European Journal of Musculoskeletal Diseases
ISSN 2038-4106/2024

Original Article

FOCUSED MECHANO-ACOUSTIC VIBRATIONS: BIO-PHYSICO-METRIC APPROACH IN NEUROMUSCULAR DISEASES

G. Barassi[1,5], G. Di Stefano[1], R. Pellegrino[2], A. Di Iulio[3], V. Gildone[4], G. Pensa[4], M. Cipriano[4], M. Matarese[4], F. d'Alessandro[4], F. Sacco[4], L. Prosperi[5], C. Marinucci[5] and M. Panunzio[6]

[1]Center for Physiotherapy, Rehabilitation and Reeducation (Ce.Fi.R.R.), venue Castelnuovo della Daunia Thermal Center, Castelnuovo della Daunia, Italy;
[2]Antalgic Mini-invasive and Rehab-Outpatients Unit, Department of Medicine and Science of Aging, Centre of Sports Medicine, "G. d'Annnunzio" University, Chieti, Italy;
[3]Department of Thoracic Surgery, "Santo Spirito" Civil Hospital, Pescara, Italy;
[4]Castelnuovo della Daunia Thermal Center, Castelnuovo della Daunia, Italy;
[5]Center for Physiotherapy, Rehabilitation and Reeducation (Ce.Fi.R.R.), venue "G. d'Annnunzio" University of Chieti, Chieti, Italy;
[6]Center for Physiotherapy, Rehabilitation and Re-Education (Ce.Fi.R.R.), venue Gemelli Molise Spa, Professionalization Didactic Center, "Catholic" University of Rome/Campobasso, Campobasso, Italy

Correspondence to:
Giovanni Barassi, PhD
Center for Physiotherapy, Rehabilitation and Reeducation (Ce.Fi.R.R.) Training Center,
Gabriele d'Annunzio University of Chieti-Pescara,
66013, Chieti, Italy
e-mail: coordftgb@unich.it

KEYWORDS: *physiotherapy, rehabilitation, neurological disorders, vibration*

ABSTRACT

This analytical retrospective observational study aims to demonstrate the effects of Focused Mechano-Acoustic Vibrations (FMVs) on people affected by neuromuscular diseases. A total of 11 patients (age 58 ± 11) underwent a protocol consisting of three weekly sessions of FMVs for one month, applied to patients affected by neuromuscular disease. Assessments made through a stabilometric platform before and after the rehabilitation protocol revealed positive, although not statistically significant, variations of the characteristics of the Center of Pressure and of the Romberg Index of patients recruited for the study. Our experience showed that the application of FMVs could be a useful tool in the rehabilitation of neuromuscular diseases. These new integrated approaches can be used in the rehabilitation field in a multidisciplinary and multispecialistic way.

Received: 25 October 2023
Accepted: 02 December 2023

ISSN: 2038-4106

INTRODUCTION

Over the past decade, many studies have been conducted to better understand the effects of whole-body and focused vibrations on the central nervous system and the related control capabilities of the musculoskeletal system. The deepening of the effects of vibrations on the central nervous system would allow to improve the understanding of the pathophysiological mechanisms underlying many neurological pathologies characterized by musculoskeletal and motor manifestations.

This study builds on previous experiences that highlighted the effects of focused vibratory stimulation in neuro rehabilitation, including neurological diseases or neurological disorders. This kind of therapy was well tolerated, effective and easy to use. Independently of the etiology of neurological pathology, it could be used to reduce spasticity, to promote motor activity and motor learning within a functional activity (1).

This study focuses on the effect of Focused Mechano-Acoustic Vibrations (FMVs) in neurorehabilitation.

MATERIALS AND METHODS

This analytical retrospective observational study was conducted at the Castelnuovo della Daunia Thermal Center (Foggia), Italy. The data relating to 11 (age 58 ± 11) patients were considered. Subjects underwent a similar rehabilitation protocol from June to September 2021.

Inclusion criteria were:
- neuromuscular disability;
- balance disorders;
- gait disturbances.

Exclusion criteria were:
- inability to maintain an upright position;
- open wounds;
- varices and telangiectasia of the lower limbs.

The data collection is part of the operative routine of the professional team involved in this study. According to this operative routine, patients are frequently assessed across their rehabilitation path. Therefore, clearance regarding the subjects, according to the Declaration of Helsinki for this study was not required (2). All patients underwent 3 weekly sessions of FMVs treatment, for a total of one month of treatment.

The technology used for the administration of the FMVs therapy is VISS (Vibration Sound System) (Vissman S.r.l., Rome, Italy). The device works through fast moving air cones to produce a square wave mechanical vibration. This vibration is transferred to the skin by means of a self-supporting transducer and, passing through the surface layers and adipose tissue, stimulates so-called “High Threshold Activation” receptors. The signals released by these receptors trigger interactions and biochemical processes, which are able to modify the course of various pathologies related to neuromuscular diseases.

The treatment was administered for twenty minutes for each session, with the transducers of the device focused on specific target muscles, which were identified in each patient according to the Bio-Physico-Metric Approach.

The Bio-Physico-Metric Approach can be defined as an operating mode based on a thorough functional evaluation which is performed to identify Key Myofascial Trigger Points KMTrPs, the elimination of which, allows the suppression of major muscle dysfunction and postural compensation.

This manual and functional assessment process to identify the areas most in dysfunction also using a skin impedance measurement tool, named ENF (Electroneurofeedback) Physio, (Fast Therapies S.r.l., Carpenedolo, Brescia, Italy) which allowed to objectify and quantify what had been assessed by the operator through the use of his hands (3, 4). For this study, the myofascial structures identified in each single patient through the Bio-Physico-Metric Approach were treated through the VISS device.

To assess the results of the studied rehabilitation protocol, an evaluation of the plantar support was carried out through a stabilometric platform (Diasu Health Technologies by Sa.Ni Corporate S.r.l., Rome, Italy).

Stabilometry is an objective assessment of body sways during quiet standing in the absence of any voluntary movements or external perturbations. The method enables the collection of information on the steady-state functioning of the postural control system and its ability to stabilize the body against gravity. This evaluation is performed using specific computerized boards that record postural adjustments of the body with high grade of sensitivity. The stabilometry was performed at the beginning (T0) and at the end (T1) of the rehabilitation protocol.

RESULTS

The data collected report information on the movement of the CoP (Center of Pressure), defining its kinematic parameters over time and the frequency of the oscillations. The coordinates of the CoP, i.e. the average value of the abscissa and ordinates of the CoP on the referential of the state kinesiogram, the oscillations in the frontal plane (X axis, right-left movement) and on the sagittal plane (Y axis, antero-posterior movement), during the upright station maintained for about 30 seconds gives us the results of the so-called "Surface of the Ellipse" or "Confidence Ellipse"; that is, the dispersion of the oscillations in relation to the precision of the system, which contains 90% of the sampled positions of the CoP. The value corresponds to the quantization of the segmentary tonic deviations of the body axis which are in direct relation to the vestibulo-spinal pathways.

In our experience, the surface of the Confidence Ellipse of the CoP decreased with eyes closed (without statistical significance), testifying a slight increase in the accuracy of the postural tonic system to stabilize the body.

The length of the CoP Sway Path traveled during the recording per unit of time represents an indicator of the energy spent by the body to stabilize itself. In our study, at the end of the rehabilitation protocol, this parameter recorded a slight reduction, which may highlight a slight reduction in the energy expenditure of the postural tonic system to maintain the upright position.

The Romberg Postural Test allows to evaluate the antigravity postural dynamics, and therefore the proprioception (ability to identify the position of the body in space), the vestibular function (the ability to recognize the position of the head in space) and the sight (in relation to the position of our body and the perception of the space where our posture manifests itself). After the rehabilitation protocol through FMVs, the Romberg Index showed a reduction (not statistically significant), which demonstrates how peripheral receptor stimulation played a fundamental role in minimally improving the parameters of proprioceptive function (Table I).

Table I. *Stabilometry: statistical analysis and data variations from T0 to T1.*

Variable	Count	Mean ± SD	p value*
ES (T0) - Opened Eyes	11	234 ± 121	
ES (T1) - Opened Eyes	11	326 ± 296	ns
ES (T0) - Closed Eyes	11	581 ± 923	
ES (T1) - Closed Eyes	11	340 ± 401	ns
SP (T0) - Opened Eyes	11	415 ±147	
SP (T1) - Opened Eyes	11	406 ±103	ns
SP (T0) - Closed Eyes	11	566 ± 394	
SP (T1) - Closed Eyes	11	560 ± 302	ns
Romberg Index (T0)	11	197 ± 216	
Romberg Index (T1)	11	122 ± 112	ns

*p value shows the differences between T0-T1 of the group (Wilcoxon Matched-Pairs Signed Rank Test)
ES: Ellipse Surface
SL: Sway Path

DISCUSSION

Documented scientific experiences regarding the therapeutic use of mechanical vibration on can be found as early as the year 1880. The French neurologist Jean-Martin Charcot observed that patients affected by Parkinson Disease experienced a reduction in tremor at rest and an improvement in sleep quality after a carriage ride or after a horse ride. Drawing inspiration from this observation, he modeled a chair vibrator that simulated the rhythmic shaking of a carriage. Georges Gilles de la Tourette extended these observations and modeled a helmet that made the head vibrate, assuming that the brain responded directly to the pulse, signaling schizophrenia and migraine.

Over the years, many scientists have perceived vibration as a suitable method to interac with the central nervous system (CNS) through stimulation of the peripheral nervous system (PNS). Indeed, numerous studies have been conducted to understand the effects of focal vibratory stimulation at various levels of the CNS. In those studies, particularly interesting were the effects demonstrated on the pathophysiological mechanisms of neurological disorders, as well as the therapeutic effects of focused vibrations in neurological disability. Based on the growing number of systematic reviews, whole body vibration and focused vibration appear to play a considerable role in reducing spasticity and improving gait, balance and motor function in patients with neuromuscular disabilities. Focal muscle vibration seemed to be more useful when applied to non-spastic antagonist muscles with reciprocal inhibitory action on spastic muscles in those individuals (5-7).

Vibration seems to be a powerful activator of the entire neuromuscular and skeletal system. In 1969, Hagbarth and Erklund, used vibrations to reduce the spasticity in stroke patients (8). Subsequently, it was used in neuro rehabilitation as well. Murillo et al. observed a significant reduction in spasticity in patients with Spinal Cord Injury, using a vibratory stimulation at 50 Hz applied to the quadriceps muscle for 10 minutes; in addition, they observed a reduction of the amplitude (H-Max) of the Soleus Muscle and the Achilles Tendon reflex (9). Ribot-Ciscar et al. observed, in quadriplegic patients, an increase in maximal isometric contractions in the Brachial Triceps while a 80 Hz vibratory stimulation was applied to the agonist muscle (7).

A study on individuals with Multiple Sclerosis combined botulinum toxin with focal vibration (at 120 Hz), in Gastrocnemius and Soleus Muscles. The study showed an improvement in spasticity and a reduction in fatigue symptoms, either with focal vibration alone or in combination with botulinum toxin, which was maintained during the 3-month follow-up period after treatment (10). In another study the authors reported the effects of vibration on the muscles Soleus and Erectors of the Spine in patients with Parkinson's during walking, showing that cadence and speed were increased (11). Pacinian Corpuscles are found in the deepest layers of the skin, consist of a single unmyelinated afferent neuron, wrapped in 20-60 concentric lamellae. They are, no doubt, the mechano-receptors most involved in the response to the perception of vibration, with the highest sensitivity at a frequency of 300 Hz. At this frequency, at 1 µm of pressure, there is an activation of different receptors:

- Type 1 Sensory Receptors, which are nerve endings, covered with gods red layers of collagen, able to turn on external stimuli;
- Unimodal Receptors, which are activated only by direct pressure;
- Phasic Receptors, which are very fast caress and follow the "all or none" principle, which means that they are activated or not.

A greater intensity of the afferent signal (charge capacity) determines a greater efferent response of the CNS. An intense efferent nerve response allows the recruitment of multiple motor units, thus the activation of multiple motor neurons which will result in more muscles being activated, and therefore a stronger muscle twitching. This results in a better engine performance, in a shorter time. After activation of the neurotransmitter receptors, various nerve and biochemicals signals are activated, thus allowing persistent forms of synaptic plasticity, including, inter alia, structural synaptic plasticity, in order to maintain information in a long-term memory. This cellular mechanism for storing information in the Central Nervous System is likely to create new synapses in selected networks (12).

CONCLUSIONS

In accordance with the scientific literature, our experience showed that the application of FMVs could be a useful tool in the rehabilitation of neuromuscular diseases. Vibratory stimulation is well tolerated, effective and easy to use, with no side effects in the field of neurorehabilitation. Focal vibration could promote motor activity and motor learning within functional activity, including in gait training, regardless of the etiology of the neurological pathology. These new integrated approaches can be used in the rehabilitation field in a multidisciplinary way.

Conflict of interest

This research received no external grants or funding. The Authors declare no conflicts of interest.

REFERENCES

1. Murillo N, Valls-Sole J, Vidal J, Opisso E, Medina J, Kumru H. Focal vibration in neurorehabilitation. *European Journal of Physical and Rehabilitation Medicine*. 2014;50(2):231-242.
2. Winter EM, Maughan RJ. Requirements for ethics approvals. *Journal of Sports Sciences*. 2009;27(10):985. doi:https://doi.org/10.1080/02640410903178344
3. 3.G. Barassi, E. Di Simone, M. Supplizi, et al. BioPhysicoMetric approach: integrated postural assessment in musculoskeletal dysfunctions. *Journal of Biological Regulators and Homeostatic Agents*. 2022;36(1):129-135. doi:https://doi.org/10.23812/21469L
4. Barassi G, Pokorski M, Matteo CD, et al. Manual Pressure Release and Low-Grade Electrical Peripheral Receptor Stimulation in Nonspecific Low Back Pain: A Randomized Controlled Trial. *Advances in Experimental Medicine and Biology*. 2021;1324:73-81. doi:https://doi.org/10.1007/5584_2020_605
5. Moggio L, de Sire A, Marotta N, Demeco A, Ammendolia A. Vibration therapy role in neurological diseases rehabilitation: an umbrella review of systematic reviews. *Disability and Rehabilitation*. 2021;44(20):1-9. doi:https://doi.org/10.1080/09638288.2021.1946175
6. Line Læssøe, Nielsen J, Fin Biering-Sørensen, Jens Sønksen. Antispastic effect of penile vibration in men with spinal cord lesion. *Archives of Physical Medicine and Rehabilitation*. 2004;85(6):919-924. doi:https://doi.org/10.1016/j.apmr.2003.08.082
7. Ribot-Ciscar E, Butler JE, Thomas CK. Facilitation of triceps brachii muscle contraction by tendon vibration after chronic cervical spinal cord injury. *Journal of Applied Physiology*. 2003;94(6):2358-2367. doi:https://doi.org/10.1152/japplphysiol.00894.2002
8. Hagbarth KE, Eklund G. The muscle vibrator--a useful tool in neurological therapeutic work. *Journal of Rehabilitation Medicine*. 2018;1(1):26-34. doi:https://doi.org/10.2340/1650197701026034
9. Murillo N, Hatice Kumru, Vidal-Samsó J, et al. Decrease of spasticity with muscle vibration in patients with spinal cord injury. *Clin Neurophysiol*. 2011;122(6):1183-1189. doi:https://doi.org/10.1016/j.clinph.2010.11.012
10. Paoloni M, Giovannelli M, Mangone M, et al. Does giving segmental muscle vibration alter the response to botulinum toxin injections in the treatment of spasticity in people with multiple sclerosis? A single-blind randomized controlled trial. *Clinical Rehabilitation*. 2013;27(9):803-812. doi:https://doi.org/10.1177/0269215513480956
11. De Nunzio AM, Grasso M, Nardone A, Godi M, Schieppati M. Alternate rhythmic vibratory stimulation of trunk muscles affects walking cadence and velocity in Parkinson's disease. *Clinical Neurophysiology*. 2010;121(2):240-247. doi:https://doi.org/10.1016/j.clinph.2009.10.018
12. Cotey DR, T. George Hornby, Gordon KE, Schmit BD. Increases in muscle activity produced by vibration of the thigh muscles during locomotion in chronic human spinal cord injury. *Experimental Brain Research*. 2009;196(3):361-374. doi:https://doi.org/10.1007/s00221-009-1855-9