0008-3194/2008/14–23/$2.00/©JCCA 2008

Treatment of posttraumatic arthrofibrosis of the radioulnar joint with vibration therapy (VMTX Vibromax Therapeutics™): A case report and narrative review of literature

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Objective: *To present the clinical features of post traumatic arthrofibrosis and response to treatment with Vibromax Therapeutics™ (VMTX™) in 28 year old male soccer player.*

Rationale: *Many studies have reported an increase in muscle performance after whole-body vibration, but to date none have evaluated the possibility of vibration application as a therapy for functional restoration after injury.*

Conclusions: *Vibration training is being utilized in, strength training, performance enhancement and rehabilitation. Despite the lack of research in this area, the literature that is currently available and the results of this case study imply that vibration therapy has the potential to aid in the management of acute soft tissue injury and the sequela of disuse and immobilization.*
(JCCA 2008; 52(1):14–23)

key words: arthrofibrosis, vibration therapy, VMTX Vibromax Therapeutics™, whole body vibration, functional chains.

Objectif : *Présenter les caractéristiques cliniques de l'arthrofibrose post-traumatique et la réponse au traitement avec le produit Vibromax Therapeutics^MD (VMTX^MD) chez un joueur mâle de soccer, âgé de 28 ans.*

Justification : *Bien que plusieurs études aient indiqué une augmentation de la performance musculaire suite à la vibration du corps entier, aucune étude n'a évalué la possibilité de l'application de la vibration comme une thérapie destinée à la restauration fonctionnelle, suite à une blessure.*

Conclusions : *L'entraînement de vibration se déploie actuellement dans le cadre de l'entraînement de la force, l'amélioration de la performance et la réadaptation. En dépit de l'absence de recherches dans ce domaine, les travaux disponibles actuellement et les résultats de la présente étude de cas laissent entendre que la médecine vibratoire possède le potentiel d'être utile au traitement de la blessure aigüe des tissus mous et des séquelles de la désuétude et de l'immobilisation.*
(JACC 2008; 52(1):14–23)

mots clés : arthrofibrose, médecine vibratoire, VMTX Vibromax Therapeutics^MD, vibration du corps entier, chaîne fonctionnelleIntroduction.

Despite an array of treatment options available, patients presenting with chronic pain and dysfunction represent a challenge to today's physician when attempting to return them to full activity without limitations. Many athletes develop excessive connective tissue fibrosis or poorly organized scar tissue in and around joints, muscles, tendons, ligaments, myofascial planes as a result of acute trauma, recurrent microtrauma, immobilization, or as a complication of surgical intervention. This can lead to chronic inflammation, soft tissue adhesions, tendinosis, fascial restrictions or dysfunction which in many cases responds poorly to conventional treatments.[1] Findings generally en-

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countered in patients presenting with arthrofibrosis are, reduced range of motion, palpable crepitus, pain with movement, muscular atrophy and weakness surrounding the affected joint. With these findings in mind, it is apparent that the muscular system, connective tissues and neural systems are involved in the pathophysiology of chronic soft tissue fibrosis. It has been proposed that the initial traumatic event causes a muscular hypertonus, which leads to inadequate circulation, which then enhances pain. In the long run, this can lead to immobilization, followed by muscular atrophy and pathophysiological loading patterns, which further establish pain chronification.[2] Patients presenting with this sequlea will typically complain they have received months of conservative treatments with various modalities and have had limited success. This leaves many therapists searching for new methods of treatment.

Vibration stimulation during strength training has recently gained popularity. Vibration has been combined with conventional resistance training in an attempt to attain greater gains in neuromuscular performance than from conventional resistance training alone. During any physical activity we can expect to experience soft tissue vibrations. The amplitude and frequency of these vibrations is partly determined by the natural frequency and dampening characteristics of the tissues.[3] The body relies on a range of structures and mechanisms to regulate the transmission of impact shocks and vibrations through the body, including bone, cartilage, synovial fluids, soft tissue, joint kinematics and muscle activity.[3] It has been proposed that the body has a strategy of "tuning" its muscle activity to reduce such deleterious effects.[2,3] This idea predicts that the amount of muscle activity used for a particular movement task is, to some degree dependant on the interaction between the body and the externally applied vibration force.[1,3] Therefore it has been proposed that vibration could be used for muscle strengthening. Muscles can damp externally applied vibrations, and, indeed, more vibration energy is absorbed by activated muscle, suggesting that active cross bridge cycling is an important part of the dampening process.[3] Studies have shown that the dampening coefficients of whole muscle groups increase with muscle activity.[1,4] A maximally activated muscle can damp free vibrations so that tissue oscillations are virtually eliminated.[1] It is thus possible that externally applied vibrations will trigger muscle activation to minimize the vibrations that occur within the tissues. The exact mechanism behind this is not clear. However, it is important to keep in mind that a certain degree of muscle activation is needed to damp the vibrations.

Although there is lack of strictly controlled studies on the vibration training effect, current findings in this area suggest that vibration may have a beneficiary acute and/or chronic training effect on strength and power enhancement.[4]

Vibration is a mechanical stimulus characterized by an oscillatory motion[3]. The biomechanical variables that determine its intensity are frequency and amplitude (peak to peak displacement in mm of vibration.)[3] The repetitive rate of the cycles of oscillation determines the frequency of the vibration (measured in Hz). Studies have suggested that low amplitude, low frequency mechanical stimulation of the body can be a safe and effective way to increase muscular strength and power.

Whole body vibration (WBV) is a neuromuscular training method where the subject stands on a platform that generates vertical sinusoidal vibrations. These mechanical stimuli are transmitted to the body where they stimulate muscle spindles. This leads to the activation of the alpha-motor neurons and initiates muscle contractions comparable to the tonic vibration reflex.[5] The tonic vibration reflex (TVR) is initiated by tendon vibration. The TVR is a reflexive contraction resulting from the very local stimulation of tendon or muscle. The change in muscle length is detected by the muscle spindles, which subsequently innervate the host muscle through 1a afferents. This activity is expressed as an increased EMG of the relevant muscle. The muscle is also able to supply some force in this way, without higher control.

Many studies have provided insight into the benefit of using vibration training to enhance muscle strength. In fact, the improvement of muscular performance after a short period of vibration training has been quoted to be similar to what occurs after several weeks of heavy resistance training.[7,8] Kerschan-Schindl demonstrated through an EMG study that exposure to seated sinusoidal vibrations increased the development of muscular fatigue in comparison to sitting alone.[23] WBV will induce vibration-synchronous EMG activity in the erector spinae muscle, which exceeds the activity in the muscle without WBV. These studies show that vibration induces muscle activation and therefore muscle training. Bosco et al. has suggested that muscle stimulation by vibration might improve the mechanical power of the lower limbs in elite athletes by means of neural adaptation. One minute of vibration applied during arm flexion in isometric conditions enhanced the average power of the arm in boxers. In another investigation, Bosco et al. showed that WBV increased the average velocity, average force and average power in well-trained subjects.[6] In a study by Delecluse et al. it was postulated that at the motor unit level, the TVR affects the subject's ability to generate high firing rates in high-threshold motor units.[5] The recruitment thresholds of the motor units during WBV are expected to be lower compared with voluntary contractions probably resulting in a more rapid activation and training of fast-twitch fibers. Bosco et al. has also found the root mean square of the associated EMG to be unchanged following the vibration treatment, but the ratio of EMG/power decreased, showing an enhancement of neural efficiency.[6] Thus, EMG activity in the trained muscle is the same or lower compared to pre-treatment levels. In this respect, the decrease in the ratio between EMG and mechanical power demonstrates that vibration induces an improvement of neuromuscular efficiency of the muscles involved in the vibration treatment.[6,7] These studies indicate that strength, and more specifically isometric, and isokinetic strength can be improved after WBV training.

WBV training utilizes a method of external vibration application. Recently, there have been indications that direct stimulation may have a more pronounced effect on the stimulated tissues. With direct vibration, the amplitude and frequency does not differ notably from the reported values measured at the vibration source.[4] In contrast, with indirectly applied vibration, the amplitude and frequency may be attenuated in a non-linear manner by soft tissues during transmission of the vibration to the target muscle.[4] This finding demonstrates that the muscle group that is nearer to the vibration source is activated more than the muscle group that is further from the source. Therefore, indirectly applied vibration may undergo more attenuation by the body structures during transmission and the method of direct vibration may have its advantages in stimulating the target muscle without signal attenuation.[3,4] Thus, given the amplitude of vibration source, direct vibration may facilitate more effective utilization of this amplitude.[4] In addition, vibration with a higher frequency may be employed in direct vibration. Some studies have also suggested that the most effective location to stimulate the muscle by vibration is the muscle tendon itself.[4]

Currently there is no consensus on the mechanism by which vibration may enhance neuromuscular performance. In fact, there is lack of research in this area. However, a number of mechanisms have been postulated upon, including: tonic vibration reflex, perceptual change by vibration, enhanced motor neuro- excitability, increased blood flow and muscle temperature, increased hormonal secretion and muscle hypertrophy.[4]

Vibration elicits involuntary muscle contraction and induces strength gain in previously untrained subjects within a short period of time without much effort from the subject. This suggests that vibration therapy has potential in a therapeutic context where it can have positive effects on acutely injured patients and the elderly, who are not able to perform standard rehabilitation exercises due to pain, inhibition or weakness.

Many studies have reported an increase in the muscle performance of subjects after whole-body vibration, but so far none have evaluated the possibility of vibration application as a therapy to enhance tissue regeneration and functional restoration after injury. It is the author's opinion that the current findings on the benefits of vibration application in a strength training setting are highly suggestive that there may be a carry over into the rehabilitation world in situations where tissue injury, pain, atrophy, disuse sequela and fibrous hyperplasia are preventing the patient from returning to normal function.

Case study

History

A 28 year old, left hand dominate male soccer player, presented with a chief complaint of left elbow pain of three months duration. The pain, which began immediately after plaster cast removal from the left forearm, was described as dull and constant. The cast was applied by an orthopaedic surgeon for a three week duration after the patient was diagnosed with an acute chisel fracture of the left radial head due to impaction sustained from a fall on an outstretched arm in a soccer match (Figure 1 and 2). The patient who had received three months (3 day/week) of microcurrent therapy (1–2 hrs per day) applied over the lateral aspect of the radial head, exercise therapy

Figure 1 *Oblique view of the left elbow demonstrating cortical disruption and a vertical lucency through the mid portion of the radial head, representing a chisel fracture of the radial head.*

Figure 2 *Lateral view of the left elbow demonstrating a moderate joint effusion with elevation of the anterior and posterior fat planes.*

and soft tissue treatment to his brachioradialis, supinator and common extensor tendon, still complained his arm and wrist were weak and described the elbow as unstable at times. The elbow was explained to be stiff with a constant, diffuse, dull aching sensation which frequently became sharp with movement of the elbow and axial loading of the wrist. The patient could not identify anything that relieved the pain. The symptoms were worsened by pronation/supination of the wrist and all activities involving axial loading of the hand and wrist. He complained he had trouble carrying heavy grocery bags and turning the steering wheel of his car due to the pain. No numbness or tingling in the upper extremity was reported. The patient denied any previous injury to the area or surgeries, as well as any family history of rheumatologic disease.

Physical Examination

Upon inspection, no ecchymosis, edema or atrophy of the arm/forearm musculature was noted. Upper and lower extremity pulses were within normal limits. Sensation and deep tendon reflexes were within normal limits. Cervical spine examination, including range of motion, neurological screening, motion palpation and Kemps, Jackson, Spurling and Valsalva tests were all negative. Shoulder examination, including range of motion, manual muscle testing and palpation were unremarkable. Full passive elbow extension caused pain located over the posterior aspect of the ulno-humeral joint. Full wrist flexion caused pain at the common extensor origin, which could be relieved by flexing the elbow. Actively, full elbow extension caused pain referring to the posterior ulno-humeral joint. Active wrist supination caused pain which referred to the lateral epicondyle. Resisted elbow extension caused pain referring to the posterior ulno-humeral joint. Resisted wrist flexion referred pain to the cubital fossa. Manual muscle testing revealed weakness (4/5) compared to the uninvolved limb (5/5), in the extensor carpi radialis longus, extensor carpi radialis brevis and tricep muscles, which was most likely due to pain. Objectively, an average of three trials of grip strength testing using a

Figure 3 *VMTX Vibromax Therapeutics™ starting position for treatment of extensor carpi radialis longus*

Figure 4 *VMTX Vibromax Therapeutics™ finishing position for treatment of extensor carpi radialis longus*

dynamometer was obtained. The values from the grip strength test were 60 Kg on the left and 79 Kg on the right. Orthopaedic testing revealed posterior-medial elbow pain with Mill's manoeuvre and bounce home test. Posterior-anterior stress applied to the elbow caused local pain. Radial head palpation was described as tender by the patient, which became sharp when an anterior-posterior stress was applied to the radial head. Palpation of the supinator, brachials, medial intermuscular septum, flexor carpi ulnaris tendon, tricep insertion, pronator teres, brachioradialis, pectoralis minor and infraspinatus all produced local pain. Palpation of the annular ligament with concomitant wrist pronation/supination revealed severe crepitus and reproduced the chief complaint of sharp elbow pain.

Clinical Impression and Management

The patient was subsequently diagnosed with post-traumatic arthrofibrosis of the radio-ulnar joint. Treatment consisted of nine visits over a period of three weeks. Vibration therapy via the Vibromax Therapeutics™ technique was employed over the radio-ulnar joint, annular ligament, all symptomatic muscles and the facial chains of the upper limb. (Figure 3 and 4)

VMTX Vibromax Therapeutics™ is an innovative soft tissue therapy technique utilizing the effect of vibration via the art of compression and tension along and over the soft tissues along the known kinetic chains to break down adhesions and scar tissues, decreasing pain, restoring function and enhancing performance with minimal discomfort to the patients and the providers. The device is called Palmpercussion™ and is manufactured by HoMedics Inc. It's specification are 110 volts and operates at a percussion rate of 2200 pulses per minute.

The patient was instructed to continue with the exercise prescription he was currently working on. This included basic resistance strengthening of the wrist and elbow. He was performing elastic resistance elbow flexion and extension along with resisted forearm supination and pronation at a frequency of 2 sets of 12 repetitions 3 times per week. He also continued his cardiorespiratory endurance training on a stationary bicycle for 35 minutes, 2 times per week.

Post Treatment Examination

After three weeks of treatment (3/week), the patient's symptoms decreased. He no longer reported pain during any of his activities of daily living or at rest, and his VAS score decreased by 50% (6/10—3/10). The patient no longer complained of any weakness or sense of instability in the elbow. The wrist pain was completely resolved. The patient reported periodic bouts of minor pain which when present, were located over the posterior-medial elbow. On examination, muscle strength testing of involved musculature was graded as 5/5 in all previously weak musculature. Mill's manoeuvre, A-P challenge of the radial head and P-A challenge of the elbow no longer produced pain. Active extension at end range and full passive flexion with over-pressure of the elbow produced minor discomfort around the olecranon fossa. Palpation of musculature revealed only slight tenderness in the brachioradialis. The patient's grip strength drastically improved from previous values compared to the uninvolved limb. These values were found to change from 60 to 82 Kg (37% increase) on the left and remained relatively unchanged on the right going from 79 to 80 Kg. No crepitus was palpated over the treated area of lateral aspect of the annular ligament, however minor crepitus was still palpable at the medial boarder of the annular ligament and reproduced the remaining symptoms reported with full passive flexion of the elbow. The patient was advised to continue with an additional two weeks of vibration therapy over the remaining symptomatic areas found in the annular ligament due to residual pain on palpation of this structure.

Discussion

The loss of motion in an elbow after a fracture and/or dislocation of the joint is a difficult problem to treat. Recent literature advocates a short period of immobility (2–3 weeks) followed be early motion in treating such conditions.[8] Despite advances in treatment options, posttraumatic arthrofibrosis remains a common complication of such injuries.[8]

Arthrofibrosis can be described as an abnormal proliferation of fibrotic tissue in and around a joint that can lead to a loss of motion. This widespread fibrous tissue growth can alter the joint biomechanics.[9] The adhesions that form often lead to stiffness and abnormal joint contact pressures and predispose the joint to cartilage degeneration. It is thought to result from abnormal tissue hyperplasia and usually follows injury. Colin et al. describes trauma as the initiating event which starts the clotting cascade and is followed by migration of inflammatory cells, then fibroblasts, to the injured area.[9] The development is likely multifactorial, with a number of risk factors identified. Immobilization can facilitate the proliferation of fibrous tissue and is a known risk factor for range of motion impairment. Even without external immobilization, Colin et al. suggests muscle inhibition due to pain or edema will limit joint motion and predispose the patient to fibrous tissue proliferation.[9] In this case, the goal of the treating physician is to maximize long-term function while minimizing muscle atrophy and loss of joint mobility often associated with injury and recovery.[10] The functional treatment required should involve a guided rehabilitation protocol focusing on reducing patient discomfort from pain and inflammation, focus on protection and healing of injured structures, with graduated strengthening aimed at remodelling the injured tissues. The process requires three phases of implementation. Phase I involves limiting the extent of injury and controlling swelling and edema.[10] Phase II is focused on restoration of motion and recovery of strength and phase III is focused on recovery of endurance, proprioception and performance.[10]

In situations of both acute injury and chronic pain, it may be in fact the pain that is the limiting factor in producing muscular force and not from tissue damage or weakness. Regardless of the answer to this question, it is clear that one of the physician's primary objectives is to control the patient's pain perception in order to optimize recovery.

Pain sensation is determined by two different processes; peripheral nociception and central sensitivity.[2] In chronic arthrofibrosis, a major part of pain sensation is the result of increased pain sensitivity. In this context, the question arises whether the improvement in pain-related limitation is simply from vibratory induced anaesthesia, a strengthening effect, or both.

According to the much debated gate control theory of pain hypothesized decades ago, fibres which transmit information from touch and vibration receptors in the skin, stimulate inhibitory interneurons in the spinal cord, which in turn act to reduce the amount of pain signal transmitted from A-ä and C fibres across the midline of the spinal cord and from there to the brain.[11]

Studies on pain sensation associated with lateral epicondylalgia found vibration of a muscle reduces pain perceived from local pressure.[11,22] Stimulation through vibration reduced the pain associated with both electrically induced and clinical pain overlying the extensor carpi radilais longus muscle.[11]

Consequently, although the gate control theory helps explain how vibration can minimize or alleviate the sensation of pain at the spinal level, other central and peripheral mechanisms may also have an influence. Further, the best pain reducing site was found to be in the area of pain of the affected muscle or tendon itself, which lends further suggestions of usefulness of direct application of the vibration stimulus.

Vibration stimulation may also be useful in a situation where the patient is unable to contract the muscle due to inhibition via pain. Hagbarth et al. demonstrated that muscle vibration overcomes an attenuated contraction force induced by an anaesthetic muscle nerve block that lowered fusimotor-driven Ia afferent inputs to alpha-motorneurons during maximum voluntary contractions.[13] Thus vibration may allow for muscle contraction when the subject is unwilling to actively contract the muscle because of discomfort.

Since the application of a vibratory stimulus has been shown to invoke reflexive contractions of surrounding muscles, thus imparting a compressive load bearing like stress application to the joints and due to the pressure applied by the vibrating device, it may be reasonable to assume that vibration therapy may be an effective intervention for limiting the deconditioning of musculoskeletal tissues when subjected to immobilization. This may in fact impart a fibroblastic production in the area. Vibration therapy may therefore allow minimization of the physiological effects of disuse and allow for a faster return to function.

Physical exercise has been recommended for the prevention and treatment of osteoporosis. However, its exact role and effectiveness is unclear.[16] While vigorous exercise of long duration enhances bone density, few injured individuals are able comply with such programs. This is where vibration therapy may have a benefit. Several observations support the role of mechanical stimuli in bone remodelling because bone is always lost when mechanical stimulus is reduced. Therefore by using vibration to impart a mechanical stress on the bone, it may stimulate a process of adaptation remodelling.

Considering the pathology that high frequency vibrations may cause to physiological systems, it should not be surprising that far lower dose of mechanical signals may actually be biologically beneficial to tissues such as bone or muscle, perhaps by enhancing tissue perfusion or amplifying regulatory signals.[18] Indeed, recent animal work has shown that high-frequency, low magnitude stimuli are strongly anabolic to trabecular bone, increasing bone mineral density, trabecular width and number in the weight-bearing skeleton, and that these signal can effectively inhibit disuse osteopenia.[18] Importantly, these mechanical signals, although small and physiologic in nature, arise from contractions of adjacent musculature and signify a low-level, dynamic mechanical signal to the bone tissue.[2,3,18] Thus, considering the anabolic nature of low-level vibration and such signals can be delivered to the skeleton via an external vibration device, it may indicate that this unique biomechanical intervention may provide a non-invasive means to treating musculoskeletal disorders caused by disuse osteopenia.[18]

Once the treating physician has pain and inflammation under control and the healing and strength of the tissue are adequate, steps must be made to ensure that the repairing tissue is capable of withstanding stress, in order to reduce the chance of re-occurrence and to guarantee a full recovery. It has been shown by many researchers that controlled tension enhances scar formation, tissue regeneration, proper orientation and type of new collagen fibres and the tensile properties of soft tissues.[20] Alferdson et al. proposed that fibroblastic orientation and collagen deposition is dependant on the direction of the applied mechanical stress and that the expression of growth factors and cytokines can be induced by stimuli such as mechanical loading.[21] A progressive eccentric training program has been proposed for tendon injuries in general. Jarvinen et al. suggests that a strength training program, consisting of isometric and gradual increasing dynamic exercises should be introduced as soon as possible after injury to prevent atrophy caused by pain-induced immobilization.[15] This is where vibration therapy can come into play. Muscle spindle primary endings (type Ia fibres) are sensitive to tendon vibration. When vibrations are applied during passive stretching of the muscle, the response of the primary sensory endings is increased. The stimulation of the muscle spindle primary endings via combined vibration and passive stretching movements provides a reflex increase in electromyographic activity.[22] It has been shown the muscle spindle endings are recruited by stretching alone or by tendon vibration alone. The reflexive contraction induced by the vibration while the muscle is lengthened produces an eccentric loading on the tissues.[22] This is associated with an increase in

EMG activity as the vibration is applied to a lengthening muscle. Hence, this modality with the induction of an eccentric load may stimulate fibroblastic activity and aid in the recovery of parallel collagen fibre alignment thus allowing the tissues to regain their tensile properties after injury. This lends support to the role of vibration therapy in reducing recovery time in a situation where the athlete is still unable to participate in full weight bearing exercises or strength training under considerable loads.

Another vital process in the regulation of an injured tissue is the vascularization of the injured area.[15,21] The restoration of vascular supply to the injured area is the first sign of regeneration and a prerequisite for the subsequent morphological and functional recovery of the injured tissue.[15] Studies have shown that mobilized muscles have an intensive in-growth of new capillaries from all boarders of the surviving muscle surrounding the injury, where as in the immobilized muscle the capillary in-growth to the injured area is almost completely negligible.[15]

An experiment conducted by Kerchan-Schindl et al. showed a significant increase in muscle blood volume in the calf and thigh and a significant increase in mean blood flow velocity in the popliteal artery after vibratory exercise.[23] This was attributed to vibration reducing the viscosity of the blood and increasing the speed through the arteries. This modality did not alter the heart rate or blood pressure.[23] This lends anecdotal evidence to imply that vibration therapy may enhance the blood perfusion to the injured area and thus enhance the recovery of the injured tissue.

Nearing the final stages of a rehabilitation program it is important to restore the original strength of the affected muscles and to restore proper proprioception. There is some evidence to suggest that vibration therapy provides assistance in attaining both of these rehabiliatative goals.[2–5,16] Although the strengthening effect of vibration training as it relates to force production and power has been extensively studied, there is also some evidence of these changes at the hormonal level. Bosco et al. looked at the hormonal response to whole body vibration in men.[6] The results showed a significant increase in the plasma concentrations of testosterone and growth hormone, whereas cortisol levels decreased. An increase in the mechanical power output was observed together with a reduction in EMG activity. Neuromuscular efficiency improved, as indicated by the decrease in the ratio between EMG and power.[24] Thus it can be argued that the biological mechanism produced by vibration is similar to the effects produced by explosive power training.[6,24] These results suggest that the vibration treatment leads to acute responses of hormonal profile and neuromuscular performance.[24] Bosco et al. has suggested that vibration treatment influences proprioceptive feedback mechanisms and specific neural components, leading to an improvement of neuromuscular performance.[6]

It is well known that the input of proprioceptive pathways is used in the production of force during isometric contractions.[5] During vibration, these proprioceptive pathways are strongly stimulated. Delecluse et al. states, the vibratory stimulus activates the sensory receptors which results in reflexive muscle contractions.[5] The increase in isometric strength after training and thus after extensive sensory stimulation might thus be the result of a more efficient use of positive proprioceptive feedback loop in the generation of isometric force.[5] Therefore it can be implied that the strength improvement seen in strength training and vibration studies may be attributed to an enhancement of neural activity together with an enhancement of the proprioceptive feedback.[6,24]

Although the first step in injury management is to address the damaged structures directly, it is also very important to address the surrounding structures both proximal and distal to the injured area to aid the subject in achieving full recovery. Kibler et al. has suggested that addressing the kinetic chain in overhead throwing athletes is a mandatory step in returning these athletes to their optimal performance.[25] The case presented in this study showed evidence of this concept. The patient complained of wrist pain on initial presentation and also demonstrated signs of weakness and myofasopathy in the external rotators of the shoulder and pectoralis minor muscle. When looking specifically at the fibrotic changes in this patient's annular ligament, one has to consider other tissues that may be affected by this pathology. A study conducted by Bozkurt et al. has successfully demonstrated the myofascial connections of the annular ligament in cadaver studies.[26] They reported that the annular ligament is an important component of both the proximal radioulnar and humeroradial joints, as well as an important component of neighbouring muscles and ligaments. Their anatomic studies have shown not only a soft tissue connection of the annular ligament with the superficial wrist extensors but, when the tendenous part of the supinator muscle was removed it was observed that the active muscle fibres were attached to the annular ligament.[26] The deeper fibres of the supinator muscle were intimately fused with the annular ligament. It was observed that the tendinous superficial portion of the supinator muscle was fused with the annular ligament, the radial collateral ligament, and the joint capsule itself.[26] These findings suggest that focusing treatment to the annular ligament alone may not resolve the problems in the kinetic chain that have become dysfunctional due to the initial injury. However, when treating the site of primary injury with vibration therapy there may be some secondary treatment being rendered to structures both proximally and distally to the area and thus impacting the kinetic chain. Kasai et al. has shown that vibration-induce activation of the muscle spindle receptors is not only limited to the muscle the vibration is applied to, but also affects the neighbouring muscles.[27]

Conclusion

More and more, vibration training is being utilized in, strength training, performance enhancement and rehabilitation therapy. The increase in muscle performance after bouts of whole body vibration has been studied a great deal in the past and the results are encouraging.[3,16,18,19,24] However, so far none have evaluated the impact that vibration therapy has on injured tissue and its role in the treatment of musculoskeletal injuries. Despite the lack of research in this area, the literature that is currently available and the results of this case study imply that vibration therapy has the potential to aid in the management and rehabilitation of subjects who present with acute soft tissue injury and the sequela of disuse and immobilization.

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