



The Role of Proprioception in The Meditation Practice

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Abstract

One of the most important aspect of mind-body interventions as Yoga practices and mindfulness-based programs, consists of focusing the attention on body position and movement. This may suggest that consciously detecting proprioceptive signals arising from the body could be necessary for obtaining the benefits of meditation practices on physical and psychic health. Recent studies show that the high frequency vibration of a single group of muscles powerfully activating muscle proprioceptors, mainly the neuromuscular spindles, increases the motor and sensory abilities and enhances the capability of learning new motor task in both healthy subjects and patients. These effects could be useful in training and recovering from motor deficit since they persist for several days, likely because the strong activation of neuromuscular spindles may lead to synaptic remodeling in the sensory-motor circuits. We hypothesize that the high intense proprioceptive activation and the consequent consolidated sensory-motor effects may contribute to a higher body awareness in the meditative practices and lead to a more general improvement of cognitive functions, emotional balance and self-awareness.

Keywords: Muscle proprioception; Yoga; Mindfulness; Focal vibration; Neuromuscular spindle

Abbreviation: FV- focal vibration; LTP- long term potentiation; LTD- long term depression

Introduction

A growing body of research supports the efficacy of Yoga practices and mindfulness-based programs to improve function in a wide range of physical and psychological processes [1-3]. Mind-body interventions require focusing the attention on body position (posture) and movement by consciously detecting proprioceptive signals [4]. suggesting that the elaboration of the proprioceptive input represents an important factor for achieving beneficial physical and psychic results. However, the mechanism at the base of the relevance of proprioceptive signals in the application of meditative procedures is not yet elucidated. It is not yet known whether the efficacy of the meditative practice in increasing motor

and sensitive abilities and improving psychic behavior, is simply a result of mental process elicited by the body awareness or it depends on the specific properties of the proprioceptive signals when their sensory inflow is consistently enhanced, as in case of the proprioceptive overactivation by muscle vibration.

Recent studies appear to support the role of proprioception in inducing meditative practice benefits. These studies evidenced that prolonged focal muscle vibration (FV) applied in a single muscle elicits plastic changes in central nervous system, improving both motor and sensory function in both healthy subjects and patients. It is well known that muscle mechanical vibration, characterized by

a sinusoidal waveform, small amplitude (<1 mm), at high frequency (about 100 Hz) selectively activates the proprioceptive afferents, mainly the primary afferents of neuromuscular spindle and drives their activity at the same frequency of the vibration [5]. Therefore, high frequency vibration induces an overflow of the spindle afferent proprioceptive signals impinging in the central sensory-motor circuits. The results of FV, applied in 3 sessions of 10 in a day for 3 consecutive days at the level of the muscular belly of skeletal muscles, are reported in a recent review [6] and consist of long-lasting potentiation of strength, speed and power of the vibrated muscle, reduction of fatigue, balance improvement. In addition, FV induces changes in locomotion [7] and space representation [8]. All these effects have been observed in healthy subjects and showed greater amplitude and duration in presence of voluntary contraction of the vibrated muscle. Positive effects of FV have been found also in patients with either negative (weakness, asthenia paresis) [9] or positive disfunctions (contractures, spasticity) [10]. Interestingly, the positive effects, characterized by significant enhancements of the motor functions, persisted several days and in some cases up to 1 year. Neurophysiological studies evidenced the development of plastic cortical changes, temporally correlated to the function improvements [10], suggesting a change in the balance of agonist-antagonist muscle activation. Moreover, even if focally applied on single muscles, the treatment showed improvement in the execution of complex movements involving multiple muscles [11].

Discussion

These results clearly demonstrates that intense and sustained focal spindle activation interacts with the central nervous system facilitating the sensory-motor responses at spinal and cortical level by enhancing the responsiveness of the system to the sensory input or by modulating the sequence of agonist-antagonist activation [10]. For the more complex movements or for the recovery of motion after functional deficit, it is possible to advance the hypothesis that the intense proprioceptive flow might increase the level of synaptic activation reaching a more operative level of activity and, consequently, a better responsiveness of the sensory-motor system.

Another question regards how FV induce central nervous system persistent adaptation

From cellular studies, long-term potentiation (LTP) and long-term depression (LTD) of synaptic transmission are the leading candidates for being the relevant activity-dependent changes in synaptic connection strength. Typically, high-frequency stimulation is used to induce LTP in brain slices, whereas LTD can be reliably evoked by low-frequency stimulation of around 1 Hz. These observations and the different studies suggest that the applied vibration frequency (100 Hz) is optimal to drive the proprioceptive afferents at the same frequency, possibly allowing the development of LTP along the proprioceptive pathway.

Another interesting aspect to be underlined is that the amount and the duration of the effect are greatly increased by the combined

voluntary muscle contraction during FV application of the treated muscle [8,10].

It is likely that voluntary activation may enhance the sensitivity of spindle through the gamma activation or the descending activity from the cortex may facilitate LTP through a combined sensory and motor activation of neurons by ascending signals from proprioception and descending signal from the cortex. This combined activation may be relevant since the synaptic responses can be potentiated by the hetero-synaptic activation. Even more interesting is the fact that these modifications are strongly enhanced if subjects during vibration pay attention to discriminate vibration frequencies [12]. The authors found that the enhanced motor learning has been achieved when the attention was directed to the part of the body that was vibrated. It has been shown that when a hand muscle was vibrated and in combination subjects paid for discriminating small change in vibration frequency, the ability to learn subsequent novel motor task requiring the activation of the same muscle was significantly enhanced. This means that through proprioceptive activation it is possible to enhance learning capacity without specific training. Up to now, the evidence of a learning without training has been provided at the sensory level, such as touch, hearing and visual [13], and further experiments should be carried out to confirm the learning capacity of the proprioceptive activation in the sensory-motor functions.

Conclusion

Based on the above reported findings, we can reasonably suggest that the intense and sustained activation of muscle proprioceptive signals by FV produces an enhancement of both the stimulated proprioceptive pathway and the correlated network, likely due to the induction of LTP. Synaptic potentiation maintains over time the improved motor and sensorial activity in the circuits that are directly involved. In this context, and beyond, seems particularly interesting the fact that internal proprioceptive activation can make the nervous system more capable of acquiring new motor patterns or improve the motor task accuracy [10,11]. Interestingly, these results are obtained by activating in combination sensory and motor systems or by focusing the attention on the muscles involved, as occurs in the various meditation practices. We can hypothesize that the focus on the proprioception in the meditative practices can enhance of the proprioceptive signal through top-down influences and, in turn, the enhanced proprioceptive activity can induce improvement not only of sensory-motor system but also of higher cognitive functions, mood balance and self-regulation. However, further experiments are necessary to demonstrate a possible influence of the intense proprioceptive activation on the cognitive and emotional functions.

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Conflict of Interests

No conflict of interests.

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