Whole Body Vibration Therapy And The Central Nervous System: Future Applications

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Introduction to Vibration Training and Vibration Therapy:

As a Physical Therapist and fitness enthusiast, I have had the distinct pleasure of experiencing both firsthand, and secondhand through my patients, the sense of euphoria, clarity, and enhanced vivaciousness that comes as a result of utilizing a Whole Body Vibration platform for training or therapeutic purposes (now referred to in the industry as "Vibration Training (VTr)" and "Vibration Therapy (VTh)"). Not to be confused with deleterious, industrial and occupational whole body vibration, this form of ***active*** exercise has already demonstrated its enormous potential to improve bone density (#1), balance responses (#2), arterial circulation (#3), and muscle strength (#4). These benefits have been described in numerous studies conducted throughout the world for the past 15+ years. Recently however, as interest from the western medicine world has increased, we have seen new and exciting potential for this technology, including the treatment of neurological diseases. In a research study just released by the University of Miami, researchers demonstrated that after a one month Whole Body Vibration therapy program, subjects with incomplete spinal cord injuries were able to increase walking speed, cadence, step length and consistency of intra-limb coordination (#5). It is extremely clear that the need now exists to look beyond the categorical musculoskeletal effects and explore the more intricate and potentially more profound role of VTr and VTh on positively influencing the vast functions of the central nervous system. Through a better understanding of these neurophysiological mechanisms, this technology's existing applications will be better clarified while allowing for the further development of its potential relevance in areas such as pain management, neuroendocrine function, mood alteration, memory, and the improvement of the efficiency and strength of the neurophysiological pathways that exist throughout the human body. The purpose of this particular article is to explore the role of VTr and VTh in helping promote increased serotonergic activity, neurogenesis via expression of Brain Derived Neurotrophic Factor (BDNF), and the associated, rapid release of enkephalins and endorphins into the bloodstream.

The Tonic Stretch Reflex and Serotonin:

To begin this exploration, it is important to first define VTr and VTh as well as the primary mechanisms by which this form of exercise interacts with the human body. Dangerous, industrial and occupational whole body vibration typically refers to low frequency, high amplitude industrial vibration being delivered to a body in an anatomically undesirable and physically inefficient position (for example, a jackhammer operator or semi truck driver). This differs from VTr and VTh in that these methods generally utilize higher frequency, lower amplitude vibration being delivered in a linear (straight up and down) or pivotal (teeter-totter) direction

to an individual in a supervised, anatomically desirable exercise position (squat, lunge or push up, plank etc.).

The primary mechanism by which VTr and VTh interacts with the human body is through the Tonic Stretch Reflex (TSR). This reflex occurs in response to a bombardment of the CNS provided by repeated muscle spindle excitation. The result is what is considered to be a more complicated version of the monosynaptic stretch reflex. In the case of the TSR, the reflex would include ***poly***synaptic pathways and the need for modulation by specific descending pathways that control posture and muscle tone (#6). Although many pathways may exert an influence over this modulation activity, the primary pathways are the vestibulospinal and reticulospinal tracts.

Of more importance when considering the purpose of this article however, we must turn our attention to the reticulospinal tract. An extrapyramidal tract, the reticulospinal tract originates in the reticular formation. The reticular formation, according to Basant et al. is a loose network of neurons located in the brainstem and containing projections to many other regions of the brain via the raphe nuclei. Through the excitatory mechanisms provided by the TSR, through exposure to a whole body vibration platform, the raphe nuclei, which are primary stores of serotonin in the brain, are activated. This activation results in increased serotonergic pathway activity and the release of serotonin. Serotonin, a type of neurotransmitter, is responsible for mood elevation, feelings of ecstasy, increased sexual desire and function, increased motivation, and improved sleep. This concept is supported by investigations involving electrical stimulation of the raphe nuclei located within the reticular formation (#7).

Clinical Applications - Fibromyalgia:

Throughout the medical community, low serotonin levels have been linked to many different conditions including depression, weight gain, sleep disorders, migraine headaches, and restless leg syndrome. In the physical therapy clinic however, the largest group that may benefit from increased serotonin production are those that suffer from Fibromyalgia (FM). Recent studies have shown that a common characteristic between Fibromyalgia patients is low serotonin levels. As a result, studies with medications designed to reduce the reuptake of serotonin in the brain have provided a valuable insight into the potential causes and treatment of FM (#8). Additionally, it has been established that lower serotonin levels signals the release of substance P. Substance P, another neurotransmitter, is responsible for transmitting pain signals throughout the central nervous system and thought to be responsible for the increased pain sensitivity seen in FM. This diagnosis, worthy of entire article in itself, is an increasingly common diagnosis seen throughout the rehabilitation world. Once thought of as a “wastebasket diagnosis”, the reality of this condition is quite apparent and the potential to utilize Vth and Vtr as a treatment modality demands further investigation.

Serotonin, BDNF and Neurogenesis:

The reciprocal relationship between serotonergic activity and the expression of BDNF has been well established (#9). As serotonin levels rise in the brain, BDNF expression is encouraged. Reciprocally, as BDNF expression in the brain is increased, serotonergic activity and serotonin release is supported. If you are unfamiliar with BDNF, now is the time to familiarize yourself. BDNF is a neurotrophin which acts upon neurons of both the central nervous system and the peripheral nervous system. Related to Nerve Growth Factor, BDNF’s role is to encourage the growth and differentiation of new neurons, while as the same time, protect existing neurons and increase the efficiency of communication between them (referred to as synaptic

plasticity). This process is referred to as neurogenesis.

Until only recently, the idea that the brain matured at age 25 was considered factual. This was further enforced by the concept that nerve cells were incapable of dividing or replicating. These "facts" are now being challenged as recent studies have shown that the adult brain is capable of generating new brain cells (#10). This finding is the primary foundation behind the increasingly promising yet most intensely debated concept of neuroplasticity. Neurogenesis occurs in the hippocampus. Part of the limbic system, the hippocampus is where higher learning and memory occurs and has been associated with Alzheimer's disease, epilepsy and post-traumatic stress disorder. The potential applications of promoting neurogenesis to occur in the adult brain are endless and although this concept is fairly new, any potential treatment modality, like above in the case of FM, must be considered and explored.

The Tonic Stretch Reflex and Enkephalins:

Returning to the influence of the TSR on the raphe nuclei, we must finally consider that besides initiating serotonergic activity there is also an association with enkephalin release through the interaction with enkephalin interneurons in the spinal cord (#11). Enkephalins, sometimes used interchangeably with the term endorphins, are naturally occurring opioids in the human body. When released, they are responsible for blocking pain and reducing nociceptor activity by binding to opioid receptors in the brain. The association between exercise and enkephalin and endorphin release is what has been referred to as a "Runner's High". This arguably addictive phenomenon has been the subject of debate for many years. However, recent research completed in Germany using positive emission topography (#12) has confirmed the very real existence of this phenomenon. Besides the potential applications for pain management with the increased production of enkephalins, the ability to create an "addiction to exercise" holds tremendous potential for fighting the war against obesity; something that researchers in the medical, health and fitness fields have spent tireless efforts to create through alternative means.

The Future:

Like quantum physics and the activities of subatomic particles, our understanding of the physiological mechanisms by which the CNS works has improved significantly in recent years. As it has improved however, like subatomic particles, the potential for these physiological mechanisms to occur differently than we have understood in the past has also proven to be much greater. The above pathways through which Whole Body Vibration may interact with the human body have been demonstrated in clinical research. A clinical demonstration of how these pathways occur in response specifically to VTr and Vth is still needed. The applications of this technology are far reaching and as we continue to pursue the refinement and clinical significance of Whole Body Vibration, we will hopefully be able to break through the barriers that still exist in the field of rehabilitation and move on to the next stage of fighting disease, improving quality of life for our patients, and encouraging the never ending continual pursuit of eliminating disability, reducing health care costs and building stronger, more efficient "mind-body" neural connectivity.

About the Author

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