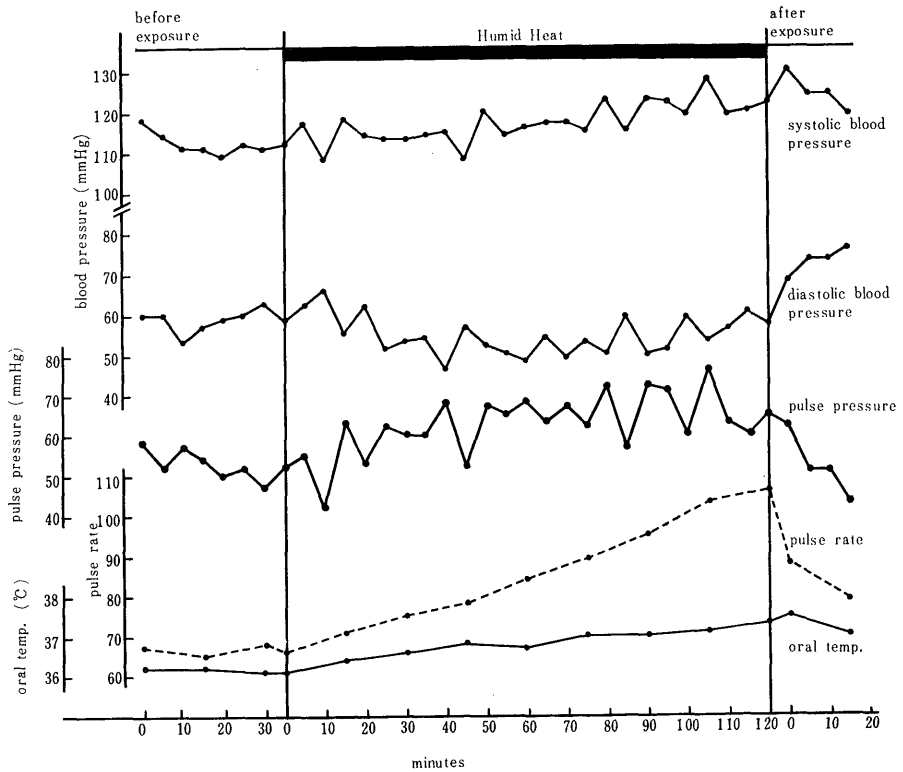
2) 30°–31°C wet bulb temperature (Fig. 2–3)

In the case of 34°C dry bulb (88°F effective temp.), the blood pressure remained almost unchanged. The oral temperature and pulse rate maintained a steady state, and the subjects continued the work easily and effectively through 150 minutes' exposure to heat. The loss of body weight was 434 gm. per hr.

The physiological reactions in this case were of the same results as those in ordinary room temperature.

In the case of 43°C dry bulb (93°F effective temp.), the systolic blood pressure remained almost unchanged, excepting a tendency of slight rise after 90 minutes' exposure. Soon after entering the climatic room, the diastolic blood pressure began to fall, and then slightly became instable. Therefore the pulse pressure increased gradually, and then became instable slightly. This instability seemed to be somewhat remarkable after 80 minutes' exposure. The pulse

Fig. 3. Influence of Humid Heat (W.B. 30°—31°C) on Subjects at Work



Note : (1) before exposure (D.B. 28.9°C, W.B. 26.3°C, E.T. 81°F)
Humid Heat (D.B. 43.1°C, W.B. 31.1°C, E.T. 93°F)
after exposure (D.B. 29.3°C, W.B. 26.8°C, E.T. 82°F)
(2) Loss of Body Weight ····· 1200gm. (600gm. per hr.)

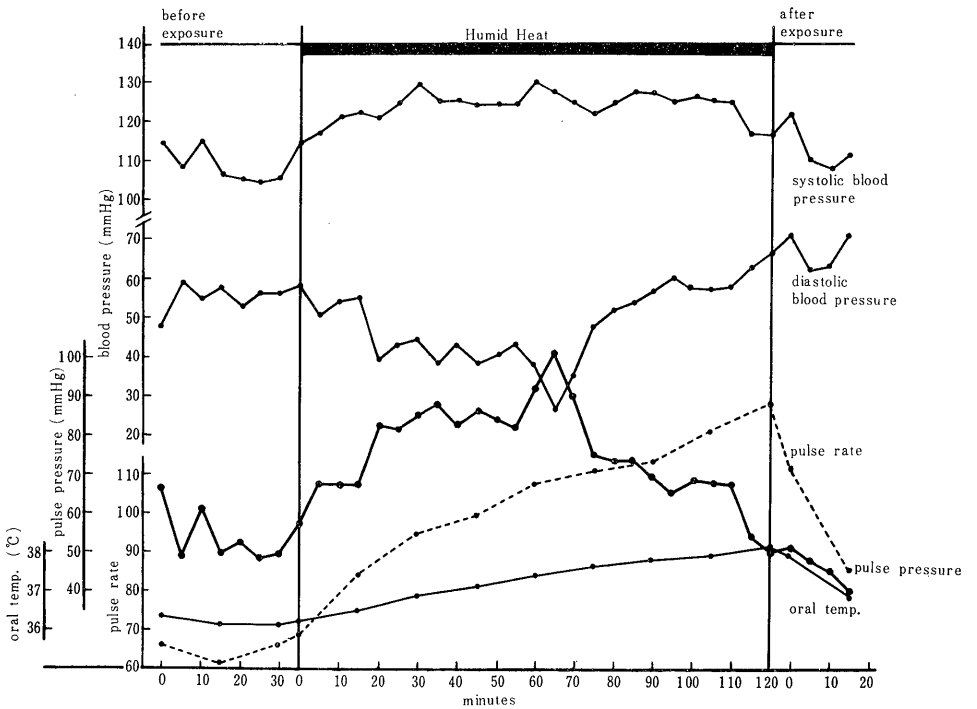
rate steadily increased through 120 minutes' exposure, but the oral temperature showed only a slight rise. The subjects flushed with heat and complained of being very hot. The loss of body weight amounted to 600 gm. per hr.

3) 33°—34°C wet bulb temperature (Fig. 4—5)

In the case of 34°C dry bulb (93°F effective temp.), the systolic blood pressure steadily rose for the initial 30 minutes' exposure, and then remained almost unchanged. The falling diastolic blood pressure rapidly turned to a rise after 65 minutes' exposure. Therefore the increasing pulse pressure rapidly turned to a marked decrease. The oral temperature and pulse rate steadily rose or increased. The loss of body weight amounted to 613 gm. per hr.

In the case of 43°C dry bulb (96° F effective temp.), the systolic blood pressure remained at a slight rise after the initial 30 minutes' exposure. After an initial fall, the diastolic blood pressure became

Fig. 4. Influence of Humid Heat (W.B. 33°—34°C) on Subjects at Work



Note : (1) before exposure (D.B. 29.4°C, W.B. 27.0°C, E.T. 82°F)
Humid Heat (D.B. 33.5°C, W.B. 33.5°C, E.T. 93°F)
after exposure (D.B. 29.4°C, W.B. 26.2°C, E.T. 81°F)
(2) Loss of Body Weight ····· 1225gm. (613gm. per hr.)

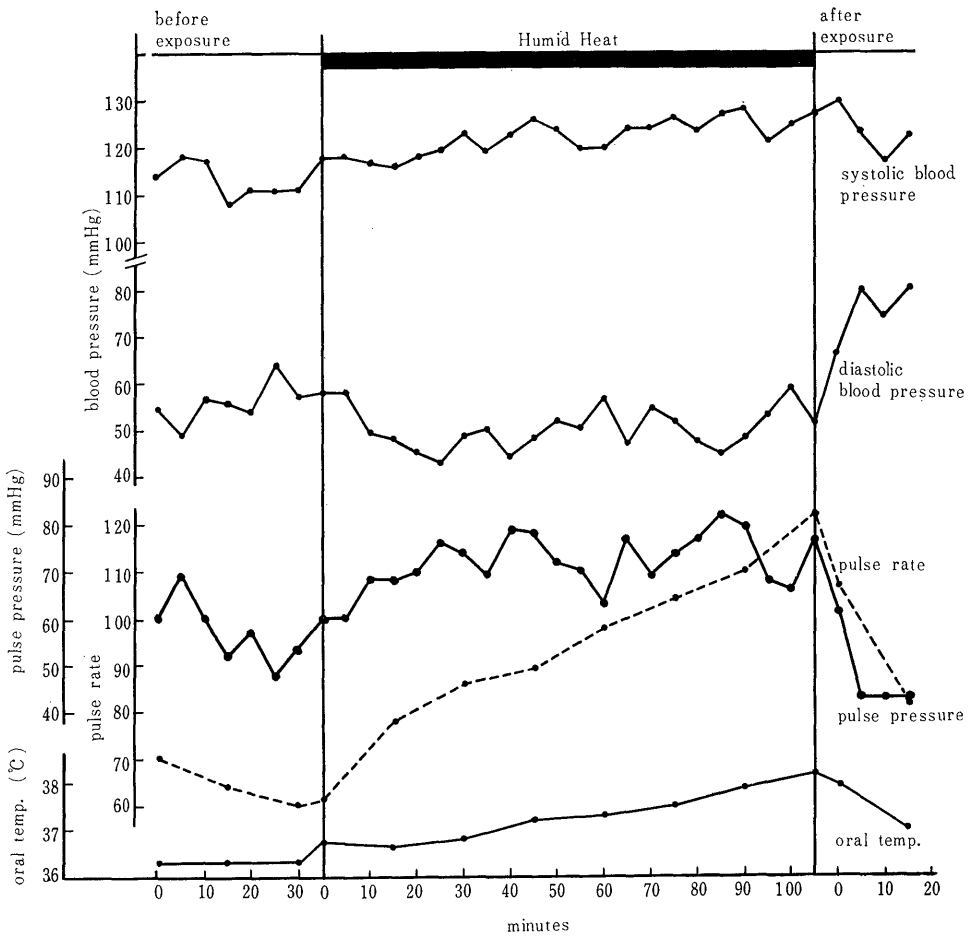
instable somewhat markedly. Therefore the pulse pressure, increasing soon after the exposure to heat, became instable somewhat markedly after 30 minutes' exposure. The pulse rate and oral temperature steadily increased or rose. The loss of body weight amounted to 857 gm. per hr.

With continued exposure, the subjects flushed with heat, and complained of weakness and of being extremely hot in the above-mentioned two cases. It seemed to be very difficult for the subjects to continue the work effectively throughout 120 or 105 minutes' exposure.

4) 36°−37°C wet bulb temperature (Fig. 6)

In the case of 40°C dry bulb (99°F effective temp.), the systolic blood pressure remained at a slight rise throughout 75 minutes' exposure. After an initial rapid fall, the diastolic blood pressure became instable somewhat distinctly for a while, and then rapidly turned to a rise after 45' minutes exposure. Therefore the pulse pressure, increasing rapidly soon after the exposure, began to decrease after 45 minutes' exposure.

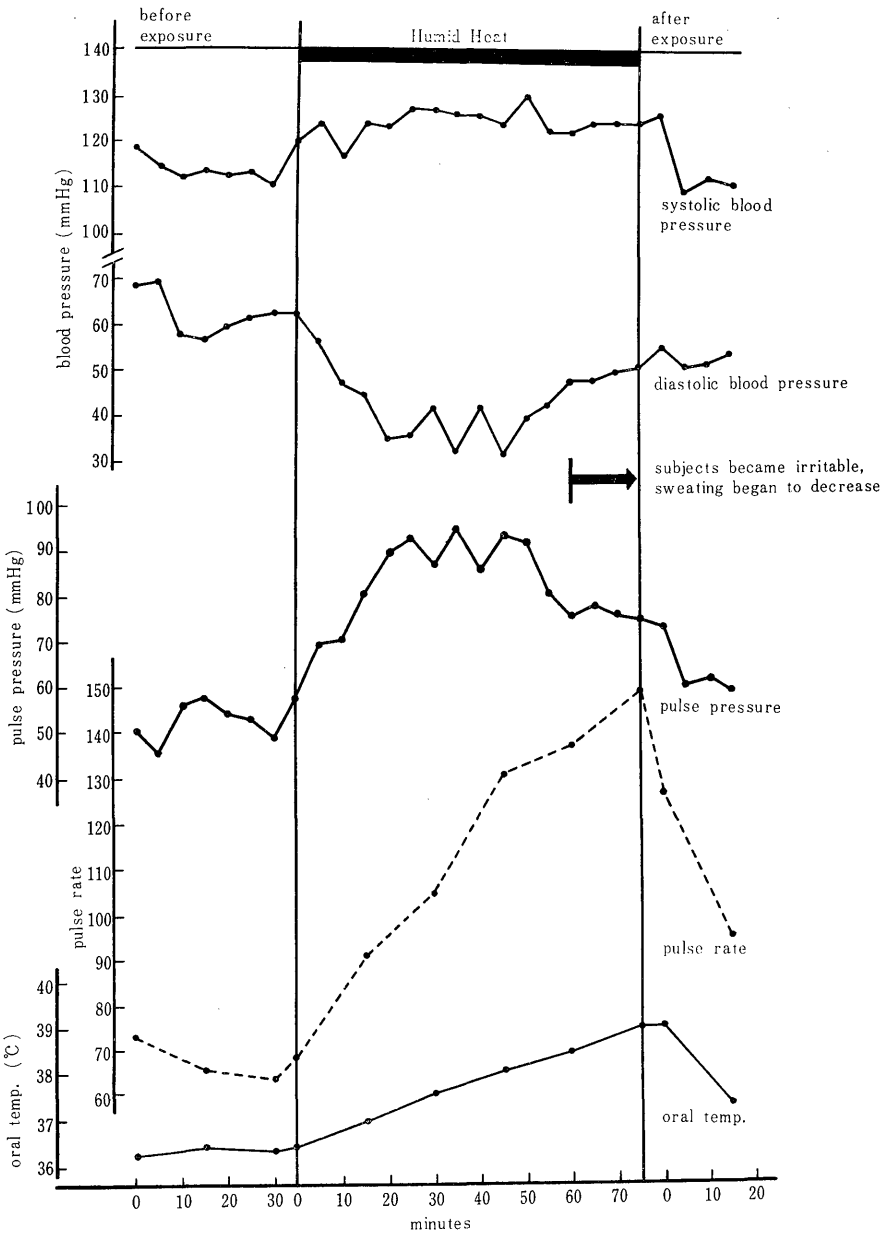
Fig. 5. Influence of Humid Heat (W.B. 33°—34C°) on Subjects at Work



Note : (1) before exposure (D.B. 29.4°C, W.B. 26.6°C, E.T. 82°F)
Humid Heat (D.B. 42.7°C, W.B. 32.8°C, E.T. 96°F)
after exposure (D.B. 29.2°C, W.B. 26.9°C, E.T. 82°F)
(2) Loss of Body Weight ····· 1500gm. (857gm. per hr.)

The pulse rate and oral temperature steadily increased or rose. After 60 minutes' exposure, the subjects flushed with heat and became irritable and complained of weakness, faintness and of being extremely hot. The sweating began to decrease. And then, the exposure to humid heat was interrupted in 75 minutes. The loss of body weight reached such large quantity as 1268 gm. per hr.

Fig. 6. Influence of Humid Heat (W.B. 36°−37°C) on Subjects at work



Note : (1) before exposure (D.B. 28.9°C, W.B. 26.0°C, E.T. 81°F)
Humid Heat (D.B. 39.7°C, W.B. 36.0°C, E.T. 99°F)
after exposure (D.B. 29.3°C, W.B. 26.4°C, E.T. 82°F)
(2) Loss of Body Weight ····· 1585gm. (1268gm. per hr.)

DISCUSSION

Numerous investigators[4)12)8)10)9)11)5)] have reported the response of blood pressure of men exposed to severe heat. They are solid for the fall of diastolic blood pressure.

In our experiments, the diastolic blood pressure of subjects exposed to such humid heat as 33°−34°C wet bulb or more (90°F effective temp. or more), also distinctly began to fall soon after entering the climatic room. But with continued exposure the falling diastolic blood pressure turned to a rapid increase. And then, physiological disequilibrium developed. Those findings were in accord with the observations by EICHNA et al. in 1945 and by AIZAWA in 1949.

In the case of 33°−34°C wet bulb, the response of blood pressure to humid heat was more distinct in the case of 34°C dry bulb than in the case of 43°C dry bulb. It seemed to be caused by the extremely humid thermal condition in the case of 34°C dry bulb.

In the case of 30°−31° wet bulb with 34°C dry bulb (88°F effective temp.), the physiological reactions remained at a steady state.

But in the case of 30°−31°C wet bulb with 43°C dry bulb (93°F effective temp.), the response of blood pressure to humid heat was very instable. And then, the loss of body weight reached 600 gm. per hr. In 1964 GERKING and ROBINSON[7)] suggested that men, whose rate of sweating being over 600−800 gm. per hr., should be subjected to heat stroke.

From the practical viewpoint of industrial health, the upper permissible limit of environmental heat for men at work was considered to be 30°−31°C wet bulb temperature and yet around 90°F effective temperature.

SUMMARY

The authors conducted the experimental study on the response of blood pressure of men at work, being middle grade for intensity, to the various levels of humid heat for the purpose of determining the permissible limit of environmental heat.

From the practical viewpoint of industrial health, it was concluded that the upper permissible limit of environmental heat for men at work seemed to be 30°−31°C wet bulb temperature and yet around 90°F effective temperature.

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