

NEUROPHYSIOLOGICAL BASIS OF FUNCTIONAL DE-AFFERENTATION OF THE NERVOUS SYSTEM CAUSED BY WEAK OR ABSENT MUSCLE CONTRACTIONS

NEVROFIZIOLOŠKE OSNOVE FUNKCIONALNE DE-AFERENTACIJE ŽIVČNEGA SISTEMA KOT POSLEDICA ŠIBKIH ALI POPOLNOMA ODSOTNIH MIŠIČNIH KONTRAKCIJ

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Arrived 2004-02-06, accepted 2004-05-10; ZDRAV VESTN 2004; 73: Suppl. II: 25-7

Abstract – *In this short article we discuss putative effect of decreased ability for movement in the progressive neuromuscular disorders on the central state of brain activity. We propose possibility that such reduced activation of proprioceptors can lead to partial functional de-afferentation.*

Furthermore, we briefly reviewed neurophysiological evidences of peripheral inputs to the central projections. We discussed contribution of the proprioceptive input after passive, active movements and movement induced by vibration of muscles tendons.

Finally we are proposing to introduce simple vibratory protocols in daily life of people with progressive neuromuscular disorders in order to prevent central effects of reduced proprioception to endurance of brain activity of people with intact mental functions.

Izvleček – *V članku razglabljamo o učinkih, ki nastanejo kot posledica upadlih gibalnih sposobnosti pri progresivnih živčno-mišičnih boleznih in se domnevno odražajo v spremenjenem centralnem stanju možganske aktivnosti. Nakazujemo možnost, da takšno zmanjšanje proprioceptivne aktivnosti lahko vodi v delno funkcionalno de-aferentacijo. Kratkemu pregledu nevrofizioloških dokazov o centralnih projekcijah perifernega proprioceptivnega dotoka sledi oris funkcionalne vloge proprioceptivnih informacij, ki je prikazana skozi analizo pasivnega in aktivnega gibanja ter gibanja povzročene ga z vibracijo mišičnih kit. Prispevek sklenemo s predlogom za uporabo enostavnih vibracijskih protokolov v vsakdanjem življenju ljudi z živčno-mišičnimi okvarami, kar lahko pripomore k povečanju mentalne vzdržljivosti teh ljudi s sicer neprizadetimi mentalnimi funkcijami.*

Introduction

Muscle contraction is origin of force during movement performance and at the same time, it is source of afferent input from stretched, contracting muscle, moving joint, skin. In the neurological conditions of chronic muscle weaknesses of muscle dystrophies and spinal muscle atrophies, as it is the case in the progressive neuromuscular disorders, the nervous system, due to weak or absent volitional and automatic movements it is deprived of multi-afferent input. In this short note our aim it is to bring to the attention of the professionals involved in the rehabilitation programs for the people with chronic muscular disorders notion that during nervous system controlled and stretched relaxed or shorten muscles. During reflex, automatic and/or volitional movements there is rise of proprioceptive input to the brain (1-3).

The purpose of this paper it is to discuss why in the life of people suffering from neuromuscular disorders it is essential to introduce simple practice of supported movements, muscle contraction in the unloaded environment for the body weight, i. e. supported standing, walking, and swimming. Furthermore, we shall argue that eliciting tonic input from muscles and cutaneous receptors by external vibration (handy devices mounted on the wheel chairs, beds, working and resting places) it is possible to enhance sensory proprioceptive

and exteroceptive inputs to the nervous system and to facilitate the brain sensory processing mechanisms, the sensory-motor integration mechanisms and augment appreciation of self body awareness, cognition of weakened movements without involving visual input and others available modalities of sensory inputs.

Proprioceptors

Receptors placed within the skin, joint ligaments, joint capsules and muscles can provide proprioceptive input. Muscle Spindle Afferent Discharge from resting and contracting muscles in humans become possible by direct recordings from fascicles of peripheral nerves of large afferents (4). It was found that when muscles were relaxed, there was a low and approximately constant discharge in the spindle afferents as a group, indicating that the fusimotor drive was very low or absent (5, 6). To passive movement, the muscle spindles responded with an increase of the discharge rate as the muscle was stretched and vice versa. In contrast, the muscle spindles were strongly activated during voluntary contraction. Furthermore, the new neuro-radiological methods, Positron Emission Tomography and Functional Magnetic Resonance and their usefulness in the assessment of functional activity of the

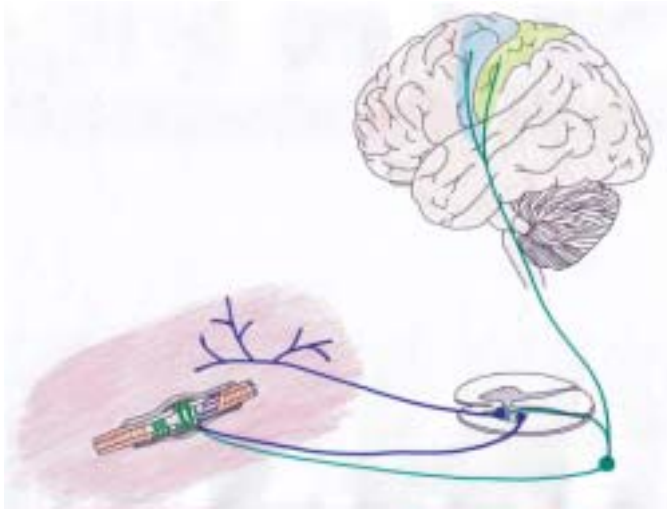


Figure 1. *The muscle spindle receptor and corresponding large fibers simplified sketch. Certain axons of primary sensory fibers are entering spinal cord gray matter to reach spinal motor cells and others extended via white matter to the rostral structures of the CNS. Numerous axons of the posterior columns of the spinal cord are projecting to the nuclear structures of the medulla oblongata, thalamus and cortical sensory and motor structures.*

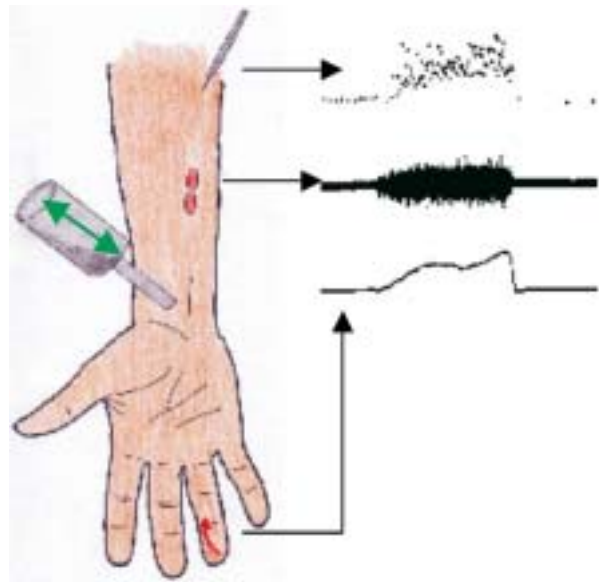


Figure 2. *Simplified sketch of applied vibrator to the forearm of the upper limb. During the vibratory tonic reflex shown in the figure at the right corner, microneurographic recording reveals large spike activity in the median nerve fascicle of the large myelinated sensory nerve fibers.*

brain functions shown that primary and secondary somatosensory cortex are involved in central processing of proprioceptive signals during passive and active movement (7). Therefore whenever we are confronted with reduced movements' activities in people with otherwise intact primary, peripheral and central sensory mechanisms we should keep in mind this in Figure 1 shown simplified illustration of segmental and brain projection of the large afferents from muscle spindles. It is important to be aware that large myelinated Ia afferents provide input to the spinal cord gray matter but in the same time muscle spindles contribute to the proprioceptive brain functions too. Thus we should give some thoughts how to enhance proprioceptive input to the brain in the people suffering from progressive neuromuscular disorders. We should remember that brain's sensory-motor integration mechanisms activity depends on sensory information from the body and the central state of brain functional level. Thus, higher nervous system functions awareness, attention and different functions of consciousness have also contribution from sensory peripheral input. Therefore, if de-afferentation is due structural lesion of peripheral nerves, ascending sensory pathways of the spinal cord, brain stem, sub-cortical one or by functional one, due to restriction of movements by splinting, prolonged bed rest, exposed prolonged conditions of reduced gravity or by muscles weaknesses due to neuromuscular disorders, we should recognize consequences of the structural as well as functional de-afferentation of the brain. When brain functions are altered then they can be repaired by another modalities of sensory inputs (i. e. visual by acoustic, proprioceptive by exteroceptive). However, this compensatory brain functions are decreasing range of brain's capacity to adapt, to anticipate, to set implementation by control and executing desired movements and appropriate movements.

Externally induced proprioception and tonic vibratory reflex

Skin, tendons and muscle receptors are also sensitive to vibration and by eliciting vibratory tonic reflex it is possible to

enhance proprioceptive input to the CNS in the people with decreased movements activities and preserved peripheral and sensory nervous system functions. In man with vibratory stimulation of skeletal muscles it is possible to evoke a high-frequency sustained discharge in the Ia afferents and slowly enlarging autogenetic reflex contraction (TVR). This TVR can have sufficient strength to lift an arm or a leg against gravity (8, 9). It has been shown in recordings from whole muscle nerve fascicles and securely fastened to the muscle tendon vibration induced barrage of impulses from the intramuscular stretch receptors increases in strength with increasing amplitude (up to 2 mm) and increasing frequency (up to 200/sec) of the mechanical oscillations (10).

Vibratory stimulus within the range of 100–200 sec and 1–2 mm applied to the tendon it is an appropriate stimulus when our intention is to activate the primary endings in humans. Vibrators oscillating at about 150/sec with an amplitude of about 1.5 mm, fairly independent of the external load, are easy made of compact cylindrical DC motors equipped with an appropriate excenter on the axis. Such small vibrators are easy to handle (11).

The following Figure 2 is illustrating simplicity of procedure for vibratory induced proprioceptive input to the CNS, shown here by microneurographic recording of induced spike activity during vibratory tonic reflex response. In the other words vibration is very simple and potent procedure when applied in the people with progressive neuromuscular disorders to accomplish externally controlled increase of proprioceptive input.

Vibratory stimulation of muscle tendons in addition to tonic movement can induce also impairments of sense and illusion of movements. Both of those effects is evidence for central effects of vibratory induced (12–14).

Let us mention that regional blood flow studies, PET tomography study, revealed that perception of passive flexion/extension movements and illusions of movements are associated with different patterns of brain activation. Primary sensory cortex and Supplementary Motor area do respond only to passive movements. However, perception of passive movement and of illusory movement induced by tendon vibration activated areas in parietal and temporal lobes (7). Thus a very

simple protocol of passive and active movements, vibratory induced proprioceptive input with different mental task can provide variety of brain activations and enhancing higher nervous system functions.

Therefore we should make an effort to prevent central effects of the decreased proprioceptive, partial 'functional deafferentation', on alterations in the subjects mood, awareness, attention and other mental functions.

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