COMMISSIONED PAPER

Rehabilitation Therapies for musculoskeletal and spinal disease in Small Animal Practice

M. R Owen[(1)]

INTRODUCTION

Increasingly, companion animal veterinary health professionals are seeking rehabilitation therapies for animals under their care suffering from or recovering from musculoskeletal and or spinal injury/disease. In man, rehabilitation therapy has the potential to assist, accelerate or enhance clinical outcomes following orthopaedic or neurological compromise and this, amongst others, is the reason that rehabilitation features in human patient care. The same ideals apply in veterinary care and under optimal conditions, rehabilitation forms part of 'best clinical practice' and attention to rehabilitation should not be reserved for attempted rescue of poor clinical outcomes. The increasing intimacy of the professional relationship between physiotherapists (who have trained and who are registered for treating animals) and veterinary surgeons has fostered the opportunity to provide rehabilitation therapies to companion animals. Rehabilitation therapies and strategies are as yet still novel in veterinary care and there is still much to learn regarding the application of and the indications for rehabilitation activities and therapies towards the spectrum of orthopaedic and spinal disease encountered in small animal practice. Veterinary clinical research is providing evidence of efficacy of designated rehabilitation programmes and practices for specific musculoskeletal problems. However, for the most part, we are currently applying rehabilitation therapies to our veterinary patients considering the principles of basic science of tissue healing, by extrapolating from human clinical practice and by reference to veterinary anecdote and small case studies. Only further prospective controlled clinical studies will enable us to identify and evaluate the treatment efficacy of specific rehabilitation practices and therapeutic modalities used in each of the clinical conditions we treat. This article aims to provide the reader with a brief introduction to some of the therapeutic interventions and exercises that are used in rehabilitation.

This paper was commissioned by FECAVA for publication in EJCAP

Therapeutic exercise on land

Early return to function generally provides the best opportunity for the fullest recovery following orthopaedic or spinal injury/disease. This is because restoration of activity assists return of normal tissue physiology and biological function. During the recovery period, when patients are not capable of unassisted voluntary function, therapeutic exercise activities are an invaluable way of promoting musculoskeletal metabolic and physiological function. In the author's opinion, whenever possible, therapeutic exercises in which the patient actively engages and uses musculoskeletal function are preferable to passive movements performed by the operator, since the latter do not necessarily promote return of voluntary function.

In a rehabilitation programme, specific therapeutic exercises are selected and performed in accordance with the needs of

It is beyond the scope of this article to provide a comprehensive review of the subject and the interested reader is recommended to refer to the texts in the Further Reading list.

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Figure 1 Paraplegic dog assisted to stand using harness

the patient and the goals of the rehabilitation programme. During recovery, as tissues heal and neuromuscular and/or musculoskeletal function improves, therapeutic exercises are accordingly modified or increased in intensity to maximise their therapeutic benefit. Examples of therapeutic land exercises include postural exercises ('sit to stand'), controlled leash activities, negotiating stairs and obstacles, dry treadmill locomotion, 'dancing' and 'wheel barrowing', controlled playing with obstacles, reaching for toys/food etc.

Postural exercises ('sit to stand,' 'lie to stand' transitions, 'assisted standing,' resisted joint flexions)

These activities are useful for patients with severe musculoskeletal or neuromuscular injury/disease which are unable to support their own weight and also for patients recovering from orthopaedic injury/surgery. Animals that cannot support their own weight can be assisted to stand so that muscular function is promoted. Patients unable or unwilling to support their own weight can be further assisted to perform these activities by supporting their weight, either using a harness or slings [Figure 1] or exercise balls or rolls [Figure 2]. Many patients appear more willing to attempt to use their limbs when supported over a ball or roll than when they are suspended in a harness hence use of the former is generably foreferable. In patients with neurological compromise, assisted standing exercise encourages neuromuscular function, 're-educates' and enhances stamina of muscles and may assist 'proprioceptive learning'. 'Sit to stand' exercises are the author's preferred rehabilitation activity for dogs recovering from spinal injury/disease since physiological movements of the limbs can be simulated (even in animals with no voluntary movement in the pelvic limbs) and positioning patients as if standing appears to promote muscular contractions, rather than the muscular relaxation observed when passive ranges of motion (ROM's) are performed on recumbent patients. When dogs have the ability to perform 'sit to stand' transitions without assistance, voluntary repetitions can be encouraged using treats and praise.

Use in orthopaedic patients

In orthopaedic patients, assisted postural activities encourage patients to use their limb through a controlled range of motion that is not achieved when the patient avoids using its limb, instead maintaining a non-weight bearing lameness. Furthermore, joints are encouraged to flex and extend and muscles are actively flexed and passively stretched through greater ranges than occur during ambulation. Excursions of limb segments and the amount or duration of weight-bearing can be manipulated using exercise rolls or balls to provide additional challenges for the patient e.g. encouraging placement of the fore paws on the roll. [Figure 3]. During therapeutic exercises patients should be given rest periods so that fatigue does not limit their value. Initially, 10-15 repetitions may be performed 3-5 times per day , with intensity of exercise increasing and the assistance provided by the clinician decreasing during patient recovery.

Figure 2 Tetraparetic dog supported on a 'Physio Roll®' facilitating postural exercises and 'proprioceptive training' exercises

® Lowri Davies, Smart Clinic, Swansea

Figure 3 Encouraging placement of the fore paws on the roll.

Figure 4 Walking on a treadmill can encourage limb use when a dog is reluctant to use the limb on land. Treadmill activity can promote normal gait patterns.

Figure 5 Limb use can also be encouraged by 'wheel barrowing.'

Modified locomotion activities

Perhaps unlike many human patients, once they are able to walk, or use an injured limb, most of our companion animal patients appear to attempt to return to levels of voluntary activity and function achieved before injury/disease with minimal encouragement. Consequently, for veterinary patients, as soon as voluntary ambulation is possible and safe, these patients can be challenged with modified locomotion exercise activities designed to increase their strength, endurance, ROM and/or proprioceptive function. Encouraging patients to actively move their limbs through exaggerated ranges of motion (compared to those achieved during normal gait) is generally better tolerated than trying to achieve enhanced ROMs by passive movements.

In the early recovery period, normal limb use is generally promoted best by restricting patient velocity, since at speed, holding the limb off the ground is encouraged. Sometimes it is necessary to enforce excruciatingly slow leash walks in order to persuade patients to use their limb but speed can be increased once the patient relearns a normal pattern of gait in which the limb is used. In order to transfer increased weight on to the limbs, patients can be made to negotiate slopes and steps/stairs. Stair climbing should be performed in a slow controlled manner to ensure that reciprocal limb use occurs, rather than hopping or jumping. Compared to over-ground walking, stair climbing results in greater excursions of the limb segments and the challenge that stair climbing poses to patients can encourage limb use where there is reluctance. Encouragement to negotiate obstacles on the ground such as rocks, boxes, a ladder placed on the ground or Cavaletti rails are all effective ways to promote use of a limb in orthopaedic patients. The modified gait required to negotiate the obstacles requires balance, it results in recruitment of different muscle contraction activities compared to simple flat ground walking and these activities provide proprioceptive challenges for animals recovering from neurological dysfunction.

Ambulatory function can be promoted by treadmill walking [Figure 4]. Dogs generally adapt rapidly to treadmill locomotion within a few minutes of exposure and resistance to the unfamiliar experience can be lessened if a handler walks alongside the patient, or encourages the patient, at the front of the treadmill. A harness is helpful to prevent the patient from migrating off the side of the treadmill and raising the treadmill into an uphill slope appears to assist accommodation to the experience in naive patients. The challenge of the moving belt encourages use of limbs that are not used during over-ground ambulation and the ability to control patient velocity enables challenge to co-ordination, balance and proprioception. The moving belt provides passive extension of the limbs during stance and this may facilitate extension of joints (hence ROM) that does not occur during voluntary overground locomotion.

Limb use can also be encouraged by 'dancing' and 'wheel barrowing.' [Figure 5] These activities result in increased extension of the shoulders/hips and increased weight is carried by the two limbs on the ground. Where it is safe, patients can be encouraged to 'jump up' into the dancing position to further encourage limb strength. Patients are rapidly fatigued by wheel barrowing and dancing and some may not take to these activities readily initially, hence for some patients, for reasons of operator safety, a muzzle should be used at least initially.

Once healing/recovery is sufficient and simple ambulatory function is restored, increased intensity activities can be introduced in order to promote a return to pre-injury levels of function. When return to a previous level of significantly athletic function is the goal of rehabilitation therapy, activities including ball chasing, running around obstacle courses, controlled jumping etc can be introduced. These will expose tissues to stresses and movements early in the healing period, to facilitate tissue remodelling during healing. Extreme care should be taken to avoid applying excessive stresses to healing tissues which may impair outcomes. At this stage of recovery, most athletically inclined pets will take care of their own rehabilitation programmes and will regain acceptable levels of pet function. Some dog and cats will pursue the dot produced from a laser pointer and this can be an effective way of promoting physical activity indoors. Less athletically-minded pets can be motivated to exercise or perform activities with judicious temptation with treats, or using toys.

Figure 6. Weight shifting exercise. The patient's hind limbs are placed onto a balance cushion and the hindquarters are displaced, altering the body's centre of gravity. This activity is intended to assist 'proprioceptive learning'

Figure 7. A horizontally placed elevated ladder provides a simple alternative to Caveletti poles. Walking through the ladder provides a challenging environment to the patient and this encourages neuromuscular control and exaggerates normal musculoskeletal function.

Proprioceptive Training

All voluntary musculoskeletal movements are controlled by proprioception and therefore all patient motivated activity and all the therapeutic exercises described may be considered to contribute to proprioceptive training. Some addition to these specific activities which require patients to perform or to resist deliberate movements may assist or accelerate the return of proprioceptive functions impaired by neurological injury/disease. These include weight-shifting exercises, in which the patient stands and its balance is challenged with a laterally applied push, encouraging a sway. Patients that are unable to stand can be assisted to stand (e.g. on an exercise roll) and the patient's balance can be challenged by displacing either the patient or the exercise roll, both craniocaudally and from side to side. Maintenance of balance requires controlled muscular contraction that resists the swaying. The patient's centre of gravity can also be redistributed by lifting single limbs off the ground, one at a time. To maintain balance, different muscle groups must be contracted according to proprioceptive input. Balance boards, platforms, cushions and trampolines can also be used to challenge the patients ability to remain balanced whilst equilibrium disturbing displacements are applied either to the patient or the surface on which the limbs are placed. [Figure 6]. Ambulatory patients can be encouraged to negotiate challenging surfaces such as partially inflated air beds, Cavalettis (or a ladder placed horizontally), deep grass, or rocky ground that require deliberate limb movements which differ from locomotion on flat ground. [Figure 7] The value of these activities in accelerating or improving proprioceptive function beyond that which occurs with controlled normal activity in companion animals remains to be quantified.

Aquatic therapy (swimming and walking in water)

Aquatic exercise (known to some as 'hydrotherapy') has become a popular activity used in assisting the recovery from musculoskeletal and spinal disease in dogs. Immersion in water is not generally accepted by cats and hence its application in this species is limited. The therapeutic value of aquatic exercise is due to the physical properties of water and the opportunities for performing activities in the aquatic environment that differ from those performed on dry land.

Physical properties of water and physiological effects of the aquatic environment

Between the temperatures of 0 and 100°C, at atmospheric pressure, water is a liquid and its density is markedly greater than that of air. The specific gravity (a measure of relative density) of pure water is 1.0. The specific gravities of body tissues range from 0.8 (fat), through 1.0 (lean muscle) to 2.0 (bone). When immersed in water, objects are apparently less heavy than they are on land due to the effect of buoyancy. Buoyancy occurs due to the displacement of water which occurs on immersion. The buoyancy of an animal in water, specifically whether or not a patient can float, is a function of its overall body density: animals with a specific gravity of less than 1.0 will float in water, whilst those with a specific gravity of greater than 1.0 will sink. If the depth of water is sufficient, buoyancy, or relative weightlessness, facilitates total non-weight bearing exercise (swimming) and at shallower depths enables reduced weight-bearing ambulatory locomotion (wading). The effect of depth of water on buoyancy in the dog has been studied [1] and water depths to the level of the hock result in 91% weight borne in water, whilst only 38% of weight is borne in water depth that reaches the greater trochanter of the femur. [Figure 8].

Immersed body parts and tissues are subject to hydrostatic pressure that is a function of the depth of immersion. This raised pressure exerted on immersed tissues can assist extracellular fluid return to the circulation and this environment may be beneficial for swollen joint or oedematous tissues. [2]. The viscosity of water is substantially greater than that of air. Consequently, movement in water encounters marked resistance, requiring greater levels of exertion than comparable movements on land, hence aquatic exercise promotes muscular strength and cardiovascular fitness. The density and viscosity of water also provides a dynamically

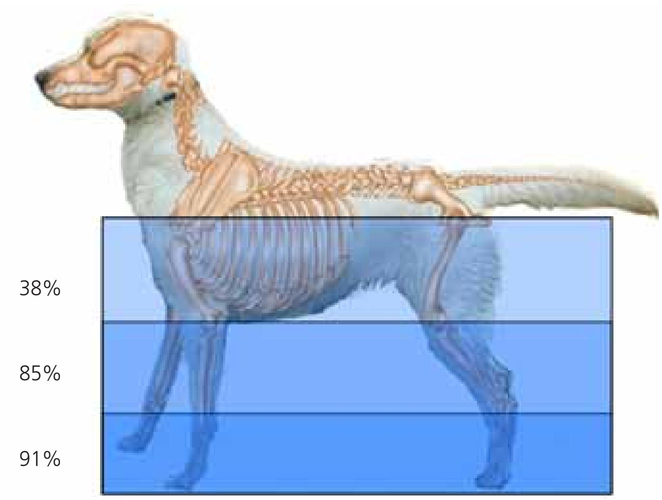


Figure 8 The effect of water depth on effective body weight. When immersed to the depth of the hock, effective body weight is 91%. In water to the depth of the stifle, effective weight reduces to 85% and water to the level of the greater trochanter reduces effective weight to 38%.

Figure 9 Swimming against jets to increase exertion (Photo courtesy of Westcoast Ltd)

stabilising environment since all body movements tend to be retarded. Consequently, it is easier to maintain balance in water than on land. The viscosity and relative density properties of water can be exploited to modify exertion levels during aquatic exercise. Judicious application of currents (or 'jets') of water can increase the perceived resistance to movement [Figure 9] Increased resistance to movement can also be achieved by increasing the surface area of a body part moving in the water by applying fins.

What are the potential therapeutic effects of aquatic environment exercise?

Evidence from studies in man show that exercise in water can improve strength, cardiovascular and musculoskeletal fitness, ranges of motion (ROM) and there can be some beneficial analgesic effects [3.4]. Furthermore, aquatic exercise is more energy demanding than similar exercise on land [5] and consequently, modest velocities of movement in water can promote levels of fitness that would require greater velocities on land. The combination of reduced velocity of exercise with buoyancy results in 'low impact' activity in comparison to overground activity in which the potentially deleterious deforming forces to which limb segments are subjected during exercise are reduced. Consequently, higher levels and intensities of exercise can be performed in an aquatic environment than on land with less risk of damage to injured and/or healing tissues. An additional clinically relevant benefit of exercise in water is the associated improved comfort of exercise because movement is damped by the viscous environment in the water, the modification of painful, undamped overground movement to slower controlled movements may be the means by which aquatic exercise can result in increased joint range of motion and in reduced pain. In man, some closed-chain exercises (under water cycling) appear to assist reduction in joint pain and to reduce joint effusion following anterior cruciate ligament surgery [6].

Water temperature must be controlled when aquatic exercise is used as an intended therapeutic intervention and for dogs. Temperatures in the range 26°C and 28°C are generally recommended to gain maximal positive effects of water warmth, without risking heat related complications.

Swimming

In comparison to walking, swimming is an activity characterised by greater excursions of the limb segment joints. In healthy dogs, swimming results in increased hip joint flexion compared to overground walking and following surgery for cranial cruciate ligament surgery, there is increased flexion of the stifle and of the hock joint during swimming compared to overground walking. [8]. The increased joint excursions achieved during swimming and during 'water walking' may be helpful in reducing musculoskeletal stiffness and loss of ROM that is characteristic of orthopaedic disease and surgery. For patient safety, clinical cases should be fitted with a floatation device during swimming, at least until the patient's ability to swim competently is established. [Figure 10]. Non-athletically minded dogs can be encouraged to swim using toys, or if essential, temptation with food treats. [Figure 11].

For dogs recovering from surgery for cranial cruciate ligament disease, the benefits of high intensity, high frequency post operative swimming had been demonstrated. In a controlled study, a group of home exercise dogs were compared to a group of dogs that were hospitalised for intensive rehabilitation on three alternate weeks during their early recovery period. These dogs swam twice daily for between 10 and 20 minutes, five days a week on these three weeks. Using force plate analysis, six months following surgery, the swimmers were less lame on their operated limb than restricted exercised dogs and in swimming dogs, there was no difference in limb function between their operated and their normal limbs. In the exercise restricted dogs, six months following surgery, limb function was still significantly less in the surgical limbs compared to their normal limbs [7]. Though differences were measurable between these groups six months after surgery by force plate analysis, visual assessment of lameness in dogs recovering from cranial cruciate ligament surgery suggests a greater difference between swimmers and non-swimmers in

Figure 10 During aquatic exercise for safety patients should be fitted with a flotation device.

Figure 11 Encouraged to swim using toys. (Photo courtesy of Westcoast Ltd).

the early post operative period than is evident six months after surgery. In order to investigate the efficacy of a less intensive post operative swimming regimen that does not require hospitalisation, but to maximise the acceleration in function obtained through post operative swimming, we have proposed a twice weekly post operative swimming protocol for fit and healthy dogs recovering from surgery for cranial cruciate ligament disease.

Swim protocol for eight week post operative recovery period following cranial cruciate ligament surgery [9]

Swim	Time (minutes)	Pool Jet Power
1	5	0
2	5	0
3	7	0
4	10	0
5	6	10%
6	8	10%
7	10	10%
8	6	25%
9	8	25%
10	10	25%
11	6	50%
12	8	50%
13	10	50%
14	8	75%
15	10	75%
16	10	100%

When jets are used, swimming starts and also ends with an additional period of 1 minute swim without jets. For jet swims, for the first half of the swim the dog swims into the jet stream, subsequently, the dog swims with the jet stream.

Aquatic exercise is a popular recommendation by veterinary clinicians for dogs with a wide spectrum of musculoskeletal disorders including developmental, acquired, traumatic degenerative conditions and even diseases for which a diagnosis remains a mystery. Interestingly, meta-analysis of clinical studies of aquatic exercise by the Cochrane Collaboration (www.cochrane.org) for the management of pain control in musculoskeletal disorders including osteoarthritis in man has not shown superiority of aquatic exercise compared to over ground exercise. In dogs, with the exception of the post surgical treatment of cranial cruciate ligament disease, the therapeutic value of aquatic exercise in the management of musculoskeletal disease remains to be quantified through a published controlled prospective clinical study.

Swimming for dogs with neurological disease

Immersion in water can provide a stimulus for voluntary limb movement in dogs with neurological or neuromuscular disease. Dogs that have insufficient function to display voluntary limb movement on land can demonstrate limb movement when encouraged to swim. This may due to the stimulus of the immersion in water and perhaps the different neuromuscular recruitment that occurs during swimming compared to overground locomotion. Alternatively, movement may occur because there is sufficient strength to move the limbs when the body is buoyant in water but insufficient strength to support body weight on land. Regular swimming sessions can be a useful stimulus to encourage return of voluntary movement in plegic dogs and when swimming, greater joint excursions are achieved compared to impaired overground ambulation. Swimming also enables muscular strength and fitness training without injury through abrasion or falling on the ground. Swimming has been suggested to be as an important aid in recovery following spinal dysfunction presumed secondary to fibrocartilagenous embolic disease [10]. The beneficial effects of swimming for veterinary neurological patients have not been quantified in comparison to non-swimming matched controls in published clinical studies.

Figure 12 Using a 'Physio Roll®' as a safe 'back stop' to encourage walking on the belt during UWTM (Photo courtesy of Lowri Davies)

Figure 13 Buoyancy aid applied to the distal limb to modify limb segment excursions in the UWTM. (Photo courtesy of Lowri Davies)

Walking in water and under water treadmill (UWTM) activity

In water, the nature of movement of the joints and limb segments differs to compared to overground locomotion. For dogs walking on water treadmills this effect is influenced by the depth of water used. Typically, carpal and tarsal flexion increases as water level increases from ground level up to the level of the carpus. Additional increase in water level towards level of the elbow/stifle joint appears to result in increased elbow/stifle flexion. Water depth seems to have less influence on flexion of the hip/shoulder. The modified gait exhibited by dogs walking in water is also seen in dogs with mild neurological deficits and it appears that when walking in water, the tendency for these dogs to walk with their paws 'knuckled over' is lessened. In such cases, correct placement of the paws may be assisted by the water's resistance to movement, that results in splaying of the toes, the webbing between the toes acting as a 'fin.' As the splayed toes are pushed against the water, the feet tend to land properly. Correct placement of the paws may assist 'proprioceptive training' though clinical studies are required to ascertain and quantify the therapeutic benefit of this phenomenon in dogs. In deep water, in addition to the paw positioning effect, there is an effect of enhanced dynamic stability due to the combined effects of buoyancy, viscosity and relative density of water. Consequently a deep water environment can assist locomotory function and musculoskeletal activity for dogs with weakness, severe marked neuromuscular dysfunction or lameness. For dogs showing progressive clinical improvement, the depth of water used in the UWTM can be progressively reduced in accordance with the improvement in locomotor function, working towards return to unassisted locomotor function. The duration of each period of activity in the UWTM should be short enough so that fatigue does not limit function. Hence multiple repeats of short periods of activity are recommended, allowing recovery between active periods. The duration and intensity of exercise can be increased (by increasing velocity of movement or depth of water) in accordance with increase in function during clinical recovery.

UWTM for orthopaedic disease

Characteristically, following orthopaedic injury of surgery, painful joints are held in a degree of flexion in order to protect the limb from potentially injurious forces and the potentially painful stimulus of load-bearing. For dogs recovering from musculoskeletal injury and disease, the beneficial effects of buoyancy created by deep water can be exploited to encourage ambulatory limb function in diseased/operated limbs. Using an UWTM, water depth can be adjusted (increased as necessary) to ensure that the diseased limb is voluntarily extended and that functional steps are made using the limb. The moving belt of the treadmill is an unfamiliar experience for most patients and reluctant walkers can be effectively assisted to walk on the belt by an assistant restraining and encouraging the patient. Placing a large soft object (e.g a gym roll or ball) into the water behind the dog, at the back of the treadmill provides a soft effective back of the treadmill, which encourages dogs to move forward onto the advancing treadmill belt. [Figure 12] In deep water, buoyancy can also be used to assist joint excursion by application of a floatation device to the distal limb segment (e.g to the carpus/tarsus). Such application increases passive elbow/stifle joint flexion in deep water. In contrast, assisted extension of an injured limb can be encouraged by applying a buoyancy aid to the contralateral (normal) distal limb. [Figure 13] The resultant increased swing phase on the normal limb encourages extension and stance on the injured limb. Hence the aquatic environment can be used to facilitate soft tissue stretching and when limb use improves, this form of exercise can be employed to improve muscular strength and to promote use of the limb during overground ambulation. [11] have described the use of under water treadmill exercise alongside postoperative physiotherapy for a small group dogs recovering from surgery for cranial cruciate ligament disease. Following suture removal 10 days after surgery, water treadmilled dogs were exercised three times per week in the treadmill. Six weeks following surgery, thigh muscle mass of the surgical limbs (measured as thigh girth) was greater in UWTM dogs compared to home-exercised dogs.

Figure 14 Application of cold therapy to the stifle joint following recent surgery. Cold packs should not be applied directly to the skin. To avoid cold burns, a moistened towel can be used as an insulating layer which facilitates transfer of heat energy.

Despite the popularity of the recommendation UWTM aquatic exercise by veterinary clinicians for dogs with musculoskeletal injury/disease, to date, the author is not aware of evidence of efficacy of this exercise modality compared to over-ground exercise from clinical studies of large numbers of dogs.

Figure 15 Using a hair dryer to warm tissues

Physical Agents

Heat, cold, low frequency ultrasound, electrical stimulation, laser and extra-corporal shock waves are some of the physical agents used in rehabilitation programmes for musculoskeletal and neurological injury and disease.

Cold (cryotherapy)

The application of cold is referred to as cryotherapy. The intention of application of cold is to draw heat energy from body tissues, resulting in a reduction in tissue temperature. Some of the physiological effects of tissue cooling include (but are not limited to) reductions in the following:

1. blood flow
2. inflammation
3. oedema
4. local tissue metabolism
5. pain sensation
6. spasticity

and an increase in the factors below:

1. tissue stiffness
2. muscle viscosity (resulting in reduced ability to contract/extend rapidly)

Application of cold is indicated to assist the management of the following conditions

1. acute injury
2. acute inflammation, swelling or oedema
3. to increase range of motion (ROM) when it is limited by pain

Care should be used during the application of cold to avoid thermal injury to the tissues (frostbite). Injury should be prevented using the following guidelines:

1. Use cold therapy within the first 24-72 hours of acute injury
2. Use ice packs or commercial cold packs chilled to temperatures not lower than -20°C
3. Do not apply ice or gel pack directly to the skin. Ensure that a thermal insulating layer is used against the skin. This is especially important when the animal's hairy coat has been clipped. A moist cloth provides some insulation whilst facilitating transfer of some heat energy [Figure 14]
4. Apply cold source for up to 20 minutes at a time. (Often, "15 minutes on, 15 minutes off" is recommended).
5. Ensure that tissues are given the opportunity to return to their preferred physiological temperature at the end of the treatment period. (Total treatment periods are generally governed by practical constraints but are not normally continued for more than one hour).

The relative analgesic efficacy afforded by cold therapy compared to postoperative bandaging has not been investigated in companion animals and in general, it is the author's preference to apply dressings in the immediate postoperative period to control swelling and to protect limbs from painful jarring movements. Cold therapy can be applied through light postoperative dressings since light bandages are not total insulators of heat/cold.

Heat

Superficial heat therapy

The intention of heat therapy is to increase the temperature of the treated tissues. This can be achieved superficially (up to 2cm depth) using conduction, radiation and convection from external heat sources. Examples of heat sources for superficial warming include warm packs, spas and whirlpools, infra red lamps and warm air heaters/hair dryers [Figure 15]. Warming of deep tissues requires transfer of energy to deep tissue that is absorbed and converted to heat energy. Heating of deep tissues is achieved using ultrasound (US) and electricity (short wave diathermy).

Some of the physical effects of heating tissues include (but are not limited to):
1. relief of pain and spasm
2. increased tissue compliance
3. increased blood flow
4. increased tissue metabolism
5. increased muscle relaxation
6. increased capillary permeability (which can promote oedema)

Application of heat is indicated in the following conditions:
1. chronic musculoskeletal discomfort
2. decreased ROM due to stiffness

Heat should be applied according to the following conditions:
1. Apply hot packs (generally not hotter than 75°C) using thermal insulation padding.
2. Heat pack Temperature should be tested against the operator's skin if there is any uncertainty regarding the risk of causing a burn to the patient.
3. Apply heat packs for 15 to 30 minutes.
4. Thermal baths and whirlpools should be used at temperatures not exceeding 35°C. Locally applied warm water can generally be used safely at higher temperatures (up to 40°C).

Heating of deep tissues

In small animals, even deep tissues may be heated using superficial heat therapy. For example, the joints of small animals will be warmed when heat packs are applied because the depth of the tissue will not exceed 2 cm from the skin surface in many patients. Heating of deeper tissues by an energy source requires transmission of energy and conversion to heat energy because sufficient transfer of heat from superficial application cannot occur without burning. This can be achieved using relatively low frequency (approximately 20 kHz to 3MHz) ultrasound (US). Tissue heating so created tends to be of short duration following treatment and treatment periods are generally in the region of 10 minutes. A hairy coat absorbs US and results in poor transmission of energy and consequently, skin must be clipped to enhance energy transmission to the tissues. Debate continues regarding the therapeutic efficacy of deep tissue heating in human medicine [12] and its efficacy in companion animals is also undetermined. However, commercial recommendations suggest that emission intensity of 1.0W cm^2 and higher for 10 minutes heats tissues. In order to achieve thermal effects an elevation of tissue temperature of 1°C to 4°C is recommended.

Suggested clinical indications for tissue heating by US include tendonitis and bursitis and joint contracture secondary to chronic inflammation or immobilisation. Studies in man suggest that US can accelerate soft tissue healing and fracture healing, although enhanced fracture healing has not been demonstrated in controlled conditions in dogs.

Treatment guidelines include:

1. use a water-soluble gel as a coupling agent to the skin to facilitate US transmission.
2. use a coupling cushion if the US head does not conform to the surface of the tissues treated.
3. follow the application guidelines applicable to the power rating and the frequency delivered by the US unit used to ensure tissue heating and to avoid thermal injury.
4. consider any vocalising or avoidance behaviour to be attributable to discomfort and stop treatment. Use lower intensity or duration of treatment next time.
5. treat for approximately 4 minutes for each position of the sound head and for a maximum of four adjacent positions of the sound head per session.
6. keep transducer moving at approximately 4cm per second to avoid localised overheating of tissues.

Electrical stimulation

Electrical stimulation of tissues is primarily used in veterinary care to assist pain control and to increase muscle strength. Amelioration of pain is achieved by the depolarisation of sensory nerve fibres whilst electrically induced muscle contraction is achieved by motor nerve depolarisation.

Variables in electrical stimulation

A wide variety of electrical stimulators is commercially available, many of which produce unique combinations and ranges of electrical outputs. The variability of the output includes
- frequency.
- amplitude (the maximum electrical current delivered).
- waveform (symmetric, asymmetric, balanced, unbalanced, bi/mon/polyphasic etc).
- polarity.
- pulse rate.
- ramp (rate of acceleration of amplitude from start of pulse to peak amplitude).

Different models of stimulator claim to be more appropriate for specific applications e.g. pain control.

Electrical energy is delivered to tissues using surface electrodes. Ideally these are flexible so as to conform to the tissue to which they are applied. Some (single use) electrodes can be trimmed to size so that they fit well and so that they only stimulate the tissues of interest. (If electrodes are too large, they will stimulate unwanted muscle groups to contract). Electrodes should have a low resistance and conduction to the skin can be increased using appropriate gel.

Electrical stimulation for pain control

Guidelines for electrical stimulation for pain control in animals are limited and are based extrapolation from use in man and on small studies performed in dogs. One study showed significant improvement in limb function in dogs with chronic stifle osteoarthritis for up to 180 minutes following electrical stimulation [13] .Daily treatments are recommended although the duration of analgesia provide by stimulation is poorly quantified. Treatment periods of 20-30 minutes are recommended using 50-150 Hz with pulse duration of 2-50 microseconds for acute pain and 100-400 microseconds for chronic pain. The relative value of interferential, premodulated interferential or pulsed current (AC or DC) waveforms is, as yet, unquantified in companion animals.

Electrically induced muscle contraction

When a patient is not or cannot voluntarily use its limb, electrical muscle stimulation can help reduce loss of muscle strength. The ideal delivery of electrical stimulation is unknown but small clinical studies suggest that stimulation frequencies between 25 and 50 Hz produce strong titanic contraction whilst minimising fatigue. A symmetrical biphasic pulse is preferred and is allegedly the most comfortable waveform according to some reports in man. Pulse durations of 100 to 400 microseconds with ramp durations of 2-4 seconds should also maximise comfort in dogs. [14]. Treatment frequencies of five times per week have been used, though daily treatment may seem equally sensible.

Patient safety: Operators must receive appropriate training before using electrically operated energy transmitting devices in rehabilitation programmes

Laser treatment

The type of laser used in injury and disease is the low-level laser, which typically produces an output of between 1 and 5 mW. There are several types of emitters, but Helium-Neon (HeNe) is one of the most popular laser used in human and in veterinary work, emitting visible red light with a wavelength of 633nm. The therapeutic application of lasers has been investigated since the 1970s and putative therapeutic indications include soft tissue wound healing, osteochondral wound healing, management of osteoarthritis, pain control and regeneration of spinal cord following injury. The under pinning mechanistic theory of laser-induced tissue response is that photons are delivered to tissues, absorbed by chromophores and cytochromes resulting in oxygen production, stimulating the formation of proton gradients across cell membranes. These changes result in ATP production and cellular metabolism and growth are up regulated. Unfortunately the results of laboratory studies that document enhanced soft tissue and osteochondral healing have not been reproduced in published clinical studies in man or companion animals and hard evidence to support laser therapy for enhanced tissue healing in wounds in healthy animals is not currently available. In man, the value of laser therapy has been investigated for the management of knee pain due to osteoarthritis [15,16,17]. Interestingly, positive results appear more likely when the study is published in a journal containing 'laser' in its title.

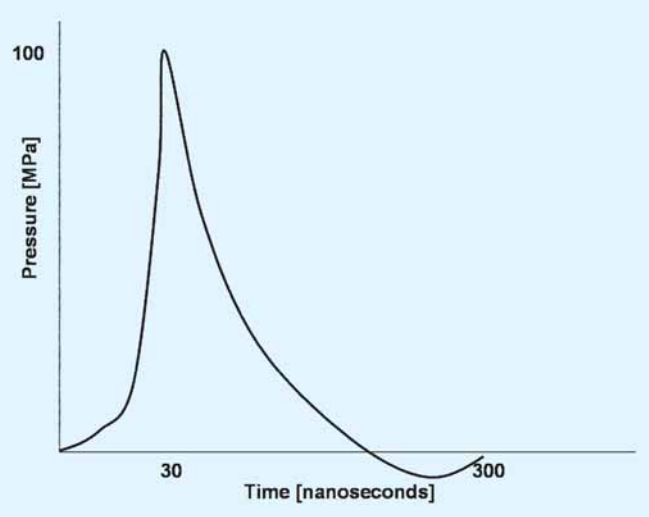
Extracorporal shock wave therapy (ESWT)

In man, some clinical studies have demonstrated therapeutic efficacy of ESWT in the management of delayed and non-union fractures, and pain management of chronic conditions such as lateral elbow pain ('tennis elbow'), plantar fasciitis, Achilles and patellar tendonitis and osteoarthritis.

What is ESWT?

Shock waves are high energy, high amplitude acoustic pressure waves generally in the range of 20-100 megapascals (MPa). Shock waves are generated in a liquid medium by the conversion of electrical activity to mechanical energy by electrohydraulic, electromagnetic or piezoelectric transducers. The waves are characterised by a massive rapid rise in energy and a subsequent exponential decay, all of which takes place in approximately 300 nanoseconds. [Figure 16]. Shock waves travel through tissues and energy is released at boundaries between different tissue densities, at bone-tendon interfaces, for example, generating heat. Shock waves have direct effects (compression and tension) and indirect effects (cavitation, tension and shear) on tissues. The microscopic disruption to tissue may be the mechanism by which ESWT modifies tissue physiology. ESW treatment results in induction of cytokines and growth factors including transforming growth factor 1, substance P, osteocalcin and vascular endothelial growth factor [18]. Nitric oxide synthase induction is also stimulated, and this may an important part of the mechanism by which ESWT influences bone healing. Inhibition of afferent pain signals may occur secondary to stimulation of nociceptors.

Figure 16 Profile of an extracorporeal shock wave showing the rapid rise in energy and short duration of the acoustic wave. As the energy is released in the tissues, there is negative pressure.



Shock waves can be delivered to tissues in a focussed manner to a small area of tissue, in which depth of penetration can reach 11cm. Radial application delivers to the surface of the body resulting in dispersion of energy over a wide and predominantly superficial area. [Figure 16]

Application of ESWT in veterinary medicine is established in equine work for the treatment of a spectrum of musculo-skeletal disorders including suspensory ligament desmitis, tendinopathies, back pain, navicular disease, osteoarthritis and stress fractures. [19,20]. There are reports of small numbers of dogs with musculoskeletal disorders (including tendinopathy, tendonitis and osteoarthritis) treated with ESWT [21,22,23]. One of these reports [23] was a controlled study that investigated the efficacy of ESWT in controlling pain in hip and elbow osteoarthritis in dogs.

Figure 17 Equipment for delivering shockwave therapy (insert of contact endpiece) (Photo courtesy of GHSMedical [Woolf])

Improvements were documented in limb function (as measured by force plate analysis) and in comfortable range of joint motion following ESWT treatment but not in sham treated controls.

ESWT may be a useful adjunct to the management of painful musculoskeletal disease in dogs, particularly if analgesia cannot be safely provided using non-steroidal anti-inflammatory drugs. However, heavy sedation or anaesthesia is required for most forms of ESWT in dogs and this may limit widespread application of the technique. Because ESWT is a local treatment, careful identification of the regional anatomy of the diseased limb is necessary to ensure accurate direction of the shock waves. Treated areas must be clipped to allow transmission of shock waves which is greatly facilitated using ultrasound coupling gel. The potentially injurious effects of cavitation necessitate that EWWT is not applied to the lung field, brain, heart or major blood vessels or nerves Furthermore, care should be taken during treatment because ESWT can produce local tissue damage resulting in bruising, petechiation and haematoma. These effects can be controlled by applying the transducer to soft tissue and not to bony prominences. Excessive treatment can result in thermal tissue damage and following treatment, dogs can be sore for several days, during which analgesia may be required. Claims of the long-term analgesic effect of treatment suggest efficacy for up to 12 months. Currently, treatments are predominantly based on manufacturer's recommendations extrapolated from USWT in man. Recommended treatment protocols for canine musculoskeletal disease are not readily available in the published veterinary literature and controlled studies are needed to fully evaluate and optimise efficacy of treatment.

Conclusions

Our knowledge and understanding of the activities, exercises and practices that encompass rehabilitation in veterinary patients is constantly expanding. The expertise in veterinary rehabilitation is largely derived from practices used in human medicine and the veterinary profession has gained much from our developing relationship with our physiotherapy colleagues. Veterinary clinicians should continue to work closely with physiotherapists to ensure that patients under their care engage in appropriate rehabilitation that provide them the best standard of care.

Further reading

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