Medical Motion Control

Quicksilver and VibeTech Collaborate on Therapy System

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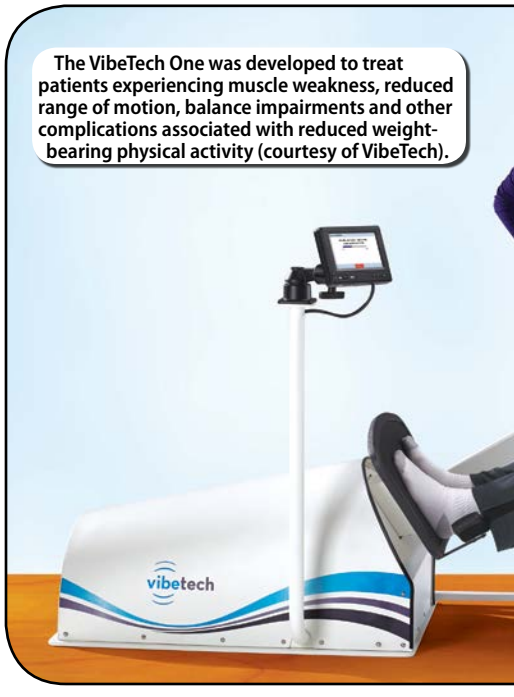
The lack of gravity in space reduces the mechanical loading seen by both the muscles and bones of the body, especially those related to standing and moving. The body adapts to reduced loading by losing bone mass and muscle mass. In long-duration space flights this leads to "disuse atrophy," which requires rehabilitation once the astronauts return to earth. An astronaut may lose as much as 20 percent of his bone mass in a single year in space. A countermeasure therapy using passive vibration for neuromusculoskeletal stimulation was originally designed by Dr. Jeff Leismer, to enable longer space flights by reducing atrophy. The therapy is now being used to help terrestrial patients with impaired mobility to regain strength and function.

Technology to prevent muscle and bone atrophy for astronauts is now being brought to people experiencing disuse atrophy on Earth (courtesy of NASA).

A similar bone loss and muscle loss occurs on Earth for those with reduced mobility due to injury, surgery, hospitalization and the aging process. Just as in space, the lack of sufficient loading of the muscles and strains on the bones signals the body to match the capability with the need — and bone loss along with muscle loss occurs. The result is that many patients suffering from disuse atrophy do not have the balance or strength to perform weight bearing physical activity, making conventional physical therapy difficult. Thus a new therapy modality was developed to mimic biomechanical loading acting on the region of the body most affected by disuse — the lower extremities — without requiring any effort on part of the patient. Studies that have applied similar vibration to standing users have shown that the treatment can help restore both muscle mass and bone density, and further help improve coordination and neural sensation by stimulation of the nerves. The desired outcome of the passive form of vibration therapy is to improve strength, mobility and balance in patients for whom standing is difficult or impossible, thus resulting in improved independence, quality of life and health outlook for the patient. Other vibration studies involving animals indicate that the therapy can also help speed the healing of broken bones, which could be especially important for healing hip fractures as well as reducing the associated atrophy and functional decline that is so detrimental to hip fracture patients.

This therapy relies on the alignment of an adjustable compressive force with a precisely controlled vibration along the axis of the tissue to be treated. The compressive force preloads the tissues to be stimulated and allows effective vibration transmission from the foot, through the lower extremities and into the lower back. This pathway simulates vibrations that are transmitted through the legs due to foot impact with the ground during walking. The force/vibration may be applied and aligned to target different treatment areas with appropriate intensity and



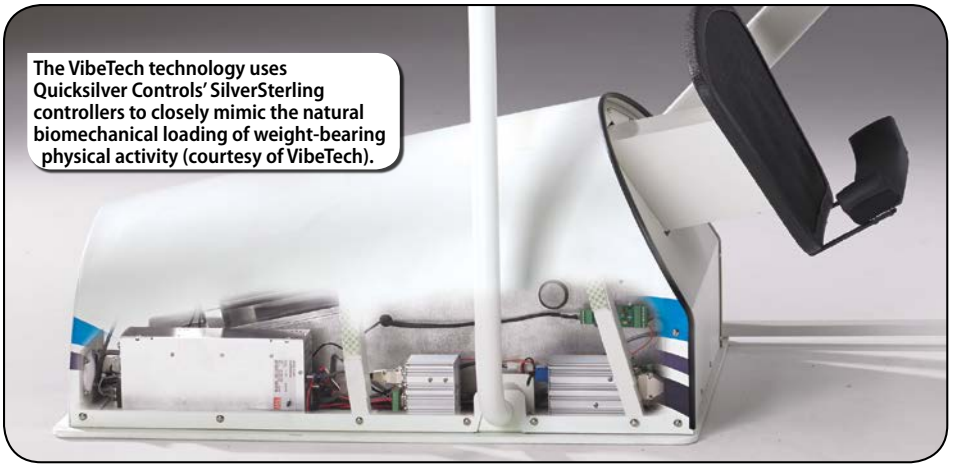
The VibeTech One was developed to treat patients experiencing muscle weakness, reduced range of motion, balance impairments and other complications associated with reduced weight-bearing physical activity (courtesy of VibeTech).

frequency profiles. Standing methods for vibration therapy that use gravity as the force component not only require balance and strength to receive treatment, but also apply the vibration to the "whole body," which necessarily requires a compromise to protect the more fragile tissues.

The physics behind the treatment involves applying controlled stresses to the bones, resulting in minute tissue deflections (strains). Bone cells detect these controlled strains and direct the body to increase bone density in the portions of the bone experiencing these deflections. For bones with weakened areas, larger deflections will occur in those areas, thus signaling the bone to adapt — add density — right where it is needed. In the case of a healing fracture, this same process again helps direct repair mechanisms at the fracture site, speeding healing. This challenging of the bone to adapt and strengthen is especially important while the bone is still healing and will not support the weight of a patient standing.

The physiology related to improving muscle strength and nerve response with vibration therapy is based on using frequencies and amplitudes which stimulate the body's stretch reflexes. Correctly applied vibrations engage reflexive muscle contractions — exercising the muscle to reduce atrophy and restore neuromuscular coordination. This process also stimulates nerves which may have been compromised. This later effect may be useful in the development of proper treatment protocols for neuropathy — nerve damage resulting from diabetes as well as other diseases. Improving strength and neural sensation in the legs could also help reduce the risk of falling.

The engineering and motion control challenges include the need to provide repeatable and programmable partial bodyweight loading through the lower extremities while generating precise, adjustable vibration dosing targeted at key muscle groups throughout the lower extremities and lower back. The vibratory source needs to be programmable both in amplitude and in frequency to account for the wide spectrum of patients who can be treated by the system (ranging from comatose patients and those with significantly reduced lower extremity function to elite athletes who are recovering from sports injuries). The motion control needs to be consistent over a wide range of partial body weight load levels and of patient tissue properties. The stimulation requires the power capability needed to adequately provide stimulation. Finally, the noise level must be kept low for the patient.



The VibeTech technology uses Quicksilver Controls' SilverSterling controllers to closely mimic the natural biomechanical loading of weight-bearing physical activity (courtesy of VibeTech).

For the first time, VibeTech, Inc. has made gravity-independent, effort-free rehabilitative vibration therapy available to people on Earth. The VibeTech One provides reactive loading through a QuickSilver Controls QCI-S2-IG that controls a loading mechanism in real time through closed-loop feedback of applied force. Precisely controlled vibrations are generated by a BEI-Kimco voice coil actuator using a QuickSilver Controls QCI-S3-IG controller and closed-loop feedback from a high resolution position sensor. The motion of both actuators is directed by the therapist by means of an HMI. **PTE**

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