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CORRELATIONS AMONG EXAMINATION FINDINGS, SUBJECTIVE SYMPTOMS AND CLASSIFICATION OF STAGES IN VIBRATION SYNDROME

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ABSTRACT

From data collected in 1966, 1973, 1986 and 1989, we analyzed the correlations among examination findings, subjective symptoms, stages in the disorder of vibration syndrome and vibration exposure. As vibration syndrome progressed and vibration exposure accumulated, abnormality of examination findings, the prevalence of vibration induced white finger (VWF), numbness (N) and other subjective symptoms increased. Abnormality of examination findings and prevalence of subjective symptoms in the VWF(+) N(+) group were greatly different from those in the VWF(−) N(−) group. Both findings and symptoms showed closer correlations with VWF(+) than with N(+). Stages in the disorder traced the progression from VWF(−)N(−) to VWF(−)N(+), then to VWF(+)N(+/−), and finally to VWF(+/++)N(+/++). Pathophysiologically, it seems that VWF(+) and N(+) relayed many more cold and pain signals from the hand to the central nervous system. Such signals may activate autonomic nervous activity.

In the recovery, subjective symptoms correlated more closely with N(+) than with VWF(+). This is because VWF involves the autonomic nervous system's hyperactivity and hypersensitivity to cold, both of which subside gradually in the recovery; N, however, involves pathological changes in nerve tissue which are irreversible.

Key Words: Vibration syndrome, Progress, Recovery, Stage

INTRODUCTION

Vibration syndrome is influenced by many factors, particularly by vibration exposure. However, from clinical observations on the progress of the disorder, the presence of VWF seems to be a more important factor than vibration exposure in the appearance of subjective symptoms and abnormalities in our examination findings. In the recovery, pain and numbness play a significant role in delaying recovery. We examine such correlations based on data collected during our extended surveys.

METHODS

Physical examination and investigation of subjective symptoms

Physical examinations and investigations of subjective symptoms were undertaken in 1966, 1973 and 1986. A further investigation of subjective symptoms was made in 1989. The following factors were examined. 1. Peripheral circulation via skin temperature and nail press test. 2.

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Raynaud's phenomenon. 3. Peripheral sensation threshold levels via pain and vibratory sensation. 4. Grasping power. 5. Hearing levels. Subjective symptoms were identified by use of a questionnaire interview. In 1988, a survey scored subjective complaints according to the severity of symptoms in which 0 = none, 1 = slight, 2 = moderate and 3 = severe, and circulatory disturbances as subjective symptoms according to the frequency of VWF attacks in which 0 = none, 1 = cold in hand without VWF, 2 = occasional attacks, and 3 = frequent attacks.

Subjects

The subjects in the 1966 test were 224 chain saw operators in the national forests, in the 1973 test 515 chain saw operators in private forests, and in the 1986 test 340 chain saw and pneumatic hammer operators in private enterprises.

372 of 515 operators in the 1973 test ranged in age from 30 to 59. 372 were divided into three groups based on years of chain saw operation: under 5 years; 5 to 9 years; and 10 years or more. These groups contained 85, 151, and 136 workers, respectively. (Table 1)

Subjects in each year tested were divided into four groups. Each group included four characteristic types: VWF(+)N(+); VWF(+)N(−); VWF(−)N(+); and VWF(−)N(−). The VWF(+) type included sufferers of occasional and frequent VWF attacks (VWF+ and VWF++) and N(+) type included those with mild and severe cases of numbness (N+ and N++). Then subjects in each VWF-N group were matched in age and years of operation: 38 pairs in the 1996 test (total 152), 36 in the 1973 (total 144), 28 or 28×2 (=56) in the 1986 (total 168). (Table 2,3,4)

In the 1989 test, 2619 national forest workers registered with occupational vibration syndrome were diagnosed. The mean elapsed time since all had ceased chain saw operation ranged from 15 to 17 years. Two groups were formed: a retired workers group of 1233 men in their sixties; the other of 960 active workers in their fifties (for a total 2193 subjects). Each of these groups was comprised of four subgroups; VWF(+)N(+); VWF(+)N(−); VWF(−)N(+); and VWF(−)N(−). The VWF(+) workers included both frequent (++) and severe (+) sufferers of VWF, while the N(+) workers experienced severe (++) and mild (+) numbness and tingling.

Another division of the total 2193 in 1989 subjects was made comprising three N groups [severe (++), moderate (+) and non-sufferers(−)], and two age groups (50- and 60-year-old) (Table 5).

RESULTS

Table 1 shows the results analysed in terms of years of chain saw operation. There were three groups: under 5 years; 5 to 9 years; and over 10 years. Mean age in each group was 42.7 to 43.2 years. The difference in mean age was not significant. However, in those over 10 years, the difference in vibratory sensation was significant. There was also a significant difference in the prevalence of VWF between those over 10 years and those 5 to 9 years. And, finally, the degrees of numbness and tingling, hypersensitivity to cold, forgetfulness, feeling of heavy headedness and irritability were significant in the over 10 year group.

Table 2 to 4 show results of examinations and subjective symptoms in four VWF-N groups in the 1966, 73, 86 test. Differences of age and years of operation of workers in each VWF-N group in each year test were not significant. Abnormalities observed in examination results and prevalence of subjective symptoms in each year test occurred in the descending order of: VWF(+)N(+); VWF(+)N(−); VWF(−)N(+); and VWF(−)N(−). This suggested that VWF is an important factor for progress.

Table 1. Years of operation, examination results and subjective symptoms of chain saw operators in private forests (1973)

Chain saw operation	over 10 years	5 ~ 9 years	below 5 years
Number of chain saw operators	136	151	85
Mean age	42.7 ± 7.4	43.2 ± 7.7	43.2 ± 8.5
Years of chain saw operation	11.7 ± 2.2	6.7 ± 1.3	2.7 ± 1.2
VWF	**79 (58.1%)	**82 (54.3%)	24 (28.2%)
Physical examination			
Skin temperature (°C)	29.9 ± 4.0	29.3 ± 4.2	29.3 ± 3.8
Skin temperature (5 min. after cooling)	21.4 ± 5.4	20.3 ± 5.2	20.8 ± 5.1
Skin temperature (10 min. after cooling)	25.9 ± 5.0	24.8 ± 5.0	25.4 ± 5.0
Nail press test (seconds)	2.5 ± 1.1	2.5 ± 1.2	2.4 ± 1.0
Pain sensation (g)	14.9 ± 10.6	14.5 ± 10.9	14.8 ± 10.0
Pain sensation (after cooling)	20.6 ± 11.4	19.3 ± 11.7	19.0 ± 10.0
Vibratory sensation (dB)	**15.6 ± 9.0	13.2 ± 2.7	11.8 ± 7.1
Vibratory sensation (after cooling)	25.7 ± 10.1	24.0 ± 10.5	23.2 ± 10.3
Grasping power (kg)	43.4 ± 8.6	44.0 ± 7.8	43.8 ± 8.0
Subjective symptoom			
Numbness	**84 (61.8%)	66 (43.7%)	34 (40.0%)
Hypersensitivity to cold	**53 (39.0%)	46 (30.5%)	19 (22.4%)
Difficulty in fine finger movement	24 (17.6%)	17 (11.3%)	8 (9.4%)
Fatigue	**68 (50.0%)	62 (41.1%)	26 (30.6%)
Forgetfulness	**49 (36.0%)	34 (22.5%)	16 (18.8%)
Sleep disturbance	32 (23.5%)	35 (23.2%)	12 (14.1%)
Hyperperspiration	24 (17.6%)	26 (17.2%)	10 (11.8%)
Heavy headedness	**31 (22.8%)	21 (13.9%)	6 (7.1%)
Tinnitus	31 (22.8%)	30 (19.9%)	12 (14.1%)
Irritability	**27 (19.9%)	13 (8.6%)	3 (3.5%)

**, * : $p < 0.01$, $p < 0.05$

The differences between VWF(−)N(−) and the other groups were statistically significant ($p < 0.01$ or $p < 0.05$) in the following items. In the 1966 test: skin temperature in VWF(+)N(+); nail-press test in VWF(+); vibratory and pain sensation in VWF(+) and N(+); hearing level in VWF(+); and grasping power in VWF(+)N(+) ($p < 0.01$ or $p < 0.05$). (Table 2)

In the 1973 test: skin temperature in VWF(+); nail-press test value in VWF(+) and VWF(−)N(+); threshold of pain sensation in VWF(+); and hypersensitivity to cold, difficulty in fine finger movement, fatigue, sleep disturbance and headache in VWF(+)N(+). (Table 3)

In the 1986 test: skin temperature and vibratory sensation in VWF(+)N(+), pain sensation in fingers and feet in N(+) and VWF(+)N(−); hypersensitivity to cold in VWF(+) and feelings of heavy headedness and tinnitus in VWF(+)N(+). (Table 4)

Table 5 shows investigation results into subjective symptoms in the 1986 survey of 2193 workers who had long since ceased to operate chain saws. These results show the characteristic profile of subjective symptoms in recovery. The results of each subgroup were compared with

Table 2. VWF, N, and examination results of chain saw operators in national forests (1966)

	VWF(+)N(+)	VWF(+)N(−)	VWF(−)N(+)	VWF(−)N(−)
VWF	++ or +	+	−	−
Numbness	++ or +	−	+	−
Number	38	38	38	38
Mean age	40.9 ± 5.5	40.3 ± 5.9	40.3 ± 6.0	40.2 ± 5.9
Years of chain saw operation	6.3 ± 2.2	6.6 ± 1.8	7.4 ± 2.0	7.0 ± 1.5
Physical examination (at 18 to 19 C)				
Skin temperature (°C)	**26.0 ± 3.5	26.7 ± 3.1	26.4 ± 4.0	27.9 ± 3.4
Skin temperature (after cooling)	*23.9 ± 4.5	24.3 ± 3.8	25.2 ± 4.8	26.3 ± 4.1
Nail press test (seconds)	*2.6 ± 1.5	*2.4 ± 0.9	1.8 ± 0.9	2.0 ± 0.8
Nail press test (after cooling)	*3.7 ± 2.3	**3.5 ± 1.8	2.6 ± 1.3	2.7 ± 1.1
Vibratory sensation	**2.7 ± 1.0	**2.5 ± 0.9	2.5 ± 2.2	1.9 ± 0.7
Vibratory sensation (after cooling)	**5.2 ± 3.3	*4.0 ± 2.5	*4.2 ± 2.7	3.0 ± 1.7
Pain sensation (g)	**3.2 ± 2.7	**2.8 ± 2.1	*3.5 ± 5.8	1.3 ± 2.0
Pain sensation (after cooling)	**6.9 ± 6.4	*5.2 ± 4.6	4.9 ± 6.4	2.7 ± 4.4
Hearing level (dB)	**30.8 ± 13.2	**36.6 ± 16.6	32.8 ± 15.3	26.4 ± 15.5
Grasping power (kg)	*39.7 ± 6.4	40.5 ± 6.4	40.7 ± 5.8	42.2 ± 5.6

VWF +: occasional VWF attacks VWF ++: frequent VWF attacks
N +: mild numbness and tingling N ++: severe numbness and tingling

Table 3. VWF, N, examination results and subjective symptoms of chain saw operators in private forests (1973)

	VWF(+)N(+)	VWF(+)N(−)	VWF(−)N(+)	VWF(−)N(−)
VWF	++ or +	+	−	−
Numbness	++ or +	−	+	−
Number	36	36	36	36
Age	42.6 ± 5.8	42.7 ± 5.6	42.2 ± 6.3	43.2 ± 6.1
Years of chain saw operation	7.9 ± 2.7	7.9 ± 2.7	8.0 ± 2.7	8.0 ± 2.7
Physical examination				
Skin temperature (10 min. after cooling (°C))	**23.6 ± 5.8	**23.6 ± 4.9	26.7 ± 4.6	26.3 ± 4.1
Nail press test (after cooling) (seconds)	**4.6 ± 2.2	**4.7 ± 3.0	**3.9 ± 2.5	3.1 ± 1.4
Vibratory sensation (dB)	15.4 ± 8.6	13.5 ± 8.2	13.8 ± 7.1	13.3 ± 8.4
Vibratory sensation (after cooling)	26.4 ± 10.9	25.5 ± 10.3	22.8 ± 7.1	22.7 ± 8.6
Pain sensation (after cooling) (g)	*21.8 ± 11.0	*21.2 ± 11.6	18.3 ± 11.7	15.7 ± 10.5
Grasping power (kg)	42.6 ± 7.6	43.7 ± 7.1	45.1 ± 6.3	45.1 ± 6.7
Subjective symptom				
Hyper sensitivity to cold	*14 (38.9%)	10 (27.8%)	8 (22.2%)	4 (11.1%)
Difficulty in fine movement of finger	*8 (22.3%)	4 (11.1%)	5 (13.9%)	1 (2.8%)
Fatigue	*22 (61.1%)	14 (38.9%)	16 (44.4%)	11 (30.6%)
Forgetfulness	8 (22.2%)	10 (27.8%)	12 (33.3%)	8 (22.2%)
Sleep disturbance	*12 (33.3%)	9 (25.0%)	9 (25.0%)	3 (8.3%)
Hyper perspiration	8 (22.2%)	5 (13.9%)	14 (38.9%)	3 (8.3%)
Heavy in headedness	8 (22.2%)	3 (8.3%)	9 (25.0%)	3 (8.3%)
Headache	*6 (16.7%)	2 (5.6%)	6 (16.7%)	3 (8.3%)
Irritability	8 (22.2%)	4 (11.1%)	6 (16.7%)	2 (5.6%)
Tinnitus	12 (33.3%)	7 (19.4%)	6 (16.7%)	6 (16.7%)

VWF +: occasional VWF attacks VWF ++: frequent VWF attacks
N +: mild numbness and tingling N ++:severe numbness and tingling

Table 4. VWF, N, examination results and subjective symptoms of chain saw and chipping hammer operators in private forests and stone quaries (1986)

	VWF(+)N(+)	VWF(+)N(−)	VWF(−)N(+)	VWF(−)N(−)
VWF	++ or +	+	−	−
Numbness	++ or +	−	+	−
Number	56	28	56	28
Age (in years)	56.0 ± 5.6	56.4 ± 5.1	55.7 ± 5.7	54.8 ± 6.3
Experience year of chain saw or chipping hammer operation	20.7 ± 7.7	21.6 ± 7.1	20.4 ± 7.0	20.3 ± 8.1
Physical examination				
Skin temperature (°C) (after cooling)	*16.8 ± 2.1	17.1 ± 2.1	18.6 ± 2.1	17.9 ± 2.3
Vibratory sensation (dB)	*12.4 ± 9.9	6.6 ± 8.6	9.4 ± 8.3	6.9 ± 9.8
Pain sensation (g) (in finger)	**9.5 ± 7.6	9.3 ± 8.6	**10.3 ± 8.8	4.5 ± 5.8
Pain sensation (g) (in foot)	**5.5 ± 6.6	*4.5 ± 4.6	**6.1 ± 7.1	2.4 ± 2.8
Hearing level (dB)	53.8 ± 19.0	44.8 ± 17.5	45.2 ± 21.3	47.2 ± 28.5
Subjective symptom				
Hyper sensitivity to cold	**15 (26.8)	**8 (28.6)	8 (14.3)	0 (0.0)
Forgetfulness	16 (28.6)	4 (14.3)	16 (28.6)	4 (14.3)
Sleep disturbance	8 (14.3)	3 (10.7)	4 (7.1)	1 (3.6)
Hyper perspiration	12 (21.4)	3 (10.7)	7 (12.5)	5 (17.9)
Heavy feeling in head	*8 (14.3)	0 (0.0)	2 (3.6)	0 (0.0)
Tinnitus	*13 (23.2)	4 (14.3)	11 (19.6)	1 (3.6)
Irritability	8 (14.3)	1 (3.6)	6 (10.7)	2 (7.1)

VWF +: occasional VWF attacks VWF ++: frequent VWF attacks
N +: mild numbness and tingling N ++: severe numbness and tingling

VWF(−)N(−). Difference in age and years of operation of each group were not significant. The prevalence of subjective symptoms (stiff shoulders, fatigue, irritability and feelings of heavy headedness) remained higher (in descending order) in: VWF(+)N(+); VWF(−)N(+); VWF(+)N(−), and VWF(−)N(−). This descending order was different from that in progress, suggesting that N is an important factor in delayed recovery.

It was noticable that the prevalence of VWF remained higher in the sixties age group (40%) than in the fifties (21%), while the prevalence rate of numbness and tingling remained 24.1% in the sixties as well as 20.7% in the fifties group.

Significance of N appeared in Table 6 as well. This table shows the mean score of each group according to age and severity of numbness among 2193 patients. Difference of age at operation in the beginning and at present, and years of chain saw operation between N(−) group and the other groups in each age group were not significant. The mean score of subjective symptoms in each N group was higher in descending order of: N(++); N(+); N(−). The score related to subjective symptoms in the upper extremities (pain in the hands, stiffness in the shoulders) was over 2.0 in N(++) group, and ranged from 2.0 to 1.5 in N(+) group in both the 50- and 60-year age brackets. The score of subjective symptoms related to the central nervous system (sleep disturbances, irritability, tinnitus) ranged from 2.0 to 1.5 in the N(++) group in both age categories.

Table 5. VWF, N, and subjective symptoms of current and retired workers recognized as occupational vibration disease patients (2,193) over 10 years after stopping chain saw operation in national forests (1989)

	50-VWF(+)N(+)	50-VWF(+)N(−)	50-VWF(−)N(+)	50-VWF(−)N(−)
VWF	++ or +	+	−	−
Numbless	++ or +	−	+	−
Number	77	202	122	559
Mean age	55.9 ± 2.3	56.8 ± 1.6	55.7 ± 2.5	55.5 ± 2.6
Years of chain saw operation	10.6 ± 4.6	9.5 ± 4.6	10.1 ± 4.1	10.0 ± 4.4
Years after stopping vibration exposure	15.7 ± 4.8	*17.0 ± 4.8	15.8 ± 4.0	16.0 ± 3.8
Subjective symptoms				
Stiffness in shoulder	**44 (57.1%)	41 (20.3%)	**73 (59.8%)	90 (16.1%)
Fatigue	**31 (40.3%)	12 (5.9%)	**36 (29.5%)	32 (5.7%)
Tinnitus	**16 (20.8%)	17 (8.4%)	**31 (25.4%)	39 (7.0%)
Irritability	**23 (29.9%)	4 (2.0%)	**26 (21.3%)	11 (2.0%)
Heavy headedness	**18 (23.4%)	13 (6.4%)	**20 (16.4%)	32 (5.7%)

	60-VWF(+)N(+)	60-VWF(+)N(−)	60-VWF(−)N(+)	60-VWF(−)N(−)
VWF	++ or +	+	−	−
Numbness	++ or +	−	+	−
Number	163	330	134	606
Mean age	64.1 ± 2.7	64.0 ± 2.7	64.2 ± 2.8	63.8 ± 2.6
Years of chain saw operation	9.4 ± 4.4	9.5 ± 4.4	10.0 ± 4.2	10.1 ± 4.3
Years after stopping vibration exposure	17.3 ± 4.8	17.5 ± 4.3	16.4 ± 4.0	16.8 ± 4.2
Subjective symptoms				
Stiffness in shoulder	**84 (51.5%)	*63 (19.1%)	**62 (46.3%)	82 (13.5%)
Fatigue	**52 (31.9%)	25 (7.6%)	**35 (26.1%)	28 (4.6%)
Tinnitus	**51 (31.3%)	*47 (14.2%)	**38 (28.4%)	58 (9.6%)
Irritability	**30 (18.4%)	12 (3.6%)	**17 (12.7%)	14 (2.3%)
Heavy headedness	**35 (21.5%)	15 (4.6%)	**20 (14.9%)	29 (4.8%)

VWF +: occasional VWF attacks VWF ++: frequent VWF attacks

N +: mild numbness and tingling N ++: severe numbness and tingling

Difference of mean score for each subjective symptom between both the 50- and 60-year age group were almost the same.

Table 6. Data on subjective symptoms of 2,193 patients in national forests (1989)

	60s-N++	60s-N+	60s-N−	50s-N++	50s-N+	50s-N−
No. (Total=2,193)	297	655	281	199	469	292
Numbness & tingling	++	+	−	++	+	−
VWF & cold	2.1	1.6	1	1.6	1.4	0.9
Age	64.2	63.9	63.7	55.8	55.8	55.5
Age (at beginning of operation)	37.5	36.7	36.6	29.8	29.8	29.1
Years of chain saw operation	9.7	10.0	9.5	10.3	10.0	9.4
Subjective symptoms						
Pain in arm	●2.7	○1.8	1.1	●2.7	○1.9	1.0
Stiffness in shoulder	●2.3	○1.7	1.2	●2.4	○1.8	0.2
Fatigue	●2.0	○1.5	0.9	●2.1	○1.5	0.8
Pain in back	●2.0	○1.6	1.0	○1.9	○1.6	1.1
Hypesthesia	○1.9	1.4	0.5	○1.8	1.2	0.3
Sleep disturbance	○1.8	1.2	0.6	○1.8	1.2	0.5
Irritability	○1.5	1.1	0.4	○1.6	1.0	0.4
Tinnitis	○1.6	1.3	0.8	○1.5	1.1	0.7
Hearing disturbance	○1.7	1.3	0.8	1.3	1.0	0.6
Heavy headedness	1.4	0.9	0.4	1.4	0.9	0.5

Numbness & tingling;
+: mild,
++: severe

Score of VWF & cold:
0: none,
1: cold without VWF,
2: occasional VWF attacks,
3: frequent VWF attacks

Score of subjectie symptom;
0: none,
1: slight,
2: mild,
3: severe

DISCUSSION

The earlier-reported[1,2] dose-response correlations between symptoms and vibration exposure were the same as shown in Table 1. It is clear epidemiologically that long term vibration increases abnormality in examination results and preavalence of subjective symptoms.

Clinically among groups matched by age and years of vibrating tool operation, VWF and N show a close correlation with abnormality in examination findings and prevalence of subjective symptoms, as shown in Tables 2, 3, and 4. Such changes were notable in the descending order of VWF(+)N(+), VWF(+)N(−), and VWF(−)N(+), as compared to VWF(−)N(−).

Abnormality in sensorineural function appears in VWF(−)N(+), while in circulatory function it appears in VWF(+)N(−). Such abnormality has a high incidence in VWF(+)N(+). Muscle function disorder appears only in severe cases.

Subjective symptoms are localized in the hand and arm in the early stage. It is clear that numbness and tingling (N) are the first signs of vibration syndrome. The presence of VWF plays an especially important role in the appearance of subjective symptoms. As the severity of VWF and N increases, hypersensitivity to cold, sleep disturbance, feelings of heavy headednesss and tinnitus appear. In recovery, as shown in the 1989 test, VWF(+)N(+) and VWF(−)N(+), i.e., the N(+) group showed a high prevalence of fatigue, stiff shoulders, tinnitus, irritability and feelings of heavy headedness. The presence of numbness and tingling in the hand and arm was more significant than VWF in the recovery phase.

In discussing the pathophysiological features of vibration syndrome, many researchers have noted the presence and significance of its subjective symptoms.[7-10] These studies demonstrated that subjective symptoms related to the central nervous system are clearly present in VWF(+)N(+) during the progress and in N(+) during the recovery.

These results suggest the following evolution in the progression of vibration syndrome. The first stage of vibration is VWF(−)N(−), and the second is VWF(−)N(+) or VWF(+)N(−). Workers with hypersensitivity to vibration and cold suffer VWF, i.e. VWF(+)N(−). The third is VWF(+)N(+) and the forth is severe VWF(+)N(+) containing VWF++ and N++.

"Taylor & Pelmear's Classification of the Stages of Vibration Syndrome" appeared in Europe in 1968, and was replaced by the Stockholm Classification[3,4] in 1986. The former work looked into the "Condition of Digits" (VWF, numbness and tingling) and "Work and Social Interference"; the later made a distinction between vascular and neurological components in the "Condition of Digits," and went on to describe the "Classification of Cold-Induced Raynaud's Phenomenon and the "Classification of Sensorineural Affects" ("Work and Social Interference" was deleted). Our description is characteristic in its combination of grades of VWF and N.

Why is there more abnormality in examination findings and prevalence rate of subjective symptoms in workers with VWF(+)N(+) in progress? Why is there a higher prevalence rate of subjective symptoms in patients with N++ or N+ in the recovery?

In the disease progression, long-term vibration exposure elevated the activity of the blood vessel walls and autonomic nervous system to cold, and these effects promoted vasoconstriction of peripheral blood vessels and a drop in skin temperature, whereas a direct effect of vibration exposure and circulatory disturbance caused peripheral nervous disturbances. Cold signals due to low skin temperature and VWF, and pain and/or numbness signals due to peripheral nervous disturbances from the hand to the central nervous system, may mediate the activity of the autonomic nervous system. Such repeated, long-term feedback is characteristic of vibration syndrome. In 1990, Nakamoto et al.[11] reported a marked increase in plasma NA concentration following exposure to cold among workers with VWF and numbness. This suggests that long-term cold and pain signal activate autonomic nervous system reacting to the cold exposure.

It is noteworthy that Tables 2, 3, and 4 show some workers with VWF(+)N(+) and others with VFW(−)N(−), although their ages and years of tool operation were the same. This suggests the existence of individual differences in sensitivity to vibration and cold.

CONCLUSIONS

Our investigation into the correlations among examination findings, subjective symptoms, stages in progress of vibration syndrome and vibration exposure in surveys conducted over the years may be summarized as follows:

1. As the use of vibration tools proliferated, there was a corresponding increase in the prevalence of VWF and numbness as well as other symptoms related to the extremities and the central nervous system. 2. In the progression of the disorder among workers of the same age and with equal years of tool operation, changes in examination findings and subjective symptoms appeared at a clearly higher rate in VWF(+)N(+) and a slightly higher rate in VWF(+)N(−) as compared to VWF(−)N(−). 3. In the recovery, long after the cessation of vibration exposure, subjective symptoms remained at a higher rate in N(+) than in VWF(+). 4. The progress of vibration syndrome was tracked from VWF(−)N(−) to VWF(+ or −)N(+ or −) and, finally, to VWF(+ or ++)N(+ or ++). 5. The reason why changes in examination findings and subjective symptoms appear so markedly in VWF(+)N(+) may relate to the hyperactivity of the auton-

omic nervous system mediated by the long-term combined effects of vibration, cold and pain signals.

REFERENCES

1) Miyashita, K., Shimoi, S., Itoh, N., Kasamatsu, T. and Iwata, T.: Epidemiological study of vibration syndrome in responses to total hand-arm operating time. *Br. J. Ind. Med.*, 40, 92–98 (1983).
2) Suzuki, H. and Iwasaki, S.: Effects of the reduction of vibration intensity of chain saws on the prevalence rates of vibration syndrome among forestry workers. *Sangyou. Igaku.*, 32,1, 18–25 (1990).
3) Pelmear, P.I. and Taylor, W.: Clinical picture (Vascular, Neurological, and Musculoskeletal). In *Hand-Arm Vibration, Comprehensive Guide for Occupational Health Professionals.* pp.26–40 (1992), Van Nostrand Reinhold, New York.
4) Brammer, A.J., Taylor, W. and Piercy, J.E.: Assessing the severity of the neurological component of the hand-arm vibration syndrome. *Scand. J. Work Environ. Health,* 12 (4 Spec No), 428–431 (1986).
5) Futatsuka, M., Ueno, T. and Sakurai, T.: Follow up study of vibration induced white finger in chain saw operators. *Br. J. Ind. Med.*, 42 (4), 267–271 (1985).
6) Futatsuka, M., Inaoka, N. and Ueno, T.: Validity of function tests on the upper extremities in established a prognosis in vibration syndrome. *Ind. Health,* 28 (2), 41–52 (1990).
7) Yamada, S.: Vibration hazards in Japan. *Proc XVI Int. Congr. Occup. Health,* pp.139–140 (1969), ICOH, Tokyo.
8) Matoba, T., Kusumoto, H., Mizuki, Y., Kuwahara, H., Imanaga, K. and Takamatsu, M.: Clinical features and laboratory findings of vibration disease, a review of 300 cases. *Tohoku J. Exp. Med.*, 123, 57–65 (1977).
9) Futatsuka, M., Takamatsu, M. and Sakurai, T.: Vibration hazards in forestry workers of the chain saw operators of a determined area in Japan. *J. Sci. Labour (part II),* 56, 27–48 (1980).
10) Burdorf, A. and Monster, A.: Exposure to vibration and self-reported health complaints of riveters in the aircraft industry. *Ann. Occup. Hyg.*, 35 (3), 287–298 (1990).
11) Nakamoto, M.: Responses of sympathetic nervous system to cold exposure in vibration syndrome subjects and age-matched healthy controls. *Int. Arch. Occup. Environ. Health,* 62, 177–181 (1990).