J Occup Health 2005; 47: 165–170

Journal of Occupational Health

Hand Arm Vibration Syndrome among Quarry Workers in Vietnam

Makoto FUTATSUKA[1], Masahiro SHONO[1], Hisataka SAKAKIBARA[2] and Pham QUOC QUAN[3]

[1]Department of Public Health, Graduate School of Medical Sciences, Kumamoto University, [2]Nagoya University School of Health Sciences, Japan and [3]Vietnam National Institute of Labor Protection, Vietnam

Abstract: Hand Arm Vibration Syndrome among Quarry Workers in Vietnam: Makoto FUTATSUKA, *et al*. Department of Public Health, Graduate School of Medical Sciences, Kumamoto University—Few studies have focused on the health effects of vibrating tools on workers in the tropical area. Work conditions and health effects related to rock drill operation were studied in 102 quarry workers, including 73 rock drill operators in Vietnam. We aimed to clarify (1) risk of vibration exposure, (2) occurrence of vibration-induced white finger (VWF), and (3) characteristics of hand-arm vibration syndrome (HAVS). Total weighted r.m.s. acceleration of the Chinese -or Russian-made rock drills, was 45–55 m/s^2. According to work observation studies, daily exposure time to vibration was 160–210 min. ISO5349 predicted that this exposure level would be associated with a high risk of HAVS in workers. We found no clear evidence of VWF. There may be several reasons why no worker exhibited VWF: (1) warmer work conditions, (2) younger and less experienced workers, (3) seasonal changes in work operations, and (4) healthy worker effect. On the other hand, 5–10% of rock drill operators might be suffering from moderate HAVS which was sensori-neural type dominant. There may be some characteristic features of HAVS among quarry workers in the tropical area.
(J Occup Health 2005; 47: 165–170)

Key words: Hand arm vibration, Vibration induced white finger, Quarry workers, Peripheral circulation, Sensori-neural function

Industrial mechanization has progressed rapidly in developing countries, particularly in Southeast Asia. Hand held vibrating tools have come into widespread use with the progress of industrialization in this area. In the developed countries hand arm vibration syndrome (HAVS) has become a representative of occupational diseases in the last few century[1–3]. A lot of studies have focused on and clarified the characteristics of this syndrome. Vibration induced white finger (VWF) is a well-known typical clinical feature of this syndrome. Cold ambient temperature is known to provoke VWF in northern countries. On the other hand, for a long time no information on hand arm vibration syndrome has been available from developing countries in tropical areas.

The authors have previously stated that a tropical climate inhibited the occurrence of vibration-induced white finger (VWF) according to risk estimation studies of HAVS among chain saw operators engaged in tropical forestry[4–6]. However, few studies have focused on the health effects of vibrating tools in the tropical area[7]. This study examined the health effects of vibrating tools among quarry workers in Vietnam, focusing on the following aspects of their working situation: (1) vibration exposure from rock drills as determined by observation and measurements; (2) life history and subjective complaints ascertained by interviews; and (3) occurrence of HAVS estimated by health examinations.

ISO has already set up international standards for hand-transmitted vibration, although the standards were based only on information from developed countries[8]. It is impossible to assess the impact of the labor situation on the health of workers in tropical areas because of the lack of data from these areas. This study aimed to clarify the characteristics of HAVS due to rock drill operation in the tropical area.

Materials and Methods

Fifty quarry companies in the Qui Nhon area, in southern Vietnam, which produce 30% of the stone quarried in the country, were selected for the study. In this area, the ambient temperature is higher than 25°C throughout the year, and during the rainy season from

Received Aug 23, 2004; Accepted Jan 20, 2005
Correspondence to: M. Futatsuka, Department of Public Health, Graduate School of Medical Sciences, Kumamoto University, 1–1–1 Honjo, Kumamoto 860-8556, Japan
(e-mail: fmakoto@gpo.kumamoto-u.ac.jp)

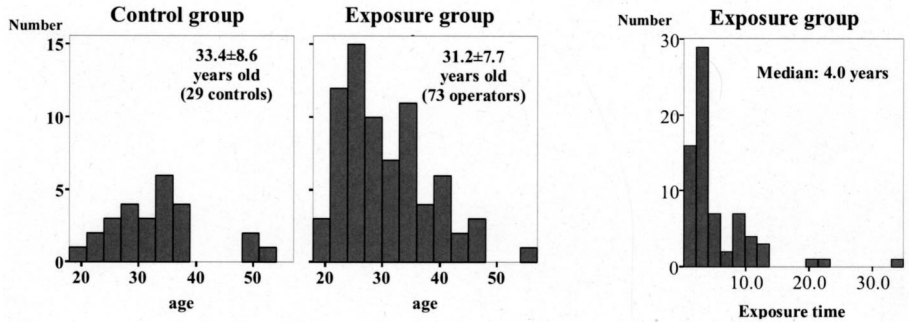

Fig. 1. Age and esposure time of the subjects.

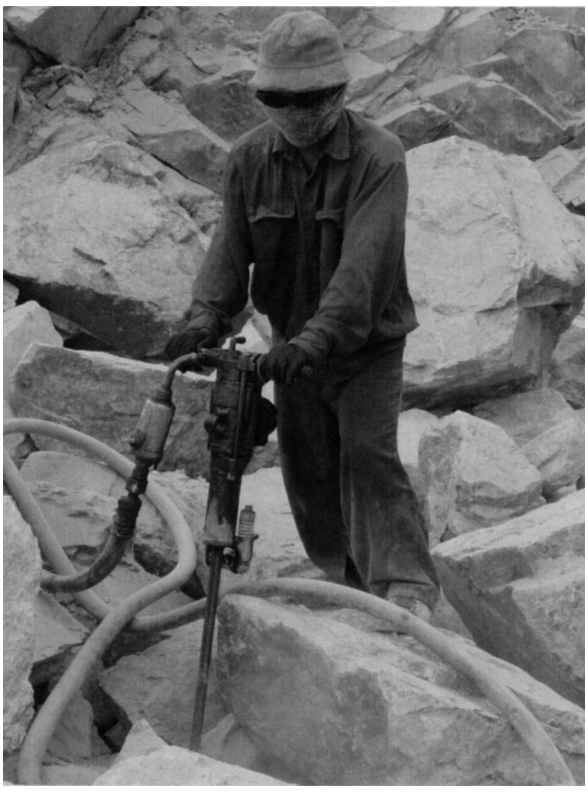

Fig. 2. Rock drill operation

November to February it is impossible to operate rock drills. The subjects were 73 rock drill operators, about 50% of the operators in this area, and 29 control workers who performed manual tasks in the same companies. The mean ages of the subjects and controls were 31.2 ± 7.7 and 33.4 ± 8.6 yr, respectively, and the median operation time was 4.0 yr, in both groups (Fig. 1).

Vibration acceleration in operation was measured for the handle of rock drills made in China or Russia using a Human Vibration Meter (Larson-Davis HIV100) according to ISO5349-2.[9)]

Exposure time to vibration per working day was observed and recorded in the actual working environment by researchers (Fig. 2).

The subjects' life histories, employment histories, histories of illness, and subjective complaints were checked by interview. The function tests consisted of peripheral circulatory and sensori-neural tests. Peripheral circulatory function was assessed by measuring finger skin temperature, recovery time after finger nail compression, and recovery of finger skin temperature after cold provocation (immersion of a hand in water at 10°C for 10 min). Sensory function was assessed on the basis of the threshold of vibration and pain sensation. In addition to these functional tests, tapping ability and grip force were also measured. The methods and criteria were presented in detail elsewhere[4)]. The ambient temperature of the testing room was 27.5–30.0°C during the test procedure.

The statistical significance of differences between the mean values of the two groups was evaluated by Student's t-test. *p*-values less than 0.05 were considered significant. Using these items as continuous variables, factor analysis was carried out in order to extract common effects on these tests. Factor loadings were computed using Maximum-Likelihood extraction and promax rotation. All analyses were carried out using SPSS12.0J statistical software.

Results

Total weighted r.m.s. acceleration of the rock drills was 45–55 m/s^2. According to the results of work observation studies, daily exposure times were 160–210 min. Regarding major subjective complaints, no workers were identified as having a history of suffering from white finger (Table 1). The prevalence of finger hypoesthesia was 67.6% ("always": 16.2%) in rock drill operators and 3.8% in control workers. The prevalence of weakness of hands, hypoesthesia of fingers, and coldness of hands was significantly higher than that of controls. The prevalence of complaints by exposure time is shown in Table 2. The prevalence of muscle and joint impairments and noise-induced disturbances were significantly higher

Table 1. Prevalence of subjective complaints among rock drillers

Complaints	rock drillers		control	
	Prevalence	(always**)	Prevalence	(always**)
COLDNESS OF HANDS AND LEGS	15 (20.3%)*	1 (1.4%)	0	0
HYPOESTHESIA OF FINGERS	50 (67.6)*	12 (16.2)	2 (6.8)	0
TREMOR/SHIVERING OF FINGERS	22 (29.8)*	7 (9.5)	2 (6.8)	0
DEXTERITY DISTURBANCE	6 (8.2)	3 (4.1)	2 (6.8)	0
WEAKNESS OF HANDS	64 (86.5)*	17 (23.0)	2 (6.8)	0
MOBILITY DISTURBANCE OF ELBOW	14 (18.9)	6 (8.1)	2 (6.8)	0
SHOULDER/NECK STIFFNESS	15 (20.3)	5 (6.8)	4 (13.8)	0
LOW BACK PAIN	40 (54.1)	11 (14.9)	11 (37.9)	1 (3.8)
EASILY TIRED	53 (71.7)	14 (18.9)	18 (62.1)	1 (3.8)
HEADACHE	29 (39.2)	2 (2.7)	10 (34.5)	0
DIZZINESS	40 (54.0)*	6 (8.1)	10 (34.5)	0
TINNITUS	35 (47.3)*	7 (9.5)	5 (17.2)	2 (7.7)
HEARING LOSS	20 (27.1)	11 (14.9)	4 (13.8)	2 (7.7)

**always: complain every day *$p<0.05$

Table 2. Prevalence of subjective complaints by exposure time

Complaints	rock drillers	
	Less than 5 years	5 years or more
COLDNESS	10 (19.6%)	5 (13.9%)
HYPOESTHESIA	28 (54.9)	22 (61.1)
TREMOR	15 (29.4)	8 (22.2)
DISTURBANCE OF DEXTERITY	3 (5.9)	4 (11.1)
WEAKNESS	41 (80.4)	23 (63.9)
MOBILITY DISTURBANCE OF ELBOW	5 (9.8)	10 (27.8)*
SHOULDER STIFFNESS	6 (11.8)	11 (30.6)*
LOW BACK PAIN	21 (41.2)	23 (63.9)*
EASILY TIRED	37 (72.5)	28 (77.8)
HEADACHE	17 (33.3)	15 (41.7)
DIZZINESS	26 (51.0)	19 (52.8)
TINNITUS	16 (31.4)	19 (52.8)*
HEARING LOSS	6 (11.8)	13 (36.1)*

*$p<0.05$

in the long exposure group.

Table 3 shows the mean values of function tests in the operators and controls. No significant differences were observed in any of the tests. The prevalence of poor recovery (<60%) of skin temperature after the cold water immersion test was 6.8% (n=5) among operators and none among the controls, as shown in Fig. 3. The prevalence of abnormal vibration sensation (125Hz.>7.5dB) was 16.2% (n=12) among operators and 7.7% (n=2) in the controls, and that of pain sensation (>3g) was 25.7% (n=19) in the operators and none among the controls ($p<0.05$), as shown in Fig. 4.

The prevalence of having both subjective complaints (hypoesthesia of fingers) and abnormal findings of functional tests (both vibration and pain sensation) was 6.8% (n=5) among the operators.

Discussion

In the early 1960s HAVS was reported in hard-rock miners using jackleg hammers and stopper drills in Canada[10–12]. Subsequently reports came from Europe[13–15], Japan[16, 17], and Korea, together with further reports from Canada[19–24] and America[25]. The prevalence ranged from 12.5 to 50% and the median latent intervals

Table 3. Physical functions in the operators and controls

		Controls (N=26)		Operators (N=74)	
		Mean ± SD	median	Mean ± SD	median
Finger tapping (n/30s)		123.4 ± 21.8	124.0	120.0 ± 23.9	120.0
Pinching power [kg]	(Right finger 1–3)	4.2 ± 1.2	4.0	4.2 ± 1.1	4.2
	(Right finger 1–3)	3.0 ± 1.2	2.6	3.2 ± 1.2	3.2
Skin temperature (°C)		33.2 ± 1.8	33.6	33.3 ± 1.4	33.4
Nail compression test (min.)		1.9 ± 1.6	1.9	1.9 ± 0.4	2.0
Mobility of elbow joint	(flexion degree)	149.0 ± 4.2	150	148.2 ± 3.6	150
	(extension degree)	–1.7 ± 5.6	0	–0.1 ± 5.3	0

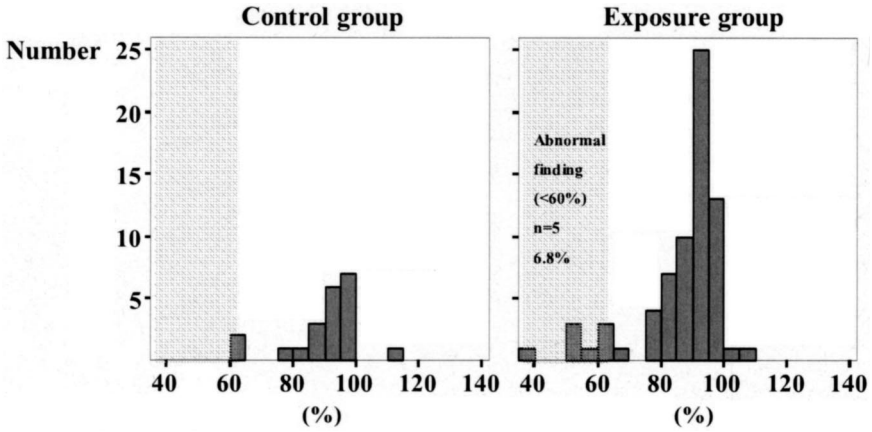

Fig. 3. Recovery rate of skin temperature

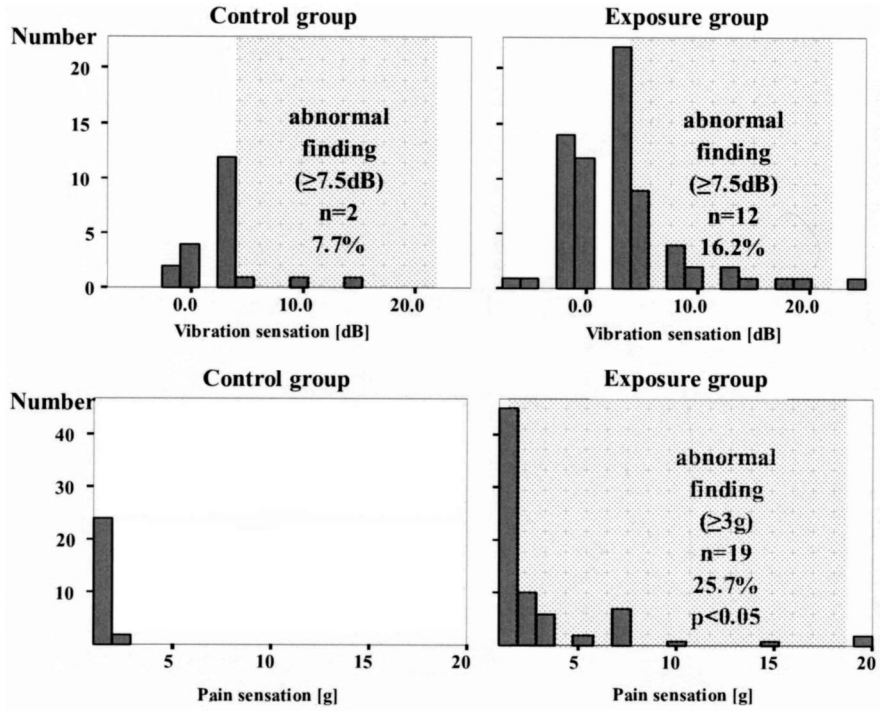

Fig. 4. Distribution of the threshold of sensation

Table 4. Factor analysis of the functional tests

	1	2	3	4
Vibration sensation				
(before cold imm.)	0.810	0.056	0.077	0.160
(20min. After imm.)	0.673	–0.268	–0.002	–0.031
Skin temperature				
(before cold imm.)	–0.097	0.779	0.053	0.131
(20min. After imm.)	–0.183	0.512	0.074	0.039
Nail pressure test				
(before cold imm.)	–0.102	–0.451	0.157	0.161
Mobility of elbow joint				
(Extension)	–0.076	–0.143	1.000	–0.002
(Flexion)	–0.306	–0.262	–0.467	0.076
Tapping ability	–0.034	0.089	0.034	–1.004
Grip force	0.266	0.151	–0.065	0.277
Pain sensation	0.059	0.049	0.011	0.210

were from 4.5 to 17 years.

The stonecutters of Bedford, Indiana, were revisited in 1978 by Taylor *et al*.[26]. Alice Hamilton's investigation had found a prevalence of 89% in 1918 and the prevalence was still 80% in 1978. Bovenzi *et al*.[28], in 1988, surveyed a similar group of stone drillers in Tuscany, Italy. The prevalence of HAVS was 35.5% with a mean latent interval of ten years.

Since the 1970s, mechanization, including the use of rock drills in quarries, has been spreading in tropical areas including Vietnam. Little research has focused on the health of quarry workers in these areas.

The present study selected subjects after receiving the agreement of workers, employers and workers' unions, so it was impossible to neglect selection bias. The difference of age distribution between operators and controls did not appear to be very large in the 20–30 yr old group.

The rock drills used by the workers in this study were late 1980s to early 1990s models, and ISO5349–1 predicted that their acceleration levels would be associated with a high risk of development of HAVS in workers using them according for 8 h/d. Energy-equivalent values[8]: 45 m/s^2, 160 min exposure, A(8) 26.0 m/s^2 and 55 m/s^2, 210 min exposure, A(8) 36.4 m/s^2. However, we found no clear evidence of the occurrence of white finger according to either physiological function tests or interviews regarding subjective complaints. We have already reported similar results obtained among chain saw operators in Papua New Guinea and Indonesia[5–7].

Those results may indicate that cold triggers blanching attacks and a pathophysiological mechanism operates in the finger vasculature as either a manifestation of sympathetic hyperactivity or as an enhanced response of the vasomotor receptors to cold stimulus. Suzuki and Ito reported that the critical ambient temperature for the provocation of white finger was around 15°C[29].

The reasons why no worker exhibited VWF may be explained as follows: (1) warmer ambient work conditions (higher than 25°C throughout the year), (2) younger average age and less work experience, (3) seasonal change in work operations (impossible to use rock drills during the rainy season for 2–3 months of the year), and (4) a healthy worker effect in a cross-sectional health examination.

On the other hand, 5–10% of rock drill operators might be suffering from moderate HAVS (6 operators seemed to be S-1 grade on the Stockholm Scale), which was sensori-neural type dominant. As shown in Table 4, factor analysis of functional tests suggested that circulatory and sensori-neural functions were clearly independent. There may be some distinctive characteristic features of HAVS in the tropical area.

Comprehensive occupational health administration not only of HAVS but also of the effects of noise and dust is needed for these quarry workers.

Acknowledgments: This study was an international cooperative study conducted by Japan and Vietnam (National Institute of Labor Protection: Director. Prof. Ph.D. Le Van Trinh). We are grateful to and acknowledge the contribution of the staff of the quarry companies and the Preventive Medicine Center of Quang Ninh province.

References

1) Griffin MJ. Handbook of human vibration. London: Academic Press, 1990.
2) Pelmear PL, Taylor W, Wasserman DE. Hand-Arm vibration. New York: Van Nostrand Reinhold, 1992.
3) Yamada S, Futatsuka M. Hand arm vibration syndrome (Japanese). Kawasaki: Institute of Labor Science, 2004.

4) M Futatsuka, T Inaoka, R Ohtsuka, K Moji and T Sakurai: A preliminary study on the function tests of the vibration syndrome in tropical rain forest workers. J Human Ergol 15, 95–99 (1991)
5) M Futatsuka, T Inaoka, R Ohtsuka, T Sakurai, K Moji and T Igarashi: Hand-arm vibration in tropical rain forestry workers. Cent Eur J Public Health 3, 90–92 (1995)
6) M Futatsuka, T Inaoka, R Ohtsuka, T Sakurai, K Moji and T Igarashi: Life and health of chain saw operators in tropical rain forests: changes in work conditions and health due to the mechanization of forestry. Environ Sciences 4, 135–145 (1996)
7) HS Yu, TH Yao, HM Teng, ST Ho and CT Chen: Vibration syndrome. With special reference to the effects of temperature on vibration induced white finger. J Dermatol 15, 466–472 (1988)
8) International Organization for Standardization. Mechanical vibration measurement and evaluation of human exposure to hand-transmitted vibration-Part 1. ISO5349, 2001.
9) International Organization for Standardization. Mechanical vibration measurement and evaluation of human exposure to hand-transmitted vibration-Part 2. Practical guidance for measurement at the workplace. 2001.
10) Williams N, Riegert AL. Raynaud's Phenomenon of occupational origin in uranium miners. In: Proceedings of the 13th International Congress on Occupational Health. New York, 1962: 819–825.
11) WF Ashe, WT Cook and JW Old: Raynaud's phenomenon of occupational origin. Arch Environ Health 5, 333–343 (1962)
12) WF Ashe and N Williams: Occupational raynaud's. Arch Environ Health 9, 425–433 (1964)
13) Lindstrom IM. In: Wasserman DM, Taylor W, Curry MG, eds. Vibration injury in rock drillers, chisellers and grinders. Cincinatti. Proceedings of the international occupational hand-arm conference, DHHS (NIOSH) publication No. 77–170, 1977, 77–84.
14) DS Chatterjee, A Petrie and W Taylor: Prevalence of vibration induced white finger in fluorspar mines in Weardale. Brit J Ind Med 35, 208–218 (1978)
15) Rodgers LA, Eglin D, Hart WFD. In: Brammer AJ, Taylor W, eds. Rock-drill vibration and white fingers in miners. New York: Vibration effects on the hand and arm in industry, 1982: 317–323.
16) H Iwata: Effects of Rock Drills on Operators. Part 2. Survey and examination on Raynaud's phenomenon. Ind Health 6, 37–47 (1968)
17) T Matsumoto, S Yamada and N Hisada: On vibration hazards in rock-drill operators of a metal mine. Jpn J Ind Health 19, 256–265 (1977)
18) Moon YH, Roh JH, Cheon YH. Vibration hazards in rock-drill operators of the anthracine mine. In: Proceedings of the 10th Asian conference on occupational health 1, 1982: 402–407.
19) SG Hutton and RL Brubaker: Vibration effects on mine workers. CIM Bulletin 75, 85–93 (1982)
20) RL Brubaker, CJG Mackenzie and SG Hutton: A study of vibration white finger disease in rock drillers. J Low Freq Noise Vib 4, 52–65 (1985)
21) PL Pelmear, I Taraschuk, D Leong and L Wong: Cold water immersion test in hand-arm vibration exposure. J Low Freq Noise Vib 4, 89–97 (1985)
22) PL Pelmear, D Leong, I Taraschuk and L Wong: Hand-arm vibration syndrome in foundrymen and hard rock miners. J Low Freq Noise Vib 5, 26–43 (1986)
23) RL Brubaker, CJ Mackenzie and SG Hutton: Vibration-induced white finger among selected underground rock drillers in British Columbia. Scand J Work Environ Health 12, 296–300 (1986)
24) PL Pelmear, J Roos, D Leong and L Wong: Cold provocation test results from a 1985 survey of hard-rock miners in Ontario. Scand J Work Environ Health 13, 343–347 (1987)
25) DE Wasserman, VJ Behrens, PL Pelmear, R Ilka, DD Reynolds, TE Doyle, S Samueloff and RJ Goff: Hand-arm vibration syndrome in a group of U.S. uranium miners exposed to hand-arm vibration. Appl Occup Environ Hyg 6, 183–187 (1991)
26) W Taylor, D Wasserman, V Behrens, D Reynolds and S Samueloff: Effect of the air hammer on the hands of stonecutters. The limestone quarries of Bedford, Indiana, revisited. Brit J Ind Med 41, 289–295 (1984)
27) A Hamilton: A study of spastic anaemia in the hands of stonecutters. Bulletin 236, US Bureau of Labor Statistics (Part 19), 53–66 (1918)
28) M Bovenzi, A Franzinelli and F Strambi: Prevalence of vibration-induced white finger and assessments of vibration exposure among travertine workers in Italy. Int Arch Occup Environ Health 61, 25–34 (1988)
29) T Suzuki and S Itoh: Relationship between ambient temperature and white finger attacks. Jpn J Ind Heath 12, 189–191 (1970)