

Transcutaneous partial pressure of oxygen in the forearm in the determination of the hand-arm vibration syndrome

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INABA R, FURUNO T, OKADA A. Transcutaneous partial pressure of oxygen in the forearm in the determination of hand-arm vibration syndrome. *Scand J Work Environ Health* 12 (1986) 242–244. The purpose of this study was to apply the change in forearm transcutaneous partial pressure of oxygen (tcPO₂) during a cold provocation test (5°C, for 10 min) to the diagnosis of vibration syndrome. The finger skin temperature of the referents descended rapidly soon after the start of the test and rose slightly after 5 min. In the workers with vibration-induced white finger (VWF), the finger skin temperature did not rise during the test. These results suggest that the cold vasodilatation reflex of the finger is absent in workers with VWF. The forearm tcPO₂ of the referents increased gradually during the first 3 min of the test and decreased thereafter. It returned to the pretest level in 5 min. In the workers with VWF, the forearm tcPO₂ also increased during the first 3 min of the test, but it did not change thereafter. The level of tcPO₂ increases with the increase in skin blood flow. Therefore, it might be supposed that the forearm tcPO₂ changes in the workers with VWF were caused by the continuous relative increase of blood flow in the forearm skin, the blood flow increase having been induced by the lack of a cold vasodilatation reflex of the finger.

Key terms: cold provocation test, skin temperature, tcPO₂.

Recently an apparatus for measuring the partial pressure of oxygen (PO₂) in arterial blood transcutaneously and continuously was invented and has been utilized clinically in several medical divisions (such as neonatal intensive care units and cardiac surgery) for monitoring arterial PO₂. There are, however, few reports on the application of this apparatus in the field of occupational health. Therefore, we have measured the transcutaneous PO₂ (tcPO₂) change in the forearm during a cold provocation test using this device in order to apply this apparatus to the diagnosis of vibration syndrome. It was considered useful for the early detection and diagnosis of the vibration syndrome.

Subjects and methods

The subjects were seven male workers, 54–77 years of age, all with vibration-induced white finger (VWF), and seven healthy male referents without any history of vibratory tool use. Vibrating tools (mainly chain saws) had been used from 4 to 34 (mean 16.9) years by the workers with VWF.

Prior to the diagnostic test the subjects were at rest for more than 30 min in the laboratory with the temperature regulated at 23 ± 1°C. The test was performed by means of immersing the left hand in cold water (5°C) for 10 min. The skin temperature of the

second fingertip of the left hand and the left forearm was monitored for 30 min, from 10 min before the provocation test began to 10 min after it. In other words, the skin temperature of the second fingertip of the left hand was measured at an environmental temperature of 5°C. At the same time the tcPO₂ of the left forearm was monitored.

The skin temperature and forearm tcPO₂ were measured by a digital thermistor (Takara Co, HD111) and a tcPO₂ monitor (Biochem Co, Life Span 100 tcPO₂), respectively. This experiment was carried out in the winter.

The statistical significance of the results was tested by Student's t-test.

Results

Although the values of the skin temperature and the forearm tcPO₂ slightly varied individually, their variation during the cold provocation test was almost the same among the subjects in each group. Therefore the results have been expressed by mean values.

Figure 1 shows the changes in the skin temperature of the left forearm and second fingertip of the referents after the cold provocation test. The forearm skin temperature of the referents decreased gradually during the test, and it recovered gradually after the test. On the other hand, the finger skin temperature of the referents decreased rapidly soon after the start of the test and rose slightly after 5 min from the start. This result suggests that an intact cold vasodilatation reflex was operating. Five minutes after the end of the cold provocation the finger skin temperature rose above that of the forearm. The finger skin temperature al-

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most recovered in the 10 min after the end of the test.

Figure 2 shows the changes in the skin temperature of the left forearm and second fingertip of the left hand of the subjects with VWF after the cold provocation test. The forearm skin temperature of these workers decreased gradually during the cold provocation in a manner similar to that of the referents, although it did not rise after the end of the test. At the start of the test the level of the finger skin temperature of the workers with VWF was slightly lower than that of the referents, but the difference was not statistically significant. In the workers with VWF an increase in the finger skin temperature during the test was not observed. Furthermore, the temperature recovery was delayed in comparison to that of the referents, and the finger skin temperature did not rise above that of the forearm as it did in the referents.

Figure 3 shows the changes in the left forearm $tcPO_2$ after the cold provocation test of both groups of subjects. The level of the forearm $tcPO_2$ at the start of the test was 71.5 (2 SD 25.4) mm Hg [9 532.5 (2 SD 3 386.4) Pa] and 78.1 (2 SD 16.4) mm Hg [10 412.5 (2 SD 2 186.5) Pa] for the workers with VWF and the referents, respectively. The difference was not significant. The forearm $tcPO_2$ of the referents gradually increased during the first 3 min after the start of the test and decreased thereafter. It returned to the pretest level 5 min after the start of the test. On the other hand, in the workers with VWF, the forearm $tcPO_2$ increased during the first 3 min after the start of the test, but did not change thereafter during the rest of the test. After the end of the test it slightly decreased and did not return to the pretest level in these subjects.

Discussion

Among different factors, particularly skin blood flow affects the level of $tcPO_2$ (1). The $tcPO_2$ increases with the increase in skin blood flow. In both the workers with VWF and the referents the finger skin temperature rapidly decreased after the start of the cold provocation test. This result suggests that the blood vessels of the hand and fingers constricted following the immersion in the cold water, and consequently the blood flow in the forearm skin increased. This is the reason for the forearm $tcPO_2$ increase after the test. Likewise, the finger skin temperature of the referents increased for 5 min after the start of the test, and this result suggests that the blood vessels in the hand dilated and the blood flow in the forearm skin relatively decreased. Thus the forearm $tcPO_2$ in the referents decreased. Therefore, it might be assumed that the forearm $tcPO_2$ changes in the workers with VWF occurred due to the continuous relative increase in the blood flow of the forearm skin, the increase in blood flow having been induced by the lack of a cold vasodilation reflex of the finger.

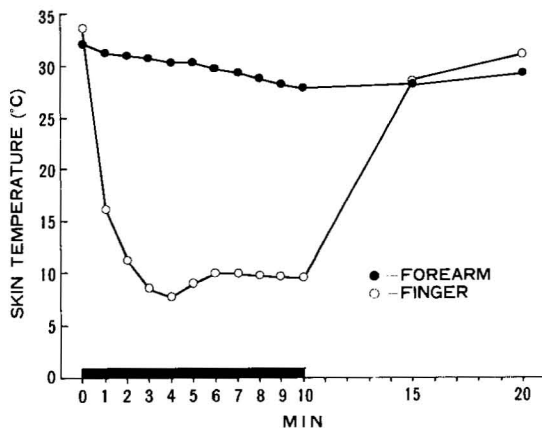


Figure 1. Changes in the skin temperature of the left forearm and the second fingertip of the left hand of the referents after the cold provocation test. Each point represents a mean value.

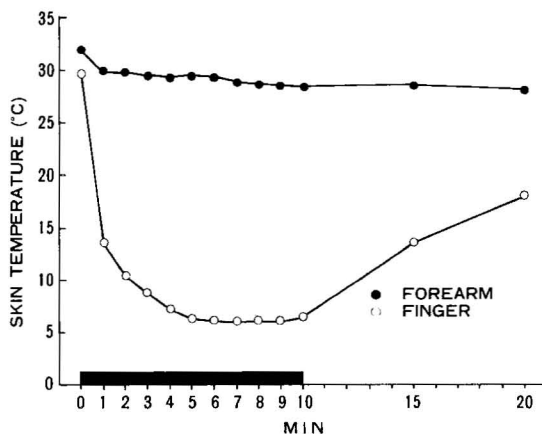


Figure 2. Changes in the skin temperature of the left forearm and the second fingertip of the left hand of the workers with vibration-induced white finger after the cold provocation test. Each point represents a mean value.

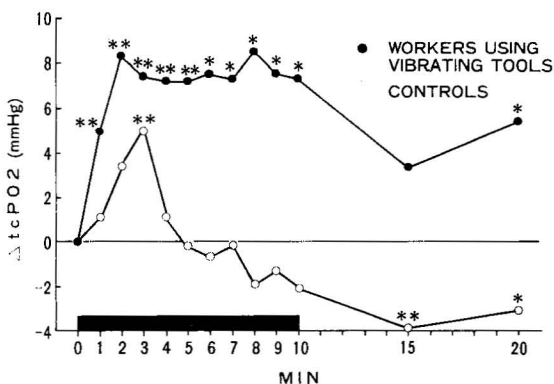


Figure 3. Changes in the transcutaneous partial pressure of oxygen ($\Delta tcPO_2$) of the left forearm after the cold provocation test. Each point represents a mean value. (* $p < 0.05$, ** $p < 0.01$, compared with the initial level; 1 mm Hg $\approx$ 133.3 Pa; controls = referents)

There has been no report on the relationship between the skin temperature of the forearm and the finger during a cold provocation test. In this study we found that the finger skin temperature in workers with VWF did not rise above the forearm skin temperature 5 min after the end of the cold provocation test.

Thus it was found that, during the cold provocation test, both the forearm $tcPO_2$ and the skin temperature of workers with VWF showed a characteristic change which differed from that of the healthy

referents. Observation of the changes in the forearm $tcPO_2$ and the skin temperature of the fingertip and the forearm after a cold provocation test may be a useful objective method for evaluating VWF.

References

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