A Revised Cold Water Immersion Test for Assessing Peripheral Circulatory Function

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Summary: To improve the conventional cold water immersion test for assessing peripheral circulatory function, the immersed area of the hand was changed in this study. Twenty-seven healthy medical students with a mean age of 24 years participated in the study. The cold water immersion tests were carried out using two methods (in 5°C water for 1 min), in which the immersed area was up to the metacarpophalangeal (MP) joints (hereafter, MP-method) which is a new method, or to the wrist (hereafter, W-method) which is a conventional method. The recovery of skin temperature, vibratory perception threshold and complaints of finger pain were determined during cold immersion tests with the two methods. The mean skin temperature for the MP-method after immersion recovered more quickly than that for the W-method. However, the time courses of recovering were parallel for the two methods. Significant differences were noted at 3 min, 5 min and 10 min after cessation of immersion. There was a significant positive correlation in the recovery rates at 5 min after immersion between the two methods (correlation coefficient = 0.65, p<0.01). The mean vibratory thresholds for the W-method were higher than those for the MP-method, and the difference was significant (p<0.01). All subjects preferred the MP-method to the W-method because there was less finger pain. These results indicate that the MP-method, immersion up to the MP joint of a hand, for assessing peripheral circulatory function is better than the W-method.

Key words: cold immersion test — diagnostic method — hand-arm vibration syndrome — revised method — smaller immersion area

Introduction

The cold water immersion test has been used as a diagnostic method for peripheral circulatory disorders in patients with hand-arm vibration syndrome in Japan (Matoba and Sakurai, 1987). A laboratory test should be evaluated not only by the simplicity for the application but also by the validity. From a physiological viewpoint, the cold water immersion test has an advantage for the detection of functional disorders of the peripheral circulatory system in patients with the syndrome (Chang, 1976; Sakakibara et al. 1982). However, the interpretation...
of the results has led to much controversy because of many variable factors (Pelmear et al. 1992). In a reevaluation of the cold water immersion test, the results should be compatible with the degree of physiological damage in the immersed hand. The aim of this study was to evaluate the changes of skin temperature after cold immersion of different areas of a hand in normal subjects.

**Subjects and Methods**

Twenty-seven healthy medical students with a mean age of 24 years participated in this study. All subjects were carefully instructed on the study procedures, and gave their informed consent. No symptoms or signs of peripheral circulatory disorders were found in the subjects.

The cold water immersion tests were carried out using two methods: one was a new method of immersion of the hand up to the metacarpophalangeal (MP) joint in 5 °C water for 1 min (hereafter, the MP-method), the other was a conventional immersion of the fingers up to the wrist with the same water conditions (hereafter, the W-method) as a control method. Subjects were randomly divided into two groups. One group carried out the MP-method first and then the W-method was performed after recovery of the skin temperature to the pre-immersion value. The reverse order of methods was used for the other group. Skin temperature was measured with a thermistor on the back of the middle phalange of the middle finger every 1 min for 10 min after finishing the immersion, while the subject held his hand at the level of his heart. The rewarming activity was evaluated by the following formula:

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\text{Recovery rate at } X \text{ min} = \left(\frac{(T_x - T_{\text{post}})}{(T_{\text{pre}} - T_{\text{post}})}\right) \times 100\%
\]

- \(T_{\text{pre}}\): skin temperature before immersion
- \(T_{\text{post}}\): skin temperature immediately after cessation of immersion
- \(T_x\): skin temperature at various times after cessation of immersion

The threshold for a 125 Hz vibratory perception was determined at the tip of the middle finger of the right immersed hand before, immediately after, 5 min after and 10 min after cessation of the immersion. The vibration thresholds were determined with a vibrotactile sensation meter (RION, AU-02B). Complaints of finger pain due to cold were evaluated by a self-administered scale method. All tests were performed between 4 and 6 p.m. in February, 1995. The room temperature and humidity were maintained at 21–23 °C and 50–65%, respectively.

Before the immersion test, the subjects were acclimatized for 30 min in the test room in a sitting position. Smoking was prohibited, 2 hours before the examination. The significance of differences in the laboratory data from the two groups was determined by a paired t-test. The recovery of finger skin temperature after immersion was evaluated by regression analysis.

**Results**

*Time course of recovery of finger skin temperature after immersion*
There was no significant difference due to the order of the immersions, thus all the data was analyzed together. Figure 1 shows the changes in finger skin temperature with MP- and W-methods. The mean skin temperature during recovery from the MP-method was higher than that with the W-method. The mean recovery rates of skin temperature with MP- and W-methods were 41% and 33% at 3 min, 54% and 44% at 5 min and 71% and 58% at 10 min, respectively. There was a significant difference between the two methods (p<0.01). To compare the recovery with the two methods, linear regression was applied to two parts of the recovery period: from 1 min to 5 min after immersion, and from 5 min to 10 min after immersion. In the latter time period, the slope of the regression line was quite similar for the two methods, as shown in Fig. 1.

Figure 2 shows the relationship between the MP- and W-methods on the recovery rates at 5 min after immersion. There was a significant positive correlation (correlation coefficient=0.65, p<0.01).

Changes of vibratory perception threshold with cold immersion

The mean vibratory perception thresholds for the MP- and W-methods were -2.9 dB and -0.5 dB immediately after immersion, -6.9 dB and -4.6 dB at 5 min after immersion and -8.9 dB and -6.8 dB at 10 min after immersion, respectively. Each threshold from the W-method was significantly higher than that from the MP-method (p<0.01). The mean recovery course of threshold with
the MP-method was parallel to that with the W-method.

Complaints of pain in the fingers

Approximately eighty-nine percent of the subjects had definitely more pain with the W-method than with the MP-method. During the recovery period, all subjects complained a little and there was less numbness and coldness in the fingers with the MP-method. With an evaluation using a 5-point scale, a significant difference between the two methods was found immediately after immersion (MP-method=3.5, W-method=4.8; p<0.01). All the subjects preferred the MP-method to the W-method.

Discussion

A cold water immersion test has been used as one of the simple diagnostic methods for peripheral circulatory disorders due to hand-arm vibration syndrome in Japan (Matoba and Sakurai, 1987). The subject immerses a hand up to the wrist in 5 or 10°C cold water for 10 min (hereafter, 5°C-10 min method and 10°C-10 min method, respectively). The 10°C-10 min method induced fewer complaints of chest tightness, finger pain and other symptoms as compared to the 5°C-10 min method (Chang, 1976; Sakakibara et al. 1982). In some cases, Raynaud’s phenomenon occurs in the immersed fingers. In a previous paper it was reported that immersion in water at 4°C for 1 min (4°C-1 min method) was useful to detect functional disorders (Ishitake et al. 1992).

The major point of this study was
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how large the immersed area of a hand must be to induce complaints. The immersed area was changed from the wrist to the MP joint, which induced less finger pain but had the same validity. In this study, the recovery of skin temperature after immersion with the MP-method was parallel to that with the W-method, especially at 5 min to 10 min after immersion. It was also suggested that there is no need to measure the time course of skin temperature over 5 min after immersion because there was a significant positive correlation between recovery rate at 5 min and that at 10 min. This is another advantage for saving time of examination. In addition, complaints of pain in the hand with the MP-method were milder than those with the W-method. Thus, this method had almost the same recovery of skin temperature after cold water immersion as the 10°C-10 min and 4°C-1 min methods. The present MP-method may be used to assess peripheral circulatory function. Further studies, however, should be done on patients with hand-arm vibration syndrome. In conclusion, this revised method of immersion up to the MP joint, which is a smaller immersed area than with the conventional method, may be superior to the conventional immersion to the wrist because of fewer complaints of pain due to the cold water.

References