INTENSE LOW-FREQUENCY NOISE EFFECTS ON HUMANS

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Introduction Sound in the low-frequency range (between 50 and 100 Hz) has been shown in limited tests at levels up to 150 dB to invoke physiological and psychological responses that do not involve the ear[1], and hence cannot be mitigated by wearing hearing protectors, or by any other practical means. The purpose of this program was to scientifically verify the effects on humans of intense, low-frequency noise at higher levels, and identify the potential limit of human tolerance.

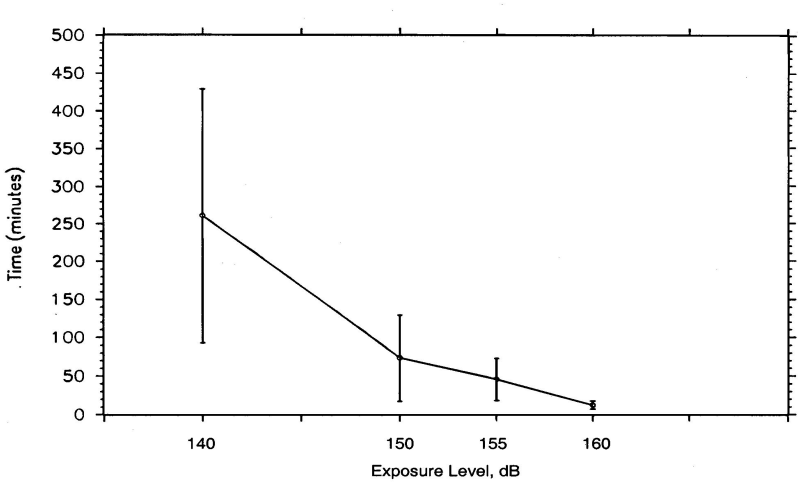
Test procedure The human testing was conducted in a Wyle facility located in El Segundo, California, using a test plan that had been approved by the U.S. Army's Office of the Surgeon General. The tests were conducted in a reverberant test chamber which was connected to a high-powered noise source. The subjects were seated in the chamber and connected to instrumentation which non-invasively monitored their arterial pressure, heart rate, respiration, eye movements, and gastric motility. Prior to the first noise exposure, the subject was given a pre-test audiogram and baseline values were established for each of the physiological parameters being monitored. Before exposure to the noise signals, the subject was fitted with both earplugs and earmuffs to protect his hearing.

The acoustic fields to which the subject was subjected consisted of two, approximately equal, one-third octave bands of noise at center frequencies of 63 and 100 Hz. The initial exposure was at a total sound level of 140 dB, followed by a second exposure at a total sound level of 150 dB, a third exposure at a total sound level of 155 dB, and a fourth exposure at a total sound level of 160 dB. Each exposure lasted for a period of 7 minutes. Throughout the test, the subjects were engaged in a proofreading task that required mental concentration and minor motor skills.

The sound tests and frequencies used in the tests were similar to those which humans have previously been exposed without any permanent physiological or psychological effects. These test differed from previous studies in that quantitative measurements were made of physiological and psychological parameters as the sound level was increased.

Results Of the 20 subjects who participated in the test, half terminated the test before completing the final noise exposure. After each noise exposure, subjects were asked how long they could have tolerated the exposure sound level. The average response dropped from 73 minutes for the second noise exposure, to 45 minutes for the third noise exposure, and to 12 minutes for the fourth noise exposure. Extrapolation of this curve to higher levels indicates that none of the subjects would have tolerated (for the prescribed seven minutes) a noise exposure at a sound level that was 5 dB higher than that of the fourth noise exposure (i.e., 165 dB).

There were no instances of unusual physiological findings during the tests that required cessation of the test. There were marked changes in the various physiological parameters, but these were well within the range of expectation in young adults performing a difficult task. The sensation of respiratory discomfort, although intense, was immediately reversible upon cessation of the noise. None of the subjects showed objective signs of respiratory difficulties after the noise exposure was completed.



Response to the Question:
"How Long Could You Have Stood This Exposure Level?"
(Error bars are ± 2 standard errors of the mean.)

It was concluded that the most important physiological effect of the noise exposure was on the respiratory system. The subjects' post-test comments indicated that, particularly during the fourth noise exposure (160 dB), they had trouble breathing because of pressure on the chest The subjects' physiological measurements indicated that the intense noise exposure directly affects the sensory receptors in the airways that are responsible for the cough reflex. Those "irritant" receptors are normally stimulated by inhalation of foreign particles, e.g., dust, smoke, and fluid droplets from post-nasal drip. It appears that the low frequency intense sound waves also have the ability to stimulate these receptors. If this hypothesis is correct, the effect of the noise exposure would be exacerbated by the presence of water droplets (fog) or dust particles into the chamber.

At the highest exposure level, the subjects' responses also indicated that the intense noise exposure directly interfered significantly with their ability to carry out the assigned proofreading task. Difficulty in thinking, reading, and writing were all reported.

Summary The tests demonstrated clearly that intense, low-frequency sound does produce severe non-auditory effects on humans (males). From the results, it is estimated that exposure to a sound level of 165 dB for a period of seven minutes would be intolerable.

Keywords: noise effects, low Frequency

References

1. Mohr, G.C. et al, “Effects of Low-Frequency and Infrasonic Noise on Man”, USAF Aerospace Medical Research Laboratories Report AMRL-TR-05-69, September 1969.