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Vibration syndrome

ALICE M. STEWART and D. F GODA[1]
Department of Social Medicine, University of Oxford

Stewart, Alice M., and Goda, D. F. (1970). *Brit. J. industr. Med.*, **27**, 19-27. **Vibration syndrome.** Raynaud's phenomenon, or the finger blanching of men who work with vibrating tools, is undoubtedly due to vasospasm. Nevertheless the abnormal element in the situation is not a series of traumatized nerve endings but a deposition of callus under the palmar surfaces of fingers and thumbs. This deposition is a late consequence of the most distinctive, but not necessarily the most painful, of the numerous effects incurred as a result of the tool speed being completely out of the control of the operator and of the tool/component rebound being only partially under his control. The replacement of soft finger pads by rigid callus is also the only consequence of hard manual work to show how necessary it is for a structure like a finger – which is largely composed of bones, joints, tendons, and skin – to have a reservoir, the equivalent of a blood-filled sponge, between every joint to accommodate any sudden reduction in blood volume, or indeed any sudden increase in the volume of blood held in the arteries and veins relative to the amount held in the capillaries.

It is still a moot point whether users of vibrating tools have more arm complaints of a serious nature than other manual workers. They do, however, have a multiplicity of aches and pains, ascribable to various causes including tool speed and tool/component rebound, which are *in toto* very sensitive to such things as blunt impacts, hard components, heavy tools, awkward jobs, and inept handling of tools, whether the ineptness be due to inexperience or to advancing age. Users of vibrating tools have more pain in the hands and wrists than in the elbows and shoulders, but the pain tends to persist longer in the latter sites than in the former sites.

The purpose of the present enquiry was to obtain a better understanding of the arm complaints of men who work with semi-automatic or vibrating tools and, if possible, to discover whether there is any truth in the suggestion that all tissues of the upper limb are liable to be irretrievably damaged as a result of vibrations producing permanent and possibly progressive damage to nerve endings (Reynard, 1954; Marshall, Poole, and Reynard, 1954). This idea had arisen because these investigators decided that they had found evidence of such damage, remote from the points of contact with the vibrations, in 50 clinchers and flangers who were also suffering from finger-blanching of the type known as Raynaud's phenomenon. These men had been examined within minutes of laying down their pneumatic hammers, and one cannot help suspecting that the results of a series of meticulous neurological tests might have been interpreted differently if the symptoms had not included finger-blanching. For instance, slight weakness of a particular thumb muscle at such a moment might have been due to a special type of muscle fatigue; just as slight loss of tactile sensation and slight delay in hand-blushing might have been related to the excessively thick skin which is supposed to be so characteristic of vibrating tool users (Telford, McCann, and MacCormack, 1945). As, however, the finger-blanching was supposed to be due to damaged nerve endings and consequent irritability of small blood vessels in the immediate vicinity of the damage (Lewis and Pickering, 1934; Telford, 1934), and since there seemed to be no dissenters from this view (Hunter, McLaughlin, and Perry, 1945; Agate, 1949; Jepson, 1954; Allen, Barker, and Hines, 1962), Marshall and his colleagues (1954) finally decided that they had uncovered evidence of similar trouble elsewhere.

[1]Present address: Dept. of Statistics, Aberdeen University.

In spite of the implications of these conclusions, the Ministry of Pensions and National Insurance[1] continued to work on the assumption that there were no hidden risks to which vibrating tool users were exposed and that the obvious risk, namely, Raynaud's phenomenon, did not merit scheduling the relevant occupations (Ministry of Pensions and National Insurance, 1954). On the other hand, since the mechanism whereby a damaged finger can become oversensitive to cold has never been satisfactorily explained, uncertainty about whether or not users of vibrating tools were exposed to hidden risks continued.

Data collection

We decided to begin the enquiry by studying relationships between Raynaud's phenomenon, or the 'white finger' component of vibration syndrome, and other troubles in the hands, arms, and shoulders, or the 'arm pain' component. So we were not particularly disconcerted to discover that there was no means of identifying a random sample of all users and ex-users of vibrating tools. We obtained the active co-operation of 16 major enterprises and visited all but a handful of the foundries, engineering workshops, shipbuilding yards, and shoemaking factories under their jurisdiction. With one exception, we asked the managers of these establishments only if we could interview operatives who were currently using certain tools or were known to have used them at some time in the past. We did, however, try to interview all such men and women who were actually working either a day or night shift on specified dates between June and December 1967 (see Appendix, p. 25).

The one exception to the general rule was made in the case of the factory which had co-operated with Marshall and his colleagues 14 years previously. We visited this factory first, and in addition to the usual request we also asked to see as many as possible of the men who had been examined in 1953. In this way we discovered that 46 of the 50 men described in the 1954 report were not only still working full time on various jobs (including the one they had been advised to abandon) but that they were in such good shape (judging by their appearance when interviewed and their sickness absence records) that it was impossible to believe that they had been suffering from permanent and possibly progressive damage to the hands and arms for nearly 15 years.

The excellent condition of these men after so long a time alerted us to the possibility that accepted ideas about Raynaud's phenomenon might be fallacious. We also began to doubt the existence of nerve injury as a cause of finger-blanching when we discovered how many men over the age of 50 years were prepared to admit to having white fingers and painful hands or arms but never seemed to regard this as a reason for not working overtime on jobs which, in our opinion, would have overtaxed the strength of a majority of healthy young men in this country (see Appendix, p. 25).

In short, it was impossible to believe that the finger and arm complaints of these men were not occupational in origin, and equally impossible to believe that virtually all the seasoned operatives in the foundries and shipyards which we had visited were suffering from an obscure neuropathy. So we finally decided to use the data we had collected to test a novel hypothesis concerning the causes and mechanism of the occupational variant of Raynaud's phenomenon.

Theoretical considerations

According to this theory, the health hazards of working either with powered or vibrating tools or with unpowered or conventional tools are essentially the same. The only reason why the former produce white fingers and the latter do not is that a fast-moving tool tends to produce calloused finger pads as well as calloused palms, whereas a slow-moving tool, by requiring less in the way of finger control, produces only calloused palms. Following the development of these 'tool-speed callosities' (which are often painfully acquired) the volume of blood which can be held in the capillaries of an affected finger segment eventually falls to the level which allows one to see temperature-induced changes in blood volume, or changes which are constantly occurring but are usually invisible (Fox, 1968).

The theory goes on to say that (*a*) the end results of working with a vibrating tool are quite different from the immediate effects and may take several years to develop; and (*b*) both the immediate and the final effects are due to a combination of tool speed, tool/component rebound, and tool handling. Since the only constant feature in these three elements is tool speed, and time is an important factor, there is bound to be not only a high degree of variation between tools, jobs, and operatives but also several more or less distinct phases in the development of vibration syndrome, depending upon whether the men concerned are (*a*) passing through the painful stage of a disease which may affect anything from one finger of one hand to the shoulder girdle and both arms; (*b*) beginning to reap the muscular rewards and the skin-hardening effects of their hard labours; or (*c*) beginning to feel the effects of advancing age. In short, the end result could be anything from a small callosity on the palmar aspect of one finger (associated with blanching in one segment of this finger) to two exceptionally hard and powerful hands (with a complete set of apparently weather-sensitive digits), as well as two exceptionally

[1]Now in the Department of Health and Social Security.

powerful arms and a shoulder girdle whose muscles have developed under stress to twice their normal size.

Data analysis

The analyses are based on the following assumptions:

(1) Vibration syndrome is a mixture of skin friction effects, muscle endurance effects, and ageing effects.

(2) Callus is a late effect of skin friction and may be preceded by bruises, bursae, and pain.

(3) Muscle fatigue begins by being associated with pain and weakness and ends by producing muscle hypertrophy.

(4) Aching arms and hands may accompany muscle hypertrophy and hand-hardening or be part of an ageing process.

(5) Tool speed is a more constant factor in relation to powered tools than tool/component rebound.

(6) Tool/component rebound is greater for blunt tools than for sharp tools, greater for heavy tools than for light tools, and greater for hard components than for soft components.

(7) Women and physically sub-standard men are automatically excluded from jobs which combine a high degree of tool/component rebound with tool speed but are well able to cope with jobs combining a high degree of tool speed with a low degree of tool/component rebound.

According to these assumptions, the white finger component of vibration syndrome is a late effect of skin friction, and the arm pain component is partly an early effect of muscle endurance and partly a late effect. Therefore a classification of occupations by tool/component rebound should reveal a steeper gradient for arm pains than for white fingers (Table 1), and a classification of operatives either by length of employment or by numbers of finger callosities should split arm pains into early and later sequelae of hard work (Tables 2, 3, and 4). Also a classification of ex-users of vibrating tools by (*a*) the length of time in the new job and (*b*) the nature of this job should show that arm pains are not only more easily cured than white fingers but are also more sensitive to the nature of current activities (Table 5). Finally, by rating individuals according to (*a*) their vibrating tool occupations, (*b*) the numbers of finger callosities, and (*c*) the presence or absence of arm pains, one should be able to obtain some idea of the relative importance of inexperience and old age in determining the prevalence of arm pains in men who work with vibrating tools (Table 6).

Ratio of white fingers to arm complaints in occupations rated by intensity of tool/component rebound

By placing women in one category and dividing men into precision tool users, fettlers, and hammer-men, the 13 occupational groups shown in the Appendix (Table A) were given a four-point classification in relation to tool/component rebound (Table 1). It is highly unlikely that each of the 1 048 individuals in this Table was correctly rated in respect of this facet of his work. As, however, the purpose of this arbitrary classification was merely to detect the existence of a correlation between arm pains and tool/component rebound (while holding tool speed constant), it will have served its purpose if it shows that the ratio of white fingers to arm complaints decreases progressively with increase in tool/component rebound intensity.

In fact, the hammer-men, whom we had rated highest in the rebound scale, had the lowest ratio of white fingers to arm pains (1·02), and the women, whom we had rated lowest, had the highest ratio (3·75). Between these two extremes came the fettlers, who were rated second highest in the rebound scale, with a ratio of 1·61, and precision tool users, who were rated second lowest, with a ratio of 2·13.

Effect of time on prevalence of white fingers and arm complaints

By separating men who had worked with a vibrating tool for less than a year from other men, and regarding the former as unseasoned workers and the latter as seasoned workers (Table 2), it was shown that the ratio of white fingers to arm complaints was over four times as high for seasoned workers (1·50) as for unseasoned workers (0·38), although the ratio was not appreciably different for men who had worked with a vibrating tool for more than 20 years (1·74) than for men who had worked only between five and 10 years (1·68).

By altering the definition of unseasoned workers from men who had worked for less than a year to men who had never had an attack of white fingers (*i.e.*, the 458 men who, according to the new theory, had not yet had time to develop even one finger callosity) and applying similar criteria to the 547 men who had records of which fingers were affected by blanching, it was possible to divide 1 005 vibrating tool users into six groups which (according to the theory being tested) roughly corresponded to the extent of the finger pad callosities on the 'operative hand' or the hand exerting the tightest grip. In this way the extent of the white finger component of vibration syndrome could be directly related to the frequency of arm pains in occupations with high, medium, and low risks of finger injury. For this purpose occupations in which more than 70% of the operatives had white fingers were rated high and occupations in which less than 40% of the operatives were affected were rated low (Table 3).

Also the same classification (by finger callosity rating) could be used to study the extent of the white

TABLE 1

RATIO OF WHITE FINGERS TO ARM COMPLAINTS IN OCCUPATIONS RATED BY INTENSITY OF TOOL/COMPONENT REBOUND

Job rating by tool/component rebound	*Actual occupations*[1]	*No. of operatives*	*Affected workers as % of total with*		*Ratio A:B*
			White fingers (A)	*Arm pains (B)*	
1	Women	27	15	4	3·75
2	Precision work	247	34	16	2·13
3	Fettling	579	61	38	1·61
4	Hammering	195	54	53	1·02
1–4	Total	1 048	52·1	34·7	1·50

[1]See Appendix.

TABLE 2

RATIO OF WHITE FINGERS TO ARM COMPLAINTS IN OPERATIVES RATED BY DURATION OF EXPOSURE TO VIBRATING TOOLS

Exposure period (yrs)	*No. of male operatives*	*Condition*		*Ratio A:B*
		White fingers (A) %	*Arm complaints (B)* %	
<1	47	11·8	31·3	0·38
1–4	183	33·6	26·5	1·27
5–9	183	51·5	30·7	1·68
10–19	309	58·6	43·0	1·36
>20	299	69·1	39·7	1·74
Total	1 021	53·4	36·5	1·46

TABLE 3

FREQUENCY OF ARM PAINS IN MEN RATED BY EXTENT OF FINGER-PAD OR TOOL-SPEED CALLOSITIES AND CLASSIFIED ACCORDING TO TOOL-SPEED CALLOSITY RISKS OF THEIR OCCUPATIONS

Finger callosity rating[1]	*Men with arm pains as % of men at risk*					
	Finger injury classifications of occupations[2]					
	High risk		*Medium risk*		*Low risk*	
	No.	%	*No.*	%	*No.*	%
0	68	43	189	38	201	20
1	16	21	29	24	18	18
2	35	44	79	37	28	21
3	51	61	53	28	25	33
4	47	65	51	41	53	48
5	19	53	29	67	14	68
Total		50		39		24
No. at risk	236		430		339	

[1]or the number of fingers affected by blanching on the operative (or worst affected) hand.
[2]See text.

finger component of vibration syndrome in relation to two facets of the sickness absence records, namely, days lost per man and spells per man (Table 4).

From these analyses, the men whom we had rated lowest in the finger callosity scale did have more in the way of arm pains than the men whom we had rated second lowest, but less than the men rated either highest or second highest in this scale. In other words, men who had never suffered from Raynaud's phenomenon had both more arm pains and more sickness absence than men who had mild symptoms of this complaint but fewer arm pains and less sickness absence than men who had extensive finger blanching in cold weather.

Effect of change of occupation on vibration syndrome effects

Because there were only 113 ex-users of vibrating tools among the 1 021 men who were selected on the basis of their occupations, we have included in Table 5 the 38 men who were examined by Marshall and his colleagues in 1954 but who, when interviewed by us in 1967, had changed their occupations. In this Table we have introduced a classification of arm

TABLE 4

SICKNESS ABSENCE RECORDS OF MEN RATED BY EXTENT OF FINGER-PAD CALLOSITIES

Finger callosity rating[1]	*Sickness absence records*		*No. at risk & records of sickness absence*
	Days lost/man	*Sickness spells/man*	
0	7·0	0·62	349
1	4·0	0·47	45
2	10·7	1·19	112
3	10·1	0·94	112
4	11·2	0·94	113
5	12·1	0·93	70
Total	8·8	0·81	801

[1]See Table 3.

TABLE 5

EFFECT OF CHANGES OF OCCUPATION ON VIBRATION SYNDROME EFFECTS

	Improvement rates for different components of vibration syndrome					
	White fingers		*Arm pains*			
			(A) Hands and wrists		*(B) Elbows and shoulders*	
	No.	*%*	*No.*	*%*	*No.*	*%*
Interval to last vibration exposure						
< 5 yrs	42	21	32	78	16	19
> 5 yrs	66	30	57	75	33	55
New occupation						
Manual	78	23	60	70	36	31
Inspectors	30	37	29	90	13	77
Reason for change of occupation						
Medical	28	28	28	82	11	55
Non-medical	80	26	61	74	38	39
No. of cases	108	27	89	76	49	43
No. of men			151			

troubles which allowed the same men to feature three times in the analysis, *i.e.*, with finger-blanching, with pain in the hands or wrists, and with pain in the forearm, upper arm, elbow or shoulder.

By doing this and, at the same time, relating these troubles to (*a*) the interval to the last vibrating tool exposure, (*b*) the present ('new') occupation, and (*c*) the reasons for the change of occupation, we have been able to show that:

(1) finger-blanching is more persistent than arm pain;

(2) shoulder and elbow pains are more persistent than hand or wrist pains;

(3) men who cease to do manual work recover from the effects of vibration syndrome more quickly and more thoroughly than men who continue to do manual work but all ex-users of vibrating tools are liable to retain their finger callosities either indefinitely or for many years;

(4) men who changed their jobs because they could not stand the strain of working with a vibrating tool ('medical reason') did no worse and possibly slightly better than men who changed jobs for other reasons.

Effects of inexperience and ageing on arm complaint component of vibration syndrome

The results of trying to gauge the effects of inept handling of a vibrating tool due to inexperience and to advancing age are shown in Table 6. The so-called *standard group* in the Table includes the 63 men whom we had rated second lowest in the finger callosity scale (*i.e.*, they had experienced blanching but so far only in one finger of the operative hand),

TABLE 6

EFFECTS OF INEXPERIENCE AND AGEING ON ARM COMPLAINT COMPONENT OF VIBRATION SYNDROME

Group	*Occupation*	*Arm pains*			
		Hands and wrists		*Elbows and shoulders*	
		Standard	*Actual*[1]	*Standard*	*Actual*[1]
Standard	Mixed	100	7·8	100	9·4
Inexperienced users of vibrating tools	Mixed	247	19·3	151	14·2
Skilled men	Precision tools	220	17·2	79	7·4
	Fettlers	302	26·3	303	28·5
	Hammer-men	832	64·9	547	51·4

[1]Affected men as % of all men at work.

and the group of *inexperienced users of vibrating tools* includes 458 men whom we had rated lowest in this scale (*i.e.*, they had never experienced finger-blanching). The remaining men were designated *skilled operatives* and were divided (as in Table 1) into 131 hammer-men, 280 fettlers, and 73 precision tool users. For each of these groups the proportion of men with one or other type of arm complaint other than white fingers (Table 5) was ascertained and is shown in Table 6 both as a prevalence rate and as a prevalence rate scaled to a standard figure for each type of complaint (standard rates = 100).

According to this analysis, the only men to suffer as much from shoulder pain as from hand or wrist pain were skilled fettlers, who were, in both respects, three times worse off than the men in the standard group. Skilled users of precision tools had less than the standard rate of shoulder pain and twice the standard rate of hand or wrist pain. In the latter respect inexperienced users of vibrating tools resembled skilled users of precision tools, but they also rated 50% above standard for shoulder pain. Finally, the hammer-men were in a class by themselves, with eight times the standard rate for hand and wrist pain and five times the standard rate for shoulder pain.

Discussion

Though difficult to refute at a clinical level, the nerve injury theory of Marshall and his colleagues is hard to reconcile with the group of symptoms it is trying to explain, particularly if these are studied in relation to time. For it stretches incredulity to breaking point to be asked to believe that Raynaud's phenomenon is the result of vibration-induced injury to nerve endings (and consequent heightened sensitivity to cold of smooth muscle fibres) when it (*a*) can be caused by plunging an arm into hot water, (*b*) is difficult to produce while gripping a vibrating tool, and (*c*) may be confined to a single segment of a finger (Jepson, 1954; also unpublished data from the present survey). In fact the anatomical restriction alone makes it impossible to accept vasospasm as an abnormal as distinct from a salient factor in the situation. For in order to have the effects of vasoconstriction limited to a finger segment the affected blood vessels must be smaller than arterioles. Yet such vessels (*i.e.*, capillaries) have no power to contract and can only expand if the surrounding tissues are sufficiently soft and flexible to admit the extra blood.

The following case history illustrates how the normally soft basis of a finger pad could be totally obliterated by callus even when a high level of tool speed is combined with a low level of tool/component rebound. The man concerned was an engine tester in an aeroplane factory who had never in his life worked with a vibrating tool. However, finding himself on a night shift with no engines to test, he proceeded to pass the time etching engine numbers on to small metal components. These were so light that he was able to hold a small pair of tongs (*i.e.*, a component holder) in one hand and the etching tool in the other hand. While doing this work there was no discomfort, but as soon as he stopped both hands began to sting and feel stiff, and the following night they were so painful that he could get no sleep. Finally, no sooner had he 'recovered' than he noticed that where he had previously felt pain he could now see spots. Thinking that he had contracted a skin infection he saw the same factory doctor who had had one of us working in his office during the previous week. Realizing that the pressurized areas in both hands were mapped out with a multitude of petechial haemorrhages, the factory doctor contacted us and eventually let us have all the details we have described.

The callus or capillary occlusion theory recognizes a large element of vasospasm in Raynaud's phenomenon but insists that this is a normal reaction to cold of a hand whose reserves of capillary blood are no longer sufficient to 'buffer' either the effects of a sudden fall in blood volume, due to contraction of a digital artery of large calibre, or (in extreme cases) the effects of a sudden increase in the volume of arterial and venous blood (at the expense of capillary blood) due to widespread vasodilatation under the influence of a sharp rise in temperature.

So long as a man is earning a good living with a vibrating tool he is probably better off if he has tool-resistant albeit cold-weather-sensitive hands than if he has tool-sensitive and cold-weather-resistant hands. He could, however, afford to have softer hands when he retires, and in order to produce these he would be well advised to seek the treatments which are regularly meted out to men and women whose living depends upon their having delicate fingers. If such treatments were generally available, the impression that the occupational variant of Raynaud's phenomenon is a 'life sentence' would probably be replaced by the idea that tough hands are as necessary an adjunct to certain occupations as are well-developed muscles; but, unlike the muscles, they usually need more than complete rest to revert to normal.

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APPENDIX

Data collection format

1. Firm
2. Factory
3. Workshop
4. Sex and date of birth
5. Present occupation with starting date and white finger rating
6. Previous occupations with starting and end dates and white finger rating
7. Hospital admissions with reasons and dates
8. Other illnesses and injuries with reasons and dates
9. Have you ever had an attack of white or dead fingers?
10. Date of first and last attacks
11. Ring affected digits:

	Thumb					Little finger
Right hand:	0	1	2	3	4	5
Left hand:	0	1	2	3	4	5

12. Are you normally right- or left-handed?
13. What provoked the first attack?
14. When do they occur?

	Winter			Autumn
Seasons	1	2	3	4
Cold water				
Hot water				
Watching football				
Diurnal: Before leaving home				
During transit				
While walking				
At night				
Week-ends only				
Never				

15. Is the finger blanching Seen but not felt?
    Associated with pins and needles?
    „ „ other sensations (describe)
16. Has an attack ever led you to consult a doctor?
17. Between attacks have you Pain in the fingers?
    hands?
    wrists?
    forearms?
    elbows?
    upper arms? (Describe)
    shoulders?
18. Are fingers notably stiff or clumsy when not white?
19. Have you had to give up any hobbies, *e.g.*, cycling, swimming, gardening, other (describe)?
20. Do you suffer from chilblains, whitlows, or other hand complaints?
21. Are your white fingers a family complaint?
22. Describe any serious illnesses or premature deaths in near relatives
23. Do you regard white fingers as an occupational disability?
    a reason for changing your job?
24. Official sickness absence records for any period between 1965-1967 (Photostat copies)

APPENDIX TABLE A

OCCUPATIONAL ANALYSIS OF VIBRATING TOOL USERS, SHOWING MEAN AGES AND EXPOSURE PERIODS FOR 1 021 MEN AND 27 WOMEN INCLUDING 524 MEN AND 4 WOMEN WITH VIBRATION-INDUCED FINGER BLANCHING

Ref. No.	*Occupation*	*Principal tool action*	*Products*	*Workers*		*Males (cases of)*		
				Male[1]	*Female*[2]	*C.W.F.*[3]	*V.W.F.*[4]	
							No.	*%*
1	Clinchers and flangers	Hammering	Car doors	109 (50)	—	2	80	73
2	Chippers and chisellers	Chiselling‡	Steel bars	93	—	1	67	72
3	Riveters and holders	Hammering	Steel plates	40	—	3	11	28
4	Taggers and strikers	Hammering	Golf clubs	46	—	1	14	30
5	Concrete and road drillers	Punching and drilling‡	Repair work	33	—	—	9	27
6	Groovers and etchers	Drilling*	Aero engines	42	23	1	5	12
7	Cabinet blasters	Abrasive*	Propellers	38	—	2	4	11
8	Other punching tools	Punching and drilling*	Various	37	—	1	20	53
9	Foundry grinders	Abrasive‡	Metal patterns	90	—	1	77	86
10	Roughers and pounders	Polishing*	Ladies' shoes	37	—	1	25	68
11	Lathe grinders and polishers	Polishing*	Aero engines	130	2	3	50	38
12	Fettling and emery dressing	Punching and abrasive‡	Metal patterns	151	—	2	75	50
13	Other and multiple jobs	Miscellaneous‡	Various	175	2	3	105	60
			Totals	1 021 (50)	27	21	542	53

*Precision tools.
‡See fettlers in Tables 1 and 6.
[1]Figures in parentheses = men seen in 1953 and not included in the rest of the table.
[2]Including four cases of C.W.F.
[3]Cases of finger blanching excluded from later analyses (cold-induced or begun before work with vibrating tools).
[4]Cases of finger blanching included in later analyses (vibration-induced or begun after work with vibrating tools).

APPENDIX TABLE B

VIBRATING TOOL USERS RATED BY AGE, DURATION OF EMPLOYMENT, AND FINGER BLANCHING

Occupation[1]	*Age (years)*				*Duration of employment (years)*		*Occupationally-induced white fingers*			
	At interview		*At first exposure*				*No. of affected fingers*		*Years to first attack*	
	Mean	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*	*Mean*	*S.D.*
1	43·8	12·72	32·5	10·19	9·7	9·51	3·6	3·04	2·5	3·73
2	45·4	9·65	29·4	8·83	15·2	9·95	2·9	2·89	4·3	5·40
3	44·9	8·54	25·4	10·97	19·0	12·52	1·8	3·06	7·2	5·29
4	42·7	13·84	25·1	8·30	14·9	19·48	1·9	3·24	5·5	10·26
5	47·1	8·56	34·7	10·72	12·3	9·89	1·7	3·26	10·4	11·36
6	40·7	12·32	33·0	10·02	7·5	7·46	0·2	0·72	9·3	7·59
7	46·9	11·01	39·7	9·80	7·0	6·64	0·5	1·91	2·3	2·49
8	45·0	10·73	24·3	9·56	19·2	12·15	3·1	3·68	12·9	11·58
9	43·7	12·81	23·4	7·49	20·3	12·81	4·9	3·55	5·3	6·32
10	40·0	16·00	28·0	9·99	12·0	11·58	3·9	3·40	1·9	2·05
11	40·1	11·52	27·6	7·91	12·5	10·30	1·6	2·38	7·3	8·10
12	44·6	10·41	31·6	9·54	12·8	10·29	2·1	2·87	6·9	8·75
13	47·5	9·92	28·3	8·43	19·0	9·80	2·7	2·83	6·5	7·68
Total	44·3	11·50	29·2	9·82	14·6	11·50	2·5	3·10	5·7	7·47

[1]See Appendix Table A.

APPENDIX TABLE C

ARM COMPLAINTS OTHER THAN FINGER BLANCHING: AFFECTED MEN AS PERCENTAGE OF ALL MEN AT RISK

Occupation	*Men with white fingers on*			
	Neither hand %	*One hand only* %)	*Both hands* %	*All men* %
1	44	70	68	63·3
2	44	45	50	44·6
3	42	(50)	(75)	45·0
4	39	(33)	55	41·3
5	12	(0)	(50)	18·2
6	12	(33)	(0)	12·9
7	8	(0)	(33)	9·4
8	25	(57)	82	51·4
9	42	33	43	37·8
10	(100)	(25)	33	33·3
11	11	(0)	24	13·8
12	35	44	50	40·0
13	44	24	32	32·9
Total	29·8	42·4	44·5	36·6

Figures in parentheses are based on less than 10 cases.

APPENDIX TABLE D

ARM COMPLAINTS OTHER THAN FINGER BLANCHING BY AGE AND DURATION OF VIBRATING TOOL USE: AFFECTED MEN AS % OF MEN AT RISK

Years with vibrating tools	*Age at interview (yrs)*		
	<34 %	*35–49* %	*>50* %
<4	22	33	36
5–9	26	37	23
10–19	51	42	41
>20	—	39	40
All continuous	29	39	38
,, discontinuous	29	39	39
No. at risk (continuous) ..	206	374	315
Total at risk	227	431	363

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