

Prevention of the hand-arm vibration syndrome

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SAITO K. Prevention of the hand-arm vibration syndrome. *Scand J Work Environ Health* 13 (1987) 301–304. In order to determine the prevalence of the hand-arm vibration syndrome before preventive countermeasures were taken, a special health examination was carried out among 417 national forestry workers operating chain saws in the northern area of Hokkaido, Japan. Thirty-two chain-saw workers (7.7 %) were diagnosed as exhibiting the vibration syndrome. The highest prevalence rates were 15.8 % among the workers who had operated the saws for 11 to 15 years and 20.3 % for workers in their 50s. Improved work conditions for chain-saw workers have increasingly prevented the vibration syndrome in the state forests of Japan since 1978. The present report covered the six years since 1978, and evaluated the effects of these improved work conditions on chain-saw workers from data on the recovery rates of skin temperature and the vibration sense threshold after a cold provocation test. As a result, recovery rates of skin temperature and the vibration sense thresholds at the fifth and tenth minutes after the immersion of the hands in cold water were significantly better than those six years earlier. It is suggested that adequate restrictions on the operating time of the chain saw and on the age of workers can completely prevent the vibration syndrome even if the total operating time is appreciably lengthened.

Key terms: prevalence, prevention.

It is well known that the hand-arm vibration syndrome occurs after the long-term operation of many kinds of vibrating tools and that cold in the work environment and noise induced by vibration tools are associated factors (4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 16).

Large numbers of forestry workers exhibiting the syndrome have been observed in mainland Japan since 1965. We have also experienced the same phenomenon in Hokkaido. In order to determine the incidence of the hand-arm vibration syndrome before preventive countermeasures were taken, a special health examination was carried out in 1978 among 417 national forestry workers operating chain saws in the northern area of Hokkaido. Thirty-two chain-saw operators (7.7 %) were diagnosed as suffering from the hand-arm vibration syndrome. The distribution of the cases, classified by the scheme of the Forestry Agency, Japan (3), was 50 % in grade I, 31.2 % in grade II, and 18.8 % in grade III (table 1). Twenty-seven of the 32 authorized patients had been treated with periodic therapy and had been prohibited from chain-saw operation prior to this special health examination. The highest prevalence rate for workers with the hand-arm vibration syndrome was 20.3 % for those in their 50s, and 15.8 % among those who had operated chain saws for 11 to 15 years (table 2).

The real work conditions of the chain-saw workers have been improved in the state forest of Japan since 1978, so that the operators now work 2 h in the morning or 2 h in the afternoon per day, while one

operating cycle lasts 10 min only. The operating time is less than 4 d a week, not more than 2 d continuously, less than 32 h a month, and less than 120 d a year (table 3). Improvements in the design of the chain saw have also led to a decrease in its vibration.

The effects of these alterations in the work conditions of forestry work on chain-saw workers were evaluated from data showing the recovery rates of skin temperature and the vibration sense threshold after a cold provocation test (immersion of the hand in cold water). The data were collected during special health examinations over a period of six years.

Table 1. Prevalence rate of the hand-arm vibration syndrome among chain-saw workers in the state forests of northern Hokkaido (total number of chain-saw workers 417).

Severity of the syndrome	Workers with vibration syndrome	
	N	%
Grade I	16	3.9
Grade II	10	2.4
Grade III	6	1.4
Grade IV	0	0.0
Total	32	7.7

Table 2. Operation time of chain-saw workers suffering from the hand-arm vibration syndrome in northern Hokkaido.

Operation time (years)	Total number of workers	Workers with vibration syndrome	
		N	%
0–5	191	13	6.8
6–10	138	9	6.5
11–15	57	9	15.8
16–20	29	1	3.4
21–25	2	0	0.0

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Table 3. Improvements made in the work conditions of chain-saw workers for the prevention of vibration syndrome in the state forests of Japan since 1978.

	Maximum
One operation cycle	10 minutes
Operating time per day	2 hours
Consecutive operating days	2 days
Operating days per week	4 days
Operating hours per month	32 hours
Operating days per year	120 days
Nonoperating period for one year	2 months
Age restriction	55 years

Table 4. Finger (digit IV of the left hand) skin temperature of chain-saw workers at room temperatures of 20 to 23°C.

Year	Mean (°C)	Standard error of the mean	Range (°C)
1978	31.5	0.15	26.2–35.0
1979	31.3	0.11	26.0–34.5
1980	32.6	0.17	27.0–36.5
1981	32.2	0.17	26.0–35.6
1982	32.4	0.19	23.6–35.5
1983	32.0	0.19	22.1–34.9

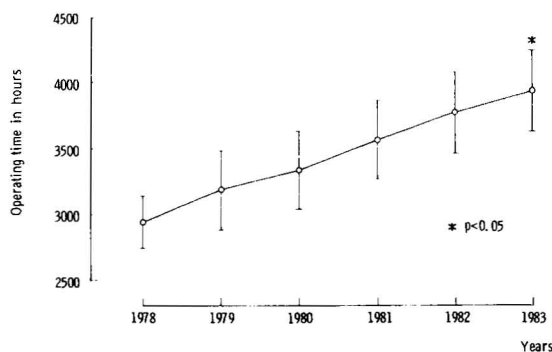


Figure 1. Changes in the operating time of chain-saw workers from 1978 to 1983.

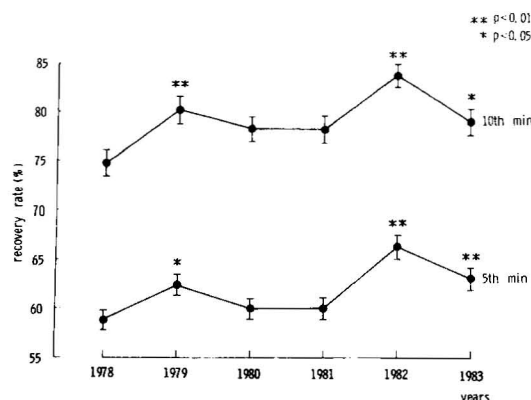


Figure 2. Changes in the recovery rates of skin temperature at the fifth and tenth minutes after immersion of the hands in cold (10°C) water.

Subjects and methods

One hundred and fifty-five male chain-saw workers between the ages of 24 and 53 (mean 45.1, SE 0.6) years were studied. They were surveyed for their chain-saw operating times and their subjective symptoms for the six years from 1978 to 1983. Their skin temperatures, vibratory sense thresholds, recovery time of nail blood color in the nail compression test (17), and the pain sense of their fingers were measured annually at a room temperature of 20 to 23°C and at the fifth and tenth minute after a 10-min immersion of the hand in cold water at 10°C. The data obtained from the six-year special health examinations given to the workers were analyzed to evaluate the effect of the new work conditions since 1978.

Results

Changes in operating time, skin temperature and vibratory sense threshold of the workers

Figure 1 shows the changes in the operating time of the chain-saw workers who were engaged in the state forests of Hokkaido, Japan, from 1978 to 1983. The mean operating time of the workers increased from 2 990 h in 1978 to 3 944 h in 1983. The increase in operating time over five years was significant.

Table 4 shows that the skin temperature of the chain-saw workers at a room temperature of 20 to 23°C did not reveal any significant difference by year, but that the recovery of skin temperature after the cold provocation test among men in their 20s was faster than for other ages.

Details of changes in the recovery rate of skin temperature after the 10-min cold provocation test are shown in figure 2. The recovery rates at the fifth minute after the test were significantly better in 1982 and 1983 than in 1978. Recovery rates at the tenth minute after the test were also significantly better in 1982 and 1983 than in 1978. The values of the mean ages, operating times, and recovery rates of skin temperature for the chain-saw workers in 1983 are shown in table 5.

The vibratory sense thresholds of the workers at the fifth minute after the cold provocation test were sig-

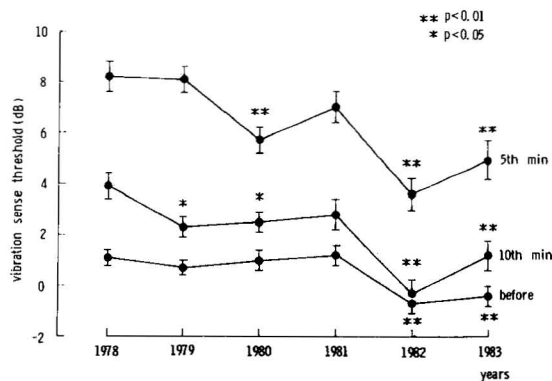


Figure 3. Changes in the vibration sense threshold of chain-saw workers before and 5 and 10 min after immersion of the hands in cold (10°C) water.

nificantly better in 1980, 1982, and 1983 than in 1978; similarly the thresholds at the tenth minute after the test in 1979, 1980, 1982, and 1983 recovered significantly (figure 3).

Table 6 shows the vibratory sense thresholds of the chain-saw workers in 1983. Analysis also showed significant differences by age under conditions of room temperature and at the fifth and tenth minute after the cold provocation test. The values of the vibratory sense thresholds among the older workers were markedly lower than those of the younger workers. The recovery of vibratory sense after immersion of the hands in cold water showed a tendency to be faster than that of their skin temperature.

In any case, the recovery of skin temperature and the vibratory sense threshold among the chain-saw workers has become progressively better since 1982, three years after improvements in the work conditions.

Relationship of skin temperature and vibratory sense to age and operating time

The correlation coefficients between the findings for age, operating time, and the recovery rates of skin temperature at the fifth and tenth minute after the cold provocation test are shown in table 7. There are significant correlations between age and operating time in each year from 1978 to 1983, between the recovery rates of skin temperature at the fifth and tenth minute after the cold provocation test in 1983, and between the recovery rates in every year from 1978 to 1983. The correlations between the chain-saw operating time and skin temperature recovery rates after the cold provocation test were not significant. The correlations between age and the vibratory sense thresholds before and after the cold provocation test and between the values both before and after the test were positively significant, but the correlations between the chain-saw operating time and vibratory sense threshold were not significant (table 8).

Discussion

It is recognized that the operating time of vibrating tools affects the occurrence of the vibration syndrome. The chain saw was first used in Japanese forestry work

to dispose of many trees felled by a typhoon in 1953. Since then, the increasing mechanization of forestry processes has meant the increasing use of such tools. But for 20 years the operation time of vibrating tools was not limited, so that forest workers might well have operated for as many as 6 h a day. Between 1966 and 1969, signs and symptoms of illnesses arising from the use of the power saw in forestry operations were reported from Japan, Sweden, and Australia (1, 2, 6, 7, 9). Taylor et al (16) reported that a marked increase in the prevalence of the hand-arm vibration syndrome was apparent over eight years among the chain-saw users in England. Pyykkö (13) reported that in eastern Finland 40 % of 118 lumberjacks operating chain saws were found to have traumatic vasospastic disease and that the mean latency period of the patients was 5 600 workhours and four years after the beginning of chain-saw operation. In our 1978 field study of the northern area of Hokkaido, Japan, the hand-arm vibration

Table 5. Age, operating hours, and recovery rate of skin temperature of digit IV of the left hand of 155 chain-saw workers after a cold provocation test in 1983.

	Mean	Standard error of the mean	Range
Age (years)	45.1	0.6	29—58
Operating time (h)	3 944.2	306.2	447—19 899
Recovery rate of the skin temperature (%)			
After 5 min	63.1	1.1	43.9—92.8
After 10 min	79.1	1.3	50.2—111.2

Table 6. Vibratory sense threshold of digit III of the right hand of chain-saw workers in room temperatures of 20 to 23°C before and after a cold provocation test (immersion in cold water) in 1983. The threshold was measured with 125 Hz with an apparatus for measuring vibratory sense (Rion Model AU-02) (14). (dB re 308 mm/s²)

	Mean (dB)	Standard error of the mean	Range (dB)
Before immersion	-0.39	0.41	-10.0—15.0
Fifth minute after immersion	4.94	0.79	-10.0—30.0
Tenth minute after immersion	1.19	0.64	-10.0—27.5

Table 7. Correlation coefficients for age (A), operating time (O), and recovery rate of the skin temperature 5 (S5) and 10 (S10) min after a cold provocation test (immersion in cold water).

Items	1978	1979	1980	1981	1982	1983
A vs O	0.3690 **	0.3559 **	0.3520 **	0.3545 **	0.3579 **	0.3549 **
A vs S5	-0.2901 **	-0.1592	0.2824 **	-0.2317 **	-0.1956 *	-0.2336
A vs S10	-0.2009 *	-0.1713 *	-0.1643	-0.0523	-0.1191	-0.1867 *
O vs S5	-0.1010	-0.0853	-0.1032	-0.1321	-0.1345	-0.1060
O vs S10	-0.0917	-0.0048	-0.0494	-0.0087	-0.0953	-0.0574
S5 vs S10	0.8186 **	0.8118 **	0.7899 **	0.7981 **	0.7867 **	0.7940 **

* $P < 0.05$, ** $P < 0.01$.

Table 8. Correlation coefficients for age (A), operating time (O), and vibratory sense thresholds before (V_0) and 5 (V_5) and 10 (V_{10}) min after a cold provocation test (immersion in cold water).

Items	1978	1979	1980	1981	1982	1983
A vs O	0.3711 **	0.3579 **	0.3540 **	0.3565 **	0.3600 **	0.3570 **
A vs V_0	0.2885 **	0.3736 **	0.2210 **	0.2244 **	0.1949	0.1893 *
A vs V_5	0.2217 **	0.1589	0.1896 *	0.1543	0.0976	0.3061 **
A vs V_{10}	0.1773 *	0.2281 **	0.0770	0.0482	0.0219	0.2780 **
A vs V_0	0.1406	0.0383	0.0542	0.0868	0.0944	-0.0567
O vs V_5	0.0627	0.0315	0.0400	0.0464	0.0411	0.0927
O vs V_{10}	0.0091	-0.0415	0.0304	0.0156	-0.0366	0.0540
V_0 vs V_5	0.2781 **	0.2610 **	0.3011 **	0.2938 **	0.1584	0.2482 **
V_0 vs V_{10}	0.3029 **	0.3747 **	0.2629 **	0.2106 *	0.1633	0.3270 **
V_5 vs V_{10}	0.7953 **	0.6922 **	0.7449 **	0.7004 **	0.6911 **	0.8543 **

* $P < 0.05$, ** $P < 0.01$.

syndrome among 417 chain-saw workers was found to be 7.7 %. The peak duration of the operation time of the patients was from 11 to 15 years, and half the patients were over 50 years of age.

Of the 417 chain-saw workers, 155 were observed in special health examinations over a period of six years, apart from 32 patients with the hand-arm vibration syndrome. Their mean operation time for working the chain saws changed from 2 990 to 3 944 h over the six-year period after the official countermeasures had been taken in work conditions. They did not complain of any symptoms of the hand-arm vibration syndrome during this observation period.

Miyashita et al (12) have reported on the relationship between the progress of the vibration syndrome and the total chain-saw operating time among forestry workers. They showed that a group with 2 000 to 5 000 h of chain-saw operation had peripheral nerve and circulatory disturbances, including Raynaud's phenomenon, while even the group with less than 2 000 h of experience complained of tingling, numbness, or pain and that the group with over 5 000 h of exposure suffered severe functional, or organic changes owing to vibration. No special countermeasures to prevent the hand-arm vibration syndrome had been taken, however, until a special health examination was undertaken for an epidemiologic investigation.

Our results suggest that adequate countermeasures to restrict the operating time of chain saws and the age of the workers as shown in table 3 can completely prevent the hand-arm vibration syndrome even if the total operating time is appreciably lengthened.

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