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Transmissibility of 15-hertz to 35-hertz vibrations to the human hip and lumbar spine: determining the physiologic feasibility of delivering low-level anabolic mechanical stimuli to skeletal regions at greatest risk of fracture because of osteoporosis.

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Abstract

STUDY DESIGN: Experiments were undertaken to determine the degree to which high-frequency (15-35 Hz) ground-based, whole-body vibration are transmitted to the proximal femur and lumbar vertebrae of the standing human. OBJECTIVES: To establish if extremely low-level (<1 g, where 1 g = earth's gravitational field, or 9.8 ms-2) mechanical stimuli can be efficiently delivered to the axial skeleton of a human. SUMMARY OF BACKGROUND DATA: Vibration is most often considered an etiologic factor in low back pain as well as several other musculoskeletal and neurovestibular complications, but recent in vivo experiments in animals indicates that extremely low-level mechanical signals delivered to bone in the frequency range of 15 to 60 Hz can be strongly anabolic. If these mechanical signals can be effectively and noninvasively transmitted in the standing human to reach those sites of the skeleton at greatest risk of osteoporosis, such as the hip and lumbar spine, then vibration could be used as a unique, nonpharmacologic intervention to prevent or reverse bone loss. MATERIALS AND METHODS: Under sterile conditions and local anesthesia, transcutaneous pins were placed in the spinous process of L4 and the greater trochanter of the femur of six volunteers. Each subject stood on an oscillating platform and data were collected from accelerometers fixed to the pins while a vibration platform provided sinusoidal loading at discrete frequencies from 15 to 35 Hz, with accelerations ranging up to 1 g(peak-peak). RESULTS: With the subjects standing erect, transmissibility at the hip exceeded 100% for loading frequencies less than 20 Hz, indicating a resonance. However, at frequencies more than 25 Hz, transmissibility decreased to approximately 80% at the hip and spine. In relaxed stance, transmissibility decreased to 60%. With 20-degree knee flexion, transmissibility was reduced even further to approximately 30%. A phase-lag reached as high as 70 degrees in the hip and spine signals. CONCLUSIONS: These data indicate that extremely low-level, high-frequency mechanical accelerations are readily transmitted into the lower appendicular and axial skeleton of the standing individual. Considering the anabolic potential of exceedingly low-level mechanical signals in this frequency range, this study represents a key step in the development of a biomechanically based treatment for osteoporosis.

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