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Effect of local vibration on the brain monoamines of rats

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ARIIZUMI M, YAMAGUCHI Y, OKADA A. Effect of local vibration on the brain monoamines of rats *Scand J Work Environ Health* 12 (1986) 435—437. The experimental study investigated the effect of local vibration on brain monoamines, and the effect was compared with that of whole-body vibration. The hind legs of rats were exposed to local vibration with frequencies of 20 and 120 Hz under constant acceleration of 50 m/s^2 for 240 min. The rats were decapitated immediately thereafter. The levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in the whole brain or its parts were detected by fluorometric methods. In the whole brain, the NE level showed a tendency to decrease at 120 Hz. The levels of DA and 5-HT showed no changes at either frequency. NE showed a significant decrease at 120 Hz in the hypothalamus and the hippocampus. 5-HT showed significant increases in the hypothalamus at both 20 and 120 Hz. The amines in the whole brain were not significantly affected by local vibration (20 Hz, 50 m/s^2), but were by whole-body vibration (20 Hz, 50 m/s^2). The NE level was significantly decreased by whole-body vibration (20 Hz, 50 m/s^2) and showed a tendency to decrease due to exposure to local vibration (120 Hz, 50 m/s^2). 5-HT was remarkably elevated by whole-body vibration, but less elevated by local vibration. Thus the effects induced in brain monoamines by local vibration are considerably less than those induced by whole-body vibration.

Key terms: central nervous system, dopamine, norepinephrine, serotonin.

While many studies have been done on the physiological effects of local vibration exposure, there are few systematic studies on the effect of local vibration on the central nervous system.

Vibration received by some sensory organs, such as the pacinician corpuscles, travel through the spinal cord to reach the hypothalamus and the cerebral cortex, where the information is recognized.

Some investigators (1, 2, 6) have reported stress-induced changes in the concentrations of some biogenic amines, such as norepinephrine (NE), dopamine (DA), serotonin (5-HT), in the whole brain and brain regions. These amines have been known to be the neurotransmitters in the brain. Each amine shows a characteristic distribution in its concentration in various regions of the brain, and the changes in the concentrations of these amines reflect the functional status of each region. Therefore, we thought that, from the biochemical point of view, the investigation of changes in the concentration of these amines in the brain would be an important step in the study of the effects of vibration on the central nervous system.

In this paper we also intended to examine the regional differences in the changes induced by local vibration in the concentration of these amines. Furthermore the effect of local vibration was compared with that of whole-body vibration.

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Materials and methods

The animals used were 40 male Wistar rats weighing 200—250 (average 242) g. During the preexperimental control period, the animals were kept in the light from 0800 to 2000, and for the remaining time they were in darkness. The room temperature was fixed at 23 (±2)°C. Food and water were provided freely.

Vibration exposure

The apparatus for vibration exposure consisted of an electromagnetic shaker coupled to an amplifier, a function oscillator, and a vibration meter.

For local vibration exposure, the hind legs of rats were subjected to vertical and sinusoidal vibration for 240 min. The rats were placed in individual wire mesh cages, in the prone position. The hind legs were outside the cage and the plantar surfaces were horizontally fixed to the vibrating plate by means of double-sided adhesive tape so that the vibration would be transmitted only to the hind legs. The part of the cage containing the rest of the body was fixed on a non-vibrating plate separated from the shaker (figure 1). The vibration frequencies used were 20 and 120 Hz under a constant acceleration of 50 m/s^2.

For the whole-body vibration exposure, the rats were individually kept, in the prone position, in wire mesh cages, which were tightly fixed on the vibrating plate. Accordingly, the rat's whole body was subjected to vertical sinusoidal vibration (20 Hz, 50 m/s^2) for 240 min.

The control rats for each experiment were placed in wire mesh cages like those of the exposed rats, and the cages were placed near the operating shaker during the exposure. Therefore, they were exposed to the noise generated by the shaker without experiencing the vibration itself. Each group consisted of four rats.

Assay of brain monoamines

Both the vibration-exposed and the control rats were killed by decapitation immediately after each experiment. Their brains were carefully removed from the cranium. Those used for the examination of the regional parts were immediately divided into seven regions — cerebellum, medulla oblongata and pons, hypothalamus, striatum, midbrain, cortex, and hippocampus (4). These tissues were then frozen in dry ice and kept deep frozen until the assay. After separation from the brain tissue with an Amberlite CG-50 column, NE, DA and 5-HT in the whole brain and its different regions were measured with fluorometric methods (3, 5).

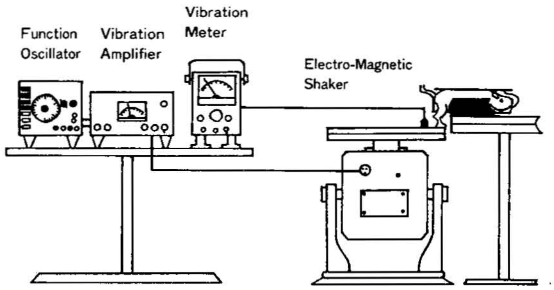

Figure 1. Apparatus for local vibration exposure to the hind legs of rats.

Statistics

Student's t-test was used for the comparison of the mean values between the vibration-exposed group and the control group. The values of $p<0.05$ and $p<0.01$ were regarded as significant; a p-value of <0.10 was considered as suggestively significant.

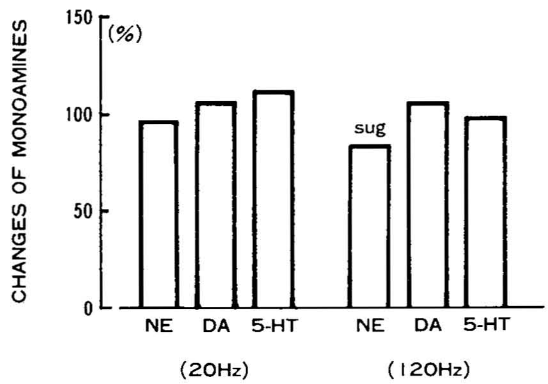

Figure 2. Effect of local vibration (20 Hz, 120 Hz; 50 m/s^2), subjected to the hind legs of rats for 240 min, on the levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in the whole brain. [sug $p<0.10$ versus control group (t-test)]

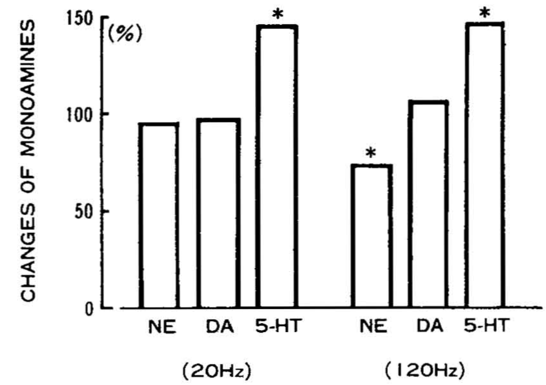

Figure 3. Effect of local vibration (20 Hz, 120 Hz; 50 m/s^2), subjected to the hind legs of rats for 240 min, on the levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in the hypothalamus. [*$p<0.05$ versus control group (t-test)]

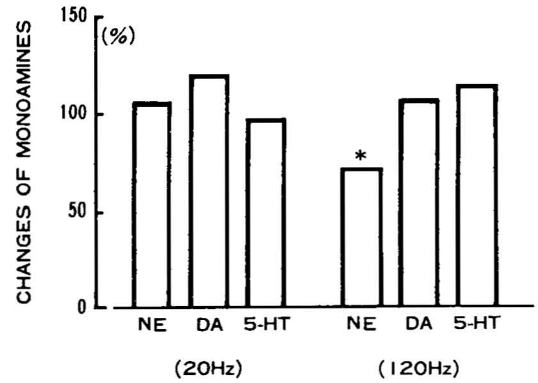

Figure 4. Effect of local vibration (20 Hz, 120 Hz; 50 m/s^2), subjected to the hind legs of rats for 240 min, on the levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in the hippocampus. [*$p<0.05$ versus control group (t-test)]

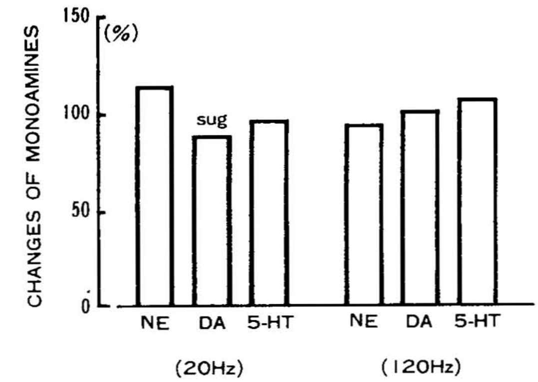

Figure 5. Effect of local vibration (20 Hz, 120 Hz; 50 m/s^2), subjected to the hind legs of rats for 240 min, on the levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in the striatum. [sug $p<0.10$ versus control group (t-test)]

Presentation of results

The results are presented as the relative change (%) of the mean value of the vibration-exposed group from that of each control group (indicated 100 %).

Results

Figure 2 shows the effect of local vibration on the levels of NE, DA, and 5-HT in the whole brain. The amines were not significantly changed by local vibration with a frequency of 20 Hz. At 120 Hz, on the other hand, the NE level in the vibration-exposed rats showed a tendency to decrease in comparison with that of the control group ($p<0.10$). The concentrations of DA and 5-HT were not significantly changed.

Figure 3 shows the effect of local vibration on the levels of NE, DA, and 5-HT in the hypothalamus. 5-HT showed a significant increase at the frequencies of 20 and 120 Hz ($p<0.05$). NE showed a significant decrease at a frequency of 120 Hz ($p<0.05$). DA showed no particular change at either frequency.

Figure 4 shows the effect of local vibration on the levels of NE, DA, and 5-HT in the hippocampus. NE showed a significant decrease at the frequency of 120 Hz ($p<0.05$). DA and 5-HT were not particularly changed at either frequency.

Figure 5 shows the effect of local vibration on the levels of NE, DA, and 5-HT in the striatum. At a frequency of 20 Hz, DA showed a tendency to decrease ($p<0.10$). The concentrations of NE and 5-HT were not meaningfully changed at either frequency.

Figure 6 shows the comparative effects of whole-body vibration (20 Hz, 50 m/s^2) and local vibration (120 Hz, 50 m/s^2) on the levels of NE, DA, and 5-HT in the whole brain. NE was significantly decreased by whole-body vibration ($p<0.05$) but only NE showed a tendency to decrease during local vibration ($p<0.10$). DA was not affected by either type of vibration. 5-HT was remarkably increased by whole-body vibration ($p<0.01$).

Discussion

Monoamines such as NE, DA, and 5-HT have been known as the neurotransmitters in the brain. Changes in the concentrations of these amines are induced by some physical factors (1, 2, 6).

In the present study, we have tried to investigate the effect of local vibration on the central nervous system. For this purpose, the changes in the concentrations of the biogenic amines NE, DA, and 5-HT were determined as the response of the central nervous system.

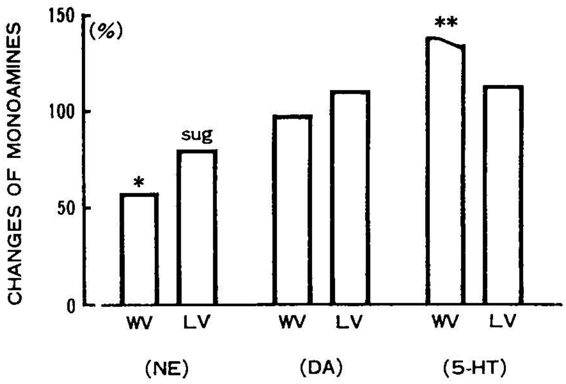

Figure 6. Comparison of effects between whole-body vibration (20 Hz, 50 m/s^2) and local vibration (120 Hz; 50 m/s^2) on the levels of norepinephrine (NE), dopamine (DA), and serotonin (5-HT) in whole rat brain. The rats were each subjected to vibration for 240 min. [WV = whole-body vibration; LV = local vibration; sug $p<0.10$, * $p<0.05$, ** $p<0.01$ versus control group (t-test)]

In the whole brain, the changes were small; only NE showed a tendency to decrease. The affected regions of the brain were the hypothalamus, striatum, and hippocampus. Each of the amines was affected independently in these regions. The regions of the brain principally affected by vibration will be of functional significance. Furthermore, when the effects of local and whole-body vibration on the central nervous system were compared, whole-body vibration seemed to have more influence.

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