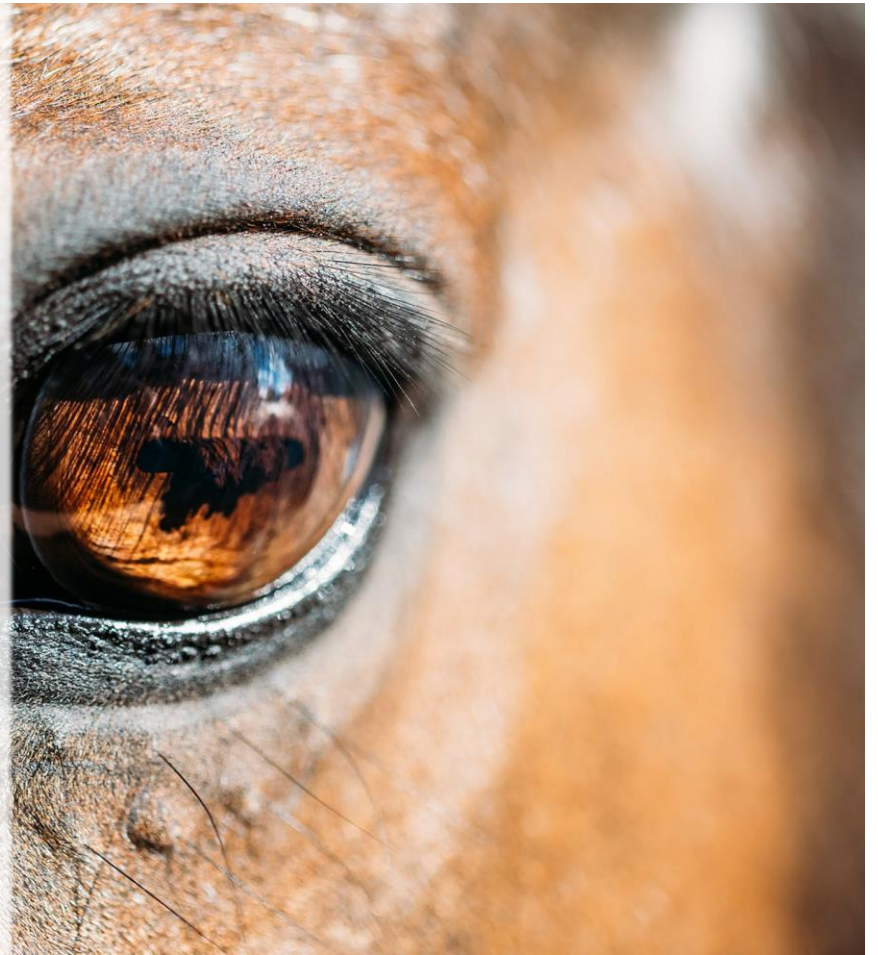


The impact of Osteopathic Manipulative Treatment (OMT) on the training of horses

Linda Zoutman

2024



To be well prepared for a certain job, horses need training. Can Osteopathic manual techniques optimize training? What is the scientific mechanism behind the techniques? Muscle building, flexibility, healthy fascia, neural adaptability and minimizing injury are important factors for training a horse. This thesis will cover these topics and explain the neurobiology behind them. The hypothesis of this thesis is that by applying OMT, horses can be trained more effectively and stay more supple during their life. To confirm this hypothesis, scientific literature and meta-analyses have been used to find the effect of OMT. Literature is conflicting about which stretching method works best, and if it can cause harm as well. Luckily, the other techniques described are positively affecting human training. Human research is likely to relate closely with horse training, but to be sure more research needs to be done with horses.



London College of
Animal Osteopathy

London College of Animal Osteopathy
380 Wellington St, Tower B,
London, Ontario N6A 5B5 Canada
+ 44 02 08 187 1178 (UK + EU)
info@aosteocollege.com

The impact of Osteopathic Manipulative Treatment (OMT) on the training of horses

BY LINDA ZOUTMAN

TREGARON, WALES

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LONDON COLLEGE OF ANIMAL OSTEOPATHY

RACHEL PACHEK



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Introduction

For a long time, humans have trained horses. In the first place for transport, war, or agriculture. However, nowadays horses are mainly trained for recreational purposes and sport in several different disciplines. Sometimes horses are trained for specific jobs, like police work, coaching, shows, and movie stunts. This thesis is not about how to train a horse for a certain job or purpose. Instead, it is about the physical and psychological systems necessary to train a horse in general and how Osteopathic Manipulative Treatments (OMT) can influence the training of horses. To be well prepared for a certain job, horses need to be trained physically and mentally. For physical training; muscle building, flexibility, healthy fascia, and minimizing injury are important, but mental training, neural adaptability and body awareness are important too. This thesis will cover these topics and explain the neurobiology behind them. This thesis hypothesizes that by applying OMT, horses can be trained more effectively and stay more supple during their life.

The first thing necessary to develop a strong and flexible horse is musculature. Muscles need to be strong, healthy, flexible and injuries need to be minimized. Growth of muscles is also called muscle hypertrophy and this can be separated into two types, myofibrillar and sarcoplasmic muscle cell growth. Myofibrillar muscle growth activates contractor muscles, whereas sarcoplasmic muscle growth increases the glycogen storage in muscles. Musculature consists of different cells like myoblasts and satellite cells. Myoblasts are cells that fuse in bundles of contractile multinucleated muscle fibres. Muscle fibres are single muscle cells with many nuclei and contain multiple myofibrils, see Figure 1. Satellite cells are located between these myofibrils and the basal lamina (Menetrey & Laumonier, 2016). Muscle hypertrophy is influenced by two pathways, mechanical tension and metabolic stress. Mechanical tension (training) increases anabolic hormone levels and activates myogenic stem cells to help in the growth and repair of muscle fibres (Sarfabadi, et al., 2023). Metabolic stress releases hormones and also leads to hypoxia, a low oxygen tension that drives among others cell survival, metabolism, and metastasis (Warfel & Jensen, 2022).

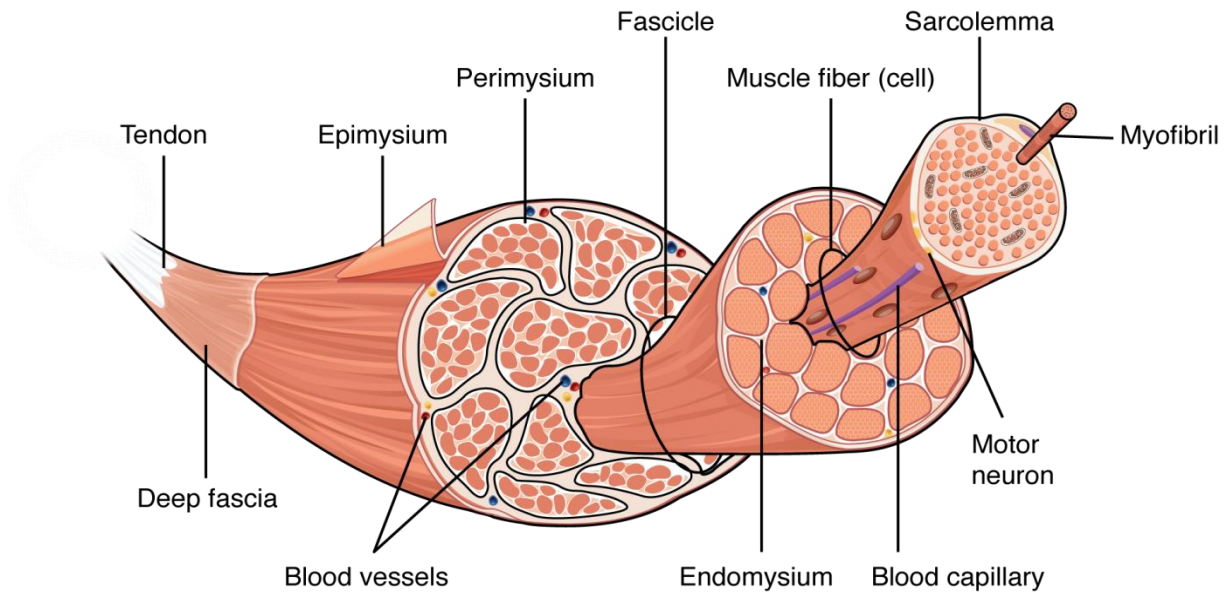


Figure 1 Tendon and muscle covered by deep fascia. The muscle consists of perimysium, multiple fascicles, and blood vessels. A Fascicle consists of muscle fibres and endomysium. Muscle fibres have blood capillaries running beside them and consist of sarcolemma and myofibrils.

Muscle growth on its own is not enough for muscle cells to function, they also need energy for contraction and relaxation. In cells, adenosine triphosphate (ATP) is this energy that causes muscles to contract. The small bundles of myofibrils contain sarcomeres with two types of microfilaments, thin actin filaments and thick myosin filaments. ATP binds onto the myosin to activate myosin heads. ATP also causes the release of calcium ions from the sarcoplasmic reticulum that bind to troponin. Troponin was blocking the myosin binding sites on the actin filaments, but these are now available for the myosin heads. The active myosin heads bend towards free binding spaces and pull the muscle together, this is how contraction takes place. See Figure 2.

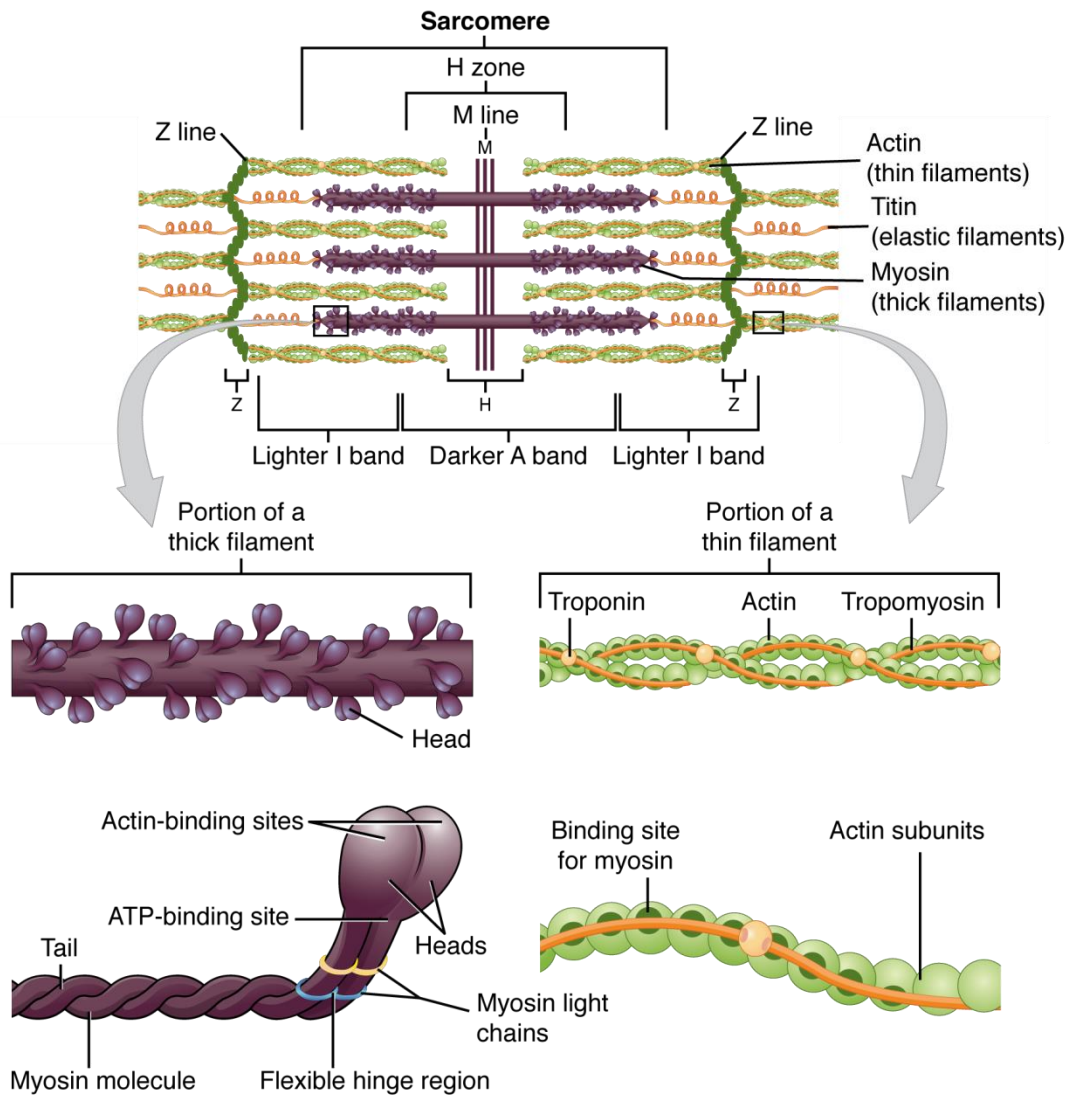


Figure 2 Sliding filament model of striated muscles. Troponin and Tropomyosin block myosin binding places on actin filaments. Ca^{2+} can bind to Troponin to free the myosin binding places. ATP can bind to the binding site on the myosin heads to activate them and bend them towards the actin proteins, causing contraction of the sarcomere. (College)

ATP can be made in the body via two ways; aerobic which needs oxygen, and anaerobic which takes place when there is no oxygen available. Normally horses have enough oxygen available and their food can be used to make ATP via glycolysis. Glucose is then broken down by enzymes to form pyruvate. The Krebs cycle then uses pyruvate and creates the electron carriers NADH and FADH^2 which fuels ATP synthesis in the electron transport chain. When there is no oxygen available, pyruvate is oxidized into lactic acid. Fermentation of lactic acid creates ATP anaerobically but also creates a burning feeling in muscles and is only a temporary mechanism.

There are three different ways muscles can contract. The contraction that causes muscles to shorten is called a concentric contraction. This movement closes the distance between the origin and the insertion of the muscle. In extensor muscles, concentric contraction increases joint angles. An example is the propulsion phase of a stride. Muscles that undergo lengthening while contracting are in eccentric contraction. The distance between the origin and the insertion of the muscle becomes larger. This movement allows horses to brake and limits the decrease of joint angles during the loading phase of a stride. The power of muscles is provided through

potential energy that is accumulated during the lengthening phase of the muscle, resulting in efficient muscle action (Denoix, 2014). Isometric contraction is the least common in equine disciplines. The length of the muscles at the time of contraction causes the muscles to either shorten or lengthen to stabilize and control the joints during exercise. An example of this type of contraction is the collection of the head and neck and pelvic flexion.

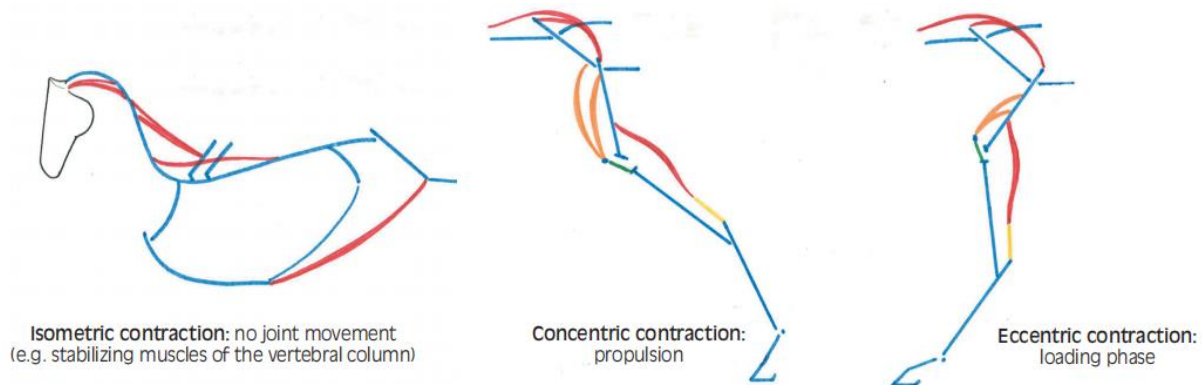


Figure 3 Three different types of contraction in skeletal muscles. Isometric contraction stabilizes joints and muscles. Concentric contraction increases the angles of the joint, lengthening the muscles. Eccentric contraction decreases the angles of the joints, shortening the muscles. (Denoix, 2014)

Neural mechanism

None of the previously mentioned contractions can happen without neuronal stimulation. Efferent motor neurons signal from the central nervous system to the muscles to contract them. When motor neurons are not stimulated, or are inhibited, muscles can relax. There are also sensory neurons that send signals from the muscles to the central nervous system, these are called afferent neurons. Muscles use the central nervous system as well to protect themselves from sudden stretches, which is called the stretch reflex. The muscle contains several muscle spindles, which are sensory organs that sense the length of the muscle. An afferent annulospiral type Ia neuron attaches to the intrafusal muscle fibres of the muscle spindle and senses whether or not the spindle centre is under too much tension. In a normal situation, when a muscle stretches, the stretch of the muscle spindle becomes bigger, the type I neuron will stimulate an α -motor neuron to contract the same muscle and prevent it from overstretching. At the same time, a γ -motor neuron is stimulated that contracts the intrafusal muscle fibres, to regain a net change of zero on the central sensory compartment of the muscle spindle (Dowd, 2020).

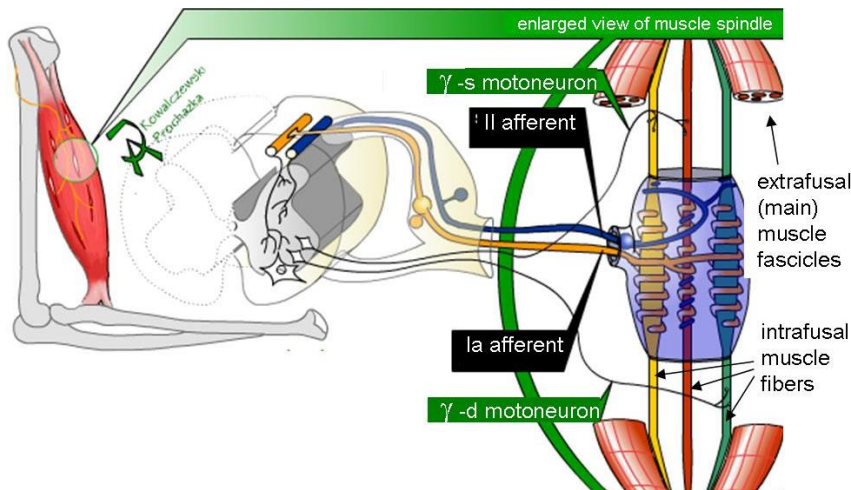


Figure 4 The neurons that innervate a muscle spindle. Ia afferent is the annulospiral neuron that reports the stretch of the muscle to the CNS. γ -motor neurons shorten the intrafusal muscle fibres. α -motor neuron that contracts the extrafusal muscle fibres is not shown. II afferent is the flower spray ending receptor. (Farrell, 2017)

The stretch reflex of muscles becomes a problem when an injury or quick stretch happens. For example, a kick to or from another horse or a slip in the field. Because of this sudden stretch of the muscle, the annulospiral nerve becomes overactive, and also overexcites the α - and γ -motor neurons (muscle spindles, n.d.). Because of the homeostasis between the α - and γ -motor neurons, after all this activity, the sensory spindle compartment is now neutral again (Dowd, 2020). This is mainly because the type II afferent neuron, also known as the flower spray ending, is an old and slow receptor. It perceives the last position of the muscle in homeostasis as a neutral position, which is now a shortened position. Therefore, every time the muscle is lengthened, this type II neuron reports a stretch and perceives the neural position as overstretched. With this receptor activated, both excitatory and inhibitory neurons are overstimulated, which affects not only the muscles but also the skin, fascia, ligament, tendon, and bone receptors that innervate the same CNS segment as the muscle that suffered an injury (Korr, 1975). As a result, proinflammatory neurotransmitters are released in one or more different locations, creating a or more tender points. These tender points are palpable by therapists and osteopaths.

Relaxation of muscles by OMT

Relaxation of muscles is very important for its function. Muscles contain active and passive tension. Active tension is caused by motor neurons to contract the muscle, but passive tension is caused by fascia and other structural properties of the muscle (Page, 2012). If muscles are not completely relaxed there is a decreased contraction possible. Therefore, both stretching of muscles and relaxation of muscles is an important part of training to create optimal functioning muscles. Osteopathic manual techniques (OMT) such as; passive stretching (Page, 2012) (Metaxas, et al., 2014), manual intraoral or extraoral release, and strain-counter strain technique (Dardzinski, Ostrov, & Hamann, 2000) could be used to help muscles go back to their relaxed state after training and create a bigger range of motion, longer muscles and/or increased tolerance to stretching.

Not all techniques might have a scientific explanation behind them yet for the way they work. In 1955, Dr. Lawrence Jones created the strain-counter strain technique, and even though it

worked for his patients, the science behind it was then still unknown. Nowadays we have a much better understanding of the neurophysiological systems behind this technique. The somatic dysfunction or tender point that is observed by the therapist is a symptom of overstimulated nerve endings, as mentioned before. The type II afferent nerve ending perceives a false neutral position. Therefore, during therapy, a new neutral position has to be created, just like how a new (false) neutral position was created during the injury. Dr. Jones would press on the tender point and move the patient into the place of greatest comfort, the current neutral position. The patient has to stay as passive as possible, and the therapist would move the patient into the new and correct neutral position as slowly as possible to prevent overstimulation of any neurons. When the muscle is still passive, type II flower spray neurons will perceive this new position as neutral and the tender point will disappear. (Korr, 1975) With horses, it is important to wait in the position of greatest comfort until they relax into it and are passive. Only if the horse is passive, can you start moving the muscle into a new position. When the horse is no longer passive, try to move back to the comfort position or start again.

Trigger points

When muscles are used frequently, sometimes trigger points occur. Trigger points are compressed muscle fibres that are not able to relax themselves (Müggenborg, et al., 2023). A possible development of trigger points is via sustained low-level muscle contractions. Routine tasks that require precision and postural stability, like typing behind a computer or playing a musical instrument are likely to trigger muscle fibres into a contracted state. A muscle fibre that is metabolically overloaded and continuously activated is more likely to suffer muscle damage and calcium dysregulation (Shah, et al., 2015). It has been suggested that sustained contractions in the muscle fibre could cause decreased intramuscular perfusion. This could lead to ischemia, hypoxia, insufficient ATP synthesis, increased acidity, increased Ca²⁺, and increased contraction of sarcomeres. As a result of all of this, neuroinflammatory substances such as bradykinin, substance P, serotonin, norepinephrine, nerve growth factor, and adenosine may be released, causing local and referred pain and tenderness. Nociceptors report a pain signal to the CNS and can also secrete chemicals such as inflammatory cytokines and growth factors from their peripheral nerve endings (Armstrong & Herr, 2024). The continuous overstimulation of the receptive field of pain can cause abnormal function and structural changes in the dorsal root ganglia and the dorsal horn neurons. Referred pain could be explained by activation of previously silent dorsal horn synapses (Hoheisel, Koch, & Mense, 1996). Neurons that are connected or are located close to each other can be stimulated by inflammatory cytokines originating from peripheral nerve endings or afferent neurons. The signal, which is normally directed towards the spinal cord, is then fired backward due to overstimulation.

Due to referred or local pain and myofascial pain that trigger points can cause, they are also likely to limit the range of motion of the muscle. Trigger points are also indirectly associated with limited mandibular movement and pain in the mouth (Müggenborg, et al., 2023). This might cause horses to go against the bit, try to avoid good

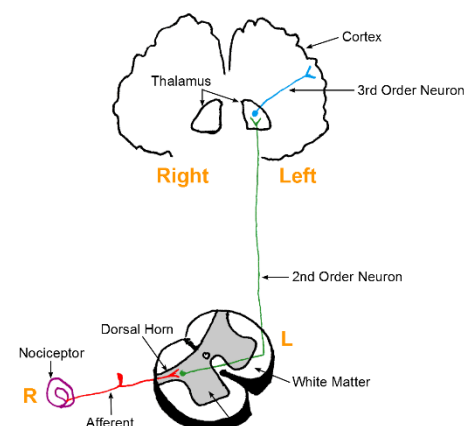


Figure 5 Pain pathway from nociceptor via dorsal horn and thalamus to cortex. (Flowchart, 2022)

posture while training and not listen to training aids. Osteopathic manual techniques (OMT) such as; manual pressure on taut bands (Gautschi, 2013), trigger point pressure release (Simons, <https://doi.org/10.1054/jbmt.2002.0271>, 2002), ischemic compression (Simons & Travell, *Myofascial Pain and Dysfunction: The Trigger Point Manual*, 1993), manual fascial techniques (Marelli & Bordoni, 2015), myofascial release (Al-Madzha, Al-Mudahka, & Ajimsha, 2015), passive stretching (Page, 2012) (Metaxas, et al., 2014), manual intraoral or extraoral release, and strain-counter strain technique (Dardzinski, Ostrov, & Hamann, 2000) can be used to loosen up the muscle fibres, stretch them and release the trigger points. Myofascial pain can be decreased or completely removed with these techniques as well, which also benefits the movement and training of the horse.

Pain relief

Manual therapy uses mainly touch, and apart from all the different effects that different techniques have on a horse, touch also has its effect. Pain relief through deep touch, also known as the pain gate theory. The pain gate theory was first described in 1965 and is still used to understand and reduce pain (Melzack & Wall, 1965). It originates from rubbing a painful spot on the body to manage the pain better. Pain, originating from a pain stimulus, is received by a nociceptor on A δ or C fibres and sends a signal via a primary neuron to the dorsal root ganglia and the substantia gelitana of Rolando (SGR) on the same side of the body. In the SGR, the primary neuron synapses to a secondary neuron which carries the signal via the white matter on the opposite site of the body into the Thalamus. Here, the secondary neuron synapses to a tertiary neuron that finally sends the pain signal to the cortex, where the pain enters awareness. Deep touch interferes with this pathway. The skin contains sensors which are called Pacinian corpuscles, which send stimuli via the dorsal column-medial lemniscus (DCML) pathway to the SGR. Here, the DCML synapses with an inhibitory interneuron and also continues on the same side of the body to the medial lemniscus where it crosses to the other side before continuing to the thalamus.

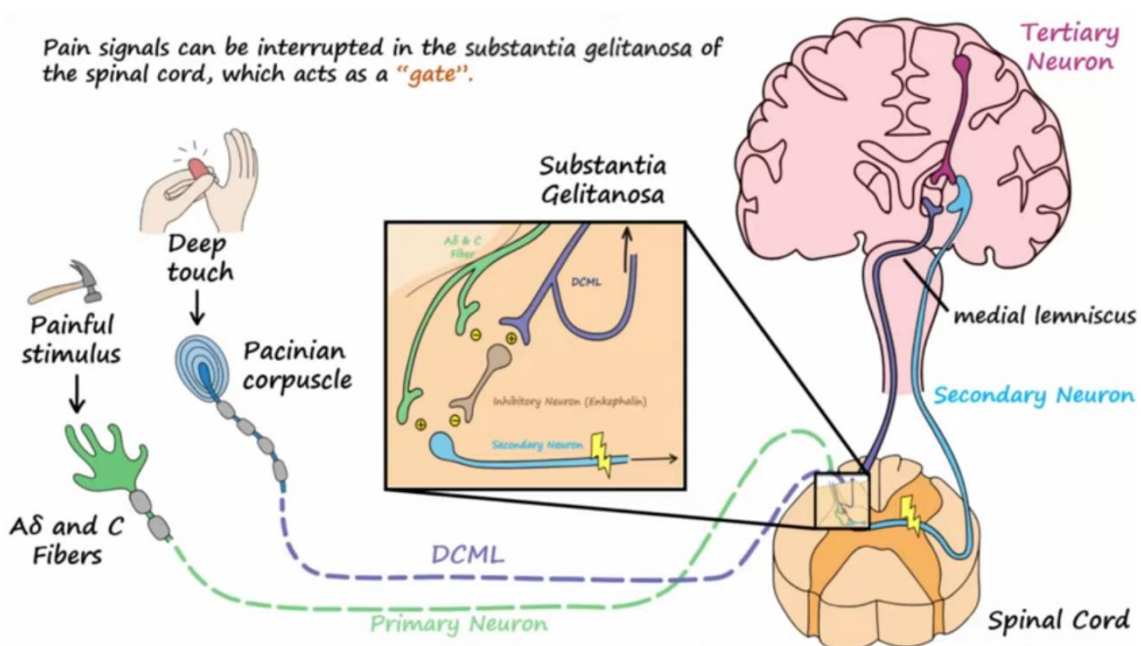


Figure 6 Pain gate theory. Touch signals inhibit pain signals via inhibitory interneuron in the substantia gelitana (SGR) (PhysioPathoPharmaco, 2020)

By activating the inhibitory interneuron in the SGR, the secondary neuron in the pain pathway is less active, which leads to less pain awareness in the cortex of the brain (Heitler, 2023). For more in-depth information about the synapse mechanism and neurotransmitters, see [Comitato and Bardoni, 2021](#) (Comitato & Bardoni, 2021). Via the pain gate mechanism, OMT, including massage can help with pain relief multiple pathologies. Transcutaneous electrical nerve stimulation (TENS) also works via the pain gate mechanism. TENS is delivered via a small battery-powered device with electrodes that are positioned close to the painful area. It stimulates neurons via an alternating current in which the pulse frequency and pulse intensity are adjustable (Vance, Dailey, Rakel, & Sluka, 2014). Unfortunately, both, deep touch, like massage and TENS only work temporarily. As soon neural stimulation stops, the stimulus from the nociceptor isn't (partly) blocked anymore, and pain will be fully perceived again.

Range of motion in joints

Muscles work closely together with the joints, a logical result of more movement in muscles is also more movement in joints. However, flexibility and range of motion are not the only requirements for an optimal functioning joint. Stability of the joint is also very important; without stabilizers the joint would collapse and no movement would be possible at all. There are three different functions for muscles, closing a joint by shortening the muscle (concentric contraction) stabilizing a joint (isometric contraction), and limiting the closure of a joint while lengthening the muscle (eccentric contraction) (Denoix, 2014). All of the muscles need to be both strong and flexible and work together to receive optimal joint function. Research on the effect of manual manipulation on gait showed a significant increase in the sagittal range of motion in joints (Yanuck, Fox, Harting, & Motyka, 2024). Also, correcting somatic dysfunction with OMT reduced asymmetry in gait (Hill, Romero, Rogers, Queen, & Brolinson, 2021) which is likely due to the increase in the range of motion of joints as well. Several studies show an increased range of motion in joints after static and dynamic stretching (Beedle & Mann, 2007) (Miyazaki, et al., 2019) (Amiri-Khorasani, Abu Osman, & Yusof, 2011). Osteopathic Articular Balancing (OAB) is a dynamic stretching technique (Page, 2012) with an active stretch. Joints are repeatedly moved through their full range of motion to stretch muscles and loosen up structures around the joint. Dynamic stretching can be used to increase the range of motion and enhance performance according to several studies (Curry, Chengkalath, Crouch, Romance, & Manns, 2009) (Beedle & Mann, 2007).

Discussion

OMT techniques can help humans and animals to achieve a greater range of motion in their joints and muscles. However, the literature is conflicting regarding the effects of stretching on the performance of athletes. Static stretching has different effects on performance; positive, neutral, and negative. Too much flexibility might cause a lack of strength, because of a lack of stability in the joints (Behm, Alizadeh, Daneshjoo, & Konrad, 2023). Stretching will receive a greater range of motion in the joints in most studies (Beedle & Mann, 2007) (Amiri-Khorasani, Abu Osman, & Yusof, 2011) (Hill, Romero, Rogers, Queen, & Brolinson, 2021) (Yanuck, Fox, Harting, & Motyka, 2024) (Miyazaki, et al., 2019), but this is not always a result of lengthening in muscles. Most static stretching studies show an increased tolerance to stretch instead of increased muscle length (Halbertsma & Göeken, 1994) (Ylinen, et al., 2009) (Ben & Harvey, 2010) (Law, et al., 2009).

The time of stretching appears to be important, as well as the difference between static and dynamic stretching. Stretching before warm-up can have a negative effect and cause strength loss in the muscle. On the other side, the contraction of a muscle before stretching will reduce the loss of strength and increase the range of motion (Blazevich & Kay, 2010) (Cosgrave & McHugh, 2010). Therefore, it is important that a horse is always warmed up before stretching. Static stretching after the warm-up has resulted in decreased (Cè, Margonato, & Casasc, 2008) (Young, Elias, & Power, 2006) (Kistler, Walsh, Horn, & Cox, 2010), neutral (Taylor, Sheppard, Lee, & Plummer, 2009) or increased performance (Herman & Smith, 2008). Dynamic stretching has increased sprint performance after warm-up (Fletcher & Jones, 2004). The decrease in performance after static stretching could be caused by increased compliance of the musculotendinous unit, resulting in a decreased ability of the musculotendinous unit to store elastic energy in its eccentric phase (Fletcher & Jones, 2004). Dynamic stretching (like osteopathic articular balancing) might be better because it allows elastic energy to power the muscles because of the rehearsal of specific movement patterns. The reduced performance of static stretching is mostly seen in terms of speed (Young, Elias, & Power, 2006) (Cè, Margonato, & Casasc, 2008) (Taylor, Sheppard, Lee, & Plummer, 2009) (Kistler, Walsh, Horn, & Cox, 2010), however strength, sustained power, muscular endurance, anaerobic capacity and agility are improved after warm-up and static stretching (Herman & Smith, 2008). Therefore, more studies need to be performed to verify the effect of different types of stretching on previously mentioned parameters. Until then, it is probably better to avoid static stretching before a race or training that involves speed and replace it with active dynamic stretching such as osteopathic articular balancing. Also, it is important to make sure horses are warmed up before performing osteopathic manipulation, especially stretching. Fortunately, this is almost always incorporated in a treatment, because a therapist needs to assess the horse by looking at the movement, flexibility, and bounce of a horse. This assessment is performed in multiple gaits, like walk, trot, and sometimes canter when possible or necessary. It is probably a good idea to have horses canter and trot more during the assessment to provide them with a proper warm-up before the treatment, which also gives the therapist extra time and multiple perspectives to perform a high-quality assessment.

An interesting fact is that performance can be improved via mental practice, as demonstrated by motor skill acquisition research (Feltz & Landers, 1983). Another study showed that mental

and physical training had similar results of improvement in performance (Pascual-Leone et al., 1995). After mental training, increased voluntary strength was found in both distal and proximal human muscles (Ranganathan, Siemionow, Liu, Sahgal, & Yue, 2004). This raises the possibility that awareness alone might benefit training. Osteopathic Articular Balancing (OAB) is a method that moves joints, flexes, and stretches muscles, but it also makes a horse aware of its movement. Would this awareness caused by OAB, increase the activation of neural pathways, and improve strength? Recommendations for further research into this topic would be to see if muscle strength and performance in horses improve with regular OAB therapy.

The last point of discussion is the fact that most research has been done on rodents and humans. Even though horses have the same musculoskeletal system as humans and rodents, it would still be good to perform more research on horses. Measuring brain activity might be harder in horses, but measuring strength and performance improvements after regular OMT would be easier to arrange.

Even though more horse-specific research concerning OMT is necessary, there is enough proof that OMT benefits the health in both training and revalidation. The awareness of its efficiency is growing and will continue to grow. Hopefully, more people will have osteopaths coming to check their horses and to support the training of their horses to create and maintain suppleness and strength in their healthy, happy athletes.

Conclusion

Concluding, OMT has positive effects on muscle strength, joint movement, flexibility, and performance in general. OMT can have a pain-relieving effect via touch because of the neural pain gate. Also, there is evidence that awareness or mental training might improve muscle strength and performance and OAB possibly could trigger this awareness. This idea needs to be explored in the future. There are conflicting results about stretching techniques, but these can be prevented by contracting the muscles before stretching. Therefore, a recommendation is a good warm-up/gait assessment before stretching. Practically, the next aim is to share these results with trainers and competitors. To create more awareness of the effectiveness of OMT in training horses and to support horses in their career to be healthier and happier. Finally, more research, specifically aimed at horses could be a valuable addition to OMT credibility specifically in the equine world.

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