COMBINED AND SINGLE EFFECTS OF PROLONGED NOISE AND VIBRATION EXPOSURE ON EMPLOYEES' COCHLEO-VESTIBULAR FUNCTIONS AND URINARY CATECHOLAMINES

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INTRODUCTION

In viewing recent findings about work conditions in the Finnish metal industry, it appears that employees at work are simultaneously exposed to numerous different environmental factors. On the basis of present knowledge, noise and vibration can be rated one of the most common and potential hazards in modern working environments.

The available studies concerning man's responses to occupational vibration have been reviewed quite extensively. A number of investigators have reported both physiological and psychological performance decrements under vibration exposure and the greatest biodynamic responses are known to occur in the low-frequency range. Concern about the deleterious effects of noise on human physiology has been expressed by several investigators. Permanent hearing loss is supposedly the best known health hazard caused by long-term noise exposure. In this connection, observations described by Russian authors are very interesting. For example Temkin found frequent disturbances of cochleo-vestibular function among workers at reinforced-concrete plants. A less firm standing posture has also been recorded in drivers of dump-trucks at the end of the work shift. Analogously, subjects may present vestibular symptoms such as nausea and vertigo during and after an intense noise and vibration exposure. In studies on professional stress some authors have discovered a marked relationship between the load of the working environment and disturbance of the endocrine balance.

Despite the excellence of stress studies, comparatively little is known about the reaction of the human endocrine system, particularly to coexisting physical environmental hazards. In view of this the present investigation sought to characterize the alteration in the sympatho-adrenal system which may accompany the subjection of industrial workers to prolonged noise and general vibration.

MATERIAL AND METHODS

A total of 388 male employees served as subjects in the study and all of them worked in three engineering plants. The sample comprised representatives from different stages of production and types of exposure. The data were collected
during the METELI research programme and certain parameters from sample population were published earlier. 10

Results from audiometric and equilibrium tests were used as indices of extended exposure to noise and vibration. Both tests were carried out during a detailed health examination. The hearing thresholds of both ears were determined by pure tone clinic audiometry and on the basis of the results subjects were classified as having "good" hearing (loss of hearing no more than 40 dB at any frequency of 3, 4 and 6 kHz) and impaired hearing (loss of hearing more than 45 dB at the frequencies concerned). To assess the functional state of the vestibular system each subject was required to stand on a wooden board; the board was kept balanced by means of a sensitive horizontal bearing. Every person tried to stand on this balance board so that neither edge of the board touched the electric sensors mounted on the floor level. Every touch and the total time of the touches were registered and interpreted as minus scores, whereas the length of time the subjects were able to maintain their balance was registered as a plus score. A single trial took one minute. After the approved performance an index of balance was computed, and for further presentation of the results individuals were classified as having "good" balance (index of balance 65 or more) or impaired balance (index of balance less than 64).

During the research programme surveys and interviews were carried out to evaluate the histories of diseases and traumas of hearing and the vestibular organ. In addition, detailed descriptions of characters of working environments were made through both instrumental measurements and the subjective rating technique. Based on the results of the mail survey, an index of hazards was formed by cross tabulating individual variables such as noise and vibration with each other. The greater the index value, the more hazardous the working environment is with regard to its vibro-acoustical features. Urine samples were collected in factories during the last three hours of the same day shift on Monday morning, and catecholamine concentrations were determined using the fluorometric technique. 11

For data processing subjects were grouped into two age classes (24-40 years and 41-64 years old). Within each age class the material was further divided into four classes which distinguishes degrees of the state of cochleo-vestibular performance. For group comparisons the changes in urinary catecholamine excretion are given in per cent. Percentage transformations are made using the calculated grand mean values as initial values.

RESULTS

The association between hearing loss and decreased balance performance is shown in Fig. 1. Among young people (under 40 years) the arithmetic mean (±S.D.) of the
The percentage differences in the urinary excretion of adrenaline and noradrenaline according to four degrees of the cochleo-vestibular performance are set out in Fig. 3. There is a decreasing tendency in adrenaline output from the first up to the third class. Young employees having "good" hearing and balance excrete

![Graph showing index of balance and index of hazards for young and old employees.](image1)

![Graph showing mean values for index of balance in the hearing classes among old and young employees.](image2)

![Graph showing mean percentage changes in urinary adrenaline and noradrenaline excretion according to the degree of employees' hearing and balance impairments.](image3)
relatively little adrenaline into urine as compared with the other subjects
classified with regard to cochleo-vestibular performance decrements. Percentage
differences in adrenaline excretion between classes are rather similar among both
age classes, although adrenaline concentrations are somewhat lower among the old
than the young. The most marked differences are between the class of impaired
hearing and balance (class 4) and the class of impaired hearing and "good" balance
(class 3).

In contrast to alterations observed in adrenaline excretion data from the
noradrenaline output proves to have a rather clearcut increasing tendency, and
the percentage elevation in noradrenaline excretion seems to be related inversely
to functional disorders. The noradrenaline excretions in both age classes for
employees with either impaired hearing or balance are higher than among people
with "good" hearing and balance. When hearing loss is combined with impaired
balance, urinary noradrenaline output seems to increase correspondingly.

DISCUSSION

Employees working repeatedly under industrial-type noise and vibration suffer
defects in hearing as well as disturbances in postural equilibrium. Following
decreasing performance in hearing and balance, synchronous changes in the sympatho-
adrenal system arise, and the more serious the cochlear-vestibular disorders, the
more noticeable the gradual changes in urinary catecholamine excretion are.
Elevated liberation of urinary noradrenaline in classes of both impaired hearing
and balance emphasize the possible association between prolonged exposure and
cardiovascular diseases. Such data linking long-term exposures to occupational
noise with heightened blood pressure and hypertension in workers have also been
previously documented by the author. 12 In general, the phenomenon agrees fairly
well with early findings in this field. 13,14,15 Nevertheless, the results do not
lend easily themselves to proper interpretation.

A tentative explanation lies in the close anatomic link between the cochlear
and vestibular structures. 16 According to one postulation noise-induced trauma
afflicts not only the cochlea but also the vestibular system. 17 In Parker's view 18
it is inconceivable that sound energy could somehow bypass the vestibular receptors
and act directly on the central nervous system. On the other hand, mechanical
vibration might be a contributory factor in temporary or permanent hearing
loss. Simultaneously applied acoustic and vestibular stimulation indicate an inter-
action of the acoustic and vestibular system, 22 and depending on the exposure
conditions, both routes of stimulation might be used. In the low-frequency range
in particular, effects and transmission routes of noise and vibration could be
essentially the same. Within these statements the joint impact of work related noise and vibratory stress is conducted in the inner ear, and after moderation the resultant neural impulses are further transmitted to and processed by the central nervous system. In the case of combined effects, the functional changes involved are more pronounced than the single effects of the same individual factors. However, there are certain differences in neural amplification and vital function between the auditory and vestibular system and with regard to the most prominent distinction even impairment of the hearing organ is said to develop more quickly than the symptoms of the vibration disease. So far, the use of the present classification for characterization of gradual deterioration of the organs seems reasonable. In any case, the complex nature of the findings demands complementary and tightly-controlled studies; one such study is already in progress.

As frequently noted in evaluating the long-lasting exposure to environmental hazards, there are plenty of difficulties. Not the least of these are instrumental measurements for a number of years. That is why the results may well have extra relevance for determinations of biological influences and labour protection. In the light of observations, stabilometry and audiometry seems to offer suitable methods through which the quantified biological indicators quite accurately mirror the noxious characters of peoples' everyday working environments. Naturally, the relatively high reliability of employees' discomfort ratings due to environmental noise adds value to present argumentation.

**SUMMARY**

Work related coexisting noise and vibration stress for extended periods of time may produce in human body an additional load, which is detectable through synchronous functional disturbances of the inner ear and the synthesis of adrenomedullary hormones.

**REFERENCES**