Assessment of Central and Peripheral Nerve Functions in Chain-Saw Operators: A Study of Short-Latency Somatosensory Evoked Potential and Peripheral Nerve Conduction

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Murata, K., Araki, S. and Aono, H. Assessment of Central and Peripheral Nerve Functions in Chain-Saw Operators: A Study of Short-Latency Somatosensory Evoked Potential and Peripheral Nerve Conduction. Tohoku J. exp. Med., 1987, 151 (1), 25-31 — In order to clarify the effects of local vibration on the peripheral and central nervous system, peripheral (median) nerve conduction velocities and short-latency somatosensory evoked potentials (SSEP) following stimulation of the median nerve at the wrist were measured in 15 male forest workers in 1986. They had engaged in chain-saw operation for 16-34 (mean 22) years; their working days in 1985 averaged 124 days with a range of 50–203 days. The results indicated significant delays in maximal motor and sensory nerve conduction velocities followed by prolongation of all 4 peak latencies of SSEP up to the sensory cortex of the brain (N9, N13, N20 and P23 latencies) in chain-saw operators; their N9 and P23 latencies were significantly correlated with total working days per year. On the other hand, no significant prolongation of the interpeak latencies of SSEP (i.e., cervico-spinobulbar and central conduction times) was found in the workers. It is concluded that local vibration predominantly affects peripheral nerve conduction; cervico-spinobulbar and central nerve conduction may not be significantly affected.

In a previous study of peripheral nerve conduction (Araki et al. 1976), we found that local vibration predominantly affects distal segments of sensory and motor nerve fibers in the upper limbs of chain-saw operators. The result was consistent with the findings in a few preceding studies (Dylewska 1970; Seppäläinen 1972; Nishi et al. 1972), and has been confirmed by subsequent investigations (Torii et al. 1978; Tanabe and Kameda 1979; Hisanaga 1982; Juntunen et al. 1983).

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In Japan, some investigators have reported that exposure to local vibration might affect the central nervous system. For example, in the electroencephalogram (EEG) of workers using vibrating tools, abnormal waveform patterns have been observed (Futatsuka et al. 1974; Arikawa et al. 1978); prolongation of the latency of "long-latency" somatosensory evoked potentials, i.e. delay in nerve conduction from the upper limb to the cerebral cortex, has been reported in vibrating tool operators (Ohta et al. 1979, 1985; Tanabe and Kameda 1979; Kusunose et al. 1984).

In this study, to assess relative strength of the effects of local vibration on the peripheral and central nervous system, we measured peripheral nerve conduction velocity and "short-latency" somatosensory evoked potentials (SSEP) in chainsaw operators. The effects of vibration on peripheral, cervico-spinobulbar and central nerve conduction were compared with each other.

**Subjects and Methods**

**Subjects**

Fifteen male forest workers, aged 41–62 (mean 54) years, were examined in March, 1986. They had engaged in chain-saw operations for 16 to 34 (mean 22) years, and worked for 50–203 (mean 124) days in 1985 (the daily working hr averaged 3.8 hr with a range of 0.5–6.0 hr). The workers ingested alcohol equivalent to 0–755 (median 360) ml of 100% ethanol per week; their height was 158–169 (mean 162) cm. None of them was occupationally exposed to neurotoxic substances such as heavy metals and solvents, and had ever suffered from neurological disease and diabetes mellitus.

Control subjects, matched to each chain-saw operator in sex (male sex), age (same 3-year span) and skin temperature at the time of electrophysiological study (same 2°C span), were selected randomly from 91 male “healthy” adults living in the same residential area as the chain-saw operators. They neither engaged in occupations using vibrating tools nor suffered from neurological or endocrinological disorder. Their age, skin temperature at the time of electrophysiological study, alcohol ingestion and height were not significantly different from those in chain-saw operators (paired-sample t-test, t = -1.16, -0.63, -1.66 and 0.59, respectively).

**Methods**

The maximal motor nerve conduction velocity of the median nerve (MCV) and overlying skin temperature were measured in the forearm utilizing a method previously reported by us (Araki and Honma 1976). The sensory median nerve conduction velocity (SCV) in the forearm and palm segments were measured using the antidromic technique (Smorto and Basmajian 1979).

Four peak latencies of SSEP were measured by the same method reported previously by us (a modified Jones’ method; Jones 1977; Murata and Araki 1985). After electrical stimulation of the right median nerve at the wrist, the N9 peak was recorded at the Erb’s point above the clavicle; the N13 peak was recorded at the second cervical vertebra; and N20 and P23 peaks were on the scalp overlying the sensory (parietal) cortex contralateral to the stimulated limb. The interpeak latencies of N9-N13 and N13-N20 represented cervico-spinobulbar and central conduction times, respectively.

Electrophysiological studies were conducted in a warm laboratory (28–32°C) using Medelec MS-92 two-channel electromyograph; skin temperature was maintained in the range of 32–35°C for all subjects. The daily variation (coefficient of variation) in the MCV,
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SCVs and peak latencies of SSEP has been described previously (Murata and Araki 1985; Araki et al. 1986).

**RESULTS**

The MCV and SCVs in the median nerve were significantly slowed in chain-saw operators (Fig. 1). Similarly, all peak latencies of SSEP were significantly prolonged in the operators (Fig. 2). On the other hand, no significant difference in the interpeak latency of SSEP between chain-saw operators and the matched controls was found (Table 1). The N9 and P23 latencies of SSEP were significantly correlated with total working days in 1985 in chain-saw operators (Fig. 3).

Subjective symptoms at work in fifteen chain-saw operators are shown in Table 2.

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**Fig. 1.** Differences in maximal motor and sensory nerve conduction velocities (MCV and SCV) of the right median nerve between fifteen chain-saw operators and the same number of control subjects (matched to chain-saw operators in sex, age and skin temperature) (paired-sample t-test). Open (○) and solid (●) circles indicate chain-saw operators with and without a history of white finger attacks. Transverse line shows mean values for fifteen subjects.

**Table 1.** Differences in the interpeak latency of short-latency somatosensory evoked potentials (mean with range in parentheses, msec) between 15 male chain-saw operators and the same number of control subjects (matched to chain-saw operators in sex, age and skin temperature)

<table>
<thead>
<tr>
<th>Interpeak latency</th>
<th>Chain-saw operators</th>
<th>Matched controls</th>
<th>Matched differences*</th>
</tr>
</thead>
<tbody>
<tr>
<td>N 9-N13</td>
<td>3.6 (2.9-4.5)</td>
<td>3.6 (3.0-4.2)</td>
<td>0.0±0.7</td>
</tr>
<tr>
<td>N13-N20</td>
<td>6.6 (5.7-8.2)</td>
<td>6.3 (5.3-6.9)</td>
<td>0.3±0.8</td>
</tr>
<tr>
<td>N20-P23</td>
<td>6.5 (4.4-9.4)</td>
<td>6.3 (5.3-7.6)</td>
<td>0.2±1.1</td>
</tr>
</tbody>
</table>

* Mean and s.d. of matched differences (the differences are not statistically significant, paired-sample t-test \( p > 0.05 \)).
Fig. 2. Differences in N9, N13, N20 and P23 latencies of short-latency somatosensory evoked potentials between fifteen chain-saw operators and the same number of matched controls. Matched controls, open and solid circles, transverse line and statistical analysis same as in Fig. 1.

Fig. 3. Relationships between total working days in 1985 and N9 and P23 latencies of short-latency somatosensory evoked potentials in fifteen chain-saw operators (Spearman's rank correlation).
Peripheral nerve conduction velocities were significantly delayed in chain-saw operators. Similarly, all peak latencies of SSEP were significantly prolonged in them; the N9 and P23 latencies were significantly correlated with total working days per year. On the other hand, no significant prolongation of the interpeak latency of SSEP was found in the operators. These results indicate that chain-saw operation predominantly affects peripheral nerve conduction; cervico-spinobulbar and central nerve conduction may not be significantly affected.

The peripheral nervous system effects of local vibration shown in the present study are in line with those in the following reports: (1) Slowing of peripheral nerve conduction velocities in vibrating tool operators having been observed in the bulk of studies including one by our group (Dylewska 1970; Seppäläinen 1972; Nishi et al. 1972; Araki et al. 1976; Torii et al. 1978; Tanabe and Kameda 1979; Hisanaga 1982; Juntunen et al. 1983), although it has not been demonstrated in all published reports (Abbruzzese et al. 1977; Chatterjee et al. 1982). (2) Demyelinating neuropathy in the finger of pneumatic vibrating tool operators with Raynaund’s phenomenon, with remarkable loss of nerve fibers, increase in Schwann’s cells with high collagen formation, and thickening of the peri- and epineurium (Takeuchi and Imanishi 1984).

This is probably the first report which discloses significant prolongation of peak latencies of “short-latency” somatosensory evoked potentials. Among the

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numbness in upper limbs</td>
<td>14</td>
</tr>
<tr>
<td>White finger attack*</td>
<td>11</td>
</tr>
<tr>
<td>Pain in upper limbs</td>
<td>9</td>
</tr>
<tr>
<td>Low back pain</td>
<td>8</td>
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<tr>
<td>Arthralgia</td>
<td>8</td>
</tr>
<tr>
<td>Insomnia</td>
<td>8</td>
</tr>
<tr>
<td>Sensory symptoms in legs</td>
<td>6</td>
</tr>
<tr>
<td>Distal muscle weakness</td>
<td>6</td>
</tr>
<tr>
<td>Neck pain</td>
<td>4</td>
</tr>
<tr>
<td>Headache</td>
<td>3</td>
</tr>
<tr>
<td>Tremor</td>
<td>3</td>
</tr>
<tr>
<td>Vertigo</td>
<td>1</td>
</tr>
</tbody>
</table>

* White finger attack was induced by 10-min immersion test in cold water at 5°C in five chain-saw operators, who had a history of the attacks.
latencies, N20 and P23 latencies have been assumed to represent conduction times from stimulation point (wrist) to the primary and parietal sensory cortex of the cerebrum, respectively (Chiappa and Ropper 1982). Therefore, the results are compatible with those of “long-latency” somatosensory evoked potentials in occupational vibration disease as reported by some investigators, i.e. prolongation of P1, N1, P2 and N2 latencies. Furthermore, the present study newly disclosed significant prolongation of N9 and N13 latencies, i.e. delays in nerve conduction from the wrist to the brachial plexus and to the gracile and cuneate nuclei (or the spinal grey matter), respectively. However, as described above, it is to be emphasized that all these findings do not indicate significant effects of vibration on the central nervous system.

Finally, non-specific symptoms referable to the higher autonomic centers have been reported in workers exposed to local vibration, including excessive sweating, headache, vertigo, insomnia, anxiety and impotence (Gemne and Taylor 1983; Färkkilä 1986). Additionally, Futatsuka et al. (1974) have reported a high frequency of sleep patterns in the EEG of forest workers using vibrating tools; Arikawa et al. (1978) have observed an increase in fast, especially spindle-shaped, activity in patients with a vibration disease. In the present study, however, it does not appear that the frequency of central autonomic nervous system symptoms was high in chain-saw operators with white finger attacks (Table 2). Therefore, further studies are needed to clarify whether or not local vibration has significant effects on the central nervous system.

Acknowledgments

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References