P501(11/87) Tatarinov AM, Grigor'yev AI, Dzenis VV, Yanson KhA, Oganov VS, Rakhmanov AS.
Changes in the state of tibia bones in humans during hypokinesia with head-down tilt.
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[6 references; none in English]
Authors' Affiliations: Latvian Scientific Research Institute of Traumatology and Orthopedics, Riga; Institute of Biomedical Problems, USSR Academy of Health, Moscow; A.Ya Pel'she Polytechnical Institute of Riga.

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Hypokinesia, Head-down Tilt; Countermeasures, Exercise, Drugs

Abstract: The goal of this experiment was investigation of changes in the biomechanical properties of tibia bones of men undergoing long-term hypokinesia with head-down tilt combined with various exercise programs and pharmacological countermeasures. Data on these bones obtained through ultrasound scanning and photon absorptiometry were compared. Subjects were 15 men, aged 19-44, who were undergoing a 120-day period of bed rest with head-down tilt of -5°. Three of these subjects, the controls, received no countermeasures, 3 were given a pharmacological substance (not specified) to prevent the deleterious effects of the treatment, 4 participated in a physical training program, and 4 received both the drug and the training. Bone measurements were made in the baseline period, and at the end of months 1, 2, 3, and 4 of hypokinesia, and 4 days and 1 month after the treatment terminated. All measurements were performed in the morning. Ultrasound scanning measurements were made along the medial surface of the tibia, at 10 zones, each one of which was 1/10th of the total bone length, and was from 3.3 to 4.3 cm. wide, depending on subject. Piezo electric leads were used. Measurements were made 3 times in each zone, with contact between the lead and the calf reestablished each time. This procedure enabled measurement of the speed of propagation of a deflected ultrasound wave in the compact bone tissue of the tibia. Photon absorptiometry was performed using a commercial bone mineral detector in the seventh and eighth zone measured by ultrasound scanning.

Because of substantial individual differences, noted in the baseline period, group differences in ultrasound or photon absorption data were not statistically significant. However, the combined prophylactic measures condition appeared to be associated with the fewest changes in bone parameters over the period. When data for individuals was examined, 3 patterns of change were discerned in parameters over the course of treatment. In some subjects (group I, n=6), parameters (mean speed of sound, and mineral content) decreased to a minimum after 1 or 2 months, and then were restored to approximately baseline value by the end of 4 months. In group II subjects (n=5) these parameters continued to increase over the course of treatment, and in group III (n=4) they decreased steadily. For all groups, direction of change in ultrasound parameters coincided with that of parameters from photon absorptiometry, indicating that ultrasound scanning can provide data about mineral content of bones. Measures of the degree of difference in wave propagation speed in different

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zones of an individual's tibia are interpreted as indicating adaptation to loading. These values are not correlated with mineral content parameters.

Table: Comparison of the effectiveness of prophylactic measures against changes in ultrasound and absorptiometry parameters for experimental groups

Figure 1: Determination of ultrasound parameters using overall averaged curve of distribution of rate along the length of the bone

Figure 2: Examples of acoustic heterogeneity of the medial surface of the tibia

Figure 3: Averaged curves of ultrasound propagation rate along the length of the bone and standard deviations for the different treatment groups

Figure 4: Changes in ultrasound and photon absorptiometry parameters for treatment groups

Figure 5: Changes in speed along the length of the bone

Figure 6: Changes in ultrasound and photon absorptiometry parameters in groups showing different patterns of change

Figure 7: Distribution of ultrasound parameters in groups showing different patterns of change

Figure 8: Correlation between monthly measurements of change in rate of ultrasound propagation and mineral content of the bones