

Dry Needling Reverses Vibration-induced Changes in Spinal Motoneuronal Pool: Is there any Basis for its Action on Muscle Tone?

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Abstract

Acupuncture or dry needling, in clinical practice have been used successfully in the treatment of pain associated with muscle tone alterations. However a possible direct effect on muscle tone has never been clearly separated from its analgesic action. The H-reflex is a recognised neurophysiological index of the excitability of spinal motor neuron pool. This reflex is highly inhibited by the application of a vibration stimulus of 100 Hz.

The aim of the study was to evaluate in a group of normal subjects and in absence of pain if acupuncture stimulation was capable of acting at the segmental level, modifying the 100 Hz vibratory inhibition of the H-reflex.

H-reflex amplitude significantly varied in relation to the application of vibratory stimulus and acupuncture stimuli. Before vibration (H-Basal) the average amplitude was $292 \pm 59.3 \mu V$. During vibration (H-Vib) the amplitude reduced to $118 \pm 73.6 \mu V$ (H-Bas vs. H-Vib $p < 0.05$). Insertion of the needle (H-Vib+needle) produced a statistically significant increase in amplitude of the H-reflex to $218.8 \pm 95 \mu V$ (H-Vib vs. H-Vib+Ago $p < 0.05$).

Through the use of neurophysiological techniques on man e.g. H-reflex, the existence of a direct effect of acupuncture on the excitability of the spinal motor neurons has been demonstrated suggesting an action of acupuncture on muscle tone separate from its well-known analgesic effect.

Keywords: High frequency vibration; Dry needling; Muscle tone; Motor neurones; Spinal cord; H reflex

Introduction

Painful conditions of the musculoskeletal system, as, myofascial pain syndrome, constitute one of the most widely represented chronic painful muscle condition in daily clinical practice. Myofascial pain is commonly encountered in active population particularly in these activities that stress upper and lower back [1]. Its treatment is often a source of dissatisfaction for both the patient and physician. The above therapeutic difficulty substantially reflects the inefficiency of the various pharmacological and non-pharmacological approaches used in clinical practice [2]. Among these non-pharmacological techniques, one of the most interesting forms of physical treatment is the so called "dry needling" or acupuncture stimulation [3]. It has been consolidated in the treatment of painful musculoskeletal diseases where besides recognised pain patterns [4] there is also clinically evident alteration of muscle tone [5,6].

The efficacy of acupuncture stimulation indirectly pops up from a systematic review [7] concerning the trigger points injection of different substances, where the mechanism of action was related to the

act of needling, irrespective of the substances used, and defined as the "needle effect".

The paucisynaptic Hoffmann reflex or H-reflex [8] is considered homologous to the tendon reflex where the first is evoked by electrical stimulation and the second by mechanical stimulation. The H-reflex is a recognised neurophysiological index of the excitability of spinal motor neuron pool. It is used in clinical practice and research as a quantitative index of muscle tone disturbances [9]. The reflex is usually studied in the lower limbs but it is also obtainable from the upper limbs [10]. This reflex is highly inhibited by the application of a vibration stimulus of 100 Hz [11,12].

Although these data indicate a possible direct action of acupuncture stimulation on muscle tone, this effect has never been clearly distinguished from its nociceptive one. At the same time little is known about the presence of a direct segmental levels involvement in this effect.

Aim of the Study

The aim of the study was to evaluate in a group of normal subjects, in absence of pain, if acupuncture stimulation can modify the amplitude of the H-reflex conditioned by a 100 Hz vibratory stimulation applied to the upper limb to confirm a direct segmental

action of acupunctural stimulation on muscle tone independently away from its analgesic effect.

Materials and Method

Following the Helsinki principles for research in humans, 12 healthy male subjects (aged between 29 and 42), all of whom are hospital employees, were informed on the scope and method of the research, and then enrolled in this research. 24 hours before the beginning of the evaluation, every subject were instructed to avoid smoking, coffee [13] or to take any pharmacological treatment (i.e. occasional use of NSADs COX2 or hypnotic drugs) to eliminate as much as possible any influence on muscle tone. Only male subjects were enrolled to avoid possible influence due to the different hormonal pattern on the reflex [14].

The H-reflex was evoked from abductor pollicis brevis [10] by stimulating the median nerve at the wrist. The parameter of the electrical stimulus and the registration techniques where those suggested by Hugon [15] for the recording from the soleus muscle of the lower limb. The vibratory stimulus (conditioned stimulus) was obtained by a mechano-acoustic device (VISS-Vibration Sound System, Circe Bologna) with a transducer (4 cm diameter), placed on the arm ipsilaterally to the H-reflex on the skin corresponding to the C6 dermatome. The stimulus parameters are those proposed by Hagbarth (vibration amplitude=0.5-1 mm; frequency=100 Hz) [16].

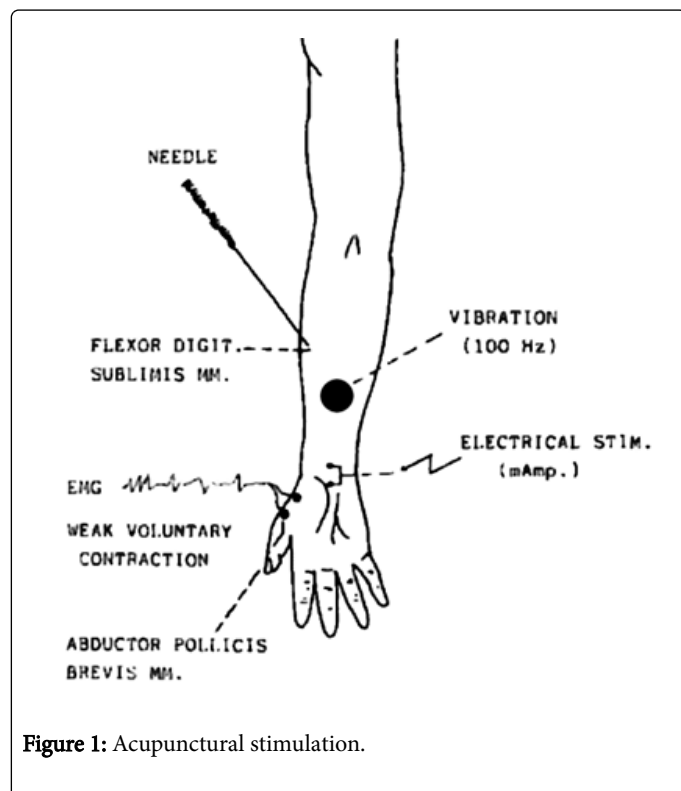


Figure 1: Acupunctural stimulation.

Acupunctural stimulation (conditioning stimulus) consisted of the insertion and manipulation of an acupuncture needle in the Kongzzui point LU 6 present on the radial part of the arm, 7 cm above the wrist on the C6 dermatome. A Sedatelec needle (52 mm long and 0.30 mm diameter) was inserted 15 mm deep into the muscle belly. The correctness of the acupuncture technique was verify by the provocation of a well localized pricking pain (needle insertion), followed by a deep

pain in the arm which lasted throughout the whole procedure (needle manipulation). The acupuncture was performed by a trained physician with a recognized diploma in acupuncture not involved in the electrophysiological recordings and measurements.

After having obtained the maximum H-reflex amplitude, the 100 Hz vibratory stimulus was delivered for 60". After 60", the needle was inserted, left in place and the vibrations continued for a further 5' (Figure 1).

The average value of the H-reflex amplitude (mV) was recorded at rest (before vibration, H-Basal), during vibration (H-Vib) and during vibration with acupuncture (H-Vib+Needle).

Result

In the group of subjects examined, the amplitude of the H-reflex significantly varied during the experiment in relation to the application of the vibratory stimulus alone (conditioned stimulus) or the superimposition of the acupunctural stimulation (conditioning stimulus).

Before the application of vibration (H-Basal) the average amplitude of the H reflex was $292 \pm 59.3 \mu\text{V}$. During vibration the (H-Vib) the amplitude reduced to $118 \pm 73.6 \mu\text{V}$ (H-Bas vs. H-Vib $p < 0.05$). Insertion of the needle (H-Vib+Needle) produced an increase in amplitude of the H-reflex to $218.8 \pm 95 \mu\text{V}$ which is statistically significant with respect to the amplitude of the H-reflex during vibration (H-Vib vs. H-Vib+Needle $p < 0.05$) (Figure 2). H reflex amplitude remained statistically inferior to the amplitude of the H at basal conditions H-Bas vs. Vib+Needle $p < 0.05$).

Upon manipulation of the needle, all the subjects perceived a deep pricking sensation, which was well localized, followed by diffused pain over the whole arm. The insertion of the needle caused deep pain, which was difficult to localize as described in books of acupuncture as "Te-chi".

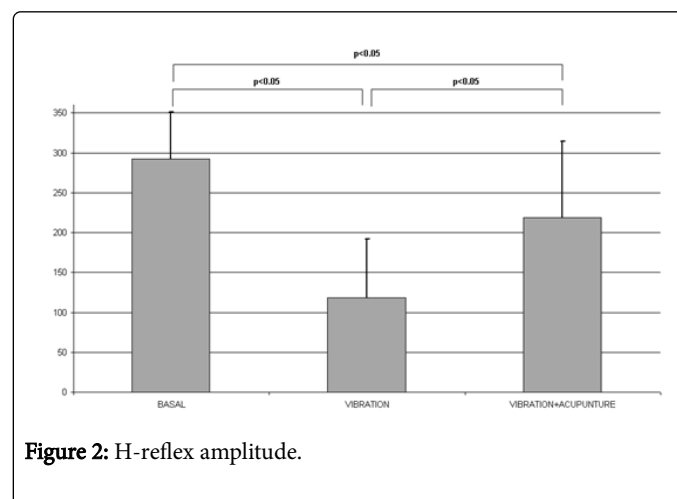


Figure 2: H-reflex amplitude.

Discussion

Regional myofascial pain of the upper back and limbs along with low back pain is the most widely represented muscle pain disorder in clinical practice especially in active populations [17].

This is referred not only to workers of the heavy industry [18] or to traumatic sequelae [19], but also in very different categories of the

population such as artists [20]. In these regional myofascial pain syndromes, acupuncture needling is considered to be a useful treatment to reduce pain and related muscle contracture [21]. However in literature it is not clearly defined if the therapeutic action is primarily due to an analgesic action, which is followed by myorelaxation, or if, vice versa, there exists a direct action of acupuncture on muscle tone separated from the analgesic effect.

Our research was focused on the effect of acupunctural stimulation on the H-reflex inhibitory effect induced by a 100 Hz vibration recorded from the upper limb in a group of subjects without any painful condition, so that the presence of pain and the analgesic effect of acupuncture stimulation on muscle tone would not in any way influence the result.

The H-reflex represents a recognised index of the excitability of the spinal motor neurons pool and it is currently used to evaluate the effect of muscle relaxants like baclofen [22]. H-reflex is evoked by the electrical stimulation of the Ia intra-fusal afferent fibres, and in human it is strongly conditioned by the application of a vibratory stimulus of 100 Hz [16]. This conditioning is possible through the presynaptic inhibition of the paucisynaptic pathway [12,23] and through an effect called "busy line" [16]: the vibrations seems to massively engage the primary afferents (Ia fibres) so blocking the conduction of successive afferent volleys.

In 1980, Homma, Endo and Sakai demonstrated how the insertion of a needle for acupuncture was capable of reducing the mechanical tension of the finger flexors provoked by a 100 Hz vibration on the fingers [24]. This action is better known as tonic vibration reflex [15,16]. Our research utilized the same vibration frequencies, broadened the early experience of Homma and Coll., adding a new detail on the presence of a normalizing action on the spinal excitability, as evidenced by restoration of the normal excitability of motor neuron pool that is responsible for the paucisynaptic H-reflex.

Our data are pointing out a clear evidence of a spinal action of acupunctural stimulation on the amplitude of the H-reflex, indicating a direct effect on spinal control mechanisms of muscle tone. However, the peripheral pathways involved in this counterinhibition and the possible role played by the supra-segmental levels more generally involved in acupuncture mechanism of action deserve some comment.

As concerns this last point, the supra-segmental control of muscle tone induced by acupuncture, has been partly attributed to its opiate action. The use of naxolone, a morphine antagonist, is capable of counteracting the effect of acupuncture, indeed suggesting that acupuncture induces an inhibiting effect on the motor neuron pool through the activation of the opiate descending control systems [25]. In analogy it has been shown that a clinical dose of morphine (1 mg/kg) increases the H-reflex [26]. However these data are not homogenous as there is still controversy over the effects of opiates and naloxone on spinal reflexes. Dosage, and interactions with different opiate receptors may account for the different findings present in literature. That some effects on the motor spinal pool is at least in part due to the activation of opiate descending inhibitory systems has been demonstrated as this modulation is present in normal subjects, but not in the spinal cord-injured subjects [27].

The counter effects of the acupuncture stimulus on the 100 Hz vibration induced inhibition of H-reflex, although not completely reversed, was already present within 5' after needle insertion, showing a remarkable speed of action. Due to the speed with which the action appeared, a spinal action rather than supra-spinal control of the opiate

pathways seems to be maintainable. This is indirectly supported by the fact that a supraspinally induced reflex responses variation appear 20' after stimulus application and that this variation is parallel to the amount of endorphines released [28]. This data are in agreement with what is present in literature about the variation of the level of opiates with acupuncture stimulus after about 20'-30' in humans [29], as well as in animals [30]. The incomplete reversal of amplitude of the H reflex by acupunctural stimulation, showed by or data, may be interpret taking into account that what we recorded was a short latency electrophysiological modulation on the spinal cord induced by acupuncture and that in electrophysiological studies the reflex amplitude was almost completely reversed when using high dose of morphine (morphine 1 mg/kg) [26].

Another point to be cleared out is related to what kind of afferent fibres are involved in the transport of the stimulation able to influence the H reflex. Indeed whatever the level, spinal or supra-spinal, the question is how the acupuncture stimulus was able to overcome the barrage produced by vibration as we know that 100 Hz vibration is able to engage Ia afferent with the so called busy line effect. Insertion of the needle deep in the muscle and its manipulation may capable of stimulation other afferent fibres of different diameter as well as the Ia fibres. However, even admitting that there is a mechanical activation of Ia fibres, since even a suprathreshold electrical stimulation is not capable of overcoming the conduction block along the Ia fibres involved in the "busy line" effect produced by vibration, so a hypothesis which contemplates the role of Ia fibres stimulated by acupuncture in overcoming this said block seems very unlikely.

In the clinical practice as well as in the subjects involved in our research gave evidence that deep insertion and manipulation of the needle provoked severe poorly localized pain which tented to diffuse throughout the whole arm. The said sensation is described in acupuncture manuals by the name of "The Chi".

This type of sensation described by the subjects involved in our research is characteristic of activation of poorly myelinated group C-fibres and A-delta fibres [31]. It is therefore possible that the deep insertion of the acupuncture needle in the striated muscle belly is capable of provoking an afferent volée not through the Ia fibres already involved in vibrations but instead through the C-fibres and A-delta fibres, in order to by-pass the effect of the "busy-line" which is the pre-synaptic inhibition of Ia fibres induced by vibration. Although it has been stabilized that the fibres involved are A-delta and type C, it remains to be clarified how these fibres escaped the inhibitory effect of vibration on H-reflex. The electrophysiological basis of the this effect are explained by the discovery that the afferent A-delta and C are in contact with the Alfa-motorneurons through a polysynaptic pathway described by Eccles and Lundberg [32]. These sensory afferents are not going to "remove" the vibratory inhibition on the Ia fibres, but will increase the excitability of the spinal motor neuron pool. In this way the Ia fibres activated by electrical stimulus and not involved in the vibratory barrage would find the anterior horn more facilitated, and therefore capable of producing H reflex with bigger amplitude in comparison to the H reflex obtained under the vibration.

The use of systemic muscle relaxants has been always characterised by the relevant presence of side effects such as generalised muscle weakness. Moreover a recent metanalysis points out that for many usually used drugs as gabapentine, clonidine, diazepam, amytal and oral baclofen a lack of evidence for a clinical significant effectiveness also for spasticity [33]. As far as we know even the most recent studies

on acupuncture have not showed side effects like those found in the pharmacological treatments [34].

Conclusion

The spinal modulatory action of acupuncture stimulation herein demonstrated can be therefore used in clinical application not only for the above mentioned effects on muscle tone but also for the substantial absence of iatrogenic effects like excessive muscle weakness or even hypotonia.

Finally it should be stressed that this demonstrated fast segmental, non-opiatergic electrophysiologically mediated action, on muscle tone can be followed and even potentiated by a second, slow rising, suprasegmental opiatergic system, modulating both pain and muscle tone [35,36].

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