Effects of Room Temperature, Seasonal Condition and Food Intake on Finger Skin Temperature during Cold Exposure Test for Diagnosing Hand-Arm Vibration Syndrome

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Abstract: For diagnosing the hand-arm vibration syndrome, peripheral circulation and sensory tests immersing one hand in cold water at 10°C for 10 min have been performed widely in Japan. The authors investigated the effects of room temperature, seasonal condition and food intake on the test results, especially finger skin temperature. Six healthy males were examined repeatedly under six different room temperatures at 10°C, 15°C, 20°C, 22.5°C, 25°C and 30°C. Eight healthy males were examined under room temperatures at 10°C, 20°C and 30°C, repeatedly in winter, spring, summer and autumn. Six healthy males were examined in summer under room temperature at 22.5°C repeatedly 1 hr after, 3 hr after meal and after fasting for 13 hr. The finger skin temperature was strongly affected by room temperature. The finger skin temperature was also affected by seasonal condition. No remarkable effect of food intake was observed. For estimating circulatory function of the upper extremities using the finger skin temperature, the room temperature should be strictly controlled and the effect of seasonal condition must be taken into consideration.

Key words: Hand-arm vibration syndrome, Finger skin temperature, Room temperature, Seasonal condition, Food intake

Introduction

For diagnosis of the hand-arm vibration syndrome, cold exposure test immersing one hand in cold water at 10°C for 10 min has been performed widely in Japan. As the indicators of peripheral circulation and sensory function, finger skin temperature, nail press test, vibration sense threshold and pain threshold are measured¹⁾. Because sensitivities of these indicators are not so high, evaluation with the values at cold exposure test is generally recommended²⁾.

Among the above indicators, vibration sense threshold

has the highest sensitivity followed by nail press test. As to the finger skin temperature, the sensitivity without cold exposure was about 10% and that at cold exposure test increased 25% when the specificity was controlled at approximately 95%. Although the sensitivities of finger skin temperature are relatively low, its diagnostic significance is independently of that of the indicators of sensory function³⁾.

The test results of the upper extremities, especially indicators of peripheral circulation, are thought to be influenced by the measurement circumstances such as environmental temperature, clothing condition, cigarette smoking, food intake. For using the test for the purpose of epidemiological study as well as diagnosis, standardizing

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of the test condition is needed. The standardization of vascular assessment method is under discussion in the International Organization for Standardization (ISO/TC108/SC4/WG11)⁴⁾. We investigated effects of several factors, room temperature, seasonal condition and food intake, on the immersion test results.

Subjects and Method

Three experiments were performed. The subjects of each experiment were all healthy males, that were medical students and university researchers.

In experiment 1 for effect of room temperature, six subjects aged 23 to 29 were examined repeatedly under six different room temperatures at 10°C, 15°C, 20°C, 22.5°C, 25°C and 30°C. The seasons were autumn (November) and winter (December). The average values of outdoor atmospheric temperatures at the periods were similar; 12.4°C and 9.0°C, respectively.

In experiment 2 for effect of seasonal condition, eight subjects aged 28 to 39 were examined under room temperatures at 10°C, 20°C and 30°C, repeatedly in winter (February), spring (May), summer (August) and autumn (November). The average values of outdoor atmospheric temperatures were 4.5°C in winter, 12.4°C in autumn, 17.7°C in spring and 24.5°C and 27.3°C in summer.

In experiment 3 for effect of food intake, six subjects aged 21 to 26 were examined repeatedly 1 hr after, 3 hr after meal and after fasting for 13 hr. The room temperature was at 22.5°C and the season was summer (August), while average outdoor atmospheric temperature was 26.6°C. The energy of meal taken before the experiment was controlled

as 754 kcal.

As to the cold exposure test, left hand of each subject was immersed in stirred water at 10°C for 10 min, and the change of skin temperature of the left middle finger was measured. In the experiment 1, vibration sense threshold at 125 Hz of the left middle fingertip and severity of pain in the hand were also evaluated during the cold exposure test. The severity was scored as 1 (none), 2 (weak), 3 (moderate), 4 (strong) and 5 (extreme).

Number of clothes was controlled as same in each room temperature. Every subject wore four pieces as fundamental clothes; an undershirt without sleeves, a shirt with sleeves, underpants and trousers. For room temperature at 10°C and 15°C, two and one white overalls were on them, respectively. For room temperature at 22.5°C in the experiment 3, a shirt with sleeves was removed from the fundamental clothes.

Before the immersion, each subject was rested for 30 min in the test room. Variation of each room temperature was controlled less than $\pm 0.5^\circ\text{C}$. For measuring finger skin temperature and vibration sense threshold, digital thermometers (D-921 and D-317, Takara, Japan), and vibration sensimeter (AU-02, RION, Japan) were used, respectively. For statistical test, analysis of variance was used.

Results

Figures 1 and 2 show changes of finger skin temperature during immersion test under different room temperatures. The finger skin temperature was strongly affected by room

Fig. 1. Changes in finger skin temperature during immersion test under different room temperatures
n=6, mean $\pm$ SE.

Fig. 2. Effects of room temperature on finger skin temperature during immersion test
n=6, mean $\pm$ SE.

temperature; those before immersion varied from 16°C to 34°C, at 5-min point after immersion were from 12°C to 26°C. Between the room temperatures at 15°C and 25°C, average values of finger skin temperatures before exposure and at 10-min point after immersion changed with the range of more than 10°C. The effect of room temperature in every measuring point was statistically significant (two-way analysis of variance, $p<0.05$, $p<0.01$).

Figure 3 shows changes of vibration sense threshold of fingertip at 125 Hz. The thresholds were affected by room temperature. Statistical significance was observed except for the values before immersion (two-way analysis of variance, $p<0.05$, $p<0.01$). Figure 4 shows the severity of pain in the hand. Although there were small differences among six room temperatures, the differences were not statistically significant.

Figures 5, 6 and 7 show the changes of finger skin

Fig. 3. Changes in vibration sense threshold during immersion test under different room temperatures
n=6, mean $\pm$ SE.

Fig. 4. Changes in severity of finger pain during immersion test under different room temperatures
n=6, mean $\pm$ SE.

Fig. 5. Changes in finger skin temperature during immersion test under room temperature at 10°C
n=8, mean $\pm$ SE.

Fig. 6. Changes in finger skin temperature during immersion test under room temperature at 20°C
n=8, mean $\pm$ SE.

Fig. 7. Changes in finger skin temperature during immersion test under room temperature at 30°C

n=8, mean $\pm$ SE.

Fig. 8. Changes in finger skin temperature during immersion test under different conditions of food intake

The room temperature was 22.5°C (n=6, mean $\pm$ SE).

Discussion

Seasonal effect on the finger skin temperature was observed in the experiments 1 and 3 as well as the experiment 2. Similar to the values under the corresponding conditions of season and room temperature in the experiment 2, the finger skin temperatures measured in autumn and winter in the experiment 1 tended to be lower and those measured in summer in the experiment 3 tended to be higher.

The core temperature of human body is maintained by mechanisms of adjusting heat production and heat loss. The heat is produced by basic metabolic processes, food intake and muscular activity⁵⁾. The basal metabolic rate in Japanese general people is reported to be affected by seasonal condition. That in summer is lowest and in autumn tends to increase faster beyond the decrease of environmental temperature⁶⁾.

The effects of seasonal condition on the finger skin temperature observed in the experiment 2 were to be the reverse of changes of the basal metabolic rate. Skin temperature of finger is determined by the heat production and the blood flow level controlled by mechanisms of body temperature regulation⁵⁾. However, cutaneous vasoconstriction is induced in cold environment for maintaining the core temperature. Seasonal effects on the basal metabolic rate and finger skin temperature can be understood as coordinated mechanisms for the purpose.

On the other hand, food intake increases the metabolic rate because of its specific dynamic action (SDA). The SDA may last up to 6 hr after the food intake⁵⁾. The effect of food intake was not observed in this study. The reason is not obvious. It may be one of the reason that sympathetic

discharge is increased after food intake⁷⁾. We are investigating tonus level of the autonomic nervous system during the cold exposure test using heart rate variation analysis. For confirming the effect of season on the balance of the SDA and the sympathetic discharge, an additional experiment in winter is necessary.

Change of 1°C of room temperature in the range between 15°C and 25°C induced change of more than 1°C of finger skin temperature before and at 10-min point after cold exposure. The finger skin temperature during cold exposure test in summer was especially higher than in other seasons. The variations of the vibration sense threshold observed among six different room temperatures are interpreted as the effects of skin temperature on the mechanoreceptor^{3, 8)}. Influences of room temperature and seasonal condition should be considered when standardizing the evaluation method of finger skin temperature.

For diagnosing circulatory function, evaluation of recovery rates of the finger skin temperature to initial value is also used⁹⁾. Effects of room temperature and seasonal condition on the parameters after cold exposure need further analysis.

Conclusion

For estimating circulatory function of the upper extremities using the finger skin temperature, the room temperature should be strictly controlled and the effect of seasonal condition must be taken into consideration.

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