INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

REVIEW ARTICLE- THE IMPORTANCE OF MAGNOTHERAPY IN FUNCTIONAL REHABILITATION, IN A SUB-ANALYSIS FOR PAIN

Veterinary Science

Ângela Martins Faculdade Medicina Veterinária, ULHT, Portugal

Inês Viegas Faculdade Medicina Veterinária, ULHT, Portugal

Sónia Campos Faculdade Medicina Veterinária, ULHT, Portugal

Daniel Nunes Faculdade Medicina Veterinária, ULHT, Portugal Hospital Veterinário da Arrábida/Centro Reabilitação Animal da Arrábida, Portugal

António Ferreira Faculdade Medicina Veterinária, Universidade Lisboa, Portugal

ABSTRACT

Pain is a complex multi-dimensional experience with extreme impact in quality of life of all animals. The management of pain through medication and functional rehabilitation is of great interest in the current days. This review intends not only to elucidate important concepts as pain physiology and trigger points but also to clarify the clinical use of magnotherapy as an adjuvant modality of pain management in functional rehabilitation in companion animals.

KEYWORDS:

Magnotherapy, Pain, Functional Rehabilitation, trigger point

Introduction

Pain is inevitable, acting as an essential protection mechanism against aversive stimulus to human beings and others animals. However, in some cases, it becomes an incapacitating, continuous and grievous sensorial experience[36].

In 1979, the International Association for the Study of Pain (IASP), defined pain as "an unpleasant sensory and emotional experience, associated with actual or potential tissue damage, or described in terms of such damage"[9;59].

Pain is a sensation that, in spite of being crucial to survival, could compromise the physiological and mental status of the organism[10].

1. Pain and Nociception

It's important to make a clear distinction between pain and nociception.

Nociception is the term that designates the process where the organism detects a pain stimulus, transmitting that electric signal to the Central Nervous System (CNS)[59].

Pain is a complex multi-dimensional experience, involving sensory and affective (emotional) components[14].

Based on this last premise, it is assumed that the multidimensional pain experience is a consequence of the involvement of three systems: Nervous, Endocrine and immune system[48], in which, the disruption among this systems, constitutes the major cause for the arising of pain[5].

2. Physiology of Pain

A good way to understand the physiology of pain is by following the nociception signal pathway from its transduction in the peripheral nervous system (PNS) to it's perception in CNS[14].

Nociception's pathway (Figure 1), which not only includes nociceptors but also other important structures, consists in five events: Signal Transduction; Signal Transmission; Modulation; Projection of electric signals; Perception[8].

3. Classification of pain

Pain must be primarily classified (Figure 2) based on tissue origin, which is defined as Somatic or Visceral Pain[8].

Somatic Pain comes from highly sensitive tissues, as skin, muscles, articulations and periosteum and it's described as localized and pulsated, being many times proceeded by the fight and flight reflex[22]. Visceral Pain comes from internal organs, it is poorly localized and gives sometimes the sensation of internal burn[8].

After the distinction between somatic and visceral pain, it's important to categorize the duration of the painful process and gravity of damage tissue, being crucial differentiate acute and chronic pain[16].

Acute pain happens after a painful nociceptive stimulus, initiating a behavioral and physiological answer, to protect the damaged spot and promote the regeneration of the tissue. It's subcategorized in Physiological and Pathological pain[16;22;36].

Physiological Pain comes as an answer to potential tissue damage. Pathological Pain implies the presence of actual tissue damage[13]. It's subcategorized in Inflammatory and Neuropathic Pain[16].

Inflammation that appears after tissue damage persists until the regeneration of the tissue. The substances that result from this process are designated as "inflammatory soup". The inflammatory soup changes the chemical environment and sensitized the nociceptors[21].

Neuropathic pain is the consequence of damage neurological structures, as peripheral nerves, spinal cord or central nervous system[31].

Inflammatory and neuropathic pain are the major cause for the sensitization of PNS and CNS and the appearing of chronic pain[21]. The Chronic Pain persists even after the elimination of aversive stimulus and regeneration of damaged tissue, being a consequence of PNS and CNS sensitization[14]. Nowadays, it's also described as a pain process that overcomes the tissue regeneration expected time[42].

Apparently, chronic pain doesn't have any biologic or survival advantage to the organism, it tends to be debilitating to the patient and sometimes doesn't even answer to multimodal pain approaches[8;36].

4. Trigger Points

Trigger Points (TP) are defined as painful sites in the skeletal muscle, associated with hypersensitivity and tension in the muscle band[50].

TP are characterized by sensory, motor and autonomic expressions[7]. The most evident expressions of pain appear during the palpation of TP, where the animal often vocalizes and tries to avoid contact with the manipulator, since these signs may be increased due to sensitization of the PNS and the CNS[56].

It's still possible that the animal shows signs of muscle weakness without the occurrence of muscle atrophy, decreased joint amplitude, inhibition of muscle contraction and postural changes[3].

4.1 Trigger Points Pathophysiology

Borg-Stein and Simons concluded that a damaged motor plate will result in an increased release of acetylcholine in neuromuscular junction, leading to depolarization of muscle fibbers and shortening of the sarcomere[2]. This leads to local hypoxia and ischemia, as well as the liberation of inflammatory mediators, which sensitize nociceptors, causing pain[17].

Through electromyography, it's possible to detect any changes in the electrical neuromuscular activity, designated as endplate noises, these being particular characteristics of the TP process origin[49].

4.1.1 Trigger point in orthopedic diseased

Orthopaedic patients can easily developed myalgia and muscle dysfunction, because of mechanical stress upon the skeletal muscle system[52].

Postural changes and compensatory movements that occur in orthopaedic patients are one of the possible etiologies for the appearing of Tp[17].

4.1.2 Trigger point in neurological diseased

Neurological patients can equally develop TP, normally in neuromuscular junctions, due to inflammation of peripheral nerves or spinal cord segments[56].

4.2 Treatment and diagnosis of Trigger Points

Palpation is the ideal method for diagnosing TP, although some experience is required, and a few researchers advocate that the result depends a lot from individual interpretation of the manipulator[17].
Treatment can be done by non-invasive techniques like Laser IV, ultrasounds or massages[7], or even invasive techniques like acupuncture[3].

5. Pain Evaluation

Painful sensation is somehow subjective and individual, being hard to evaluate in humans and presenting itself as an even more arduous challenge to evaluate in animals[1].

Tachycardia, tachypnea, hypertension, mydriasis and hyperthermia are signs that emerge as consequences of such neuroendocrine change[58] which tend to remain present in chronic pain, associated with distress[41].

Skeletal muscle pain and neuropathic pain are normally associated with gait disorders, muscle stiffness, body tension and postural changes[58]
.

The concept of pain becomes more nebulous when referring to its chronicity. Chronic pain isn't a mere consequence of acute pain; it's a maladaptive painful process that causes stress, as well as physiologic and behavioural imbalances[27].

The evaluation of the animal's behaviour and well-being becomes more important in chronic pain, being the tutor's opinion crucial in the assessment of the animal's clinical progression[44].
Some multidimensional scales have been developed, such as the Glasgow, Melbourne or Colorado pain scales[57;58]. Although practical, the big majority of these scales are only useful for post-surgery acute pain[41]. The only exception is the Colorado State University canine chronic pain scale, that in spite of lacking scientific approval, can be a useful tool in clinical daily practice[58].

6. Functional Rehabilitation

Nowadays, physiotherapy and rehabilitation are indispensable for a fast and efficient recovery of both neurological and orthopaedic patients, as well as in other branches like preventive and sports medicine[39].

Functional Rehabilitation aims, by non-invasive means, to restore, maintain and promote functionality, wherever there is any kind of movement related disorder[45].

6.1 Modalities for pain management

The primary goal of any rehabilitation protocol is to maximize the functional recovery of the patient and to improve its musculoskeletal condition and well-being[45].

The basis of a functional rehabilitation protocol consists in locomotor training, like hydrotherapy or treadmill, and postural training, like kinesiotherapy[37]. However, a successful protocol equally depends on non-invasive modalities as complementary therapeutic[47], which are summarized in Table 1.

Massage	Systematic manual approach, where it is necessary to exert pressure and movement in soft tissues, skin, tendons and muscles7. Decrease local edema, as well as tissue adhesions and muscle spasm and stimulate muscle flexibility, nutrition and the elimination of metabolic waste18.
Thermothe rapy	Thermotherapy appeals to the use of superficial heat and cold, with the intention of reducing pain and edema and increasing muscle flexibility11.
Laser therapy	Laser Therapy is a modality that uses electromagnetic radiation in shape of photons35. Class IV Laser has the biggest wavelength, close to 980 nm and intensity of 1 to 15 W, allowing to reach high tissue depth, but with risk of causing burns6;35. This benefits analgesia by increasing a local and systemic circulation of B- endorphins, reducing inflammation and improving tissue healing12.
Electrother apy	Electrotherapy is a modality that consist in the application of an electric current of low to medium frequency (<250 Hz), in an effort to stimulate the sensory or motor nerves, leading, correspondingly, to a pain reduction or muscle contraction stimulation25. The two most used forms of electrotherapy are Neuromuscle Electrical Stimulation (NMES) and transcutaneous electrical nerve stimulation (TENS).
Ultrasound s	The ultrasounds allow to focus in biological tissues, with wave frequencies of 20000 HZ, producing deeper heat than thermotherapy37.

Table 1- Non-invasive modalities of complementary therapeutics during a functional rehabilitation protocol

1. Magnotherapy

The original concept of magnetism goes back to the beginning of the first civilizations, and although its widely usage for therapeutic goals in the past, only in the last century have scientists started to uncover its benefits[33].

The Functional Rehabilitation is a recent area of medicine with a progressive development of new therapeutics, which allows faster recoveries and improved well-being[26].

In Human medicine, magnetic fields can be used for diagnosis methods, like magnetic resonance, or as therapeutic modalities, like Pulsed electromagnetic field therapy of low frequency (PEMF-LF)[40].

8. Low frequency pulsed electromagnetic fields (PEMF-LF)

PEMF-LF method consists in the application of low frequency electromagnetic fields that stabilizes the electric potential of nerves and other tissue's cells, normalizing ion and nutrients flux to the cells[16;19].

This modality uses pulsed electromagnetic fields that mimic the body's electromagnetic waves[16].

It is a non-invasive, easy handling method, useful in skeletal muscle system disorders, pain management, tissue regeneration and increasing general well-being[30].

Many clinical trials suggest positive results and benefits from using this modality, though its action mechanisms are not well enlightened[33].

Sisken et al. (1995) found that the use of PEMF-LF in mices with sciatic nerve injury, during 3 to 6 days 4 to 10 hours/per day, increased nervous regeneration in 22% of the cases[51]. After that Szajkowsk et al. (2014) examined the influence of the spatial variable magnetic field on neuropathic pain after tibial nerve transection in 64 mices, 5 days a week during 20 minutes, for 28 days, concluding after histological and immunohistochemical analysis, that the nociceptive sensitivity of healthy rats was not changed following the exposition to the spatial magnetic field of the low frequency, but the use of extremely low-frequency magnetic fields of minimal induction values decreased pain in rats after nerve transection[54].

Regarding to inflammatory pain, Kanat et al. (2013) using a randomized controlled single-blind follow-up study evaluated the effect of PELM-LF in humans with handosteoarthritis, in the tested group, that received 25 Hz, 450 pulse/s,5—80 G, during 10 days and 20 min/day, magnotherapy showed better results in pain management, function and quality of life scores, than in the control group[20].

In addition to human clinical trials, Pinna et al. studied the effects of pulsed electromagnetic field (PEMF) on pain relief and functional capacity of dogs with osteoarthritis (OA) when compared with firocoxib therapy. Patients were randomly assigned to two groups: twenty five client-owned dogs were treated with PEMF once a day for 20 sessions, and fifteen dogs (control group) were treated with 5 mg/kg of firocoxib once daily for 20 days. The results showed decreased clinical signs of OA during the treatment in both groups, however in PEMF group the effects were sustained until the end of the study, whereas in the control group the progress tended to return to baseline values after the end of therapy[43].

Many clinical trials suggest positive results and benefits from using this modality, though its action mechanisms are not well enlightened[33].

8.1 Pulsed electromagnetic fields as therapeutic modality

The electromagnetic intensity is measured in Gauss (G) or Tesla (T) (1 T = 10^4 G) and the frequency in Hertz (Hz)[29].

The biological answer to the electromagnetic fields depends on the chosen parameters. It is known that there are two intensity windows that can be used with beneficial effects, 15-20 mT (150-200 G) or 45-50 mT (450-500 G)[28;29;30].

The gap frequency of 0,5-5 Hz is useful for reducing inflammation and general pain, and 5-20 Hz is used for muscle tonification and tension reduction, both during a period of 30 minutes to 1 hour a day[16]. The number of days recommended for therapy is not well defined.[30]

8.1.1 PEMF-LF biologic effects

All atoms, elements and cells produce balanced electromagnetic fields. If that energetic activity ends, life ceases to exist[4;40].

Healthy cells have a normal electric charge of -70 to -100 mV due to, the ionic flux changes in the cell's membrane[46]. Any cell damage could change the ionic flux and compromise homeostasis[4]. Nowadays, it is assumed that the primary target of PEMF-LF is cell membrane[43].

The interaction between electromagnetic fields of PEMF-LF and the cell membrane's channels, change ions' flux, like Na^+ or Ca^{2+}, normalizing transmembrane potential, signal transduction and promoting homeostasis, making this explanation the basis theory of PEMF-LF biologic effects[30;40]

8.1.2 PEMF-LF neuropathic pain

Apparently, the transmembrane potential stabilization effect by PEMF-LF reduces muscle tension and neuropathic pain[23;38].

A clinical trial conducted in mice involving tibial nerve injuries showed signs of neuropathic pain reduction after the exposure to PEMF-LF[54]. Another recent study proved that electromagnetic fields produced by PEMF-LF increase nervous fibbers' regeneration and conductivity[53]. In this study, Mert et.al (2006), studied the influence of pulsed magnetic on nerve regeneration in a model of crush injury of the sciatic nerve of rats. They used electrophysiological recordings and ultrastructural examinations, to determine the influence of PEMF-LF exposure and concluded that PEMF application for 38 days accelerated nerve conduction velocity, increased compound action potentials (CAP) amplitude and decreased the time to peak of the CAP. Moreover PEMF improved both morphological and electrophysiological properties of the injured nerves. Corrective effects of PEMF on sensory fibers may be considered an important finding for neuropathic pain therapy.[32]

8.1.3 PEMF-LF inflammatory pain

The effect of PEMF-LF in inflammatory response pathways is still unknown[34].

A plausible explanation comes from a study that clarifies the effect of PEMF in an up-regulation of adenosine receptors, related to an increase of their functional activities in bovine chondrocytes and fibroblast-like synoviocytes[55].

Recently was postulated the hypothesis that the anti-inflammatory effect of PEMF-LF is a consequence of its action as a mediator on the gene expression involved in the acute and resolution phases of inflammation, inhibiting prostaglandin synthesis by lipoxygenase pathway[24].

8.2 PEMF-LF and well being

Human medicine studies admit that the use of PEMF-LF reduces fatigue, irritability and stress manifestations[40]. It is believed that the analgesic effects from PEMF-LF are a consequence of the endogen opioid liberation from B-endorphins group, reducing pain and increasing general well-being[43;46]. This issue remain as a field to explore in the veterinary species.

Conclusion

Understanding the complexity of pain remains a challenge even nowadays. The existence of co-adjuvant modalities in the field of the functional rehabilitation medicine is of higher interest, not only for the treatment success but also for well-being issues. Magnotherapy is a promising method of pain modulation although it lacks of clinical trial that can sustain its.

It is expected that in a close future non-invasive methods start to be use more frequently, because of the effort that many researchers make day by day to scientifically sustain these modalities. The ultimate goal will be the use of minimum drugs therapy in the pain management, mainly in areas where the alternatives are already a reality, like in Functional Rehabilitation.

Bibliography

1 Anill, S., Anil, L., & Deen, J. (2002). Challenges of pain assessment in domestic animals. J Am Vet Med Assoc., 220, 313–319.

2 Borg-stein, J., & Simons, D. G. (2002). Myofascial Pain. Arch Phys Med Rehabil, 83, 40–47.

3 Cantwell, S. (2014). Mechanisms of Acupuncture Analgesia. In C. M. Egger, L. Love, & T. Doherty (Eds.), Pain Management in Veterinary Practice (First Edit, p. 180). Wiley-Blackwell.

4 Chapellier, P. Le, & Matta, B. (2010). Cellular Perception and Static Magnetic Fields Active Penetration Depth for Pain Magnetotherapy. Piers, 6(3), 287–292.

5 Chapman, C. R., Tuckett, R. P., & Song, C. W. (2008). Pain and Stress in a Systems Perspective: Reciprocal Neural, Endocrine, and Immune Interactions. The Journal of Pain, 9(2), 122–145.

6 Chow, R., Heller, G., & Barnsley, L. (2006). The effect of 300 mW, 830nm laser on chronic neck pain: double-blind, randomized, placebo-controlled study. Pain, 124, 201–206.

7 Coates, J. C. (2013). Manual Therapy. In M. C. Zink & J. B. Van Dyke (Eds.), Canine Sports Medicine and Rehabilitation (First Edit, pp. 101–103). Wiley-Blackwell.

8 Cooley, K. (2015). Physiology of Pain. In M. E. Goldberg & N. Shaffran (Eds.), Pain Management for Veterinary Technicians and Nurses (First Edit, p. 30). John Wiley & Sons, Inc.

9 Crook, A. (2014). Introduction: Pain: an Issue of Animal Welfare. In C. M. Egger, L. Love, & T. Doherty (Eds.), Pain Management in Veterinary Practice (First Edii, pp. 1–8). Wiley-Blackwell.

10 Downing, R. (2015). Pain Management and the Human-Animal Bond. In J. S. Gaynor & W. W. Muir III (Eds.), Handbook of Veterinary Pain Management (Third Edit, pp. 3–9). Elsevier Mosby.

11 Dragone, L., Heinrichs, K., Levine, D., Tucker, T., & Millis, D. (2014). Superficial Thermal Modalities. In D. Millis & D. Levine (Eds.), Canine Rehabilitation and Physical Therapy (second edi, pp. 312–326). Elsevier Saunders.

12 Enwemeka, C., Parker, J., & Dowdy, D. (2004). The efficacy of low-power lasers in tissue repair and pain control; a metanalysis study. Photomed Laser Surg, 22, 323–329.

13 Fauber, A. E. (2013). Chronic pain management for osteoarthritis and neuropathic pain. In J. C. Ko (Ed.), A color handbook Anesthesia and Pain Management in Dogs and Cats (first edit, pp. 295–297). Manson Publishing Ltd.

14 Fox, S. M. (2014). Functional Physiology of Pain. In S. M. Fox (Ed.), Pain Management in Small Animal Medicine (first Edit, pp. 47–72). CRC Press.

15 Gaynor, J. S. (2015). Energy Modalities. In J. S. Gaynor & W. W. Muir III (Eds.), Handbook of Veterinary Pain Management (Third Edit, pp. 359–361). Elsevier Mosby.

16 Gaynor, J. S., & Muir III, W. W. (2015). Definitions of Terms Describing Pain. In J. S. Gaynor & W. W. Muir III (Eds.), Handbook of Veterinary Pain Management (Third Edit, pp. 61–66). Elsevier Mosby.

17 Gerwin, R. D. (2010). Myofascial Pain Syndrome. In S. Mense & R. D. Gerwin (Eds.), Muscle Pain: Diagnosis and Treatment (First edit, pp. 18–30). Springer.

18 Goff, L., & Jull, G. (2007). Manual Therapy. In C. M.McGowan, L. Goff, & N. Stubbs (Eds.), Animal Physiotherapy- Assessment, Treatment and Rehabilitation of Animals (First Edit, pp. 164–169). Blackwell Publishing.

19 Hug, K., & Roosli, M. (2012). Review Therapeutic Effects of Whole-Body Devices Applying Pulsed Electromagnetic Fields (PEMF): Bioelectromagnetics, 33, 95–105.

20 Kanat, E., Alp, A., & Yurtkuran, M. (2013). Magnetotherapy in hand osteoarthritis : A pilot trial. Complementary Therapies in Medicine, 21(6), 603–608.

21 Klinck, M. P., & Troncy, E. (2016). The Physiology and pathophysiology of pain. In T. Duke-Novakovski, M. De Vries, & C. Seymour (Eds.), BSAVA Manual of Canine and Feline Anaesthesia and Analgesia (Third edit, pp. 97–111). British Small Animal Veterinary Association.

22 Ko, J. C. (2013). Acute pain management. In J. C. Ko (Ed.), A color handbook Anesthesia and Pain Management in Dogs and Cats (firste edi, pp. 275–278). Manson Publishing Ltd.

23 Krukowska, J., Łukasiak, A., & Czernicki, J. (2012). Impact of magnetostimulation on nerve and muscle electrical excitability in patients with increased muscle tone. Polish Annals of Medicine, 19(1), 15–20.

24 Kubat, N., Moffett, J., & Fray, L. M. (2015). Effect of pulsed electromagnetic field treatment on programmed resolution of inflammation pathway markers in human cells in culture. Journal of Inflammation Research, 8, 59–69.

25 Levine, D., & Bockstahler, B. (2014). Electrical stimulation. In D. Millis & D. Levine (Eds.), Canine Rehabilitation and Physical Therapy (Second Edi, pp. 342–356). Elsevier Saunders.

26 Levine, D., & Millis, D. (2014). Regulatory and Practice Issues for the Veterinary and Physical Therapy Professions. In D. Millis & D. Levine (Eds.), Canine Rehabilitation and Physical Therapy (Second Edi, p. 9). Elsevier Saunders.

27 Lindley, S. (2016). Pain management III: chronic pain. In T. Duke-Novakovski, M. De Vries, & C. Seymour (Eds.), BSAVA Manual of Canine and Feline Anaesthesia and Analgesia (Third Edit, pp. 159–168). British Small Animal Veterinary Association.

28 Markov, M. S. (2005). " Biological Windows ": A Tribute to W . Ross Adey. The Environmentalist, 25, 67–74.

29 Markov, M. S. (2007a). Expanding Use of Pulsed Electromagnetic. Electromagnetic Biology and Medicine, 26, 257–274.

30 Markov, M. S. (2007b). Pulsed electromagnetic field therapy history , state of the art and future. Environmentalist, 27, 465–475.

31 Mathews, K. A. (2008). Neuropathic Pain in Dogs and Cats: If only they could tell us if they hurt. Veterinary Clinics Small Animal Practice, 38, 1365–1414.

32 Mert, T.; Gunay, I.; Gocmen, C.; Kaya, M.; Polat, S. (2006). Regenerative effects of pulsed magnetic field on injured peripheral nerves. Altern Ther Health Med,12(5):42-9.

33 Meyer, P. F., Paiva, A., Maria, E., Marcel, R., Costa, L. D. S., & Ronzio, O. A. (2010). Magnetotherapy : can this resource be part of Brazilian physiotherapist routine ? Arquivos Brasileiros de Ciências Da Saúde, 36(1), 35–39.

34 Millis, D., & Levine, D. (2014). Other Modalities in Veterinary Rehabilitation. In D. Millis & D. Levine (Eds.), Canine Rehabilitation and Physical Therapy (Second Edi, pp. 393–398). Elsevier Saunders.

35 Millis, D., & Saunders, D. G. (2014). Laser Therapy in canine Rehabilitation. In D. Millis & D. Levine (Eds.), Canine Rehabilitation and Physical Therapy (second edi, pp. 359–378).

36 Muir, W., & Woolf, C. J. (2001). Mechanisms of pain and their therapeutic implications. Journal of the American Veterinary Medical Association, 219(10), 1346–1356.

37 Niebaum, K. (2013). Rehabilitation Physical Modalities. In M. C. Zink & J. B. Van Dyke (Eds.), Canine Sports Medicine and Rehabilitation (First Edit, pp. 115–128). Wiley-Blackwell.

38 Omar, A. S., Awadalla, M. A., & El-latif, M. A. (2012). Evaluation of pulsed electromagnetic field therapy in the management of patients with discogenic lumbar radiculopathy. International Journal of Rheumatic Diseases, (15), 101–108.

39 Ortel, S. (2015). Physical Rehabilitation and the Veterinary Technician. In M. E. Goldberg & N. Shaffran (Eds.), Pain Management for Veterinary Technicians and Nurses (First Edit, pp. 295–296). Wiley-Blackwell.

40 Pasek, J., Pasek, T., Siero -stołtny, K., Cie lar, G., & Cies, G. (2015). Electromagnetic fields in medicine – the state of art. Electromagnetic Biology and Medicine, 1, 1–5.

41 Pelligand, L., & Mora, S. S. (2016). Pain assessment methods. In T. Duke-Novakovski, M. De Vries, & C. Seymour (Eds.), BSAVA Manual of Canine and Feline Anaesthesia and Analgesia (Third Edit, pp. 113–123). British Small Animal Veterinary Association.

42 Phillips, K., & Clauw, D. (2013). Central Pain mechanisms in rheumatic diseases: future directions. Arthritis and Rheumatism, 65, 291–302.

43 Pinna, S., Landucci, F., Tribuiani, A. M., Carli, F., & Venturini, A. (2013). The Effects of Pulsed Electromagnetic Field in the Treatment of Osteoarthritis in Dogs: Clinical Study. Pak Vet Journal, 33(1), 96–100.

44 Reid, J., Wiseman-Orr, L., Nolan, A., & Scott, E. M. (2015). Health-Related Quality of Life Measurement. In J. S. Gaynor & W. W. Muir III (Eds.), Handbook of Veterinary Pain Management (Third edit, pp. 98–110). Elsevier Mosby.

45 Robertson, J., & Mead, A. (2013). Introduction to Physical Therapy and Massage. In J. Robertson & A. Mead (Eds.), Physical Therapy and Massage for the Dog (pp. 7–8). CRC Press.

46 Sekino, S. Y. A., Sekino, M. S., & Eno, S. U. (2011). Biological effects of electromagnetic fields and recently updated safety guidelines for strong static magnetic fields. Magn Reson Med Sci, 10(1), 1–10.

47 Sharp, B. (2010). Physiotherapy and physical rehabilitation. In S. Lindley & P. Watson (Eds.), BSAVA Manual of canine and feline Rehabilitation, suportive and paliative care (pp. 90–112). British Small Animal Veterinary Association.

48 Shilo, Y., & Pascoe, P. J. (2014). Anatomy, Physiology and Pathophysiology of Pain. In C. M. Egger, L. Love, & T. Doherty (Eds.), Pain Management in Veterinary Practice (First Edit, pp. 9–28). Wiley-Blackwell.

49 Simons, D. G., Hong, C.-Z., & Simons, L. S. (2002). Endplate Potentials Are Common to Midfiber Myofacial Trigger Points. American Journal of Physical Medicine & Rehabilitation, 81(3), 212–222.

50 Simons, D. G., & Travell, J. (1999). Intruduction. In D. G. Simons, J. Travell, & L. Simons (Eds.), Myofascial Pain and Dysfunction: The Trigger Point Manual (Second Edi, pp. 5–6). Williams & Wilkins.

51 Sisken BF, Jacob JM, Walker JL. Acute treatment with pulsed electromagnetic fields and its effect on fast axonal transport in normal and regenerating nerve. J Neurosci Res. 1995;42(5):692-9.

52 Souvlis, T. (2007). Acunpuncture and trigger points. In C. McGowan, L. Goff, & N. Stubbs (Eds.), Animal Physiotherapy- Assessment, Treatment and Rehabilitation of Animals (first edit, pp. 202–204). Blackwell Publishing.

53 Suszy ski, K., Marcol, W., & Górka, D. (2015). Physiotherapeutic techniques used in the management of patients with peripheral nerve injuries. Neural Regeneration Research, 10(11), 1770–1772.

54 Szajkowski, S., Pietrucha-dutczak, M., Cies, G., Lewin-kowalik, J., & Sieron, A. (2014). The influence of spatial pulsed magnetic field application on neuropathic pain after tibial nerve transection in rat. Electromagn Biol Med, 33(1), 35–46.

55 Varani, K., Matte, M. De, Vincenzi, F., Gessi, S., Merighi, S., Pellati, A., … Borea, P. (2008). Characterization of adenosine receptors in bovine chondrocytes and fibroblast-like synoviocytes exposed to low frequency low energy pulsed electromagnetic fields. Osteoarthritis and Cartilage, 16, 292–304.

56 Wall, R. (2014). Myofascial Pain Syndrome in Dogs. In C. M. Egger, L. Love, & T. Doherty (Eds.), Pain Management in Veterinary Practice (First Edit, pp. 161–170). Wiley-Blackwell.

57 White, K. L. (2014). Recognition and Assessment of acute pain in dogs. In C. M. Egger, L. Love, & T. Doherty (Eds.), Pain Management in Veterinary Practice (first edit, pp. 201–206). Wiley-Blackwell.

58 Wiese, A. J. (2015). Assessing Pain. In J. S. Gaynor & W. W. Muir III (Eds.), Handbook of Veterinary Pain Management (Third edit, pp. 67–96). Elsevier Mosby.

59 Wiese, A. J., & Yaksh, T. L. (2015). Nociception and Pain Mechanisms. In J. S. Gaynor & W. W. MuirIII (Eds.), Handbook of Veterinary Pain Management (Third Edit, pp. 10–41). Elsevier Mosby.