The emerging role of focal muscle vibration in rehabilitation of neurological disorders

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Abstract

Focal muscle vibration (FMV) is an innovative approach to enhance balance and motor control in various neurological diseases. In this technique a low-amplitude/high-frequency vibratory stimulus is applied to a specific muscle using a mechanical device. The use of FMV in rehabilitation is relatively new and it promises to be an effective tool in improving rehabilitation outcomes. Over the past few years, the use of FMV in rehabilitation has increased because of certain advantages over traditional rehabilitation techniques. These include better patient adherence to the rehabilitation protocols due to its long-lasting effects, increase in muscle mass, better blood circulation, improved bone density, reduction in joints and back pain. This mini review summarizes the available evidence on the role of FMV in rehabilitation, its effects, and scope across different clinical disorders and neurological conditions such as management of spasticity, improving gait pattern in stroke, multiple sclerosis and Parkinson's disease.

Keywords: Mobility, Spatiotemporal, Neurorehabilitation, Gait, Vibration, Muscle strength.

DOI: https://doi.org/10.47391/JPMA.22-106

Introduction

Historically vibration therapy by different means has been used in rehabilitation as one of the therapeutic physical agents. The mechanical vibration is the simplest and purest form of vibratory energy used in rehabilitation services. During the last few decades emphasis has gradually shifted from whole-body vibration to focal muscle vibration.[1]

Focal muscle vibration (FMV) is a technique of applying a vibratory stimulus to a specific muscle belly or its tendon on the affected/paretic side using a mechanical device.[2] In the last two decades, the use of FMV in rehabilitation has increased among rehabilitation professionals in order to improve the functional outcomes and reduce disability associated mainly with neurological disabilities.

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Classification of Vibration Therapy

Vibration therapy can be classified into three categories depending upon the frequency into low, medium and high frequency.

Low frequency vibration ranges from 30-50 Hz, and has therapeutic effects on muscle relaxation and delayed onset muscle soreness.[1]

Medium frequency vibration ranges from 80-120 Hz and on improves proprioception, reduces pyramidal spasticity and pain and causes muscle relaxation.[1]

High frequency vibration ranges from 120-300 Hz, and helps in strengthening of slow and fast muscle fibers.[1]

FMV is directly applied over the target body site, at a frequency of 30-120 Hz resulting in desired therapeutic effects. It is classified into 3 categories based on the mode of application as follows.

- pulsed on-and-off vibration at a frequency 120 Hz

- sinusoidal vibration ranging between 35 and 120 Hz

- continuous vibration at a constant frequency of 120 Hz[3]

Mechanism of Action

FMV therapy uses mechanical oscillations as a stimulus which is an effective way to enhance or maintain muscle mass, strength and function for elderly and weak individuals. The mechanical stimulus produced is thought to use proprioceptive spinal reflexes. FMV generates the 1a inputs because of the activation of primary ending of the muscle spindle. This activation leads to alteration of corticospinal pathways triggering 1a afferent impulses. These impulses are conducted to the alpha motor neurons and 1a inhibitory interneurons in the spinal cord. This afferent pathway produces involuntary contraction in the targeted muscle.[4] The aim of this stimulus is to improve muscle function by increasing muscle spindle excitatory signaling while lowering the inhibitory response of the Golgi tendon organ. Vibratory stimulus increases the gravitational load on the neuromuscular system, thereby providing a stimulus that varies the

functional capacity of skeletal muscle.[5]

Use of Focal Vibration in Rehabilitation

In the recent years, FMV has been used in different areas of rehabilitation and has shown favourable effects in improving outcomes. It has been used for neurological rehabilitation, pain relief, muscle strengthening, improving coordination, enhancing metabolism and reducing spasticity. This has been achieved by varying different parameters including the frequencies, amplitudes and duration.

1- Painful peripheral polyneuropathy: Effects of FMV on pain and muscle contraction for functional activity have been documented. It is reported that FMV significantly improves pain, mobility, balance, average pain sub-scale of brief pain inventory, as well as overall pain scores in diabetic peripheral neuropathy.[6]

2- Pain management: The analgesic effect of vibration is attributed to the "gate control" theory of pain. According to this theory, the stimulation of the Aβ afferent fibers causes the inhibition of the nociceptive fibers by the activation of the inhibitory interneurons in the lamina II (substantia gelatinosa) of the spinal cord dorsal horn.

Various frequencies are being utilized for mechanical vibration to achieve a variety of therapeutic effects (Table-1). For example muscle relaxation is achieved at around 30-50 Hz, spasticity inhibition is better achieved around 100 Hz, pain relief at 200 Hz and muscle training up to 300 Hz.[7]

Table-1: Therapeutic effects and vibration frequencies.[13]

Condition	Frequency range
Muscle relaxation	30-50 Hz
Delayed onset muscle soreness	50 Hz
Improvement of proprioception	80-100 Hz
Pyramidal spasticity	100 Hz
Pain	100-120 Hz
Strengthening of slow muscle fibers	200 Hz
Strengthening of fast muscle fibers	300 Hz

3- Motor performance: Focal muscle vibration is theorized to induce modifications in the properties of skeletal muscle. A 2016 study from Italy suggested that the focal vibrations treatment at higher frequency of 200 Hz can improve the motor control in healthy subjects.[8]

4- Spasticity: Focal vibration has been used in patients with longstanding spasticity. A vibration of 100 Hz applied on triceps brachialis lowered the biceps brachialis spasticity (agonist) and when combined with physical therapy resulted in better spasticity reduction and motor control augmentation. Authors concluded that vibration activates both central mechanisms (inhibition of cortico-spinal activity) and spinal mechanisms (reciprocal inhibition). In fact, the spinal level is the first to interact with vibratory stimulus, improving agonist antagonist coupling.[9] Literature suggested that one acute session of FMV therapy reduces spasticity for example, a vibratory stimulus, applied locally on the musculo-tendinous junction, with a frequency of 100 Hz and a low amplitude of (3mm) vibration produced a contraction after 5-45 seconds of stimulation. This contraction is strong enough to move the body segment and work against a resistance.[10]

5- Gait and mobility: A pilot study demonstrated that in patients with diabetic peripheral polyneuropathy FMV therapy improved some spatiotemporal gait parameters. These included better cadence and gait speed. The study also reported that FMV therapy also improves gait in patients with stroke, Parkinson's disease, and incomplete spinal cord injury.[11]

6- Balance and sensation: There are documented benefits of focal muscle vibration on sensation in patients with diabetic peripheral neuropathy, muscle contraction for functional activity, motor learning in patients with neurological diagnoses, pain and balance in other diseases like stroke, spinal cord injuries, and multiple scoliosis.[6]

7- Coordination: A 2018 systematic review suggested that long term effects of FMV therapy reduced reflex excitability, muscle tone and coordination deficits. The acute and chronic application of FMV therapy as a nonpharmacological approach has the potential to improve the coordination, achieving structural and functional adaptations associated with significant improvements in daily living. Therefore, goals for patients and their caregivers referring to greater independence and improved safety may be achieved more easily and time efficiently.[12]

Use of FMV in Pakistan

FMV has shown to be safe, well tolerated and can be performed easily in a variety of painful, musculoskeletal and neurological disorders. However, to the best of our knowledge it is currently not being used in Pakistan. There is a need to introduce this low-cost innovative device among the rehabilitation professionals to improve the quality of services and outcomes.

Conclusion

Focal vibration stimulation is well tolerated, cost effective and can be used to reduce spasticity, promote motor

activity and motor learning, enhancing functional recovery and gait training. It has been successfully used in neurorehabilitation of painful neuropathy, motor control, balance and sensation, spasticity and other neurological conditions like stroke, spinal cord injury, Parkinson's' disease. There is a need to explore this promising rehabilitation intervention in the local Pakistani population and to document its role and effectiveness by conducting high quality trials.

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