

Canine Rehabilitation (Last updated: 15-Oct-2010)

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Introduction

The field of physical therapy/rehabilitation has much to offer veterinarians in terms of its application to sporting dogs as well as orthopedic and neurologic patients. In 1978, canine physical therapy techniques were described by Ann Downer, a physical therapist on faculty at Ohio State University [1]. More recent texts on canine physical therapy are becoming available [2,64]. The purpose of this chapter is to present an overview of rehabilitation methods. The procedures described here are applicable to dogs with various neurological disorders, as well as dogs with orthopedic disorders.

Some of the physical therapy methods that can be adapted to canine rehabilitation include:

1. Thermal Agents (ice, hot packs, therapeutic ultrasound, diathermy)
2. Phonophoresis and Iontophoresis for Transcutaneous Drug Delivery
3. Electrical Stimulation
4. Therapeutic Exercise
5. Aquatic Therapy
6. Goniometry
7. Orthotics (braces/splints)
8. Behavior Modification Techniques for Rehabilitation

1. Thermal Agents

Superficial heating agents penetrate to a depth of approximately one centimeter. Deep heating agents can elevate tissue temperatures at depths of three centimeters or more. Deep heating agents include ultrasound and diathermy. As a general rule, cold therapy ("cryotherapy") is indicated during acute inflammation when the lesion exhibits signs of redness, swelling, pain and/or heat. Heat is indicated during the sub-acute and chronic inflammatory phases. Ice application is also indicated to resolve swelling after exercise. In some cases, such as the treatment of muscle spasm and spasticity, the therapist may need to use a trial and error method to determine if either heat or cold yields clinical improvement. In humans, ice is usually not applied for longer than 15 minutes at one time in order to avoid reflex vasodilation. This guideline seems prudent for animals, also.

The indications for alternating heat and cold ("contrast baths") include impaired venous circulation and indolent ulcers, and traumatic or inflammatory conditions during the subacute or chronic phases. The mechanism of action of contrast baths is production of alternating vasoconstriction and vasodilation of local blood vessels. This reaction is considered to stimulate blood flow to the treated area and thereby to help stimulate healing.

Therapeutic Ultrasound

Two physical therapy modalities utilize ultrasound. These modalities are therapeutic ultrasound, which produces deep heating of tissues, and phonophoresis, which utilizes ultrasound waves to move drugs through intact skin (Fig. 1)



Figure 1. Portable ultrasound equipment (Courtesy of Chattanooga Medical Supply). - To view this image in full size go to the IVIS website at www.ivis.org . -

Therapeutic ultrasound delivers ultrasound waves through a transducer head comparable in size to the heads used in diagnostic ultrasound (Fig. 1). As with diagnostic ultrasound, the transducer must be in contact with the skin surface. With therapeutic ultrasound, however, the ultrasound waves increase tissue temperatures at depths up to 3 - 5 cm or more. Energy within an ultrasound beam decreases due to scatter and absorption as the waves travel through tissue. Scattering is the deflection of sound when the beam strikes a reflecting surface. In contrast, absorption is the transfer of energy from the sound beam to the tissues. Absorption is high in tissues with a high proportion of protein [3,4] and minimal in adipose tissue [3,5]. This means that ultrasound penetrates subcutaneous fat with little attenuation, whereas tissues with a high collagen content absorb more of the energy.

Therapeutic ultrasound has both thermal and non-thermal effects. The non-thermal effects have been studied primarily in wound healing. The thermal effect of therapeutic ultrasound is a major indication for its use. Increases in tissue temperatures of 1 to 4°C are associated with increases in collagen extensibility, blood flow, pain threshold, and enzyme activity. In humans, the rate of increase in tissue temperature is directly related to the frequency of the ultrasound waves (MHz) and the intensity (watts/ cm²). Experimentally, when tissue temperatures were compared at various depths (0.8 to 5.0 cm) using thermistors inserted into muscles, the rate of temperature increase per minute ranged from 0.04°C at 0.5 W/cm² to 0.38°C at 2.0 W/cm² for 1 MHz treatment and from 0.30°C at 0.5 W/cm² to 1.4°C at 2.0 W/cm² for 3 MHz treatment [6]. Clearly, the 3 MHz treatment heated the tissues faster than the 1 MHz treatment at all intensities.

Techniques - Several techniques have been outlined for the use of therapeutic ultrasound in horses [4,7-9]. To minimize reflection of the ultrasound beam at air-tissue interfaces, a coupling medium must be applied between the sound head and skin. Direct coupling, under water immersion, and coupling cushions have been described for dogs [10]. **Direct coupling** is preferred when the skin surface is flat and is larger than the applicator surface (Fig. 2). A commercially available, water-soluble gel is applied to the skin and the sound head. The gel may be pre-heated. Coupling agents NOT recommended are electroconductive gels, lanolin-based compounds and mineral oil. The **underwater immersion method** was popular before smaller transducer heads became available [4]. Immersion can be considered when the skin surface is so uneven that direct contact is difficult, such as occurs in the distal limbs of the dog. The part to be treated can be immersed in a container of tap water at room temperature, but both the water and skin must be clean. Water in a whirlpool is not recommended if it has been agitated. Because metal containers reflect some of the ultrasound beam, which could increase the intensity in areas near the metal, rubber or plastic containers are preferred as they cause less reflection. The transducer should be held underwater 0.5 - 3.0 cm from the skin. The intensity may be increased by 0.5 W/cm² to compensate for absorption of the ultrasound by water [3]. Immersion has not compared favorably with direct coupling in several studies in which tissue temperatures achieved by these two methods were compared [14,60]. One protocol for treating humans consists of applying ice to the treatment area prior to ultrasound therapy. Adding ice to the water for ultrasound delivered underwater has been recommended for horses [8]. However, if the aim is to increase tissue temperature, then it appears that ultrasound therapy in combination with ice would yield little benefit. A **coupling cushion** is a third alternative for delivering ultrasound [10], for example, placing a water-filled balloon between the transducer head and the skin, with coupling gel at the interfaces [11].

Commercially available gel pads are preferable. A recent in vitro study compared the transmissivity of commercial gel pads, water-filled latex gloves, gel-filled latex gloves, gel-filled condoms and water bath immersion through pig skin from which the hair had been clipped [61]. They recommended that if the direct method could not be used because of the contours of the treatment surface, then the therapist should use commercially available gel pads.



Figure 2. Direct coupling is preferred when the skin surface is relatively flat and is larger than the surface of the transducer. Ultrasound gel is applied to the skin and the transducer. (Courtesy of Dr. P. Shealy, Veterinary Specialists of the Southeast, Charleston, SC, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -

What About the Hair Coat? - The presence of the hair coat may be a major drawback to ultrasound treatment and phonophoresis in dogs. Because ultrasound energy is absorbed by tissues with a high protein content, and deflection of the ultrasound beam occurs at tissue interfaces, it would be expected that ultrasound penetration through the hair coat into underlying tissues would be poor. For horses, one investigator [7] has specifically recommended clipping the hair and using adequate coupling gel, or standing the horse in water to reduce the air interface, although immersion will not prevent the

scattering due to the hair coat. We conducted a study in dogs to quantify temperatures in underlying tissues when ultrasound was delivered through intact hair coats, using commercial ultrasound gel at room temperature [12]. In that study, ultrasound delivered through either short or long hair coats produced only minimal temperature increases in underlying tissues, compared to the responses achieved when the hair had been clipped. Furthermore, there was considerable warming within the hair coat. Even hair coats as short as those of Greyhound dogs inhibited tissue heating. Future research is needed to determine if modifications such as warming the ultrasound gel might enhance ultrasound penetration through the intact hair coat.

Treatment Variables - Tissue heating depends on frequency, intensity, duration, treatment area and the characteristics of the tissue. Ultrasound beams are considered collimated such that frequencies in the megahertz (MHz) range expose a limited target area. **Frequency** determines depth of penetration. As the frequency of the ultrasound waves increases, penetration decreases. One MHz heats at depths around 2 - 5 cm [12,13]. Three MHz heat at depths around 0.5 - 2 cm [4,13,59]. Consequently, treatment of superficial lesions can be problematic if the unit delivers only 1 MHz. If there is underlying bone, then most of the ultrasound will hit the bone and the intensity cannot be turned up very high to heat the underlying soft tissue before the patient feels periosteal pain [13]. An area of study which is currently receiving attention is the use of low frequency (long wave) ultrasound (< 1 MHz frequencies). **Intensity** refers to the rate of energy delivery per unit area. The power meter in an ultrasound unit indicates both watts and watts/cm². Intensities typically range from 0.25 to 3.0 W/cm². The greatest intensity within the beam is termed "spatial peak intensity". The "beam non-uniformity ratio" compares the maximal intensity from the transducer to the average intensity, and should be low (2:1 to 6:1) to indicate that energy distribution is relatively uniform, with minimal risk of tissue damage from areas of concentrated ultrasound energy ("hot spots"). The higher the intensity, the larger and faster the temperature increases. Generally, intensities required to elevate tissue temperature to the range of 40 - 45°C vary from 1.0 - 2.0 W/cm² with continuous wave mode for 5 - 10 min. If there is less soft tissue and/or bone close to the surface, lower intensity and higher frequency are appropriate. In any case, the patient's tolerance is the final determinant [3].

Several therapists have observed that dogs sometimes whine or seem uncomfortable 5 - 10 min after commencing therapeutic ultrasound. Any distress that animals show should be assumed to be due to pain and the therapist should either reduce the intensity or terminate the session. Most therapists use intensities that produce no detectable sensation in human patients. However, some experts are advising that the intensity be increased until the person feels vigorous heating of the tissues and then be lowered [13]. This difference in opinion has probably come about because the heating effects in the underlying tissues are difficult to monitor. Therefore, although tissue damage can result from excessive ultrasound exposure, there is also the possibility of insufficient exposure. **Duty cycle** refers to the fraction of time that the sound is emitted during one pulse period. In **continuous mode**, the ultrasound intensity is constant, whereas a **pulsed wave** is interrupted in an on-off manner. Typical duty cycles range from 0.05 to 0.5. Pulsing may be used when the desired effect is based on a non-thermal mechanism or when heating is to be minimal, such as treating near bone [4]. The **duration** of treatment is short, typically 10 minutes or less. Duration of a session can be estimated as 5 min/25 in² treatment area [13]. Five to ten minutes are necessary for adequate tissue heating. For instance, in one study it took nearly 8 minutes for the temperature to reach therapeutic levels at a depth of 3 cm in the gastrocnemius muscle in humans [14]. In that study, a direct coupling technique was used, with continuous mode, at 1.5 W/cm² and the sound head was moved at 4 cm per sec. At an intensity of 1.5 W/cm² and a treatment area twice the size of the effective radiating area of the transducer, it has been recommended that treatment duration be approximately 3 - 4 minutes at 3 MHz or 10 minutes at 1 MHz [13]. Our findings with 1 MHz in dogs support these recommendations [12]. **Treatment area** should be 2 - 3 times the size of the effective radiating area of the transducer head [13]. Increasing the treatment area decreases the effective heating of the tissues. **Speed of the sound head** over the skin is usually recommended to be approximately 4 cm per sec [11] to achieve uniform distribution of energy. Moving the transducer too quickly diminishes heating and makes the therapist prone to cover too large an area. The transducer should NEVER be stationary. Because the ultrasound beam is non-uniform, some target areas could receive a large amount of energy with the risk of causing "hot spots" and cavitation. **Treatment schedules** may be daily initially, followed by less frequent sessions as the condition improves [3]. Bromiley has indicated that treatment can be daily for up to 10 days, but should not exceed two 10 day courses without a 3 week rest [4]. Grant has made similar recommendations for horses [7].

Precautions and Contraindications - Tissue burns can occur if the intensity is too high or the transducer is held stationary. These factors can put the patient at risk for cavitation, a phenomenon whereby bubbles of dissolved gas form and grow during each rarefaction phase. Also, if the transducer is held in the air while emitting ultrasound, the face of the transducer will overheat. The end result could be damage to the ultrasound transducer or tissue damage if the transducer contacted the animal's skin. Some units have a built-in system to prevent the transducer from overheating. Some ultrasound energy is unavoidably emitted through the housing of the sound head to the therapist's hand, but the effects of this "parasitic" exposure are unknown.

It is important to avoid direct ultrasound exposure to the following: cardiac pacemakers, carotid sinus or cervical ganglia, eyes, gravid uterus, heart, injured areas immediately after exercise [7,9], malignancy, spinal cord if a laminectomy has been performed, testes and contaminated wounds. One should exert caution in considering ultrasound therapy in the following situations: tissue near a bone fracture or bony prominences, tissue that has been treated with cold packs or ice, decreased circulation, decreased pain/temperature sensation (animals should not be overly sedated, restrained or under local anesthesia) and epiphyseal areas in immature animals [4,11]. Also, there is evidence that intracapsular heating may accelerate destruction of articular cartilage in acute inflammatory joint disease [3]. Although metal implants are not necessarily a contraindication, the effects of ultrasound on cementing compounds such as methyl methacrylate are unknown [11].

Clinical Applications - In human rehabilitation, ultrasound therapy has been used for many years, but it is only quite recently that this modality is being evaluated with controlled clinical trials. In some regards, the jury is still out regarding the role of ultrasound therapy. Clinical trials and outcome assessments remain to be done in veterinary medicine. In horses, ultrasound therapy has been suggested for the treatment of tendinitis, desmitis, sprains, joint lesions, lacerations, scar tissue reduction, edema, exostosis and myositis [7,8]. In human athletes, some experts consider that the most beneficial results from ultrasound are in treating tendonitis [13]. In chronic tendinitis, recommended therapy includes heating with ultrasound, followed by cross-frictional massage. Another indication is treatment of limited range of motion associated with joint contracture, for which patients receive ultrasound therapy before passive range of motion or joint mobilization techniques. A third indication is pain relief prior to activity, such as for an athlete with tendinitis which is mild enough that the person can continue training; ultrasound treatment is administered prior to activity to assist in the warm-up and provide some pain relief. **Tendinitis and bursitis** are treated with ultrasound to increase blood flow, increase temperature to reduce pain and drive anti-inflammatory drugs across the skin by means of phonophoresis. In humans, lateral epicondylitis, sub-acromial bursitis, and bicipital tendinitis are typical indications for ultrasound therapy. Animal studies suggest that the stage of healing at which ultrasound therapy is administered is important, as ultrasound during early tendon repair could be detrimental [11].

The principle of "heat and stretch" can be applied in cases of **joint contracture and scar tissue** in an effort to increase range of motion. Tissues are first heated by ultrasound and then passively or actively stretched by the therapist. The effects of heat on ligament extensibility were studied in healthy humans [15] who underwent knee joint displacement tests before and after continuous ultrasound therapy (1 MHz, 1.5 W/cm² for 8 minutes). The investigators reported only minimal increases in the extensibility of some knee ligaments after this form of treatment. Because **scar tissue** is denser than surrounding tissues, it can be heated selectively. However, more research is needed to determine optimal intensities and durations needed to affect scar tissue. **Pain threshold** usually increases after ultrasound therapy, although the physiological mechanisms underlying pain reduction remain speculative. Heating could increase the activation threshold of free nerve endings which mediate pain sensation, produce counter-irritation, or activate large diameter nerve fibers [11]. Non-thermal mechanisms also may play a role in pain relief. The mechanism of action for reduction of **skeletal muscle spasm** may rely on thermal effects that alter the skeletal muscle contractile process, reduce muscle spindle activity, or break the pain-spasm-pain cycle [11]. Additional research is needed to determine the mechanism of action of ultrasound therapy on the different stages of **wound healing** and the optimal treatment parameters. The results in wound healing appear to depend on the intensity and duration of treatment and the time after injury. Low intensities appear to enhance healing whereas high intensities may have pro-inflammatory effects. Similarly, ultrasound therapy initiated within the first week after injury may compromise tissue repair whereas the same treatment initiated after 2 weeks may be beneficial. Dyson reported that ultrasound enhanced growth of tissue in experimental wounds in rabbit ears [16]. Because the temperature increases were small, the investigators suggested that the mechanism involved acoustic streaming, a biophysical response to ultrasound energy.

Other Conditions - Claims have been made that ultrasound treatment causes **calcium resorption**. A recent study confirmed that ultrasound therapy was associated with an increased rate of calcium resorption in humans with calcific tendonitis of the shoulder [17]. The ultrasound-induced excitation of calcium bound to proteins may promote the fragmentation and resorption of calcified masses within soft tissue [4]. Ultrasound also may have a role in **reduction of swelling**, but this remains to be validated.



Figure 3. Diathermy is another method to obtain deep heating of tissues. In this figure, a single drum unit is applied over the hamstring muscles in a German Shepherd dog with fibrotic myopathy. The layer of towelling is used as spacing when the drum is positioned over the limb. However, research remains to be done to document the heating effects of diathermy in small and large animals. - To view this image in full size go to the IVIS website at www.ivis.org . -

2. Phonophoresis

Phonophoresis refers to the use of ultrasound to enhance the delivery of topically applied drugs to the underlying tissues. In humans, the most common use of phonophoresis is for treatment of localized musculoskeletal inflammatory conditions. Hydrocortisone [18], dexamethasone [19,20], salicylates, indomethacin [21,22] or lidocaine [11] are incorporated into a vehicle such as glycerol, cream, oil or water for skin application. Ultrasound is then applied over the area in an effort to drive these substances into the tissues. The major limiting factor has been low skin permeability [23]. Current research focuses on maximizing absorption of drugs and determining which drugs can be applied with this method [20]. Low-frequency phonophoresis can enhance the transdermal delivery of proteins such as insulin and interferon [23,24]. Research in animals should be directed toward documenting drug penetration through the skin, and the effect of the hair coat.

The section on Therapeutic Ultrasound and Phonophoresis was adapted with permission from Steiss JE. Physical therapy in veterinary medicine: Therapeutic ultrasound and phonophoresis. Comp Cont Edu Pract Vet 2000; 22:690-693 [55].

Iontophoresis

Introduction - Methods of transdermal drug delivery include iontophoresis and phonophoresis. Iontophoresis ("ion transfer") is a form of electrotherapy. Certain drugs which ionize in solution can be driven into the skin and underlying tissues by direct current applied through surface electrodes. Since an electrode will repel similarly charged ions, positively charged ions can be introduced into the tissues by the positive electrode (anode); ions with a negative charge can be introduced by the cathode.

Effective skin penetration of a variety of drugs has been documented in humans and laboratory animals. Therefore, it is reasonable to expect that this technique could be applied in veterinary medicine. The potential uses for iontophoresis could be of particular interest to veterinarians dealing with musculoskeletal conditions in performance animals and to anesthesiologists. The information presented here is taken from basic research articles and literature on the treatment of humans, primarily athletes.

Equipment and Techniques - The procedure and instrumentation are relatively straightforward [25]. Direct current (DC) is required to ensure the unidirectional flow of ions during the procedure. A typical battery-operated unit incorporates a control for adjusting the current output, an ammeter to measure the current, a voltage control knob and meter, and a timer. The size of units is small enough to make them easily portable (Fig. 4). In the United States, several companies market iontophoresis units. The prices vary from approximately \$500 - \$1000. New iontophoresis units ("IontoPatch"), which are currently marketed for human use, have adhesive electrodes with a built-in battery for continuous drug delivery.

The factors which determine the amount of drug introduced into the tissues include the polarity, intensity and duration of the current, the electrode size, skin resistance, ionization potential, and nature of the solvents. Typical **current intensity** is in the range of 3 - 5 milliamps (mA) with **treatment duration** of 10 - 20 min. For humans, the sensation of the stimulation can be used to gauge intensity. When initiating treatment, the current intensity usually is increased slowly until the person reports feeling a tingling sensation [25]. A guideline which could be followed in treating animals is to set current amplitude to deliver a current density between 0.1 and 0.5 mA/cm² of the active electrode surface [25]. There seem to be differing opinions on the effect of the stimulus intensity. However, many authors state that low intensity currents appear to be more effective as a driving force than currents with higher intensities [25]. Therefore, iontophoresis in animals likely could be effective at intensities which would not cause pain or discomfort.

The two **electrodes**, termed the active and dispersive electrodes, are applied to the skin surface. Electrode systems range from simple electrodes fabricated in the clinic to commercially available electrodes specifically made for iontophoresis. Commercially available disposable iontophoresis electrodes include a well that contacts the skin with a semipermeable membrane. Electrode size and shape alter current density and affect the size of the area treated. As a rule, the smaller the electrode, the larger the current density. Choice of electrode size depends on the lesion. When a larger or poorly localized area is to be treated, larger electrodes are indicated.

Frequency of Treatment - This needs to be determined based on the drug chosen and the patient's response.

What About the Hair Coat? - An intact hair coat impedes the penetration of ultrasound waves into the tissues [12]. Whether iontophoresis can be delivered efficiently through an intact hair coat remains to be studied. For human patients, authors typically caution that the skin should be shaved and cleaned in order to ensure maximum contact of the electrodes [25]. In

published animal experiments, the hair has been removed and the skin cleaned [26,27].

However, there is reason to be optimistic that iontophoresis could be performed with an intact hair coat. Proper electrical conductivity can be established despite the hair coat for other techniques involving electrical stimulation. For instance, the hair can be parted but does not need to be clipped when applying surface stimulating electrodes for nerve conduction velocity studies in domestic animals. And, electrical impedance is low enough that electroencephalograms can be recorded in dogs and other species with surface recording electrodes without clipping the hair.

Precautions - The most severe complication in humans is an adverse drug reaction. Patients allergic to a medication should not receive this treatment. The second adverse reaction is a skin burn. Burns are more common under the cathode. The incidence of burns has decreased after current-regulated generators became available. Safety features are available that automatically terminate the treatment if impedance rises too quickly or too high. Caution should be used if the skin is damaged (since damaged skin has a lower resistance to the current and a burn may occur more easily) or if the patient has a sensory deficit [25]. Banta pointed out that iontophoresis provides an excellent complication and side-effect profile compared with other methods of delivering dexamethasone [28]. In his study, no complications occurred, including no significant elevation of serum glucose in insulin-dependent diabetics.

Clinical Indications - Currently, iontophoresis is used by physical therapists primarily for (1) the treatment of musculoskeletal inflammatory conditions (bursitis, tendonitis, etc), edema, and, (2) the production of local anesthesia of the skin [29]. Most of the published clinical information on iontophoresis involves the treatment of inflammatory conditions. The goal is to use iontophoresis to concentrate the medication directly into the problem area to achieve more rapid recovery. Lidocaine iontophoresis can produce a local anesthesia of longer duration than topical application but shorter duration than infiltration, which is sufficient to enable suture placement. Lidocaine iontophoresis also has been used for performing myringotomies, where anesthesia of the ear canal and ear drum were obtained [29].

A list of indications for iontophoresis in humans includes [25,30]:

- Allergic rhinitis
- Analgesia
- Burns
- Calcium deposits
- Edema
- Fungi
- Gout
- Herpes infection
- Hyperhidrosis
- Inflammation
- Ischemia
- Muscle spasm
- Open skin lesions
- Reflex sympathetic dystrophy
- Scar tissue
- Tumors

Drugs which have been Administered by Iontophoresis - The candidate drug must be both water and lipid soluble [30]. It must be water soluble to remain ionized in solution and it must be lipid soluble to permeate cell membranes. Direct current will transfer any ions of the appropriate polarity. The drug should be in a solution that contains a limited number of extraneous ions that might compete with it [30]. The list of drugs which can be delivered by iontophoresis includes anti-inflammatories, antibiotics, antivirals, antifungals, sclerolytic agents, local anesthetics, and drugs which promote edema reduction, vasodilation, muscle relaxation, wound healing and calcium resorption.

The positive ions include [25,29-31]:

- 5-fluorouracil
- Acyclovir
- Ara-AMP

- Cefazolin
- Copper (copper sulfate as source)
- Hyaluronidase
- Idoxuridine
- Lidocaine
- Magnesium (magnesium sulfate as source)
- Ticarcillin
- Zinc (zinc oxide as source)

The negative ions include:

- 6-hydroxydopamine
- Acetate (to enhance calcium absorption; acetic acid as source)
- Alpha-methylparatyrosine
- Chloride (sodium chloride as source)
- Ciprofloxacin
- Dexamethasone
- Epinephrine
- Gentamycin
- Iodine
- Ketoconazole
- Salicylate
- Tobramycin
- Vancomycin

Research Findings - Anderson has pointed out that a number of methods for local drug delivery to musculoskeletal tissues in horses are available, but that research is required to document the disposition of the drugs delivered by such methods and to correlate the information with efficacy [32]. In order to determine the role of iontophoresis in clinical medicine, both human and veterinary, there is a need for outcome assessments comparing iontophoresis to parenteral, oral and topical routes of administration. Unfortunately, many clinical trials published on the use of iontophoresis for conditions in humans have not had optimal experimental design. Clinical trials have tended to lack adequate controls, random assignment to treatment groups, or else the relevant treatment parameters have not been reported. In some studies, patients received additional modalities such as therapeutic exercise, heating, electrotherapy, ultrasound, etc, or the patients had various musculoskeletal diagnoses and did not represent a uniform population [30].

In an animal study, iontophoresis was performed (4 - 5 mA, 20 min) on two Rhesus monkeys and there was significant penetration of dexamethasone (but not hydrocortisone) compared to controls [26]. Local tissue concentrations of dexamethasone were higher than would be obtained by systemic therapy and lower than would be obtained by local injection. The authors concluded that the concentrations of steroid recovered in the various tissues were sufficient for clinical anti-inflammatory effects. In sites treated with dexamethasone and lidocaine hydrochloride, the depth of penetration was approximately 1.7 cm. They also found evidence that iontophoresis was concentration independent; electrodes containing 8 mg of drug delivered the same amount as electrodes containing 4 mg of drug.

Several studies have been conducted on cases of tendonitis, with varying results. In 30 patients with infrapatellar tendinitis, iontophoresis (dexamethasone and lidocaine) was compared to an established protocol consisting of modalities and transverse friction massage [33]. Patients were assessed with a visual analog pain scale, a functional index questionnaire, rating of tenderness on palpation and number of step-ups needed to elicit pain. The authors concluded that iontophoresis may be more effective in decreasing pain, reducing inflammation and promoting healing. Perron et al., [34] studied acetic acid iontophoresis and ultrasound for the treatment of calcifying tendinitis of the shoulder using a randomized control trial and stratified patients according to the type of lesions seen on radiographs. No significant difference was found between groups. Gudeman et al., [35] investigated whether iontophoresis of dexamethasone in conjunction with other traditional modalities provided more rapid pain relief than traditional modalities alone in patients suffering from plantar fasciitis. He used a randomized, double blind, placebo-controlled study with treatments given 6 times over 2 weeks. Iontophoresis plus traditional modalities showed greater improvement than traditional modalities alone at the end of the treatment period. However, follow-up at one month indicated that there was no significant difference between the groups. Those results suggested that iontophoresis in conjunction with traditional modalities provides immediate reduction in symptoms and should be considered when more immediate results are needed, for example, in treating athletes.

Kaneps et al., recently investigated the iontophoretic administration of dexamethasone into the tarsocrural joint in horses [62]. The hair was clipped at the sites of electrode attachment. They found that the drug concentration in the synovial fluid was detectable but did not reach therapeutic concentrations. They did not evaluate dexamethasone concentrations in the soft tissues underlying the active electrode.

The section on Iontophoresis was adapted with permission from Steiss JE. Physical therapy in veterinary medicine: Iontophoresis in horses. Comp Cont Edu Pract Vet 2001; 23:95-99 [56].



Figure 4. Battery-powered iontophoresis unit with electrodes which are available in a variety of shapes and sizes. (Courtesy of Empi Corporation). - To view this image in full size go to the IVIS website at www.ivis.org . -

3. Electrical Stimulation

Electrical stimulation can be used in dogs with neurological disorders for the purpose of muscle strengthening, retarding muscle atrophy, muscle re-education, relief of contractures, relief of muscle spasm and trigger points, and pain relief. Electrical stimulation tends to be used in the clinical setting, but not as part of a home program. In the author's experience, most pet owners are reluctant to administer electrical stimulation on a regular basis at home, so compliance is poor.

Equipment varies considerably in price and versatility. Some portable units can be purchased for less than \$500 but have limitations on the output with respect to intensity, frequency, ramping, etc. In certain cases, the portable units could be leased to owners or owners could purchase one for home treatment programs. More elaborate electrical stimulation units are commercially available, which have the capability to deliver a more complete range of the settings indicated in Table 1. Some units combine electrical stimulation and ultrasound to allow the therapist to alternately heat the tissue and deliver electrical stimulation.

Table 1. Some of the purposes for which electrical stimulation could be incorporated into the treatment program, and the typical instrument settings.						
Clinical Application	Type of Current	Mode	Frequency (Hz)	Pulse Duration	Duty Cycle	Intensity
1. Muscle Strengthening	AC or Pulsed	Surged	30-50	10-500 μ s	1:4 or 1:5	strong motor level
2. Retard Muscle Atrophy	AC or Pulsed	Surged	30-50	20-300 μ s	1:3 or 1: 5	moderate-strong motor level
3. Facilitation (re-ed; tendon transplant)	AC or Pulsed	Surged	30-50	200-500 μ s	1:2 or 1: 3	minimal-moderate motor level
4. Range of Motion						
A. Single Motion	AC or Pulsed	Surged	30-50	20-300 μ s	1:1	minimal-moderate motor level
B. Reciprocal	AC or Pulsed	Surged	30-50	20-300 μ s	1:1 (Continuous & Reciprocal)	minimal-moderate motor level
5. Relieve Contractures	AC or Pulsed	Surged (slow ramp up & down)	30-50	100-500 μ s	4:1 or 3:1	moderate-strong motor level
6. Relieve Spasticity						
A. Fatigue	AC or Pulsed	Surged	30-50	200-500 μ s	1:1, 2:1 or 3:1	moderate-strong motor level

Clinical Application	Type of Current	Mode	Frequency (Hz)	Pulse Duration	Duty Cycle	Intensity
B. Antagonist (Reciprocal Inhibition)	AC or Pulsed	Surged	30-50	200-500 μ s	1:2 or 1:3	moderate-strong motor level
7. Circulatory Effect						
A. Muscle Pump	AC or Pulsed	Surged or Interrupted/Burst	30-50 or 2-4	20-300 μ s	1:1 or 1:3	moderate motor level
B. Medical Galvanism	DC	Continuous	N/A	N/A	N/A	low sensory level
(Polarity should be 50% of Rx "+" & 50% of Rx "-" with both pads)						
8. Iontophoresis	DC	Continuous	N/A	N/A	N/A	low/dependent on formula
(Polarity is critical and is determined by polarity of the substance used)						
9. Wound Healing						
A. Continuous DC	DC	Continuous	N/A	N/A	N/A	low sensory or sub-sensory level
(Polarity "-" for bactericidal effect and "+" for stimulation of granulation tissue)						
B. High Volt	Pulsed monophasic	Unknown	100	Preset	N/A	sensory level
10. Pain Relief						
A. Conventional TENS	AC or Pulsed	Continuous	50-100	50-100 μ s comfortable	N/A	low sensory level
B. Acupuncture-like TENS	AC or Pulsed	Interrupted/Burst	2-4	150-500 μ s	N/A	strong motor level
C. Brief Intense TENS	AC or Pulsed	Interrupted/Burst	Variable 1-4 or >100	300-500 μ s	N/A	noxious-little or no motor response

TENS = Transcutaneous Electrical Nerve Stimulation
 Modified from D. Lions, PT, University of Alabama, Birmingham, AL, USA.



Figure 5. Electrostimulation for pain relief post-operatively in an orthopedic patient. This dog was treated with high frequency, low intensity stimulation (conventional TENS). (Courtesy of Dr. P. Shealy, Veterinary Specialists of the Southeast, Charleston, SC, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 6. Dual channel (or multichannel) electrical stimulators allow more than one pair of stimulating electrodes to be applied to the dog. The purposes include: (1) Production of interferential current (amplitude modulated beats) for treatment of deep pain; and, (2) Reciprocal or alternating patterns of stimulation in cases where range of motion is restricted in two directions (e.g., flexion and extension). (Courtesy of Dr. P. Shealy, Veterinary Specialists of the Southeast, Charleston, SC, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -

4. Therapeutic Exercise

Some of the techniques employed for training agility dogs, dressage horses and human patients can be adapted for therapeutic exercise in rehabilitation programs. Because each animal is an individual, no "cook-book" recommendations can be made. However, the exercise program may include some of the following exercises, for use either in the clinic or as part of a home exercise program after the owners or handler have been instructed on how to perform the exercises.

- Weight shifting

- Step up and step down
- Step over
- Serpentine
- Circles
- Figure 8's
- Transitions (slow-fast-slow walk, walk-trot-walk, etc)
- Leash walking on level and uneven surfaces



Figure 7a. Equipment in a canine rehabilitation clinic can include mini-trampoline, sand box, treadmill, ladder (7a) and dense foam (7b). (Courtesy of C. Schulte, PT, Mission MedVet Rehabilitation Services, KS, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 7b. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 8. Physioballs are available in various sizes. In humans, this equipment is used for exercises to improve muscle strength and balance. However, physioballs may have more limited use in canine rehabilitation. Dogs can be positioned with their thoracic limbs resting on the physioball in order to increase weight bearing on the pelvic limbs. But in the author's opinion, care should be taken to avoid over-extension of the spine (lordosis), which potentially could stress the lumbosacral spine, coxofemoral joints and/or sacro-iliac joints. Other forms of exercise can be used to strengthen the pelvic limbs, e.g., gait transitions and uneven terrain. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 9. Treadmills are available in various sizes for dogs. Treadmills are convenient and allow the trainer to control the exercise with respect to time, speed and gradient. The disadvantage is that treadmills do not simulate normal movement - the ground does not usually move under the dog's feet! Consequently, the pattern of muscle activation may differ when the dog is exercising on a treadmill. Therefore, it is recommended that an exercise program incorporates other exercise in addition to treadmill work. - To view this image in full size go to the IVIS website at www.ivis.org . -

Warming Up your Dog Before Training Sessions or Competition

A dog which is in the more advanced stages of rehabilitation may be performing strenuous exercises. Warm up exercises should be considered. Warm up can be as simple as walking the dog for about 5 minutes, followed by several minutes of jogging. Even though much research remains to be done, virtually all authorities recommend some form of warm up for the purpose of improving athletic performance and protecting against injury. In other species, it has been documented that the mild increases in body temperature and muscle temperature benefit the musculoskeletal system, the cardiovascular system and enhance temperature regulation to avoid heat stress. Warm up exercise can be incorporated into programs for canine athletes and others for both the prevention of injury and as part of a rehabilitation program. Trainers often say that they do not have time to warm up and cool down their dogs. At competitive events, dogs frequently are taken directly from the truck to the line. In contrast, at horse shows, riders and horses usually are seen exercising in warm up arenas or walking on the grounds. For equine athletes, specific details about warm up routines are available. For example, the warm up for a show jumper involves moderate exercise intensity at an average heart rate of 96 beats per minute [36].

Athletic trainers have written extensively about warm up techniques for human athletes. Even though much research remains to be done, virtually all authorities recommend some form of warm up for the purpose of improving performance and protecting against injury [37,38]. The purpose of this article is to describe the potential benefits of warm up and cool down for canine athletes, based on what has been written for human and equine athletes and for racing Greyhounds [39].

What Is a Warm Up? - The warm up is a preparation phase before exercise. The purpose of the warm up is to produce a mild increase in body temperature of approximately 1 - 2 degrees F, and thereby improve performance and protect against injury.

In human athletes, warming up can include walking, jogging, swimming, and/or mild-to-moderate resistance cycle ergometry [37]. Warm up exercise should not be confused with preliminary cardiovascular conditioning [40], such as roading in Pointers early in the season to increase their level of fitness.

Warm up can be classified as passive and active. In passive warm up, an increase in body temperature is achieved by techniques such as massage, diathermy, ultrasound and heat application [41]. However, this does not significantly increase the blood flow to the working muscles [42], and passive warm up is not used to a great extent.

Active warm up is the easiest way to increase muscle temperature. It is divided into two phases, general and specific [43]. General warm up is a form of loosening up, such as walking followed by jogging/trotting. The effect is to raise core temperature (which can be estimated from measuring rectal temperature), heart rate and respiration rate [43]. Some of the procedures used for horses could be adapted for dogs. Typically, the horse is walked for several minutes, followed by trotting. For horses, warm up is often done on a lunge line or under saddle, or occasionally with a treadmill or hot walker if such equipment is available. For racing Greyhounds, 5 - 10 minutes of brisk walking or jogging prior to racing is recommended [39]. Specific (neuromuscular) warm up is a rehearsal for the activity. This phase mimics the anticipated activity and brings about full range of motion of the joints [41]. Specific warm up is thought to improve skill and coordination. Sports that require accuracy, timing and precise movements tend to benefit from some type of specific preliminary practice [41]. Dogs competing in agility would be candidates for including this phase of the warm up.

Stretching exercises have been part of the traditional warm up [37,43,44]. However, in a recent study, investigators have found that muscle stretching performed during the pre-exercise warm up in adult men did not significantly reduce the risk of exercise-related injury [45]. Instead, they concluded that fitness may be an important, modifiable risk factor. For trainers, the warm up for dogs would certainly be simplified if additional stretching procedures did not need to be incorporated.

Guidelines for Warm Up - The ideal warm up prepares the athlete for subsequent activity without creating fatigue [42,43]. Some trainers state that the ideal warm up for any endurance activity is the same activity but at a lower intensity [37]. More precisely, the goal of warm up is to exercise at a relatively low intensity which is less than 60% VO_2 max or 70% of the maximal heart rate for less than 15 minutes [42].

For people, the aim of the warm up is to increase their body core temperature 1 - 2 degrees F and the muscle temperature up to 5 degrees F [42]. Experimentally, muscle temperatures can be measured using a needle thermistor inserted into the muscle tissue. However, in the field, a guideline for trainers might be that the rectal temperature should increase by 1 - 2 degrees F in order for the muscle temperature to reach a satisfactory level [44]. Or, the trainer or athlete may simply consider that 5 - 15 minutes of low to moderate intensity exercise should be adequate [43]. If a human athlete is sweating freely in normal climatic conditions, it is assumed that this temperature has been reached [44]. Unfortunately, this particular guideline cannot be applied to dogs.

The intensity and duration of the warm up depend on factors such as the individual athlete, the event, the facilities, and the ambient temperature [42,43]. If the warm up exercise is too strenuous or the duration too long, performance can be impaired by fatigue [42]. Excessive warm up depletes energy stores, causes lactic acid build up, and/or raises body temperature too high [43]. In cold weather, a slightly longer warm up may be required, whereas in hot weather, a shorter or less intense warm up may be appropriate [43]. The level of fitness of the athlete is another factor. An elite human athlete may require 20 - 30 minutes of relatively intense exercise to achieve maximal potential, whereas this would be excessive for an unconditioned novice and would result in exhaustion [44]. Even among individuals near the same level of training, variation exists and needs to be taken into account. For instance, individual horses were found to have different increases in rectal temperature after the same duration of trotting and cantering [43].

The effects of warming up soon wear off [37]. After the warm up is completed, the activity or event should begin within several minutes [41]. This allows recovery from temporary fatigue without losing the beneficial effects of the warm up. For human athletes, it is recommended that the time interval be no longer than 10 minutes [37].

Why should Athletes Warm Up? - A. *Musculoskeletal Effects* - Numerous beneficial effects of warm up have been documented for the musculoskeletal system. Greater forces are needed to injure a warm muscle than a cold muscle [41]. With an increase in tissue temperature, collagen and the muscle-tendon junctions are more able to stretch, thereby minimizing trauma [46]. When muscles from rabbits were stretched at 35 degrees C, the muscles could be lengthened approximately 31%

before tearing whereas warming to 39 degrees C (103 degrees F) allowed the muscles to be lengthened 35% before tearing [47].

In addition, blood saturation can affect the elasticity of muscle. Cold muscles have low blood saturation and tend to be more susceptible to tears than warm muscles [48]. Increased temperature within muscles promotes vasodilation. A muscle achieves maximum endurance performance when all its blood vessels are maximally dilated [37]. Vasodilation increases blood flow and therefore increases the delivery of oxygen and nutrients to muscle and the removal of waste products [43]. At rest, 15 - 20% of the blood flow supplies the skeletal muscles; after 10 minutes of exercise, the percentage may increase to 70 - 75% [37].

No one has conducted a study to measure the limb temperatures in Retrievers working in cold conditions, such as sub-zero ambient temperatures or ponds covered with ice. The degree of thermal insulation provided by the hair coat is not known. If the temperatures of the limbs do decrease while dogs work in these cold environments, then warm up exercise might be important to minimize the tissue cooling.

Another very important result of increased tissue temperature is increased oxygen delivery to muscles. As temperature increases, hemoglobin releases oxygen from the red blood cells to the tissues more readily. Or, stated another way, the oxy-hemoglobin dissociation curve is shifted to the right [38]. Although considerable effort and expense are spent on finding supplements and other methods to increase the oxygen carrying capacity of hemoglobin and therefore enhance aerobic metabolism, here is a built-in mechanism to achieve this result.

The warm up appears to have the most benefit when athletes compete in high intensity-short duration activities, such as sprinting [43]. This could also be relevant to dogs participating in events such as Schutzhund and agility and field trials, where they may be at risk for muscle strain.

Other effects of warm up on the musculoskeletal system include increased speed of muscle contraction and relaxation [41,42]. In contrast, reaction times are prolonged and muscle excitability is reduced when the tissue temperatures are below normal. Warm up is also associated with an increase in muscle strength as well as speed [48]. Warm up has been reported to improve swimming speed and running speed [48].

B. Temperature Regulation - Warm up exercises activate the body's heat dissipating mechanisms. When horses were warmed up before brief high intensity exercise, their temperatures did not rise as high during the subsequent high intensity work and they recovered faster [49]. The investigators in that study speculated that the warm up activated blood flow to the skin, causing an earlier onset of sweating and improved heat removal.

Dogs rely on panting and heat loss through the respiratory system rather than sweating. Therefore, separate studies need to be conducted for dogs to determine if the mild elevations in body temperature achieved during warm up can enhance heat loss through the lungs or nasal cavity. Heat stress is a problem which is becoming more widely recognized in sporting dogs. Retrievers [50] and Pointers [51] sometimes have rectal temperatures approaching 105 - 107 degrees F during exercise, representing a rise in body temperature of 3 degrees F or more. Although most of these dogs appear clinically normal and their rectal temperature declines to normal soon after the activity ceases, some dogs seem to experience heat stress to the extent that their training is impaired.

C. Cardiovascular Effects - Sudden strenuous exertion can provoke adverse effects on heart function [37]. In one study, healthy men (n = 44) ran on a treadmill for 10 - 15 seconds without warming up [52]. Electrocardiograms (ECG) were recorded immediately after exercise. Seventy per cent of the men had ECG abnormalities that were indicative of insufficient oxygen supply to the heart muscle due to inadequate coronary blood flow. The abnormalities were not related to their age or fitness level. When the men (n = 22) warmed up by jogging for 2 minutes before treadmill running, only 2 had significant ECG changes.

In addition, blood pressure rises higher when there is no warm up. In the study described above, the average systolic pressure was 168 mmHg after the treadmill run. After the 2 minute warm up, the value was 140. Therefore, warm up reduces the workload on the heart.

At this time, it is unknown whether dogs have the same responses. Electrocardiograms could be recorded from dogs in a manner similar to the study described above in humans. This type of study would help to determine whether some dogs suffer

from cardiac dysfunction if they undertake strenuous exertion without warm up, and whether this could be the explanation for poor performance in some dogs.

Table 2. Summary of the beneficial effects of warm up.

- Increased strength
- Increased speed of muscle contraction and relaxation
- Increased muscle flexibility
- Increased oxygen delivery to muscles
- Increased nerve conduction velocity
- Vasodilation (and therefore increased delivery of oxygen and nutrients to muscle)
- Increased rate of muscle enzyme activity (which can increase ATP production)
- Decreased pulmonary blood flow resistance
- Decreased lactic acid concentrations after strenuous exercise
- Decreased oxygen deficit
- Decreased heart rate post-exercise

Cool Down (recovery phase, post-event warm down) - The athlete should be allowed a cool down period consisting of low intensity exercise, such as walking. This low intensity activity is used during the early recovery stage to ensure that blood continues to be circulated from the muscles to enhance the washout of the waste products of muscle metabolism, such as lactic acid, and to dissipate heat, thus shortening the recovery time [37,53]. The post-exercise cool down could mirror the warm up. For example, the cool down could consist of low-intensity sport-specific activities, followed by jogging/trotting, then walking. The time till complete recovery depends on the type and intensity of the exercise. From 10 - 20 minutes is usually considered enough time for cool down [53]. In scientific terms, the intensity of the exercise would be 30 - 65% VO_2 max [42]. Complete recovery may take several hours [53].

Cooling down after exercise is also important for the cardiovascular system. Cooling down helps to promote venous return to the heart [37]. Abruptly stopping exercise can result in a temporary decrease in venous return, reducing coronary blood flow at a time when heart rate and myocardial oxygen demands are still high. In humans with compromised coronary circulation, this situation can lead to angina pectoris, ECG abnormalities and arrhythmias [37].

Table 3. Summary of the beneficial effects of post-exercise cool down.

- Return of heart rate and blood pressure toward resting values
- Increased venous return to the heart
- Increased heat loss
- Increased removal of lactic acid

Future Research - Research on warm up techniques should be aimed at answering several questions. For example, what duration and intensity of warm up are needed to produce an increase in intramuscular temperatures? This question could be answered using methods already established for measuring intramuscular temperatures in dogs [12]. Secondly, do warm up exercises activate the dog's heat dissipating mechanisms, as has been shown in horses? Thirdly, do some dogs experience cardiac dysfunction if they perform strenuous physical exertion without warm up, as has been shown in humans? Could this be the explanation for poor performance in some dogs? And, in the long term, how much will the addition of warm up exercises into training help to prevent injuries or enhance their performance?

The section on Warming Up your Dog Before Training Sessions or Competition was adapted with permission from Steiss JE. Warming up your dog before training sessions or competition. Retrievers Online. 2001; 12(2):4-7 [57].

5. Aquatic Therapy

Aquatic therapy includes both swimming and other aquatic exercise. Providing aquatic exercise for small breed dogs is

relatively easy compared to large breed dogs. Small dogs such as Dachshunds can be lifted into a sink or tub, and easily held for support. A heavier dog which is not ambulatory is much more difficult to transport, and will require a more sophisticated pool. The types of facilities that are used for aquatic therapy include:

- Sinks
- Tubs
- Children's wading pools
- Above ground pools (Figures 10-12)
- Underwater treadmill systems (Figures 14)
- Ponds, lakes and beaches (Figures 16-18)

One of the advantages of an above ground pool is that the dog has room to swim and to play. However, the depth is usually around 3 - 4 feet, which is too deep to walk the dog or perform other types of controlled exercise with the dog standing. It is an advantage to the therapist to be able to work with the dog in an environment where the water level is not above the dog's head, so that the therapist can control the exercise. A dog which is swimming may compensate and not use the affected limb (s) in the desired manner. Above ground pools require regular maintenance of the filtration and chlorination (or bromine) systems.

The advantages of an underwater treadmill system are that the water level can be adjusted to the height of the dog and degree of buoyancy desired. The therapist can quantitate the speed and duration of exercise, and observe the gait through the side walls. In this system, the water is drained at each session. However, the interior surfaces of the underwater treadmill need to be disinfected. One disadvantage of the underwater treadmill system is that the therapist is not able to have the dog perform other types of exercises, such as lateral bending. And, an underwater treadmill may cost 2 - 3 times more than an above ground pool.

The optimal water temperature varies somewhat, depending on the type of patient. Rehabilitation pools for humans are often maintained around 90 - 92 degrees F. Lower temperatures are indicated when dogs are swimming and generating considerable body heat, or when the dog will be staying in the pool for a longer time. Patients with spasticity sometimes improve when the water temperature is lower. In other situations, the recommendation for the water temperature for dogs would be closer to 95 degrees F in order to achieve relaxation of soft tissues. Puppies have been noted to shiver after standing in 95 degree F water for 5 - 10 minutes; therefore, the temperature for them may be increased to a temperature which seems comfortable to the therapist. If there is concern about causing hyperthermia, the dog's rectal temperature can be taken.

In addition to the water temperature, attention should be given to the treatment time. The more debilitated, the shorter the duration should be. Initial treatment times may be as short as a few minutes, and then the duration can be increased considerably as the dog progresses through rehabilitation. Many dogs will have been physically inactive for several weeks or more, and then undergo surgery. It can be assumed that these dogs are deconditioned. Such dogs can easily be fatigued if required to swim. A person who has been laid up with back pain and then undergoes back surgery is deconditioned and would not want to start therapy by being put in a pool over his/her head and told to swim for 20 minutes.

Ideally, the dog's vital signs would be monitored during aquatic exercise. This is seldom done, but the therapist can estimate the degree of exertion in some manner in order to avoid exhaustion. It should be assumed that the exercise has been too strenuous when dogs are so tired that they need extra help getting out of the pool, or when they do not want to move the next day.



Figure 10. Swimming can be used for fitness and conditioning as well as for rehabilitation of neurological and orthopedic patients. (Courtesy of Dr P. Shealy, Veterinary Specialists of the Southeast, Charleston, SC, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 11a. Above ground pool (Galaxy Aquatics Inc, Houston TX) viewed from the side, showing ramp (11a) and from above (11b). (Courtesy of Dr P. Shealy, Veterinary Specialists of the Southeast, Charleston, SC, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 11b. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 12a. Another example of an above ground pool (Rio Plastics, Brownsville TX) viewed from the side, showing ramp (12a) and from above (12b). (Courtesy of C. Schulte, PT, Mission MedVet Rehabilitation Services, KS, USA). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 12b. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 13a. Examples of flotation devices for dogs (13a and 13b). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 13b. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 14a. Underwater treadmill system (Ferno, Wilmington OH) for rehabilitation of a dog with orthopedic injury. (Courtesy of University of Tennessee, College of Veterinary Medicine, Knoxville, TN, USA.) - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 14b. A yard stick can be mounted on the outside of the underwater treadmill. This is helpful in maintaining the same prescribed water level when a dog is treated over multiple sessions. - To view this image in full size go to the IVIS website at www.ivis.org . -

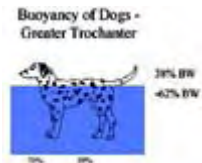


Figure 15. This figure indicates the degree of buoyancy obtained when the water is level with the greater trochanter of the femur. The body weight is reduced by approximately two thirds. (Courtesy of D. Levine, PT, PhD, OCT, University of Tennessee at Chattanooga, TN, USA.) - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 16. A pond is seldom practical for therapy. Many factors such as the water temperature and water quality cannot be controlled. However, in this situation, the therapist can work with the dog to perform a variety of aquatic exercises. This photograph shows weight shifting over the left pelvic limb. The dog's spine is kept straight. Weight shifting is an isometric exercise that is appropriate during the initial rehabilitation of most dogs with either orthopedic or neurological disorders. Weight shifting is usually done with the dog standing on a smooth, non-slippery floor. However, this exercise can be done in water with dogs who are reluctant to bear weight on the affected limb, or who are not allowed full weight bearing. This exercise can be quantitated, for example, "do 10 repetitions and hold for 5 seconds each time". - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 17. In addition to weight shifting side to side, as discussed in Figure 16, the dog's center of gravity can be shifted cranially and caudally. This exercise seems to activate the paraspinal muscles as well as the appendicular muscles. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 18. Exercise in water allows unloading of the joints for orthopedic rehabilitation. With neurological disorders, a dog with severe weakness may be able to achieve weight bearing when in an aquatic environment. Where available, a pond or beach with a level bottom allows the dog to be exercised in various heights of water to achieve varying amounts of buoyancy. In addition, equipment such as plastic benches can be used to perform step up exercises in the water (see Figure 19). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 19. Although much of the equipment available for people for aquatic therapy is not readily adapted to dogs, the benches which are seen stacked in this illustration can be placed in water to allow the dog to step up and step down. The degree of weight bearing and difficulty of this exercise will depend on the level of the water and the height of the bench compared to the size of the dog. (Courtesy of Cheryl Fuller, MS, ATC, Aquatics Director, Spain Rehabilitation Center, The University of Alabama at Birmingham). - To view this image in full size go to the IVIS website at www.ivis.org . -

What about the possibility of having access to rehabilitation pools such as the one depicted in (Fig. 20) for the purpose of treating canine patients? In many locations, county health regulations prohibit animals in or around these pools (Cheryl Fuller, Director of Aquatic Therapy, Spain Rehabilitation Hospital, UAB, Birmingham AL, personal communication, 2001). Many county health departments allow seeing-eye or care dogs on public pool decks, but do not allow them in the water with their owners (Alison Osinski, PhD, Aquatic Consulting Services, San Diego, CA, 2001).

This question was posed to Dr. Bill Johnston, State Public Health Veterinarian for the Alabama Department of Public Health. He stated that in a properly chlorinated pool, *E. coli* and *Giardia* would be eliminated but *Cryptosporidium* would be a potential concern (personal communication, 2001). Dr. Johnston recommended that the dog be bathed and brushed with a medicated shampoo containing antifungal agents, within 24 hours before entering the pool. The dog should be free of ectoparasites. The veterinarian could perform a fecal screen and even provide a signed health certificate, somewhat similar to the workup for therapy dogs performing hospital visitations.

Dr. Johnston posed this question to members of the National Association of State Public Health Veterinarians, and received the following comments:

- If in contact with the dogs, patients should not have any open or healing wounds.
- The more people in the pool at one time with the dog, the greater the risk of some form of microbe transmission.
- A clear policy is needed on handling fecal and urine contamination of the pool by both dogs and humans.
- Care must be taken to maintain the chlorine concentration at an acceptable level (pool inspection requirements by county health officials state the exact levels of chlorine required to eliminate *E. coli*). There might be concern about

patients colonized with multi-drug resistant organisms who may transmit the organism to the dog, which then becomes a source of infection for other patients.

- Even for chlorine sensitive organisms, a certain amount of contact time is needed, since inactivation is not instantaneous.
- Cryptosporidium is especially a concern. One should also consider leptospirosis.
- Although Cryptosporidium might survive and be infectious if ingested by a person sharing a pool with an infected dog, the degree of risk would not exceed the risk of swimming with a child, for example, a group in which the prevalence of asymptomatic Cryptosporidiosis probably exceeds that in most dog populations.
- Humans excreting Cryptosporidium and Giardia in pools pose more of a potential problem than a healthy clean groomed dog would.



Figure 20. This photograph shows the entrance ramp to a human therapy pool located in a rehabilitation hospital in a metropolitan area. This ramp or beach-type entrance allows easier access for many patients. The water is typically maintained around 92 degrees F. It remains to be seen if therapists in the future will be allowed access to such pools for canine patients. Some of the major issues are concerns regarding control of infectious agents and maintenance of water quality. (Courtesy of Cheryl Fuller, MS, ATC, Aquatics Director, Spain Rehabilitation Center, The University of Alabama at Birmingham). - To view

this image in full size go to the IVIS website at www.ivis.org . -

6. Goniometry

A goniometer is a device which is used to measure joint angles. The therapist places the two arms of the goniometer along the bones immediately proximal and distal to the joint being examined. The two arms of the goniometer are lined up with specific anatomical landmarks for each joint. Goniometry can be used to determine both a particular joint position and the total amount of motion available at a joint [54]. Goniometric measurements are not usually performed if the dog appears to have normal range of motion on physical examination. When goniometry is performed, the animal's limb position should be standardized so that measurements are repeatable on subsequent examinations. In cases where only one limb is affected, the contralateral normal limb can be used for comparison. There is a need for data on the normal ranges for joint angles for individual breeds of dogs. Values for the Labrador Retriever have been reported [63].

Data obtained from goniometry can be helpful in the following circumstances [54]:

- Determining the presence of dysfunction
- Establishing a diagnosis
- Developing treatment goals
- Documenting progress
- Modifying treatment
- Motivating the owner
- Fabricating splints (orthoses)
- Obtaining objective data

7. Orthotics

Low temperature thermoplastics are materials that have been utilized for many years in the fabrication of orthotic devices or splints for human use. Due to the versatility of these materials, orthotic fabrication can easily be modified in order to meet the needs of a veterinary practice.

Orthotic devices are used in the human medical model to protect joints against forces that cause pain, injury, deformity or stresses that interfere with the healing process. Orthotics, or splints, are also utilized to correct joint contractures, tendon subluxations, reduce hypertonicity in spastic musculature, and to assist movement of joints during activities when muscle strength is decreased or absent due to nerve injury or paralysis.



Figure 21. Orthotic for a Labrador Retriever with radial nerve damage and knuckling of the paw of the right thoracic limb. (Courtesy of R Johnson, Department of Occupational Therapy, University of Alabama at Birmingham, AL, USA [58]). - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 22a. Orthotic for a Labrador Retriever with partial radial nerve damage and subsequent knuckling of the paw (22a). The dog was not able to fully extend its carpus. This splint was worn 10 hr per day with excellent tolerance. The goals were to prevent flexion contracture of the carpus and to prevent skin abrasions. Vetrap was placed over the splint to prevent the splint from slipping (22b). - To view this

image in full size go to the IVIS website at www.ivis.org . -



Figure 22b. - To view this image in full size go to the IVIS website at www.ivis.org . -

Many diagnoses addressed in veterinary practice can be treated with the use of orthotic devices, and due to the characteristics of the materials and ease of molding and remodeling; it can also be of cost benefit. Joint injuries, soft tissue injuries, wounds, tendon lacerations, fractures, nerve injuries, sprains, joint laxity, contractures, and vascular repairs are common diagnoses that can benefit from splint fabrication.

There are different categories of orthotic devices, including static devices, nonarticular (fracture) splints, serial-static and static progressive devices, dynamic splints, and static motion-blocking splints. Static, serial-static, and nonarticular splints can easily be modified for use in the treatment of domestic animals. Static splinting devices are designed to prevent contractures by maintaining tissue length, resting injured tissues to reduce inflammation and pain, stabilize injured tissues, and reduce muscle tone in the treatment of spasticity. They are also utilized to unload tissues to promote resorption of lax structures such as joint capsules or ligaments in order to correct joint instability, and to position the joints in the extremities to enhance joint alignment and promote pain-free, functional mobility.

Serial-static orthoses immobilize one or more joints and are designed to reduce muscle tone and correct contractures. This is accomplished by applying a gentle, prolonged stretch to enhance the growth of contracted soft tissues. Due to the nature of low temperature thermoplastics (LTTs), the splints can be reheated and remolded to accommodate the changing tissues. Nonarticular splints do not cross any joints and are usually circumferential, which are useful in the stabilization and promotion of healing in long bone fractures.

Characteristic of Low Temperature Thermoplastics (LTTs) - LTTs are materials that are heated in water at a low temperature (150 - 175 degrees F) that can be molded directly on the surface of a client's skin or animal's fur. There are many types of LTTs available on the market, and these materials may differ in appearance, molding characteristics, durability, cost, color, and thickness. The more commonly used materials typically require a temperature of approximately 160 degrees F. When heated, the thermoplastic materials become pliable, allowing the fabricator to contour the material around the extremity or body part. The material then cools and hardens within a few minutes to its original rigidity.

Some materials have **memory**, the quality of returning to original shape when reheated. This is convenient when changing the splint angle frequently, but can pose a problem when spot heating for minor adjustments. **Drapability**, or **conformability**, is the degree to which the heated LTT readily conforms to the contours of the body part over which the material is placed. Although difficult to handle initially, this quality is appreciated when close contouring around bony prominences and tendon insertions is needed. The greater the degree of drape, the less resistant it is to stretch, which may be necessary for lengthening a splint. Some materials have the ability to achieve smoother edges after cooling than others. The better a LTT is in **edge finishing**, the smoother the finished splint will be, and more comfortable the splint will be to the client. If finished edges are rougher than desired, a light adhesive padding material can be added to the splint edges for greater comfort.

Some materials tend to be easily fingerprinted during molding, which gives a less than aesthetically pleasing product. These materials must be monitored closely during the molding stage to ensure that fingerprints are not added, if this is a priority. **Durability** is the quality of a LTT material related to the length of time that a material will last. This characteristic is important to consider when a splint will be worn for long periods of time. **Rigidity** is the ability of a material to have a high degree of strength and resistance to stretch, which is an important quality when fabricating splints for large breed dogs. Some materials are perforated, which allows for better air exchange. This is important to consider in warmer climates and seasons where sweating may cause the client's skin to become macerated. Finally, LTTs come in 1/8, 3/32, and 1/16 inch **thickness**.

Lighter weight materials may be used for individual clients who cannot tolerate the weight of thicker materials. Thinner materials are not adequately rigid enough for large splints, but are convenient to use for smaller canine and feline clients.

Fabrication of an Orthotic Device - Unheated LTT splinting material can be cut with a pair of good quality scissors or razor edge. The basic length and width can be approximated and more accurate cutting completed once the material has been heated. A pattern or template can be used and scratched or drawn onto the surface prior to heating. The material is then placed in a water bath at a temperature recommended by the manufacturer of that particular material. Most materials become pliable and are workable at a range of 150 - 165 degrees F. An electric frying pan or hydrocollator may be used; commercially available splinting pans can be purchased that have preset thermostats, which maintain a constant, consistent temperature range. A candy thermometer can be used to accurately monitor the water temperature. Too high a temperature will cause the materials to overstretch and make orthotic fabrication difficult.

Once thoroughly heated (2 - 3 minutes), the pattern can be cut from the material blank. The pattern is then dried with a towel and placed onto the surface of the affected area. The material is smoothed into place, and edges are gently flared to avoid pressure at the splint edges. The splint is then allowed to cool while gently held in place, which usually takes 2 - 3 minutes. The splint is then removed from the animal, and cooled completely by running under a faucet with cold tap water. The edges are then checked for sharp areas, and if any are present, the edge can be gently run through the hot water bath and smoothed without having to completely reheat the entire splint. Velcro loop straps are then cut and sticky-back hook Velcro is placed onto the splint in order to hold it in place. The orthotic device can also be held in place by using tailwrap or Coban wrap over the entire surface. If a wound or surgical site is present, a sterile dressing can be placed onto the affected surface prior to splint construction. The pet's owner should remove the splint and check the skin for signs of pressure after being worn for approximately one hour. The animal should be observed for signs of distress if the splint is causing discomfort. The splint can be reheated and remolded if needed several times before a new splint is warranted. The splint can be cleaned with a cool soapy cloth and rinsed, or cleansed with a cotton swab and rubbing alcohol. The splint should never be left near open heat or in an automobile on hot days, as the material can warp if exposed to heat.

Case One - A 12 month Himalayan mix cat was found with her right front leg caught in a jaw-type animal trap. The device caused a severe soft tissue injury, causing nerve damage and a resultant foot drop deformity. The nerve was damaged to the extent that a primary repair was not possible. The injury rendered the leg non-ambulatory. A large ulcer formed on the dorsal surface of the tarso-phalangeal region of the damaged lower leg, with the ulcer extending into the peritendinous fascia of the extensor mechanism. The therapist was consulted to assist with wound management by placement of the injured leg in a custom posterior splint to position the foot into dorsiflexion up to a neutral position, therefore impeding weight-bearing onto the dorsal surface. A 5 inch by 1.5 inch section of Polyflex II Light was heated to 160 degrees F and molded over the bandaged posterior leg and foot, bringing the foot into a normal weight-bearing pattern. The splint was held in place with Coban wrap. Upon regaining consciousness, the cat was able to weight bear and assume a relatively functional ambulatory status. Due to proper alignment of the foot, the dorsal surface was no longer utilized as a weight bearing surface and gradual healing of the ulcer took place.

Case Two - Cassidy is a 3 year old mixed breed dog that had been severely neglected. The dog presented with a flexion contracture of the right carpus and digits. Cassidy was referred for splinting to decrease excessive soft tissue tightness that has caused the contracture.

Over a course of 5 months, the dog was seen weekly to bimonthly for custom static progressive splinting to gradually increase dorsiflexion and decrease the flexion contractures present. Throughout the course of treatment, the foot was maintained in a constant state of low, static tension, which allowed the realignment of collagen present in the scar tissues, slowly remodeling of all soft tissues.

Case Three - Signalment: "Belle", 8-year-old female Labrador Retriever.

History: Belle was a house pet and performed as a hunting dog on weekends. On a hunting trip in November 2003, the dog appeared to be in severe pain after a retrieve. The dog had been out of sight during part of the retrieve. Therefore, it could not be determined what injury the dog had sustained.

Physical Examination: Neurological examination several days later revealed severe pain localized to the cervical spine and intermittent reluctance to bear weight on the right thoracic limb. The remainder of the neurological examination was within normal limits.

Radiographic Diagnosis: CT scan indicated partial subluxation at C5-6, a transverse body fracture of C5, and an extradural mass localized to the right side at C4-5 (Fig. 23a; Fig. 23b and Fig. 23c).

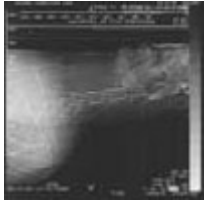


Figure 23a. Lateral view of the cervical spine. - To view this image in full size go to the IVIS website at www.ivis.org . -

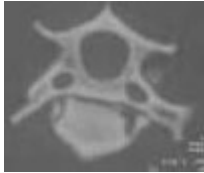


Figure 23b. Transverse view of C5. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 23c. Sagittal view of C5. - To view this image in full size go to the IVIS website at www.ivis.org . -

Treatment: Conservative treatment was chosen because the dog had minimal neurological deficits and because definitive surgical repair was unlikely. For the first week, the neck was immobilized with a soft cast and prednisone was prescribed, along with instructions to confine it in the house.

At re-evaluation at the end of the first week, the neck pain appeared to have decreased. The owner stated that the dog still occasionally "pointed" with its right thoracic limb, suggesting nerve root irritation. This sign was consistent with the extradural mass at C4-5 seen on CT scan. At this time, a cervical brace was fitted using a thermoplastic material (Synergy, Sammons Preston Rolyan Corp; 1/8 inch thickness; available at www.sammonspreston.com) and Velcro strapping (Fig 24a & Fig 24b). The owner was shown how to adjust the tightness of the brace at the neck (one finger between skin and brace), and how to take the brace on and off. Instructions to the owner included: (1) Remove the brace daily for the next 3 days in order to inspect the skin for possible abrasions caused by pressure from the brace; (2) after 3 days, remove the splint once per week to clean it (keeping the dog quiet during the brief time that the splint was removed); and (3) continue to restrict exercise and confine Belle to the house except for bathroom trips outside.



Figure 24a. A cervical brace was fitted using a thermoplastic material (Synergy, Sammons Preston Rolyan Corp; 1/8 inch thickness) and Velcro strapping. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 24b. A cervical brace was fitted using a thermoplastic material (Synergy, Sammons Preston Rolyan Corp; 1/8 inch thickness) and Velcro strapping. - To view this image in full size go to the IVIS website at www.ivis.org . -

Discussion: This particular injury was unusual, but this case represents an appropriate indication for the use of thermoplastic materials. The specific material which was chosen for this brace had sufficient rigidity to immobilize the lower cervical spine with sufficiently high rubber content to make it somewhat pliable. This allowed the panels around the thorax to be pulled apart when taking the brace on and off, and allowed precise adjusting of the fit of the brace around the neck. It would be appropriate in future cases to wean the dog off the brace by having them wear it for progressively shorter periods of time over

several weeks, and having the owner perform range of motion exercises such as holding treats at various positions in front of the dog in order to encourage movement of the head and neck in extension, flexion, lateral bending and rotation.
Follow-up: Follow-up on days 3 and 10 indicated that the brace was tolerated well. Since the owner lived several hundred miles away, the referring veterinarian radiographed the cervical spine at week 6, at which time the brace was removed. On telephone follow-up February 2004, the owner stated that the dog appeared fully recovered, and had resumed hunting 4 weeks after the brace was removed.

Case three modified from: JE Steiss, DC Sorjonen. Use of a Thermoplastic Neck Brace for Conservative Management of Fracture of the Fifth Cervical Vertebra in a Hunting Dog. American Canine Sports Medicine Association Newsletter 2004; vol.10 #1.[65]

The section on Orthotics was adapted with permission from Johnson R et al. The use of thermoplastic materials for splinting in veterinary practice. Comp Cont Edu Pract Vet 2003; 25:20-28 [58].

8. Behavior Modification Techniques for Rehabilitation

In order to provide effective and optimal rehabilitation, the therapist must be able to safely and humanely handle the patients. Companion animal patients are often in pain and being asked to undergo procedures such as hydrotherapy that may initially cause apprehension or procedures such as manual therapy for joint contracture that may cause discomfort.

A veterinarian may have learned the latest rehabilitation techniques and purchased the most sophisticated equipment known to the profession, but be unable to help a patient who is either too fearful, too painful, or too aggressive to cooperate. Clients whose dogs growl at them or are too wiggly or who run away when it is time for treatment may be unwilling or unable to comply with an otherwise well designed rehabilitation plan.

Basic principles of behavior modification and desensitization/counterconditioning are key elements to canine rehabilitation therapy. When applied correctly, behavior modification provides gentle, non-aggressive techniques for replacing negative responses with positive responses. For example, patients who are to receive hydrotherapy but are previously afraid of baths can learn to no longer fear the water or whatever it is about the bath that elicits the fear response (= desensitization). The fear response is replaced with another response (= counterconditioning) that will not impede the hydrotherapy.

Veterinarians would do well to pay attention to Ivan Pavlov, Edward Thorndike, and B. F. Skinner. Their principles of classical and operant conditioning, laws of effect, reinforcement, and schedules of reinforcement apply to the ways in which behaviors of animals as well as people can be changed.

Classical conditioning as described by physiologist Ivan Pavlov in the early 1900s provides the key to desensitizing animals to fearful or painful procedures. Pavlov discovered that dogs which salivated in the presence of food could be conditioned to salivate at the ringing of a bell. Essentially, he observed that when he rang a bell (a neutral stimulus) while presenting food (an unconditioned stimulus) to dogs who salivated (an unconditioned response to the food), the dogs continued to salivate when the bell rang even when food was not presented. Thus, after continued simultaneous presentations of the bell with food, the bell became a conditioned stimulus that would elicit salivation as a conditioned response.

The "Law of Effect" as proposed by psychologist Edward Thorndike says that individuals learn to repeat behaviors that have positive consequences. This means that if a dog who bites his therapist when his painful leg is flexed finds that the therapist stops the treatment (= a positive consequence), then the dog is more likely to bite every time the therapist begins to flex his leg. If, on the other hand, the dog finds that he gets a highly valued reward (perhaps a favorite tidbit of food) every time the therapist flexes his leg, then the dog is more likely to allow the therapist to manipulate his leg again and again. The reward (food in this example) must be of greater value than the cessation of flexion of the leg for the dog to learn to allow his leg to be flexed.

Psychologist B. F. Skinner described the importance of reinforcement for increasing the rate at which a desired behavior is repeated. He observed that regardless of what initially starts a behavior, the behavior is more likely to be repeated if it results in positive consequences. In other words, if a dog receives a valued toy when he walks on a treadmill, he is more likely to continue to walk on the treadmill.

Skinner described the powerful technique of intermittent reinforcement. This is well illustrated by people who play slot

machines. They put in a coin, pull the lever, and get some coins back. They repeat the behavior because they were positively reinforced, but the next time they get no coins back. They continue to put in more and more of their valued coins and only occasionally get coins back. In response to their intermittent rewards (also called reward on a "variable ratio schedule"), they continue the behavior. In spite of the intermittent punishment of losing their coins, they continue pulling the lever. Thus, the intermittent rewards are more powerful than the intermittent punishments.

In canine rehabilitation therapy, Skinner's principle of intermittent reinforcement means that once a dog is consistently participating appropriately in the behavior while being positively reinforced (perhaps with food, praise, petting, or play), then that positive reinforcer should be given only intermittently and on no predictable schedule. In this way, the dog is more likely to continue to repeat the described behavior that the therapist is requesting, whether it is standing in a water bath, walking on a treadmill, or lying on his side while a leg is flexed and extended.

Whenever using positive reinforcement to modify behavior, the therapist needs to give serious thought to the nature, intensity, duration, frequency, and novelty of the reinforcement:

1. Nature - avoid physically touching the dog when the goal is for the dog to respond to word commands,
2. Intensity - select the intensity needed to achieve the outcome: too little or too great will be less effective,
3. Duration - if it is too short, the animal may not be aroused enough to feel rewarded but if it is too long, the animal may habituate to it,
4. Frequency - so that the animal does not habituate to the reinforcement, it usually needs to be given often at first but subsequently unpredictably and without a normal sequence once the behavior is dependably occurring,
5. Novelty - monotones may be unrecognizable, blend in with the environment, and therefore be ignored.

When selecting a reinforcer to assist with behavior modification, the therapist needs to give serious thought to what the animal likes and dislikes. The reinforcer must be something of value. What works for one dog may be ineffective for another. It is best to have at least three positive reinforcers available during each therapy session. Begin with the reinforcer that is effective but least valued by the patient. In this way, if the dog loses interest during the session, the therapist can regain the dog's attention by going to a stronger motivator. The reinforcers can be divided into four categories:

1. Consumables - food (See case one below)
2. Activities - walks, chewing on a favorite toy, sniffing a favorite odor
3. Possessions - toys or security blanket that animal possesses but doesn't play with
4. Social reinforcement (attention) - playing together, physical contact, verbal assurances, eye contact.

To make positive reinforcements most effective, the therapist should keep in mind:

1. The reinforcer must be something the animal likes,
2. The reinforcement must be given at the moment the desired behavior occurs,
3. The dog must not get the reinforcer before the therapy sessions - for food rewards, it may be helpful for the dog to fast for 12 or more hours before the session,
4. The reinforcer must be given within 0.5 seconds (ideally) of receiving the desired behavior so that it is clear to the dog what behavior is being rewarded,
5. Food rewards must be quickly consumable - small, bite-size pieces are necessary to keep the dog's attention on the task at hand,
6. The reinforcer must **not** be given when the patient appears stressed or is exhibiting an unwanted behavior - a knowledge of how to read canine body language is helpful,
7. The dog's handler must be clear on when, how, and why to reinforce if the veterinarian is to get compliance and reliability when the dog is treated at home,
8. When done correctly, the reinforcer strengthens the bond between the handler and the dog and between the handler and the veterinarian.

By applying Pavlov's classical conditioning to canine rehabilitation, it is possible to replace a dog's fear response to a procedure with a relaxed physiological response. If, for example, a dog is physiologically relaxed when fed, he can be conditioned to respond in a relaxed manner to hydrotherapy. First, the dog is placed in an empty bath tub. If the dog shows no fear response, he is given a small amount of a food he likes. The food reward may be coupled with positive eye contact from

the handler and a few words of praise. After giving the dog a few positive reinforcements of food and praise for standing in the tub in a relaxed manner, the handler turns on a small trickle of water. If the dog shows no fear, he is positively reinforced. If he shows fear, the handler gives no reinforcements, says nothing to the dog, makes sure he does nothing to soothe the dog that could feel like a reward, and turns off the water. As soon as the fearful posture disappears, the dog is positively reinforced. Now, a little water from a cup may be put on the dog. If he shows no fear, he is positively reinforced. Then a little more water is put on him and he is positively reinforced. Gradually, the handler increases the dog's contact with water, each time rewarding the dog for a relaxed, non-fearful response and withholding rewards but not punishing the dog if he shows fear. By slow progression of positive reinforcements coupled with the contact with water, the dog will become desensitized to the water and counterconditioned to have the same physiological responses in the presence of the water as he does when he eats his favorite tidbits, hears words of praise, and/or is petted.

As with all phases of medicine, an understanding of behavior and learning will enhance the effectiveness of veterinarians and their staff. Rehabilitation therapy is by nature a therapy that requires animals to do things they don't feel like doing and to do things that may cause them discomfort. For the sake of the patients, the therapists, and the people who live and care for them, it is incumbent upon the veterinarian to make the therapy as stress-free as possible. Then treatments will have the greatest potential of being done safely and effectively. Only then will clients choose to comply with what can be long and difficult but highly successful recoveries.

Reference: Dr Caroline Schaffer, Presented at AVMA (American Veterinary Medical Association) Convention, July 2004, Philadelphia, PA, USA.

Behavior Modification: Case One -



Figure 25a. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 25b. - To view this image in full size go to the IVIS website at www.ivis.org . -

Figure 25a and 25b. Joint contracture of left thoracic limb. This cat was hit by a car. The surgeon amputated the RF & performed skin grafting of LF. She was released for rehab 3 weeks after surgery. The immobilization before and after surgery resulted in severe contracture of all joints of the left thoracic limb, with the cat bearing weight on the tips of the digits.



Figure 25c. The cat was treated as in-patient for a total of 5 days over 4 weeks. Positive reward (intermittent food & petting) was essential for sufficient patient cooperation to perform stretching 4x per day. - To view this image in full size go to the IVIS website at www.ivis.org . -



Figure 25d. 4 weeks after initiating rehabilitation, ROM of the joints of the left thoracic limb had increased enough to allow a functional gait and grooming of that limb. ROM increased 45+ degrees at the elbow. - To view this image in full size go to the IVIS website at www.ivis.org . -

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