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Vibration Syndrome

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In light of a recently completed, comprehensive study, conducted by the National Institute for Occupational Safety and Health (NIOSH), the Institute concludes that vibrating hand tools can cause vibration syndrome, a condition also known as vibration white finger and as Raynaud's phenomenon of occupational origin. Vibration syndrome has adverse circulatory and neural effects in the fingers. The signs and symptoms include numbness, pain, and blanching (turning pale and ashen). Of particular concern is evidence of advanced stages of vibration syndrome after exposures as short as one year. NIOSH recommends that jobs be redesigned to minimize the use of vibrating hand tools and that powered hand tools be redesigned to minimize vibration. Where jobs cannot be redesigned to eliminate vibrating tools such as pneumatic hammers, gasoline chain saws, and other powered hand tools, engineering controls, work practices, and administrative controls should be employed to minimize exposure.

Purpose of Bulletin

Occupational health and safety professionals, employers, and workers should be alerted to recent information on the potential hazards of vibrating hand tools. A comprehensive study recently completed by NIOSH demonstrates the seriousness of vibration syndrome in workers and provides an accurate measure of the prevalence of vibration syndrome. The study suggests that vibration syndrome is severely underreported by workers and health professionals. Workers tend to underreport the syndrome because symptoms are intermittent and occur most frequently under conditions not present in a doctor's office (e.g., early in the morning or when the hands are cold or wet). In addition, many workers are unfamiliar with the potential seriousness of vibration syndrome. Cases tend to be underreported by physicians because most have not been informed of how to distinguish the symptoms of Raynaud's phenomenon from other medical conditions where blanching or sensory loss occurs. Consequently, many doctors do not perform the appropriate clinical examination and interview to test for vibration syndrome.

Implementation of NIOSH's recommendations should reduce the incidence and severity of vibration syndrome. However, existing data are insufficient to recommend a safe duration and intensity of exposure or specific work practices that will prevent the occurrence of vibration syndrome. Through research, NIOSH is seeking additional information about the relationship between exposure duration and vibration syndrome, as well as effective control technologies to prevent vibration syndrome.

Background

Raynaud's phenomenon was first described as "a condition, a local syncope [loss of blood circulation], where persons see one or more fingers becoming white and cold all at once".[1] In 1 to 3% of the cases, these blanching attacks become progressively more severe over the years, leading to blue and cold fingers; even though the skin may become atrophic, ulcerated, or gangrenous. "Primary" Raynaud's phenomenon, originally described by Dr. Maurice Raynaud, occurs spontaneously in less than 15% of the general population.[2] The ratio of female to male patients is five to one.[3] "Secondary" Raynaud's phenomenon has the same signs and symptoms and progresses through the same stages of severity but may be correlated with a specific cause (i.e., other medical conditions, vinyl chloride, or vibrating handtools). Some medical conditions, particularly fractures,

lacerations, costoclavicular syndrome, connective tissue diseases, vascular disorders such as Buerger's disease, generalized atherosclerosis, or a long history of high blood pressure, may result in the same signs and symptoms as primary Raynaud's phenomenon. This CIB is limited to a discussion of Secondary Raynaud's phenomenon resulting from the use of vibrating hand tools, referred to as vibration syndrome.

Early stages of vibration syndrome are characterized by tingling or numbness in the fingers. Temporary tingling or numbness during or soon after use of a vibrating hand tool is not considered vibration syndrome. To be diagnosed as vibration syndrome, these neurologic symptoms must be more persistent and occur without provocation by immediate exposure to vibration. Other symptoms of vibration syndrome include blanching, pain, and flushing. The symptoms usually appear suddenly, and are precipitated by exposure to cold. With continuing exposure to vibration, the signs and symptoms become more severe and the pathology may become irreversible.

The severity of vibration syndrome can be measured using a grading system developed by Taylor.[4] After a clinical observation and an interview, a worker can be placed into one of the categories in Table 1. Clinical aspects of vibration syndrome are discussed in the Appendix.

Table 1. Stages of Vibration Syndrome

Stage	Condition of Fingers	Work and Social Interference
00	No tingling, numbness, or blanching of fingers	No complaints
OT	Intermittent tingling	No interference with activities
ON	Intermittent numbness	"
TN	Intermittent tingling and numbness	"
01	Blanching of a fingertip with or without tingling and/or numbness	"
02	Blanching of one or more fingers beyond tips, usually during winter	Possible interference with nonwork activities; no interference at work
03	Extensive blanching of fingers; during summer and winter	Definite interference at work, at home, and with social activities; restriction of hobbies
04	Extensive blanching of most fingers; during summer and winter	Occupation usually changed because of severity of signs and symptoms

Extent of Exposure

Based on a 1974 study of occupational exposures to vibration, NIOSH estimates that 1.2 million workers in the United States are potentially exposed to hand-arm vibration (Table 2).[5] These workers are potentially at risk of developing vibration syndrome.

Table 2. Workers Potentially Exposed to Hand-Arm Vibration

No. of Workers	Industry	Type of Tool
500,000	Construction	Hand Tools
200,000	Farming	Gasoline chain saws
14,000	Metal working	Hand Tools

	No. of Workers	Industry	Type of Tool
	54,000	Steel	Furnace cleaning using powered hand tools
	30,000	Lumber and wood	Gasoline chain saws
	34,000	Furniture manufacturing	Hand Tools
	100,000	Mining	Pneumatic drills
	250,000	Truck and auto manufacturing	Hand Tools
	64,000	Foundries	Hand Tools
Total	**1,246,000**		

Adapted from reference [5]

Evidence of Health Effects

Although individual workers reported symptoms of Raynaud's phenomenon and many published studies indicated that occupational exposure to vibration does cause vibration syndrome, there are few medical records of vibration syndrome. In 1979, the Bureau of Labor Statistic's Supplementary Data System contained fewer than 39 cases that might have been vibration syndrome.[6] To resolve the question of whether vibration syndrome is a rare disease or whether the small number of recorded cases is, in fact, due to underreporting NIOSH conducted a recently completed, comprehensive study designed to avoid problems noted in previously published studies. [7]

NIOSH studied 385 workers exposed to hand-arm vibration from pneumatic chipping hammers and grinders at two foundries and a shipyard. Workers in the foundries and the shipyard who had never used vibrating hand tools comprised the control group. Workers in the exposed groups were in the same work locations as the control workers, and were exposed to vibrating hand tools while on the job.

A physician on the research team who had extensive experience in the diagnosis of vibration syndrome examined each worker in the double blind study. Based on clinical observation and interview, each worker was placed in one of the stages shown in Table 1. Neither the worker nor the physician was told if a worker was classified as exposed or control.

In the foundries, 47% of the exposed workers had advanced vibration syndrome (stage 1 or more severe); 19% of the exposed workers in the shipyard were similarly affected. Although no workers in the control group were found to have vibration syndrome, 83% of the exposed workers in the foundries and 64% of the exposed shipyard workers had discernable symptoms. Table 3 displays prevalence of vibration syndrome by stage among the workers.

Table 3. Prevalence of Vibration Syndrome by Stage in Foundry and Shipyard Populations

		Controls	Exposed Workers	
	Vibration Syndrome Stages	Foundries and Shipyard N=63*	Foundries N=147*	Shipyard N=58*
Circulatory	03	0%	5%	5%
Symptoms (or	02	0%	22%	5%
combines symptoms)	01	0%	20%	9%

		Controls		Exposed Workers		
	Vibration Syndrome Stages	Foundries and Shipyard N=63*		Foundries N=147*		Shipyard N=58*
			Subtotal	47%	Subtotal	19%
Neurological	TN	0%		20%		17%
Symptoms Alone	ON	0%		7%		17%
OT	0%		9%		11%	
			Subtotal	36%	Subtotal	45%
No Symptoms	00	100%		17%		36%
Total		100%		100%		100%

N = Number of workers[return to table]*
Adapted from *Vibration White Finger Disease in U.S. Workers* [7]

Workers with medical conditions that might produce signs and symptoms similar to Raynaud's phenomenon were excluded from both the control and exposed groups. Of studies performed in the United States, these prevalence rates are the best available evidence that link Raynaud's phenomenon with exposure to vibration. These data demonstrate the potential seriousness of vibration syndrome in foundries and shipyards and by implication in other workplaces where there are similar tools and operations.

There is a direct relationship between years exposed and severity of vibration syndrome. This relationship in foundry workers is demonstrated in Table 4. Vibration syndrome of stage 1 or greater severity was found in 31% of the workers exposed 1.5 years or less, 41% of the workers exposed 1.5 to 3 years, and 71% of the workers exposed more than 3 years. A similar relationship was observed among shipyard workers Table 5.

Table 4. Exposure Duration and Severity of Health Effect for Foundry Workers Using Chipping Hammers*

	Exposure Duration (Years) and Prevalence of Symptoms			
Vibration Syndrome Stage	Less Than 1.5 N=66**	1.5-3.0 N=29**	More Than 3.0 N=52**	Percent of Total Workers at a Stage N=147**
02 and 03	11%	24%	50%	27%
01	20%	17%	21%	20%
OT, ON, andTN	48%	48%	14%	36%
OO	21%	11%	15%	17%
Total	100%	100%	100/%	100%

Chi square value 29.8 with p less than .00001[return to table]*
**N = Number of workers *[return to table]*

Adapted from *Vibration White Finger Disease in U.S. Workers* [7]

Table 5. Exposure Duration and Severity of Health Effect for Shipyard Workers Using Chipping Hammers*

	Exposure Duration (Years) and Percent of Workers at a Stage			
Vibration Syndrome Stage	Less Than 5.0 N=22**	5.0-15.0 N=17**	More Thank 15.0 N=19**	Percent of Total Workers at a Stage N=58**
TN, 01, 02, and 03	23%	29%	58%	36%
OT and ON	32%	18%	32%	28%
OO	45%	53%	10%	36%
Total	100%	100%	100%	100%

*Chi square value of 9.9 with p=.041 *[return to table]*
**N = Number of workers *[return to table]*

Adapted from *Vibration White Finger Disease in U.S. Workers* [7]

NIOSH also analyzed the length of time between initial occupational exposure and the onset of symptoms. This is given for each stage in Table 6. The average time for the appearance of blanching, advanced vibration syndrome of stage 1 or greater severity, for foundry workers was 2 years, and for shipyard workers it was 17 years. There is no definitive explanation for this difference. One theory attributes the difference to variations in work practices.

Table 6. Latency Period of Vibration Syndrome for Workers in Foundries and Shipyards

	Foundries		Shipyards	
	Number of Workers	Average Latency (Years)	Number of Workers	Average Latency(Years)
Latency of Tingling for Workers with Stages OT, TN, 01, 02, 03 (excludes ON)	94	2	21	9
Latency of Numbness for Workers with Stages ON, TN, 01, 02, 03 (excludes OT)	80	2	26	12
Latency of Blanching for Workers with Stages 01, 02, 03	69	2	11	17

Adapted from *Vibration Syndrome White Finger Disease in U.S. Workers.* [7]

Although the symptoms of vibration syndrome have also been associated with smoking and age, these associations were not seen in the study.

The results of the NIOSH study corroborate those of many published studies of Raynaud's phenomenon and vibration. In 1918, Hamilton studied workers who used pneumatic chipping hammers and drills in the limestone quarries of Indiana, and described "spastic anemia of the hands".[8] Vibration syndrome was described in the 1930's and 1940's by Seyring, who studied

workers in iron foundries[9]; by Hunt, who studied riveters who used pneumatic handtools;[10] by Telford et al., who studied workers who used electrically driven high-speed rotating handtools;[11] and by Agate and Druett, who examined casting workers who used grinding wheels.[12] Dart[13] reported vibration syndrome among 112 workers who used pneumatic and electric tools in the U.S. aircraft industry.

In 1960 Pecora et al. concluded that vibration syndrome "may have become an uncommon occupational disease approaching extinction in this country [the United States]".[14] This finding is inconsistent, however, with those of researchers from many countries that have been published before and since that report.[15-20] This may be due to the fact that Pecora et al. based their conclusions on the results of a questionnaire survey of occupational health physicians, a review of existing occupational health information and the results of an examination of some workers.

Ashe and coworkers reported on a small number of drillers from the hard rock mines of Saskatchewan, Canada, seven of whom were examined in the hospital.[15,16] In these clinical investigations, arteriography and biopsies were performed on the digital arteries of the fingers. In the worst cases, there was extensive damage to the digital artery with narrowing of the blood vessels. This investigation demonstrated that prolonged exposure to vibration could lead to extensive pathological damage to the digital arteries of the fingers.

In the 1960's and 1970's, vibration syndrome was also associated with gasoline-powered chain saws used in forestry work. For example, in Finland, Pyykko[17] found that the vibration of the two-stroke internal combustion engine (transmitted through the handles to the hands) was associated with vibration syndrome in 40% of the lumberjacks studied.

Other studies have been undertaken since the NIOSH study was initiated. In the United States, Taylor et al.[18] examined foundry workers who used pneumatic handtools; in Italy, Bovenzi et al.[19] shipyard workers; Kasamatsu et al.[20] studied Japanese chain saw operators; and Harada and Matsumoto[21] examined three groups of workers exposed to different kinds of vibration (rock drillers in a zinc mine, chipping-hammer operators in an iron foundry, and motorcycle mailmen). All studies found significant evidence of vibration syndrome.

The exact point at which vibration syndrome becomes irreversible has not been firmly established. Recently Taylor et al. reported the effect of reduced vibration levels on severity and prevalence of vibration syndrome.[22] After anti-vibration chain saws had been introduced in England, Taylor et al. found that the overall prevalence of vibration syndrome decreased. Vibration syndrome was less prevalent in workers who used only anti-vibration saws than among workers who used other types of saws. In addition, users of anti-vibration saws had an overall decrease in severity of the syndrome. The results of studies such as this have led to the redesign of other tools to reduce the degree of vibration. For example, the ARO 8316® pneumatic scaling hammer and the Vast Hardill VHB-80® pneumatic pavement breaker were specifically designed to reduce both vibration and noise levels.

Despite considerable research, little is known about the physiological basis of vibration syndrome or which specific vibration parameters, such as acceleration, frequency spectrum, or energy transferred to the hand, are the most necessary to control. The progressive stages of vibration syndrome arise from the cumulative effect of vibration-induced trauma to the hands from the regular, prolonged use of vibrating handtools in certain occupations.

Only recently have methods been developed to perform reproducible vibration measurements.[23] In the NIOSH study, acceleration levels were measured in three orthogonal directions.[7] To minimize distortion during measurement of acceleration, the lightest available accelerometers were selected and were tightly mounted to the vibrating tool. For tools with high acceleration rates, such as chippers, the accelerometer was mounted in a fixture which was welded to the chisel. Measuring devices were calibrated before and after each measurement.

Exposure Standards and Guides

The Occupational Safety and Health Administration (OSHA) has not promulgated any standards, nor has NIOSH published recommendations that addressed occupational vibration. Other countries have proposed such standards;[24,25] and the International Organization for Standardization (ISO) has proposed a draft standard for hand-arm vibration (ISO/DIS 5349-1982).[26] The draft standard specifies methods for measuring and reporting hand-transmitted vibration exposure and attempts to relate these measurements to a limited amount of epidemiological data. The reader is referred to that document. However, due to the difficulty of measuring vibration exposure and the lack of a quantitative relationship between vibration levels and health effects, the ISO draft standard has yet to be accepted in the United States and several other countries. ISO has not yet proposed a final standard to replace the draft standard.

Recommendations

Based on the recent NIOSH study and other published studies, NIOSH concludes that occupational health professionals, workers, and employers should consider the seriousness of vibration syndrome. NIOSH recommends that engineering controls, medical surveillance, work practices, and personal protective equipment be used to help reduce exposure to vibrating hand tools and to help identify vibration syndrome in its early stages among workers likely to be at risk.

Engineering Controls

The amount of exposure to vibration in many jobs can be reduced by proper job and production design. Where job redesign is not feasible, direct intervention by means of reducing tool vibration should be attempted.

1. **Recommendation 1:** Production lines should be engineered to minimize the need to use vibrating handtools. For example, quality controls on casting could be increased to reduce the average refinishing needed.
2. **Recommendation 2:** Tool manufacturers should modify and redesign tools to reduce hand-arm vibration. Tools with reduced vibration levels should be furnished to workers. Purchasers are encouraged to request suppliers to provide evidence that their equipment reduces vibration. More research is needed before a specific standard can be recommended for vibrating handtools. In the meantime, purchasers are encouraged to select tools that minimize vibration. Such information can be obtained from manufacturers' product or technical brochures.

Medical Surveillance and Worker Education

The number of vibration syndrome cases reported is small. Physicians have failed to diagnose the syndrome and workers tend not to report it. All workers who use vibrating hand tools are at risk and should be examined for signs and symptoms of vibration syndrome. An examination is recommended because the severity of vibration syndrome appears to be directly related to the cumulative duration of exposure and because health effects can become irreversible.

3. **Recommendation 3:** More research is needed in order to specify an optimum surveillance program, but for the present, NIOSH recommends that a medical surveillance program be implemented and that it should be tailored to the degree that workers use vibrating hand tools. It should include preplacement examination of all new workers and an initial examination of all present workers who use vibrating hand tools. Work histories should be included in all examinations. Work histories should include any prior exposure to vibrating hand tools. Medical records, including health and work histories, should be maintained throughout employment and for an extended period after termination of employment.
4. **Recommendation 4:** Workers using vibrating hand tools and their employers should be informed of the symptoms of vibration syndrome.
5. **Recommendation 5:** Workers should see a physician promptly if they experience prolonged symptoms of tingling, numbness, or signs of blanched or blue fingers.
6. **Recommendation 6:** Health professionals, particularly occupational health physicians, should be trained in the appropriate clinical examination and interview necessary to diagnose vibration syndrome. (A special NIOSH VWF videotape has been prepared to aid in the diagnosis of vibration syndrome[31]).

Work Practices

Some tools, such as grinders, can cause greater vibration levels to impinge on the hand when wear is uneven or their alignment slips. While insufficient information is available to recommend a safe exposure duration, it is known that the severity of vibration syndrome is related to the extent and duration of continuous exposure to vibration.

7. **Recommendation 7:** Vibrating hand tools should be carefully maintained according to manufacturers' recommendations.
8. **Recommendation 8:** Work schedules with a 10-minute break after each hour of continuous exposure may help reduce the severity of vibration syndrome. Research is needed to determine, however, whether another schedule of rest breaks on job rotation is more appropriate.
9. **Recommendation 9:** Workers are advised to:
    a. Wear adequate clothing to keep the body temperature stable and normal, since a low body temperature reduces blood flow to the extremities and therefore may trigger an attack of vibration syndrome. Workers are also advised to keep hands warm and dry while on the job. When their hands become wet and chilled, workers should dry them

to keep hands warm and dry while on the job. When their hands become wet and chilled, workers should dry them and put on dry warm gloves before additional exposure to vibration. More than one pair of gloves may be required on the job.

b. Let the tool do the work, grasping it as lightly as possible while working safely and maintaining tool control. The tool should rest on the workpiece or support as much as possible. The tighter the tool is held, the greater the vibration transmitted to the worker.

c. Substitute a manual tool or other processes where practical.

Personal Protective Equipment

Many types of gloves help maintain body warmth, and, in addition, some designs may attenuate vibration; however, this may be limited to only some of the higher frequencies found in vibrating hand tools. Although gloves alone are not recommended as a method of reducing vibration transferred to the hands, they will help keep hands warm, and thus help reduce the severity of vibration syndrome.

[signature]
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References

1. Raynaud M: Local Asphyxia and Symmetrical Gangrene of the Extremities, (MD thesis, Paris, 1862), in Selected Monographs. London, New Sydenham Society, 1888
2. Holti G: Raynaud's phenomenon–Raynaud features acrocyanosis, cryo immunoproteins, in Altura BM, Davis E, Harders H (eds): Advances in Microcirculation. New York, S Karger-Basel, 1982, vol 10, pp 1-16
3. Hines EA, Christensen NA: Raynaud's disease among men. *J Am Med Assoc 129*:1-4, 1945
4. Taylor W (ed): The Vibration White Finger. London, Academic Press, 1974
5. Wasserman DE, Badger DW, Doyle TE, Margolies L: Industrial vibration–An overview. *Am Soc Safety Eng J 19(6)*:38-43, 1974
6. Internal NIOSH memorandum to Sheldon Fishman from the Division of Safety Research, Aug 13, 1982
7. Wasserman DE, Behrens V, Taylor W, Samueloff S, Reynolds D: Vibration White Finger Disease in US Workers Using Pneumatic Chipping and Grinding Handtools, Volume I: Epidemiology Results, DHHS (NIOSH) Publication No. 82-118. Cincinnati, US Dept of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1982
8. Hamilton A: Reports of physicians for the Bureau of Labor Statistics–A study of spastic anemia in the hands of stonecutters, in Effect of the Air Hammer on the Hands of Stonecutters. Bulletin 236. Industrial Accidents and Hygiene Series, No. 19 (1918). Springfield, VA, US Dept of Commerce, National Technical Information Service, pp 53-66 (NTIS PB-254 601)
9. Seyring M: Disease resulting from work with compressed air tools. *Arch Gewerbepathol Gewerbehyg 1*:359, 1930
10. Hunt JJ: Raynaud's phenomenon in workmen using vibrating instruments. *Proc Royal Soc Med 30*:171, 1936
11. Telford ED, McCann MB, Mac Cormack DH: Dead hand in users of vibrating tools. *Lancet 2*:359, 1945
12. Agate JN, Druett HA: A study of portable vibrating tools in relation to the clinical effects they produce. *Br J Ind Med 4*:141-63, 1947
13. Dart EE: Effects of high speed vibrating tools on operators engaged in the airplane industry. *Occup Med 1*:515-50, 194
14. Pecora LJ, Udel M, Christman RP: Survey of current status of Raynaud's phenomenon of occupational origin. *Ind Hyg J 21*:80-83, 1960
15. Ashe WF, Cook MT, Old JW: Raynaud's phenomenon of occupational origin. *Arch Environ Health 5*:333-43, 1962
16. Ashe WF, Williams N: Occupational Raynaud's–II. *Arch Environ Health 9*:425-33, 1964
17. Pyykko I: The prevalence and symptoms of traumatic vasospastic disease among lumberjacks in Finland: A field study. *Work Environ Health 11*:118-31, 1974
18. Health Hazard Evaluation Report, HHE 80-189-870–Neenah Foundry Co. Cincinnati, US Dept of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1981

Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1981, 39 pp

19. Bovenzi M, Petronio L. DiMarino F: Epidemiological survey of shipyard workers exposed to hand-arm vibration. *Int Arch Occup Environ Health 46*:251-66, 1980
20. Kasamatau T, Miyashita K, Shiomi S. Iwata H: Urinary excretion of hydroxyproline in workers occupationally exposed to vibration. *Br J Ind Med 39*:173-78, 1982
21. Harada N, Matsumoto T: A study of various function tests on the upper extremities for vibration syndrome. *Am Ind Hyg Assoc J 42*:887-92, 1981
22. Taylor W, Riddle HFV, Bardy DA: Vibration-Induced White Finger in Chain Saw Operators. 8th VWF Survey of Chain Saw Operators at Thetford. Norfolk, England, UK Forestry Commission, January 1980 (In press)
23. Wasserman DE, Reynolds D, Behrens V, Taylor W, Samueloff S: Vibration White Finger Disease in US Workers Using Pneumatic Chipping and Grinding Handtools, Volume II: Engineering Testing, DHHS (NIOSH) Publication No. 82-101. Cincinnati, US Dept of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, 1981, p 89
24. Vibration syndrome again. *Br Med J 282*:1738-39. 1981
25. Griffin MJ: Vibration Injuries of the Hand and Arm: Their Occurrence and the Evaluation of Standards and Limits, Health and Safety Executive Research Paper No. 9. London, Her Majesty's Stationery Office, 1980, 36 pp
26. Draft proposal for a second international standard, ISO/DIS 5349-1982 — Guide for the Measurement and the Evaluation of Human Exposure to Vibration Transmitted to the Hand, ISO/TC/08/sc 4. International Organization for Standardization, 1982, 22 pp (unpublished)
27. Pathophysiology of Raynaud's. *Br Med J 281*:1027-28, 1980
28. Goyles KB, Dormandy JA: Abnormal blood viscosity in Raynaud's phenonemon. *Lancet 1*:1317-18, 1976
29. Wasserman D, Taylor W (eds): Proceedings of the International Occupational Hand-Arm Vibration Conference, DHEW (NIOSH) Publication No. 77-170. Cincinnati, US Dept of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1977
30. Taylor W, Pelmear PL: Vibration White Finger in Industry. London, Academic Press, 1975
31. Vibration Syndrome, NIOSH Video Tape 177. Cincinnati, US Dept of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, 1981 (27 minutes)
32. Pelmear PL: An Epidemiological Study of Raynaud's Phenomenon of Occupational Origin, thesis. University of London, 1973

Appendix I: Clinical Aspects of Vibration Syndrome

The physiological cause of vibration syndrome is not known.[27] Vibration may directly injure the peripheral nerves, causing numbness of the fingers and hands. Paresthesia of the hands may be secondary to vascular constriction of the blood vessels, causing ischemia of the peripheral nerves. Likewise, the physiological or chemical changes due to vibration in the blood and blood vessels can only be speculated upon at this time.[28]

Some medical conditions may result in symptoms similar to vibration syndrome. Table I-1 summarizes these conditions.[30]

Table I-1. Differential Diagnosis-Raynaud's Phenomenon

Primary:	**Raynaud's Disease**	
Secondary:	1. Connective Tissue Disease	a. Scleroderma b. Systemic Lupus Erythematosus c. Rheumatoid Arthritis d. Dermatomyositis e. Polyarteritis Nodosa f. Mixed Connective Tissue Disease

Primary:	**Raynaud's Disease**		
	2. Trauma	Direct to Extremities	a. Following injury, fracture or operation b. Vibrating hand tools c. Frostbite and immersion syndrome
		To Proximal Vessels by Compression	a. Thoracic outlet syndrome (cervical rib, scalenus anterior muscle) b. Costoclavicular and hyperabduction syndromes
	3. Occlusive Vascular Disease		a. Thromboangiitis obliterans b. Arteriosclerosis c. Embolism d. Thrombosis
	4. Dysglobulinemia		a. Cold hemagglutination syndrome – Cryoglobulinemia – Macroglobulinemia
	5. Intoxication		a. Acro-osteolysis b. Ergot c. Nicotine d. Vinyl chloride
	6. Neurogenic		a. Poliomyelitis b. Syringomyelia c. Hemiplegia
	7. Vibration		a. Vibration syndrome

Adapted from *Vibration White Finger in Industry* [30]

Taylor and Pelmear[30] described the clinical manifestations of vibration syndrome. Slight intermittent tingling or numbness, or both intermittent tingling and numbing, of the fingers are usually ignored by the patient because they do not interfere with work or other activities. These are the first symptoms of vibration syndrome. Later, the patient may experience attacks of finger blanching confined at first to a fingertip; however, with additional vibration exposure, attacks may extend to the base of the finger. Cold often provokes attacks but there are other factors involved in the trigger mechanism, such as central body temperature, metabolic rate, vascular tone of the vessels (especially susceptible in the early morning), and emotional state. Attacks usually last 15 to 60 minutes, but in advanced cases may last 1 or 2 hours. Recovery starts with a red flush, a reactive hyperemia, usually seen in the palm, advancing from the wrist towards the fingers. "Due to repeated ischaemic attacks in advanced cases, touch and temperature sensation is impaired. There is a loss of dexterity and an inability to do fine work. With further vibration exposure, the number of blanching attacks is reduced, and is replaced by a dusky, cyanotic appearance of the digits leading to nutritional changes in the finger pulps".[29] Ultimately, small areas of skin necrosis appear at the fingertips.[30] This condition has been called acrocyanosis. A videotape, titled Vibration Syndrome, is available from NIOSH; it describes the etiology, symptomatology, assessment, and treatment of the syndrome.[31]

The severity of the vibration syndrome condition can be measured by using the grading system developed by Taylor[4] (Table 1). Based on a clinical observation and interview, the worker is placed into one of eight categories shown.

Stage 1 and stage 2 attacks occur mainly in the winter and especially during the early morning, either at home or when going to work (i.e when the hands contact the cold steering wheels of vehicles). Workers outside in cold weather, such as forestry workers, are most prone to early morning attacks. Previous studies have shown that as duration of exposure increases, the number of attacks tends to increase.[28,32] During stage 2, workers may report interference with or limitation of activities outside their work (e.g., gardening, fishing, swimming, washing and maintaining an automobile, and woodworking). These activities have one factor in common: in the cold, they are more likely to trigger an attack.

In stage 3, the attacks occur in summer as well as winter. There is interference with work, particularly outdoor work such as forestry and construction; difficulty with fine work such as electronics; and difficulty in picking up small objects. Patients experience difficulty in buttoning and zippering clothing; inability to distinguish between hot and cold objects; and clumsiness of fingers with increasing stiffness of the finger joints and loss of manipulative skills.

In stage 4, the severity of the vibration syndrome and the interference with work, social activities, and hobbies require workers to change their occupation. In the severest forms there are advanced changes in the arteries of the fingers, leading to complete obliteration of the arteries.

Cumulative exposure to vibrating handtools (especially continuous exposure during a workshift) may lead to more severe symptoms. Accordingly, medical surveillance for vibration syndrome should be repeated at shorter intervals for workers with extended exposure to high frequency vibration. More research is needed to specify a surveillance schedule.

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