Medial Plantar Nerve Conduction Velocities among Patients with Vibration Syndrome due to Rock-drill Work

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Received October 28, 2002 and accepted October 10, 2003

Abstract: Objective: The present study was aimed at clarifying the effect of vibration syndrome (VS) on the peripheral nervous system in the lower extremities of patients with VS due to rock-drill work. Methods: Fifty-three patients with VS due to previous exposure to vibration from rock-drilling work and 55 age-matched controls were examined for sensory nerve conduction velocities in the medial plantar nerve (SCV-P). The patient group was divided into three subgroups, outdoor rock-drill workers with vibration-induced white finger (VWF) (N=10), tunnel workers with VWF (N=27) and tunnel workers without VWF (N=16). Results: ANOVA of SCV-P for the four groups showed F=3.23 (dF=3, 104, p=0.0253). A significant difference was found between the controls and outdoor rock-drill workers with vibration-induced white finger (VWF) group (p=0.0261) by multiple comparison using Scheffe’s method. Conclusion: These findings suggest that peripheral nervous system function in the lower extremities of patients with VS is affected by cold exposure and circulatory disturbance manifested as VWF.

Key words: Vibration syndrome, Rock-drill operator, Sensory nerve conduction velocity, Medial plantar nerve

Introduction

Some patients with vibration syndrome (VS) complain of tingling, numbness and coldness in the lower extremities, especially in the foot1, 2). These symptoms suggest an effect of VS on the peripheral nervous system of the lower extremities. Some Japanese researchers have observed hyporeflexia and hypoesthesia in the lower extremities among VS patients in neurological examinations3, 4), but they did not use nerve conduction velocity as an objective indicator.

From the 1970s, many researchers have used nerve conduction velocities to investigate the involvement of the peripheral nervous system in hand and arm symptoms among VS patients5–10). However, except for the work of Juntunen et al.11), there has been little research done on the peripheral nervous system of the lower extremities.

In order to clarify the effect of VS on the lower extremities, we have examined sensory nerve conduction velocities in the sural nerve and the medial plantar nerve (a peripheral branch of the posterior tibial nerve) of patients with VS and control subjects12). We reported that sensory nerve conduction velocities in the medial plantar nerve (SCV-P) of patients with VS were significantly lower than those of the controls, but this was not the case with the velocities in the sural nerve. We also discussed the possibility of the relationship of the circulatory disturbance to SCV-P reduction.
In a study on SCV-P of VS patients due to chain-saw work\textsuperscript{13}, we observed a significant reduction of SCV-P among VS patients with vibration-induced white finger (VWF) compared with that of controls, but no significant reduction among VS patients without VWF. We also discussed the effects of circulatory disturbance represented by VWF, cold exposure and thin-soled Japanese shoes on the reduction of SCV-P.

Patients with VS and VWF have been reported to show significant reduction of the skin temperature in the big toe compared with those of the controls, whereas patients with VS and without VWF did not\textsuperscript{14}. This suggested that VWF in the upper extremities is an indicator of circulatory disturbance in the feet of VS patients.

In the present study, we aimed at clarifying the effect on SCV-P among VS patients due to rock-drill work and investigate the factors related to SCV-P reduction.

**Subjects and Methods**

**Subjects**

Fifty-three male patients with VS and 55 male control subjects were examined in the summer of 1993 and 1994, in the autumn of 1994 and in the spring of 1996. All lived in the Shikoku, Kyushu and Hokuriku areas of western Japan and were certified as VS patients according to the criteria of Ministry of Labour of Japan. The patients were of a mean age of 58.4 yr with duration of exposure to vibration averaging 21.3 yr. They had been on sick leave an average of 4.03 yr after the diagnosis of VS. The selection criteria of the patients with VS were as follows: they were not suffering from other diseases or injuries which might have affected the peripheral nervous system function, had no past or current exposure to neurotoxicants including pesticides and organic solvents, did not smoke more than 40 cigarettes per day, and were not consuming more than 90 ml of alcohol a day. This information was obtained from anamnesis and the reports of their clinical physicians. The job titles of the patients were rock-drill operator in tunnels (n=43) and in outdoor construction (n=9) and mason (n=1) using rock drills. The patient group was divided into three sub-groups, the first subgroup consisted of outdoor rock drill operators with VWF in the previous winter (O+, n=10), the second of tunnel workers with VWF in the same season (T+, n = 27) and the third of tunnel workers without VWF in the same season (T–, n=16). Data from a previous study on 55 normal controls from the same region were included using the same criteria as for the patients\textsuperscript{13} [Hirata et al. 1999]. Their ages were matched to within 1 or 2 years of those of the patients (Table 1). The control subjects, except for three pensioners, had the following jobs: office worker (n=19), driver (n=13), carpenter (n=3), cleaner (n=3), engineer (n=4), farmer (n=3), wood-worker (n=3), teacher (n=1), merchant (n=1), cook (n=1), and wooden mask carver (n=1).

The patients and controls were informed of the objective and the procedure of the study and gave their written consent.

**SCV measurement**

We employed the same method of SCV measurement as in our previous study\textsuperscript{13}. The subjects, in an air-conditioned room with the temperature maintained at 24 to 27°C, were asked questions regarding the symptoms of VWF, tingling
and numbness in the extremities, their past medical history, and drinking and smoking habits. They were then asked to lie in an electrically shielded box, for examination of SCV in the medial plantar nerves (SCV-P) from the first toe (stimulation point) to the medial side of the ankle (recording point) through needle electrodes, orthodrohmically placed. The setting of electrodes on the ankle and foot was as same as described in our previous report\(^{13}\). The evoked nerve action potentials were amplified with a band-path from 20 Hz to 2 kHz using an electromyograph (Sapphire 4EM, Medelec Co., UK). Sixty-four to 256 nerve action potentials were averaged for SCV-P. In order to adjust the SCV-P which is easily affected by temperature, the skin temperature was measured at the midpoint between the stimulation and recording points using an infrared ray thermometer Type IT340S (Horiba Manufacturing, Kyoto, Japan). The SCV-Ps measured for the lower extremities were also corrected for SCV-P at 31°C of the standard skin temperature using de Jesus’ method\(^ {15}\). The formula used for the correction of SCV-P is \( Y_2 = Y_1 \left( Q_{10}^{\Delta T/10} \right) \). \( Y_2 \) is the corrected SCV at the standard temperature, \( Y_1 \) is SCV at the experimental temperature, \( \Delta T \) is the difference in degrees centigrade between the standard and experimental temperatures, and \( Q_{10} = 1.51 \).

**Statistical analysis**

The differences in SCV-Ps among the three patient groups and the controls were tested by analysis of variance (ANOVA) with multiple comparison using Scheffe’s method. The differences in skin temperature and cigarette and alcohol consumption among the four groups were also tested by ANOVA.

**Results**

Table 2 shows the skin temperature and SCV-P for all patients, T–, T+ and O+ groups and the controls.

ANOVA of SCV-P for the three groups was significant (\( dF=3, 104, F=3.23, p=0.0253 \)) with a significant difference between the controls and the O+ group (\( p=0.0261 \)) by multiple comparison using Scheffe’s method, but without significant difference between the other combinations of the two groups by the same method.

ANOVA of the skin temperature was significant (\( dF=3, 104, F=2.968, p=0.0354 \)) without a significant difference among the groups using Scheffe’s method. ANOVA of the cigarette and alcohol consumption were not significant (\( dF=3, 52, F=2.59, p=0.0630; dF=3, 63, F=1.61, p=0.197 \), respectively) and no significant difference was found between pairs of groups by multiple comparison using Scheffe’s method.

**Discussion**

The present study showed significant lowering of the SCV-P in the lower extremities among patients with VS and VWF due to vibration exposure from outdoor rock-drill work (O+), but not among those with VWF due to vibration exposure from rock-drill work in tunnels and among those without VWF (T+, T–).

Many researchers have reported a reduction in nerve conduction velocities in the upper extremities among VS patients, as well as histopathological changes in the nerve fibre of the fingers\(^ {16, 17}\). This also agrees with the finding of sciatic nerve damage in experimental animals which had a foot exposed to vibration\(^ {18, 19}\). These studies established the occurrence of peripheral nervous system disorders in part due to direct exposure to vibration.

Nevertheless, studies on the peripheral nervous system in the lower extremities of VS patients have only been reported by Juntunen et al.\(^ {11}\) and us\(^ {12, 13}\). Juntunen et al. reported a reduction in sensory nerve conduction velocity in the sural

<table>
<thead>
<tr>
<th>Patients</th>
<th>Tunnel workers without VWF (N=53)</th>
<th>Tunnel workers with VWF (N=16)</th>
<th>Outdoor rock drill workers with VWF (N=27)</th>
<th>Controls (N=55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin temperature (°C)</td>
<td>28.5 ± 2.21 (23.2–32.1)</td>
<td>27.9 ± 2.70 (23.2–32.0)</td>
<td>28.4 ± 2.01 (24.5–32.1)</td>
<td>29.3 ± 1.81 (24.3–32.9)</td>
</tr>
<tr>
<td>SCV-P (m/s)</td>
<td>41.3 ± 4.44 (32.2–61.6)</td>
<td>42.1 ± 3.43 (36.0–49.2)</td>
<td>41.9 ± 5.18 (34.4–61.6)</td>
<td>38.3 ± 3.47* (32.2–43.2)</td>
</tr>
</tbody>
</table>

*: \( p<0.05 \) by multiple comparison using Scheffe’s method.
nerve, motor nerve conduction velocity and motor conduction velocity in slower fibres in the peroneal nerve among forestry workers with peripheral nervous system symptoms in the extremities when compared with forestry workers without such symptoms, but some questions were raised on the selection of subjects and measuring methods (detailed comments were reported in our paper[13]).

Our previous study suggested that circulatory disturbance represented by VWF affected a reduction in SCV-P among VS patients due to chainsaw work[13]. Changes in the peripheral nervous system in the upper extremities in previous studies have been conventionally considered to be a localised effect due to vibration, in other words, a “direct effect”. However, the reduction in SCV-P in VS patients can be considered to be an “indirect effect” with the mediation of circulatory disturbance represented by VWF.

The reduction in SCV-P among VS patients with VWF due to rock drill work in tunnels (T+, T–) was not significant compared with the controls. This differs from the finding for VS patients with VWF due to chainsaw work. In the previous study[13], we described cold injury in the work environment as a possible factor in the reduction in SCV-P among VS patients with VWF due to chainsaw work (Ch+ group). Chainsaw work had been performed outdoors in high mountain areas with cold exposure in winter. VS patients with VWF due to rock drill work in construction and masons (O+ group) worked outdoors in the cold in winter. However, rock-drill work in tunnels, where the temperature was generally constant and not so low, is thought to be done in a warmer environment in winter than that of O+ group. Ch+ and O+ group with reduced SCV-P had common factors, cold exposure and VWF, but T+ group without reduced SCV-P had only VWF. Consequently, cold exposure might be an important factor in SCV-P of VS patients.

Since some rock drill operators who worked in close contact with rock drill stand to their foot in order to stabilize the drill, the feet of these operators might be directly exposed to the vibration.

The lowering of SCV-P must be differentiated from the tarsal tunnel syndrome (TTS), which is accompanied by pain in the ankles and foot[26], and often arises due to post-traumatic trouble. In our study, no patient complained of such pain and we had also excluded patients with a history of injury to the lower extremities. Therefore, we were able to exclude the tarsal tunnel syndrome from the etiology of the reduced SCV-P.

Based on these considerations, we conclude that factors involved in the lowering of SCV-P in patients with VS and VWF due to rock drill work may include cold exposure, circulatory disturbance represented by VWF and direct exposure to vibration in the feet, somewhat different from chainsaw workers described in our previous study[13].

References


