BLOOD SUPPLY DISTURBANCES CAUSED BY VIBRATIONS

G. Jancik

ABSTRACT

In recent years, it has been observed that long-term use of hand-held tools that produce vibration may lead to disturbances in blood supply. These disturbances were detected in workers from different kinds of industry. In a specific case, metal workers showed these disturbances in the blood supply of the upper extremities after an exposure to the vibration for only 10 to 20 min/day. From two groups of these metal workers who did the same job with different tools, only one showed the disturbances in blood supply of the upper extremities. The only difference was seen in the range of the vibrations. Vibration of about 700 Hz led to the disturbances, whereas vibration of about 2,600 Hz did not.

INTRODUCTION

At first, the disease, named after Maurice Raynaud, a Paris neurologist in 1862, was not accurately described; it was only considered a symptom of a complexity of disorders. Only in the course of later decades was "Morbus Raynaud" described in more detail. Today, this term denotes a spastic restriction of the blood vessels accompanied by abnormal sensitivity to cold. This phenomenon was recognized during the 1920's and 1930's as a consequence of the effect of vibration.

One of the causes was found to be the use of pneumatic tools. Besides joint disorders, it also resulted in this vascular reaction. Another group of illnesses was found in the shoe industry where workers had to knock the uppers of shoes mounted on blocks into shape on hammering machines. The tools were metal rollers eccentrically supported by cylinders, which rotate at speeds up to 2,000 rpm. The metal rollers were thus thrown outward and struck the shoe upper and block assembly held by the worker's hands. The blocks with the uppers were forced by the worker against the machine, and the blows and vibration were absorbed by the worker's hands. This vibration exposure mainly resulted in arterial hyperexcitation with vascular cramps, "dead fingers," sensation of cold, numbness, and stinging or steady pain. In several instances, damage to the digital joints and reduced active and passive mobility were observed. Occasionally, the patients complained of general nervous discomfort. The first symptoms became manifest after 4 to 6 weeks, but mostly only after several months of this sort of activity. The ailment appeared directly related to the length of exposure and vibration intensity. The longer the worker was at the machine, the more frequent and grave was his nervous discomfort.

Frequently the illness caused prolonged interruption to or even a need to change the worker's activity. In general, however, gradual improvement of the patient's condition could be observed when the place of work was changed. In other instances, however, complete numbness and stiffness of the fingers or the hand persisted and their use was seriously hampered. This damage was recognized as an occupational disease by German legislation in 1943.

Our work is concerned with about 90% of all reported cases caused by pneumatic tools in our geographical region. In the mining industry, angioneuroses of the vessels occurring in conjunction with joint alterations are no longer observed among pneumatic-tool operators. Apparently there must be other factors besides vibration. It appears that with older-type air tools, some of the cold air stream blew over the worker's hands and thus sensitized them. The hammering machines of the shoe industry were redesigned, new methods were introduced, and preshaped leather and synthetic materials were used to an increasing extent.

During the past 20 years, however, industry has adopted new processes, machines, and tools in which vibration either played a primary part, or just occurred during the work, and exerted an adverse effect on humans. Among the various vibrating tools, those used in road construction, drawing dividing lines, concrete compaction, and materials handling may be mentioned. Here, however, direct effects on forearms, hands, or fingers have been observed only in isolated cases. Tools such as power saws have been introduced to an increasing extent during the past 20 to 30 years. After sufficient exposure, the aforementioned

phenomena and complaints in terms of angioneuroses of the vessels appeared once again.

From papers by Jansen* and observations during the 1920's, it was gathered that noise *plus* vibration were the cause of those conditions. Assuming that noise itself results in probable reduction of blood supply in the skin through vascular constriction, it may be taken for granted that vibration is almost invariably accompanied by noise. Marochini observed the same angioneuroses in silvicultural workers in Yugoslavia in about 1965.

STUDY

When a group of workers using vibrating power saws was compared with a reference group of 317 forest workers living in an identical environment with identical habits but not using the power saws, the reference groups did not show angioneuroses of the vessels. To objectify the complaints and to exclude any other potential causes, the persons were subjected to a thorough clinical examination. X-rays of the cervical vertebral column and the hands were made, and oscillographic measurements after provocation by the cold-water method were taken.

In forest workers examined in our area, such complaints and changes were not as pronounced as those observed by Marochini in Yugoslavia. The reason for this appears to be that a shorter working period and change of activities are apt to lessen or even prevent such effects, as had been found by Koelsch in the 1930's. In German forestry, it is customary to engage in tree felling only during certain months of the year. The workers are kept busy with planting and other work for the remaining time. In Yugoslavia, however, they used teams of lumbermen who worked exclusively with power saws for 10 hr/day.

A psychological aspect of interest is that power-saw operators are conscious of a certain feeling of status and that they are reluctant to hand their saws over to fellow workers. Among such workers, I have found people with various speech disorders and others whose personality was inhibited.

The power-saw industry, through world-wide observation, has become aware of the detrimental effects of vibration and have improved their designs. The handle, which was formerly rigidly mounted to the tool, is now resiliently attached in order to reduce the effect of vibration on hands and forearms. Yet, the forest worker who had been using the rigid-handle saw for years was usually reluctant to accept the new saws. I know from personal experience of the degree of precision with which these workers must apply the saw to determine the direction in which the tree is expected to fall. The somewhat resiliently supported handle of the new types of power saw gives the worker some feeling of insecurity. For this reason they are reluctant to change over to the new tool, whereas newly trained persons find no difficulty in handling the new-type saws.

*No references are available for this presentation.

About 3 years ago, we received reports on workers in a metal-working plant who complained of vascular angioneurosis. These complaints could be objectified, by examination, in six of seven workers. They all were manufacturing bevels at the end of nonferrous metal sections. The process as such did not provide any proof of vibrational effects. Only the operation of sharpening the nonferrous metal stock by means of a milling cutter resulted in a vibrational effect on the hands and forearms. The duration of this exposure in an 8-hour shift was 10 to 20 minutes each day. The effect occurred only with stock, the alloy of which was too brittle to be pointed by a rolling operation or to be inserted into dies to produce the desired sectional configuration. Such operations did not even take place daily.

The operation is characterized in that the nonferrous bar stock must be very firmly gripped during sharpening (Figure 1) because the milling cutter would otherwise pull the wire into the machine. Vibration is thus fully transmitted to the worker's hands. The worker has to grip the wire stock more firmly than a power-saw operator would grip his tool. This seems to be the reason for the intense effect of vibration on the forearms and hands. Such harmful effects have never been observed with a subordinate and short-time operation like this. The cause was therefore sought elsewhere. Examination of the oils and greases did not reveal them as possible causes in terms of intoxication or secondary sensitization. As the nonferrous alloy also contains lead, this was investigated, since lead is toxic to the vessels and may have exerted an intensifying effect. All investigative work produced a thoroughly negative result.

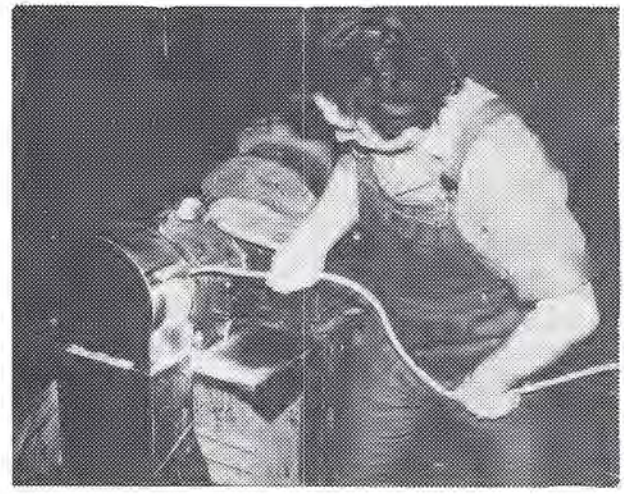

Figure 1. Beveling operation.

I tried the sharpening operation with the milling cutter myself and had an uneasy feeling in both hands after carrying out one sharpening operation. This feeling persisted for about 1 hour. However, I did

not notice any deficiency of blood supply or cold hands. It was astonishing to find that workers of a different company who performed the same operation with the same material did not have any complaints of this sort and that none could be found, either.

The cutter (Figure 2) used by the first-mentioned company had 27 teeth and the drive motor rotated at a speed of 1,520 rpm, which resulted in a frequency of 684 Hz. In the factory where no complaints were expressed, the cutter had 110 teeth and the motor rotated at 1,420 rpm, which corresponds to a frequency of 2,603 Hz.

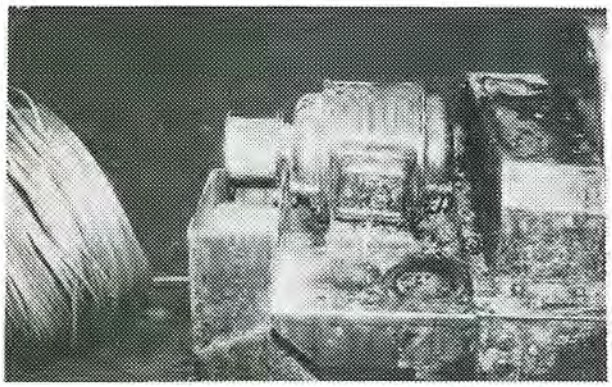

Figure 2. Milling cutter machine.

Site measurements of noise, which had been thought to be a contributing factor, revealed a sound level between 70 and 72 dB(A). Only when the wire coils were put down did the level very briefly rise to 85 dB(A). These levels are low for a metal working plant.

Results of X-rays of the hands, showed abnormal cortical thickening. Whether this condition is pathological or can be thought an adaptation of the bone cannot be conclusively established on the basis of the small number of persons examined in this study.

CONCLUSION

The damage caused by vibration not accompanied by excessive noise within a certain frequency range, as we know it from the field, should prompt us to experimentally investigate certain ranges of vibration frequency for harmful results. Conventional experiments on animals will be of no avail here, and observation of practical conditions along with suitable analysis of the working methods and processes should be substituted. This will be of great significance, especially when it comes to collecting such experience on an international level.

QUESTIONS, ANSWERS, COMMENTARY

Question (D. Wasserman, NIOSH): During your studies, did you notice any specific work practices or guidelines employed in the plants you studied? For example, were workers exposed to the hand-arm vibration rotated, or did they have frequent rests or something of this sort? Were there any specific work practices guides that you noticed either in a given plant or multiple plants?

Answer: The workers worked for a mere 30 seconds, then they rested for anywhere from 20 to 30 minutes, and because of these long rest periods, there was no need to have work practices guides.

Question (W. Taylor, University of Dundee): I wondered if anybody in the audience would comment on the bone X-rays taken in this study because of the problem of bone cysts. We're also involved in this area in the North Sea diving operations where, instead of emboli, we think clots form in the vessels of the hand in the case of vibration; similarly the bubbles of nitrogen are doing the same in those deep divers who went down 600 to 1,000 feet in the North Sea. I wonder whether, Dr. Jancik, you've noticed any bone cysts with some enlargements of the metacarpal heads? If so, did you notice inside it any bone or small necrotic pieces of bone in which, on the outside, you get new bone laid, so that you get a vacant, black area, surrounded by a very marked white nodule?

Answer: Rarely have we seen cysts; only a small enlargement was present. We have not found any cysts of the type you describe.

Question (W. Taylor): Have you done any frequency analysis of the workplace vibration?

Answer: I have only done noise frequency analysis, and not necessarily vibration frequency analysis of the tools which have been discussed. I have also done transmissibility measurements on these tools. The tools are held very tightly, and I expect the vibration transmission characteristics to be quite large.

Question (F. Dukes-Dobos, NIOSH): I don't know whether I missed from the lecture a statement concerning the length of the time these workers were exposed to this condition. Specifically, the total exposure time in years that each of these workers was exposed.

Answer: Maximum—generally, 10 months to 6 years; we observed no dysfunction from periods up to 3 months of work.

Question (P. Rentos, NIOSH): Other than the swelling of the metacarpals that you've noted, were there any other signs or symptoms that were diagnosed on these workers?

Answer: Subjects were X-rayed and, in addition to the findings of the X-rays, there appeared to be vascular disturbances in those subjects—particularly, in those subjects who were observed after a 3-year work period.

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