

Vibration syndrome among Finnish forest workers, a follow-up from 1972 to 1983

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PYYKKÖ I, KORHONEN O, FÄRKILÄ M, STARCK J, AATOLA S, JÄNTTI V. Vibration syndrome among Finnish forest workers, a follow-up from 1972 to 1983. *Scand J Work Environ Health* 12 (1986) 307–312. A longitudinal survey on the prevalence of vibration syndrome among professional forest workers was conducted from 1972 (118 workers) to 1983 (206 workers). The prevalence of vibration-induced white finger (VWF) was 40 % among the workers in 1972; it gradually declined to 5 % in 1983. Three new workers developed VWF symptoms during the follow-up period. They had only used saws equipped with antivibration handles. The prevalence of VWF has decreased mainly due to the reduction of chain-saw vibration. The prevalence of paresthesias of the hands and arms declined from 78 % in 1972 to 37 % in 1976, and then increased to 51 % in 1983. The recent increase was thought to be due to static muscle load and the ageing of the workers. No correlation was found between the severity of VWF and peripheral nerve symptoms. No significant changes in muscle fatigue occurred during the follow-up period; it was present in about 10–15 % of the workers. The forest workers subjectively assessed musculoskeletal load and strain as being more harmful than the symptoms of vibration syndrome. The preventive measures aimed at reducing chain-saw vibration, implemented since 1970, have been beneficial and explain the decreased prevalence of VWF.

Key terms: longitudinal survey, muscle fatigue, numbness, vibration-induced white finger.

During the 1950s chain saws were heavy and clumsy to use, and their operation time was limited to 1–2 h a day (2). This short and interrupted operation seldom caused vibration-induced hazards in Finland. Chain saws became more practical in the early 1960s, and trees could also be limbed with a saw. Operation time increased to 4–5 h a day as a result (13, 15). Once a certain latency period had passed since the marketing of these saws began, there was an alarming increase in the number of Scandinavian forest workers with Raynaud's phenomenon. The prevalence of vibration-induced white finger (VWF) among Finnish forest workers in the late 1960s and early 1970s was 40–60 % (12, 15, 21). These figures corresponded with the findings of other studies conducted in the same period elsewhere in Scandinavia, as well as with those from Australia and England (5, 10, 13, 20, 24).

Since 1969 technical changes in the motors and the introduction of vibration damping devices have reduced the frequency-weighted vibration acceleration on the handles of chain saws from 10–20 m/s² to about 2–4 m/s² (17, 22, 25). Both our earlier reports from Finland (18, 19) and preliminary reports from England (25, 26) indicate that a significant decrease

in the prevalence of vibration syndrome was taking place, probably due to the decrease in chain-saw vibration.

A longitudinal survey was undertaken to determine the actual situation and changes in the prevalence of vibration syndrome from 1972 to 1983 among a stable population of Finnish forest workers. Reports from the survey have previously been published about the situation in 1972, 1975, and 1980 (15, 18, 19).

Subjects and methods

The investigation was made in connection with compulsory health examinations performed in northern Finland during the winters of 1972, 1975, 1977, 1978, 1979, 1980, 1981, and 1983. All forest workers (N = 118 to 217) supervised by the National Board of Forestry were examined. As the study focused on professional forest workers, only those who had used a chain saw for at least three consecutive years, for a minimum of 500 h per year, were included in the study. The age distribution and number of forest workers studied in different years are shown in table 1. In addition to the study of all the forest workers, the symptoms of vibration syndrome were evaluated among a subgroup of workers who participated in the study for the entire follow-up period.

Before the examination the forest workers completed a questionnaire on their state of health, use of medications, and symptoms of vibration syndrome. A medical history was recorded, and a physical examination was carried out, particular attention being paid to

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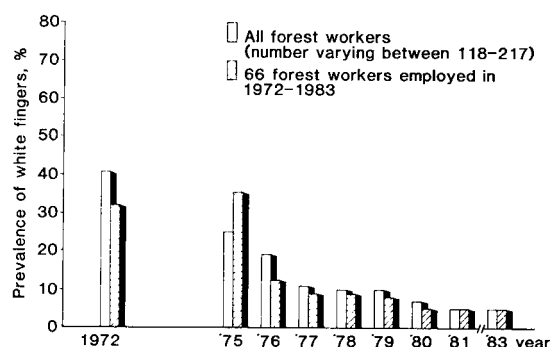
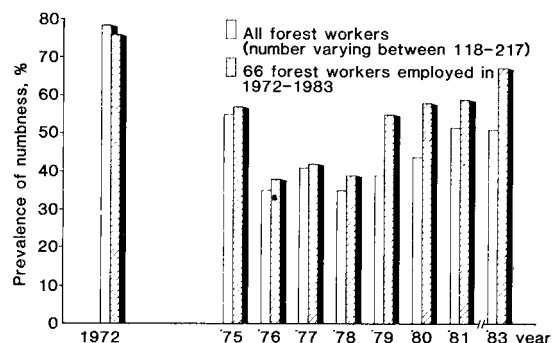
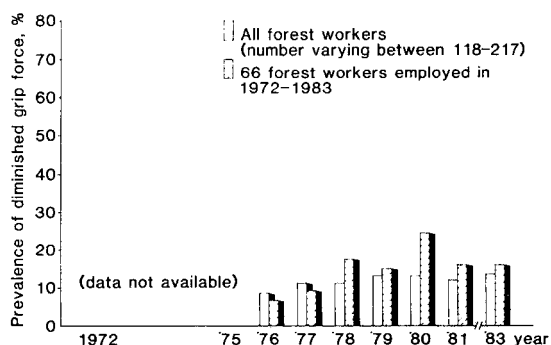
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Table 1. Age distribution of forest workers studied in different years.

Age (years)	Year of examination								
	1972	1975	1976	1977	1978	1979	1980	1981	1983
20—29	32	45	31	37	45	49	47	33	31
30—39	48	57	61	59	64	60	65	62	65
40—49	34	76	70	72	73	77	77	67	67
50—59	4	9	19	21	21	24	28	30	43
Total	118	187	181	189	203	210	217	192	206

**Figure 1.** Prevalence of vibration-induced white finger among forest workers in different years.**Figure 2.** Prevalence of numbness of the hands and arms among forest workers in different years.**Figure 3.** Prevalence of diminished grip force of the upper arms among forest workers in different years.

symptoms and signs of vibration syndrome. The same physician performed all the examinations. The subject was considered to be recovered if more than two years had passed since the last attack of VWF.

The severity of the symptoms of vibration syndrome was determined annually. In addition, for reference, symptoms linked to other major reasons for disability due to forest work were also recorded.

Two groups were formed. Group 1 comprised all the forest workers participating in the study from 1972 to 1983. Group 2 consisted of those 66 forest workers that participated in the study each year.

A cold provocation test was done for all the subjects with a history of white fingers and for a group of forest workers randomly selected each year (16).

The vibration produced by three different generations of chain saws was analyzed according to ISO/DIS 5349 (11). The first-generation chain saw was manufactured in 1958 and had no antivibration isolation. Such saws were still in general use at the end of the 1960s. The second-generation saw was manufactured in 1972 and represented the first chain saws with antivibration isolation. The third-generation saw was manufactured in 1982 and represented the most up-to-date chain saws in professional use.

Results

Vibration-induced white finger

In 1972, 52 of 118 forest workers had a history of Raynaud's phenomenon. For five subjects two years had elapsed without an attack of VWF. Thus the prevalence of VWF in 1972 was 40 % (95 % confidence limits 31–49 %). During the follow-up period the prevalence of VWF decreased consistently until 1977, after which it has remained about the same (figure 1). The prevalence of VWF among the 206 forest workers examined in 1983 was 5 %. Since 1972 only three new subjects have become disabled because of VWF. In one subject with somewhat peculiar VWF, the disorder turned out to be thoracic outlet syndrome. A reduction in the prevalence of VWF similar to that detected for the entire study group was also observed for the 66 forest workers followed for the full duration of the study period. (See figure 1.)

Numbing of the hands and arms

Numbing of the hands was a complaint of 78 % of the forest workers in 1972. It occurred more commonly in subjects with VWF than in those without ($\chi^2 = 4.27$, $p < 0.05$). Numbing of the hands started, on the average, one year later than the first attack of VWF. It had no connection with the severity of VWF, which was evaluated by means of an index value (15).

Numbing of the hands and arms was particularly common at night and was disturbing because it woke the subjects, some of them several times a night. At such times they were forced to rub and shake their hands. During the follow-up period a significant reduction in the prevalence of this symptom was also noticed (figure 2). However, since 1978 the prevalence of symptoms of numbing of the hands has slightly increased to about 51 % (44 % in 1980), a result which may be due to an increase in operation time. Paresthesias are more common among forest workers than could be expected among workers not exposed to vibration (23). The prevalence of numbness of the hands has increased more in the 66 workers followed throughout the study than in the total group of forest workers examined annually. (See figure 2.)

Muscle fatigue

Muscle fatigue has been analyzed systematically since 1975, the year we learned that this symptom is a part of the vibration syndrome. That year 36 (19.3 %) of all the forest workers had a history of excessive muscle fatigue. During the follow-up study only a slight increase was observed for this symptom, and in 1983 it was still present in 12 % of the forest workers. The extent of muscle fatigue was about the same in both groups of forest workers. Figure 3 shows the changes in such symptoms from 1976 to 1983.

Cold provocation test

A cold provocation test was done annually for all forest workers with a history of VWF. Figure 4 displays the percentage of positive test results for different years. For both groups of forest workers the curve displays a decreasing tendency that concurs with the decreasing prevalence of VWF.

Weakened occupational performance

All the forest workers' subjective assessments of disability due to various symptoms in 1976 and 1981 are shown in tables 2 and 3. We found a significant increase in the prevalence of numbing of the hands and arms which, however, was not reflected as an increase in weakened occupational performance or as a drop in wages. When compared with symptoms caused by strain or overloading of the musculoskeletal system (table 3) symptoms of the vibration syndrome (table 2) caused distinctly less interference with occupational performance. The forest workers rated health prob-

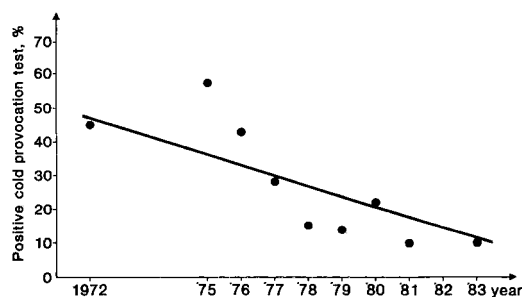


Figure 4. Percentage of positive cold provocation tests among forest workers in different years.

Table 2. Subjective assessment of weakened occupational performance due to symptoms of the vibration syndrome among all the forest workers examined in 1976 (N = 207) and 1981 (N = 192). The results are expressed as percentages of the total.

	White fingers		Diminished muscle force		Numbness	
	1976	1981	1976	1981	1976	1981
Symptom						
Not present	87	96	89	84	61	45
Present	13	4	11	16	39	55 **
Weakened occupational performance						
No	8	2	4	9	32	48 **
Slight	3	1	5	5	6	5
Considerable	2	1	2	2	1	2
Effect on wages						
Not essential	11	4 *	8	14	38	52 **
Essential	2	0	3	2	1	3

* $p < 0.05$, ** $p < 0.01$, χ^2 test, difference between 1976 and 1981.

Table 3. Subjective assessment of load and overstrain of the musculoskeletal system for the same forest workers as in table 2. The results are expressed as percentages of the total.

	Pain in the upper arms		Neck pain		Back pain	
	1976	1981	1976	1981	1976	1981
Symptom						
Not present	74	69	64	67	56	57
Present	26	31	36	33	44	43
Weakened occupational performance						
No	14	16	24	20	17	22
Slight	10	9	10	9	14	10
Considerable	2	6	2	4	13	11
Effect on wages						
Not essential	21	24	33	30	34	30
Essential	5	7	3	3	10	13

lems of the back as severe. The overall subjective assessments were similar among the subgroup of workers examined in both 1976 and 1981 (tables 4 and 5).

Vibration of the chain saws

The most vibration was measured in the chain saw manufactured in 1958 (figure 5). Evaluated according

to the guidelines in ISO/DIS 5349 (11), the weighted acceleration was 14 m/s² for the most harmful frequency component of 125 Hz (11). The weighted acceleration was much lower in the saw manufactured in 1972 (1.8 m/s²). The saw manufactured in 1982 had a

weighted acceleration of 2.4 m/s². The difference in weighted acceleration between the two latest saws was only 2 dB; evaluated with unweighted vibration, the difference was 6 m/s².

Discussion

The forest industry is extremely important to the economy of Finland. In 1966 there were 135 000 professional forest workers in this country (9). Technological advances and improved organization have reduced their number. At present (1985) there are only 25 000 economically active forest workers, but it is estimated that in 1990 there will still be about 20 000 (9).

Since the early 1970s the number of vibration-induced health hazards has been decreasing because of a decrease in the prevalence of vibration syndrome and because fewer men are working in forestry. In official records the decrease in the prevalence of vibration syndrome has become visible also in the number of verified cases of occupational diseases (figure 6). There are several reasons for the low number. Undoubtedly some are linked to the national economy, whereas others are due to the poor validity of the objective tests used to detect vibration syndrome and to the minor degree of disability caused by vibration syndrome.

An additional study was made in 1975 in order to verify that the changes in prevalence observed in the rather limited group of forest workers in Suomussalmi was representative of the changes for all of Finland (19). A total of 501 forest workers living in different parts of the country were examined. According to the self-administered questionnaires, VWF was present in 40 % of the 501 forest workers in 1975. The majority of responses from the subjects with VWF indicated that a highly significant decrease had occurred in their subjectively assessed symptoms of this disease over the last few years. Thus the decreased prevalence of VWF observed in the present survey is representative of the changes among forest workers throughout Finland.

Table 4. Subjective assessment of weakened occupational performance due to various symptoms of vibration syndrome among the 145 forest workers examined in both 1976 and 1981. The results are expressed as percentages of the total.

Symptom	White fingers		Diminished muscle force		Numbness	
	1976	1981	1976	1981	1976	1981
Not present	91	95	93	86	65	45
Present	9	5	7	14	35	55**
Weakened occupational performance						
No	6	3	3	9	30	48**
Slight	2	1	3	3	4	5
Considerable	1	1	1	2	1	2
Effect on wages						
Not essential	8	5	6	12	35	52**
Essential	1	0	1	2	0	3

* $p < 0.05$, ** $p < 0.01$, χ^2 test, difference between 1976 and 1981.

Table 5. Subjective assessment of load and overstrain of the musculoskeletal system for the same forest workers as in table 4. The results are expressed as percentages of the total.

Symptom	Pain in the upper arms		Neck pain		Back pain	
	1976	1981	1976	1981	1976	1981
Not present	78	70	63	64	59	57
Present	22	30	37	36	41	43
Weakened occupational performance						
No	12	14	27	21	15	20
Slight	9	9	8	10	15	11
Considerable	1	7	2	5	11	12
Effect on wages						
Not essential	20	22	35	32	35	29
Essential	2	8*	2	4	6	14

* $p < 0.05$, χ^2 test, difference between 1976 and 1981.

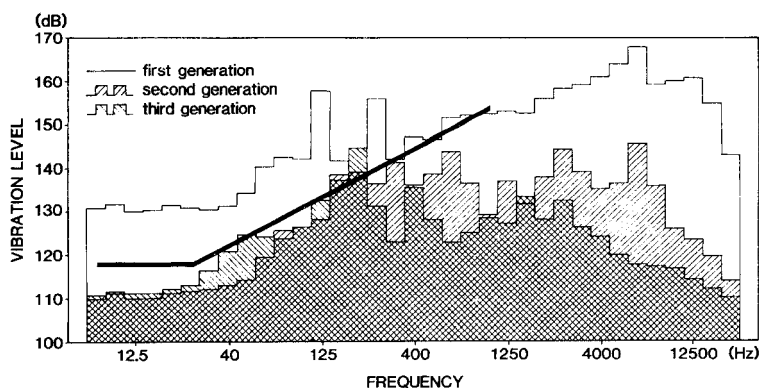


Figure 5. Vibration acceleration of chain saws in 1958, 1972, and 1980 (dB re 10⁻⁶ m/s²).

There is still some controversy as to whether or not vibration syndrome is reversible. Agate (1) reported that, in some workers, VWF was first seen some months after they had left a job with vibrating tools. In workers already having VWF, vascular disturbances showed a tendency to progress rather than to disappear after the cessation of work. Other evidence, however, favors the view that VWF is reversible. Steward & Goda (23) reported that, five years after the cessation of vibration-exposure, 30 % of the subjects no longer experienced attacks of VWF. A follow-up of forest workers operating chain saws in Sweden showed that the prevalence of VWF had decreased from 60 % in 1970 to 5–10 % in 1983 (Gemne, personal communication). In England, a similar study indicated that, in recent years, VWF has become significantly less severe among forest workers, but not to the same extent as in Scandinavia (25, 26). A prolonged period of time is required before the pathological reactivity of the vessel subsides (14, 16), and the structural changes of the vessel walls regress (3, 8, 27). In the forest workers of the present study, this recovery period has been very similar to the length of the latency period.

One factor which has had a favorable effect on the course of VWF is the increased use of heated transportation between home and the worksite in the forest, and also during leisure-time trips. If the men who formerly experienced attacks of VWF while riding to and from work on motorcycles would resume riding motorcycles, they would probably start experiencing attacks of VWF again. This claim is supported by the finding of a positive cold provocation test for men who had not had a single attack of VWF for several years (16). Thus some of these men are not really "recovered." Instead they have merely stopped "experiencing attacks," and it is probable that under other conditions they would still suffer from VWF.

The prevalence of extensive muscle fatigue in the hands and arms of forest workers, which ranged from 7 to 19 % of the subjects, indicated that occupational exposure to vibration can cause inadequate muscle contraction (18). Bannister & Smith (4) showed that the use of vibrating tools is associated with a significant decrease in manipulative dexterity, and so it seems possible that muscular weakness is at least partly due to a disturbance of the fine control of the muscles of the hands. Furthermore, Färkkilä (6) and Färkkilä et al (7) objectively demonstrated that exposure to vibration causes a significant decrease in muscle force in the hands and that the decrease is more advanced in subjects with a history of muscle weakness.

Very often, however, the same subjects who displayed extensive symptoms of peripheral neuropathy also had significantly decreased muscle force in the test. When both muscle force and nerve conduction velocity were measured in a separate study, a correlation was found between decreased muscle force and slowed nerve conduction velocities (Pyykkö et al, unpublished

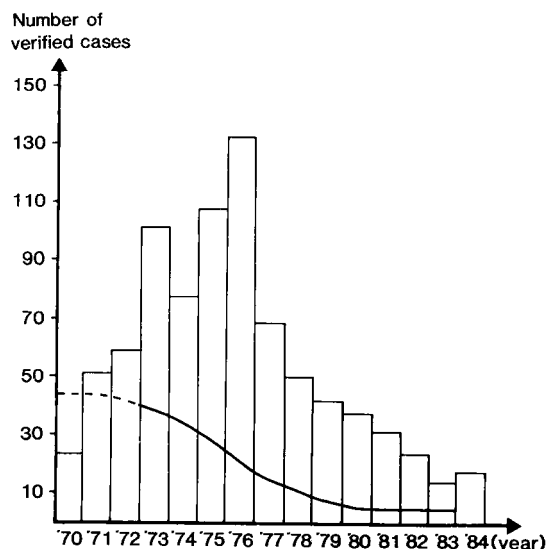


Figure 6. Number of cases of vibration syndrome newly verified as an occupational disease in different years (bars). (The prevalence (%) of vibration-induced white finger is shown by a broken (prevalences determined retrospectively) and unbroken (prevalences determined during the survey) line.)

observation). Hence it seems likely that degeneration in the nerves innervating the muscles is the immediate cause for the complaint of excessive muscle fatigue.

Both the prevalence of muscle fatigue and the high prevalence of numbing of the hands and arms decreased slightly among the forest workers studied. An external factor affecting the development of muscle fatigue was the slight decrease in workhours. The annual chain-saw operating time was reduced from 1 300 h in the early 1970s to 1 100 h in the late 1970s, and increased again to 1 300 h in the early 1980s. Furthermore, it is possible that ageing prevents the detection of full recovery from the symptoms themselves.

Conclusion

The spread in the use of chain saws that occurred in the 1960s caused a gradual increase in the prevalence of VWF among forest workers in Finland. The latency period for VWF was about five years. In Finland the highest morbidity was reached in 1970. In 1972, 40 % of the forest workers in one forestry district had VWF, but in the follow-up study in 1980 the prevalence had decreased to 5 %. A similar peak and a similar decrease in prevalence were also observed for numbness of the hands and arms.

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