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Hydroterapi för hund

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ABSTRACT

Hydrotherapy in canine patients is becoming increasingly more common. This literature study's objective is to gather information about this therapy method in dogs: how it works, when it is to be used, what is needed for successful aquatic therapy and how the outcome assessment can be made. 42 publications were used to gather information. The target group for the study is veterinary nurses and veterinary nursing students, especially the ones interested in working within the field of rehabilitation. The two types of hydrotherapy that are used for rehabilitation are swimming and using an underwater treadmill. Most of the effects achieved are due to properties of water, which include hydrostatic pressure, buoyancy, viscosity, surface tension and warmth. There are many different indications for using hydrotherapy but most of them are either orthopaedic or neurological. General conditioning is also possible as well as using aquatic therapy as palliative care due to its analgesic effect. To achieve the best possible results, hydrotherapy has to be tailored individually when it comes to for example the depth of the water and the length of the exercise. The patient should be monitored closely. Outcome assessment should be made in walk, trot and even gallop as long as it is safe for the patient. It is important to evaluate function even in rest. Multiple different tools can be used to aid in the outcome assessment, such as a goniometer, measuring devices and x-ray. The therapist can do the initial evaluation but the success of the treatment should always be monitored by a veterinary surgeon as well. Staff working with rehabilitation should have knowledge of all the factors affecting the hydrotherapy process for the best possible outcome. More research is required in this field of veterinary medicine for better understanding.

SAMMANFATTNING

Hydroterapi på hund blir alltmer vanligare. Arbetets syfte är att samla information om denna terapimetod på hund: hur den fungerar, när den ska användas, vad som behövs för framgångsrik hydroterapi och hur resultat kan bedömas. 42 publikationer användes för att samla information till litteraturstudien. Arbetet är inriktat för djursjukskötare och djursjukskötarstudenter, speciellt för dem som är intresserade av att arbeta inom rehabilitering. De två hydroterapimetoderna som används inom rehabilitering är simning och vattentrask. De flesta positiva effekter som fås genom hydroterapi beror på vattnets fysikaliska egenskaper såsom hydrostatiskt tryck, flytkraft, viskositet, ytspänning och värme. Många olika indikationer för hydroterapi finns men de flesta är ortopediska eller neurologiska. Utöver dessa kan även hundens uthållighet förbättras och hydroterapi kan användas som palliativ vård på grund av dess analgetika egenskaper. För bästa möjliga resultat ska hydroterapi anpassas för varje individ när det gäller till exempel vattnets djup och träningens längd. Noggrann monitorering är viktigt. Bedömning av resultat bör ske i alla gångarter om möjligt och i vila. Olika hjälpmedel – såsom en goniometer, måttband och röntgen – kan användas vid bedömning. Utöver terapeuten bör veterinären bedöma patienten. Personalen som jobbar med rehabilitering bör ha kunskap om alla faktorer som påverkar hydroterapiprocessen för bästa möjliga resultat. Mer forskning behövs för att nå bättre förståelse inom området.

TABLE OF CONTENTS

GLOSSARY

Buoyancy: the power of liquid that creates an upwards force that can make an object float, for example when the object is placed in water.

Hydrostatic pressure: the pressure caused by the liquid. More depth creates more pressure due to the weight of the liquid above.

Proprioception: the ability to identify the place and position of your own body parts. Proprioception is a part of body image and balance.

Surface tension: the tension on the water's surface that is caused by the cohesive forces between the liquid molecules. It makes the surface harder to pass through and creates elasticity.

Viscosity: describes fluids resistance to flow. The word can also be described as the liquid's thickness.

INTRODUCTION

Background

Companion animals undergoing physical therapy is becoming all the more common due to increasing demand and owner awareness (Veenman, 2006; Ciuperca & Millis, 2015). This includes hydrotherapy which also is considered being a rapidly growing business (Ciuperca & Millis, 2015). Hydrotherapy is the term used when water is used as a therapeutic mode (Levine & Millis, 1997). Aqua therapy is another name for the same thing commonly used in literature. The most commonly performed exercises in this group of therapies are swimming and walking on an underwater treadmill (Davis *et al.*, 2015). Aquatic therapy was developed to be a form of active exercise where the weight the patients supports during the session is reduced (Budsberg *et al*., 2008). A range of conditions can be treated with the help of hydrotherapy: postoperative rehabilitation for both orthopaedic and neurological conditions are common reasons but also issues related to behaviour and obesity can sometimes be eased with aquatic therapy (Prankel, 2008). According to a questionnaire study of 89 hydrotherapy centres in the United Kingdom, the most common conditions to be treated with hydrotherapy are ruptures of the cranial cruciate ligament, hip dysplasia, osteoarthritis (Waining *et al*., 2011).

Hydrotherapy can help with numerous different issues: muscle relaxation, better joint mobility and improved muscle tone can for example be provided. Swelling and stiffness can also be reduced (Brundell, 2011). The properties of water affect the patients which can at its best result in increased muscle mass, strength and endurance. Even some pain relief can be provided because the water takes some pressure off the joints, bones and muscles (Nganvongpanit & Yano, 2012). There is evidence that hydrotherapy, in some cases, may be used as a nonpharmaceutical component in a multimodal pain management approach (Corti, 2014).

Hydrotherapy provides exercise and is said to be useful even in fighting weight-related issues in dogs (Prankel, 2008). Swimming as an activity involves almost all major muscle groups and trains even the heart and lungs (Nganvongpanit & Yano, 2012). Despite this the underwater treadmill is sometimes considered to be better for fitness than swimming in canine patients (Prankel, 2008).

Further studies are required to determine hydrotherapy's effect on some conditions. More reliable literature is needed (Kirkby & Lewis, 2012). More studies are also needed of a variety of conditions to quantify the results within veterinary medicine (Tomlinson, 2012). Today research is made to determine more reliable evaluation methods for veterinary hydrotherapy. Evaluation of the effect on range of motion, heart and other cardiovascular parameters are of interest. In the human field the research concentrates to the analgesic effect of aquatic therapy for the moment. It is hoped that in time this may also increase the understanding of pain relief during hydrotherapy in animals (Prankel, 2008).

The types, indications and contraindications, working mechanism, success rate as well as evaluation methods of this form of physical therapy are of interest. The required equipment will also be studied as it is a big part of the rehabilitation process. Target group for the study is veterinary nurses and veterinary nursing students.

Objective

The objective of this literature study is to gather information of hydrotherapy in canine patients; when and how to use it as a part of the nursing process. The aim is to provide information to veterinary staff interested in working in the rehabilitation field.

Questions to be answered

- When is the use of hydrotherapy indicated and when is it contraindicated in dogs?
- What equipment is needed for successful hydrotherapy?
- How can the results of hydrotherapy be evaluated?

MATERIALS OCH METHODS

For this literature study 46 publications were found. The first search was done on Web of Science by combining the following search terms: hydrotherapy, aquatic therapy, swimming, underwater treadmill, dogs, canine, rehabilitation and physical therapy. After the search many sources were found via references of the already found publications. Peer-reviewed studies were the preferred type of reference chosen for this study. Publications with reliable references, such as some review articles and two books were also chosen due to the lack of primary sources or the inaccessibility of them. Some secondary references had to be made when the original source was unavailable.

From the 46 publications 42 were chosen to be used in the thesis. Two articles were dropped due to irrelevant content. Two articles lacked references and were therefore not seen as reliable enough. This led to discarding the publications.

LITERATURE REVIEW

Principles of hydrotherapy

Mechanism of action

Water has many properties that contribute to the effects of hydrotherapy. These include hydrostatic pressure, buoyancy, viscosity and surface tension. Together all of these result in a more effective exercise. Muscle mass, strength as well as endurance can be increased, while pain caused by movement can be decreased (Kongtawelert *et al*., 2014).

Hydrostatic pressure

Water provides hydrostatic pressure, which is enhanced as the water gets deeper. This pressure is said to cause a massaging effect and can thus improve venous return and reduce swelling (Prankel, 2008; Brundell, 2011). According to Prankel (2008) the effect is not significant in dogs as they do not stand very deep in the water and as the body adapts to pressure in some extent. Tomlinson (2012) states that hydrostatic pressure can even help dogs achieve a better posture.

Buoyancy

Buoyancy is the upward lift a fluid provides when a body is partly or fully submerged. The amount of buoyancy provided in water depends on density and volume of the body; the amount varies between individuals. For example an obese dog would experience more lift than a leaner one (Prankel, 2008). This lift decreases the pressure on weight-bearing joints, bones and muscles. This leads to pain relief to some extent (Kongtawelert *et al*., 2014). Exercise in this kind of environment enables training of muscles and the cardiovascular system while causing less strain on the different tissues (Prankel, 2008). Using flotation devices or supporting the animal in the water enhances buoyancy (Levine & Millis, 1997). Water depth and movement in water are also factors contributing to the effects of buoyancy (Gross Saunders, 2007).

Viscosity

While moving through water the resistance is increased due to the fact that water is more viscous than air (Brundell, 2011). More effort is therefore required for the movement to happen (Prankel, 2008). This can help to build up muscle strength in dogs (Brundell, 2011). Because of the increased resistance the lenght of the exercise is usually shorter than in the common land-based exercises. Besides requiring more effort while moving, the viscosity also supports the patient. This slows down a dog's movements and because of that minimizes the risk for sudden turns and serious falls (Prankel, 2008).

Surface tension

Surface tension of water is caused by water molecules adhering to each other (Prankel, 2008). This causes increased resistance of movement at the surface of water. Because of this, a weak dog may find it hard to move the limbs through the surface while being fully capable of doing it with the limb submerged. If excess energy expenditure is unwanted, thrashing above the surface should to be avoided (Tomlinson, 2012). According to Prankel (2008) the surface tension

of water is not something significant when executing hydrotherapy unless the surface is constantly broken by the dog. This is why very low water levels when using an underwater treadmill should only be used on fit and healthy animals or at least careful monitoring is required (Prankel, 2008).

Warmth

The warmth of the water causes blood vessels to dilate and therefore allows more blood to flow through the body. It is said that cell metabolism and toxin elimination is increased by this (Brundell, 2011). According to Marcellin-Little *et al*. (2015) even the lymphatic drainage is increased due to the warm temperature. The warmth makes hydrotherapy a form of heat therapy. Even this provides pain relief of some level (Flocker *et al*., 2014). For many dogs the warm pool provides relaxation (Levine & Millis, 1997).

Hydrotherapy as a form of rehabilitation

Hydrotherapy can for example be used for mobilizing joints while taking some pressure of them as well as for strengthening muscles and the cardiovascular system (Veenman, 2006). Greater strengthening of muscles can be achieved with minimal activity (Marcellin-Little *et al*., 2015). The decreased pressure on tissues allows also earlier weight bearing of weak limbs for instance after orthopaedic surgery and is in that sense a useful tool in rehabilitation (Connell & Monk, 2010). This applies to both walking on an underwater treadmill and swimming (Marcellin-Little *et al*., 2015). Standing assisted in water can be very comforting even for the nonambulatory patients (Marcellin-Little *et al*., 2015). Often the return of motor skills will first be noticed in water even though the animal would be nonambulatory on land (Drum, 2010). In the planning of hydrotherapy exercises the slowness of movements and the individual's attitude towards water must be taken into account (Connell & Monk, 2010). This slowness of movements allows a longer reaction time and provides more time for proper foot placement. In a best-case scenario this leads to a proper gait pattern and strengthens the dog's proprioceptive skills (Marcellin-Little *et al*., 2015). It is suggested that an animal physiotherapist or a veterinary nurse with training in hydrotherapy should be in charge of the planning process (Connell & Monk, 2010).

Swimming and walking on an underwater treadmill share many of the same characteristics but have also properties that differentiate one from another. Some conditions benefit more from swimming than walking on a underwater treadmill and vice versa (Davis *et al*., 2015). Although useful exercising methods in several cases, neither swimming nor walking on an underwater treadmill are suitable ways of training many athletic dogs when strain on bones, ligaments and cartilage is the desired outcome (Levine *et al*., 2005b).

Swimming

Swimming can be indicated in a variety of cases. It promotes the use of all limbs (Downer, 1977: see Budsberg *et al*., 2008 p. 1463). Especially forelimbs are affected by the increased work load. This may both indicate and contraindicate the use of swimming as a rehabilitation method (Davis *et al*., 2015). Even though stimulation of movement is effective while swimming, this type of exercise is often not the best choice for nonambulatory patients; it is more

useful once motor function returns. Despite this even paraparetic and paraplegic patients have the ability to exercise the core stabilizer muscles while floating (Drum, 2010).

Joint range of motion can be increased with the help of swimming exercises (Connell & Monk, 2010). Especially flexion is improved while walking on land seems to be more effective for improving extension (Davis *et al*., 2015). According to Davis *et al*. (2015) after a cruciate ligament repair the range of motion of the hip is not affected significantly by swimming when compared with walking. Swimming challenges the dog's cardiorespiratory system and also works as a balance exercise (Levine *et al*., 2005b; Davis *et al*., 2015).

Weak animals always need help from the therapist because of the strain on the cardiorespiratory system among other things (Davis *et al*., 2015). Despite of a full capacity to do so, some dogs refuse to swim at all without the trainer present (Nganvongpanit & Yano, 2012). Achieving the right gait pattern and avoiding unnecessary movements is important with patients going through rehabilitation and they should thus not be left unattended at any point (Levine & Millis, 1997; Drum, 2010). The therapist can even make the exercise more effective by stimulating a righting reflect, creating resistance or by assisting with limb movements (Davis *et al*., 2015).

According to a study by Nganvongpanit & Yano (2012) most dog owners believe that their dogs would be able to swim without training; that it is part of their natural behaviour. The results of the study showed that this was not true in numerous cases and that many dogs actually needed to be trained to swim. It would be best to introduce dogs slowly to swimming while monitoring them continuously. Signs of stress or poor use of limbs should be looked after (Connell & Monk, 2010). According to the study by Nganvongpanit & Yano (2012) 29.12% of the dogs swimming for the first time showed signs of distress. The percentage decreased significantly and steadily during the next four swimming sessions. This implies that dogs need to gain experience and become accustomed for the stress levels to decrease (Nganvongpanit & Yano, 2012). Even dogs that are accustomed to swimming in lakes, ponds and other bodies of water might need training before they are willing to swim in a restricted area like a pool. Other factors besides the water can also scare the dog, such as the stairs leading to the pool. Training should be done to reduce the dog's stress (Davis *et al*., 2015). Even if the dog can swim, it is not certain that it will like or even learn to like water. To these patients hydrotherapy is not a good choice as they may in the worst-case scenario injure themselves trying to avoid water (Levine & Millis, 1997; Gross Saunders, 2007).

Underwater treadmill

A relatively controlled exercise can be achieved by using an underwater treadmill. Movements are more controlled in comparison with swimming and it is not as easy to jump off an underwater treadmill as it is off a regular land treadmill (Davis *et al*., 2015; Marcellin-Little *et al*., 2015). It is also suggested that an underwater treadmill in some cases can be more appropriate for early rehabilitation than swimming as it places less strain on the spine and joints due to the level of control (Marcellin-Little *et al*., 2015).

While unloading the weight bearing structures, the underwater treadmill also provides gentle straining which is beneficial for building muscle mass (Connell & Monk, 2010). Dogs also get

a sensory experience when their feet are touching the floor of the treadmill. This can be utilised in the rehabilitation process (Brundell, 2011).

One of the added benefits of using an underwater treadmill is the fact that the water level can be altered (Brundell, 2011). This means that the percentage bodyweight carried by the dog can be changed according to what is appropriate in that specific situation. Deeper water carries more of the dog's weight while more shallow water leaves more of the weight to be carried by the dog (Levine *et al*., 2002: see Tomlinson, 2012 p. 624). Also the level of flexion and extension in joints can be altered together with the depth of the water. For example the extension of the pelvic limb joints is reduced when the water reaches the greater trochanter. On the other hand, lower water level allows a greater extension. This information can be used to reduce pain by reducing extension or to increase range of motion by increasing extension. It is also known that joint flexion is at its greatest when the water reaches or is slightly above the target joint. This information can also be used to tailor the exercise to fit the patient (Davis *et al*., 2015*).*

The speed of an underwater treadmill can easily be controlled. According to a publication by Davis *et al*. (2015) the typical speed for medium and large dogs is between 0.3 and 0.5 m/s. For smaller breeds the writers suggest a speed varying between 0.2-0.3 m/s. The article states that Daschshunds typically require a bit lower speeds than other small dogs, varying between 0.18 and 0.25 m/s in the beginning of the rehabilitation. A slower speed encourages weight bearing and hip extension while a faster speed is more effective in challenging the muscles and the cardiovascular system. Often a slower speed is used during the first session so that the dog gets to adapt to a new situation (Davis *et al*., 2015).

Starting hydrotherapy

When hydrotherapy is used in postoperative rehabilitation, the starting date must be adjusted appropriately in relation to when surgery was performed. The performed surgery, the surgeon's preference as well as the individual are factors to be considered (Drum, 2010; Tomlinson, 2012). According to Drum (2010), aquatic therapy can in some cases be started as early as three to five days postoperatively while Connell and Monk (2010) imply that starting hydrotherapy 14 days postoperatively is relatively early but possible with some surgeries. The one thing that affects the starting day greatly is the wound: it should be sealed before starting aquatic therapy (Connell & Monk, 2010).

Length of the exercise

No perfect duration of time for hydrotherapy has been found as it varies much between individuals but certain guidelines have been introduced in literature (Davis *et al*., 2015). Aquatic therapy should be started carefully as it demands more effort during movements than training on land (Prankel, 2008). According to a study by Chuatrakoon *et al*. (2011) the size of the dog affects greatly to the recommended time of swimming. In the conclusions of the study 15 to 30 minutes are set as the maximum limit for hydrotherapy (Chuatrakoon *et al*., 2011). It is important to remember that animals need to be introduced to swimming gradually and that even a five-minute-long hydrotherapy session can be extremely straining for many dogs. Increasing the length of the sessions and the amount of work should happen as the patient

improves (Gross Saunders, 2007; Connell & Monk, 2010). Initially, multiple short sessions are preferred over one long session as the endurance of the dog can be compromised in the beginning of rehabilitation process (Drum, 2010). Both Levine and Millis (1997) and Drum (2010) suggest starting aquatic therapy with short, one to three minutes long bursts and increasing the length as the dog adapts to the exercise. Rest periods between the exercising periods are also of great importance (Drum, 2010).

Factors to be considered

In many conditions some analgesic medication is indicated even during hydrotherapy. It is important that the therapist is informed about it beforehand as it can hide mild clinical signs. Getting information of the possibly affecting factors makes the therapist's work and outcome assessment easier (Prankel, 2008).

Patients should never be left unattended during either of the forms of hydrotherapy to prevent drowning and to monitor and help with movements. Some rehabilitation patients, for example many neurological patients, are not able to control their movements and balance and this add up to the need of supervision (Drum, 2010). Exhaustion and hyperthermia can also be prevented by close monitoring (Clark & McLaughlin, 2001: see Budsberg *et al*., 2008 p. 1463). Encouraging the correct limb movements is an important job of the therapist and cannot be done without constant supervision (Tomlinson, 2012).

After a hydrotherapy session a short, approximately ten-minute-long warm-down period is recommended by Levine and Millis (1997). This could include things such as walking at a calmer pace, doing range of motion exercises and using cryotherapy on the painful areas. Massage is also an option that can be considered (Levine & Millis, 1997).

Also the safety of the handler needs to be considered. The therapist might get injured if the appropriate precautions are not taken. This may rule out dogs that are extremely unwilling to go into the water (Levine & Millis, 1997).

Indications

Restoring, maintaining and promoting optimal function are important goals of physiotherapy – and therefore of aquatic therapy – and so is improving wellbeing and quality of life. Preventing the onset, clinical signs and progression of disorders and functional limitations are included in these aims. Multiple things from diseases to injuries may cause these disorders (Levine *et al*., 2005a). Polytrauma patients are not uncommon either (Davidson *et al*., 2005). Neurologic and orthopaedic issues are often the reason for the need to rehabilitate a dog. Especially active dogs, such as hunting dogs, are common patients. (Levine *et al*., 2005a).

Besides knowing the theoretical part, experience is important when planning rehabilitation, including hydrotherapy, of a veterinary patient. Judgement of the therapist is a big part of the planning process (Davidson *et al*., 2005). Despite the multiple indications for aquatic therapy, more research in this area is in demand (Kirkby & Lewis, 2012).

Orthopaedic conditions

Preoperative conditioning and postoperative rehabilitation

Hydrotherapy can in many cases be used as a method to optimize recovery after an orthopaedic operation, such as a repair of the cranial cruciate ligament or a surgery of a dog with osteochondritis (Veenman, 2006; Tomlinson, 2012; Henderson *et al*., 2015). A study by Baumhardt *et al*. (2012) indicates that immediate postoperative physiotherapy – including hydrotherapy – had a positive impact on regaining function after an extracapsular knee stabilization procedure. In the study other rehabilitation methods were also used simultaneously with underwater treadmill therapy so the effect of mere hydrotherapy is uncertain. Baumhardt *et al*. (2012) also states that further studies are required in this field of veterinary medicine. Aquatic therapy can also be used for conditioning before an operation, for example before a hip replacement (Prankel, 2008). The incision must have been healed before starting postoperative hydrotherapy. Even patients with external fixator are said to be able to benefit from hydrotherapy once the wounds have been healed (Davidson *et al*., 2005).

Proprioception and joint flexion are some of the benefits of postoperative therapy that includes walking on an underwater treadmill. To flex and extend the operated limb fully in the early postoperative period is something many patients can be unwilling to do (Davidson *et al*., 2005). Compared to only getting walking exercise, greater range of motion of the stifle joint has been noted in dogs receiving postoperative hydrotherapy after a ligament repair (Comerford *et al*., 2013). It is though mentioned in a publication by Davidson *et al*. (2005) that while being an exercise for conditioning, swimming does not promote hip extension. Proprioceptive training may even prevent future injuries as it improves body awareness and coordination (Doyle *et al*., 2015). Besides injuries also certain chronic diseases, such as osteochondritis dissecans, can sometimes benefit from surgical treatment and hydrotherapy following it. In these cases aquatic therapy can also often be used as a long-term management method (Davidson *et al*., 2005). In addition walking on an underwater treadmill is an effective way of building up the muscles that need it postoperatively (Doyle *et al*., 2015). According to Davidson *et al*. (2005) swimming may be too straining in the early postoperative phase; walking on an underwater treadmill is suggested to be a better choice at that point.

Chronic conditions

Hydrotherapy is also used in managing chronic conditions, such as developmental orthopaedic diseases (Tomlinson, 2012). These include for example hip dysplasia and osteoarthritis (Levine *et al*., 2005a; Tomlinson, 2012). Especially dogs suffering from degenerative joint diseases combined with obesity can benefit from aquatic therapy (Veenman, 2006). Adequate weight loss can for example significantly reduce lameness in dogs with osteoarthritis due to reduced load on joints (Brundell, 2011). Similar results have been seen in dogs with hip dysplasia (Davidson *et al*., 2005).

Managing chronic conditions includes managing pain, regaining and maintaining function and range of motion (Davidson *et al*., 2005). During their time in water the patients can use their limbs more freely through the whole range of motion of the joints (Brundell, 2011). Low impact

exercise, such as the techniques used in hydrotherapy, has been found to relieve pain and increase function in geriatric dogs with osteoarthritis. When performed regularly, this type of exercise also helps in gaining muscle mass which also contributes to increased function of the limbs (Davidson *et al*., 2005). In the rehabilitation process balance is important as overusing joints that suffer from a disease often worsens the condition and the clinical signs (Brundell, 2011). Often pain relieving medicine and other rehabilitation methods besides hydrotherapy are also needed (Davidson *et al*., 2005).

Swimming twice a week for eight weeks has been noticed to improve lameness, joint mobility, weight-bearing and overall score in osteoarthritic dogs (Kongtawelert *et al*., 2014). Levine and Millis (1997) even state that swimming is one of the best activities for these dogs. Besides visiting an animal hospital or a rehabilitating centre, also clean outside waters are choices to be considered when the climate allows it (Levine & Millis, 1997). More well-designed studies of exercises impact on osteoarthritis in dogs are needed (Henderson *et al*., 2015).

Muscle disorders are also chronic orthopaedic impairments occurring in dogs. Examples of these are for instance degenerative myelopathy and fibrotic myelopathy. These can also often be improved with physiotherapy including aquatic therapy (Levine *et al*., 2005a).

Trauma

Hydrotherapy can be used as a part of the rehabilitation process for trauma patients suffering from for example fractures. In these cases the aim is to restore function after the fracture has healed (Gross Saunders, 2007). Building up muscle mass and increasing range of motion are the major goals (Henderson *et al*., 2015). Henderson *et al*. (2015) suggests using a hot pack on the affected area before exercise to increase the extensibility of the muscle. It is worth remembering that the limb has probably been immobilized for several weeks before starting the physical therapy and exercising should therefore be started cautiously. Vigorous movements should be avoided until bone union can be seen on radiography. It is very individual when hydrotherapy can be started after a bone fracture. The type and location of the fracture impacts the healing rate greatly (Henderson *et al*., 2015).

If the fracture has been repaired surgically, the same guidelines apply as in any case where postoperative hydrotherapy is used; the incision has to be healed and intravenous catheters taken out before starting the therapy. These include patients with external fixators as the fixator itself does not contraindicate the use of hydrotherapy (Davidson *et al*., 2005).

Several muscle injuries can be rehabilitated using hydrotherapy as a part of the process. These include sprains, strains as well as conditions such as fibrotic myopathy (Gross Saunders, 2007; Henderson *et al*., 2015). Strengthening the muscle and increasing the range of motion of possibly incorporated joints is of importance. It is crucial to rest and restrict exercise before gradually starting the physical therapy. Often it is best to start training with light exercises such as slow leash walks and passive range of motion exercises and then, as a little bit more strength is gained, move on to hydrotherapy (Henderson *et al*., 2015).

Also tendon and ligament injuries, for instance rupture of the cranial cruciate ligament, occur in dogs (Comerford *et al*., 2013; Henderson *et al*., 2015). Same cautiousness as with muscle injuries should be applied to tendon and ligament trauma: activity should be restricted for an appropriate amount of time before moving on to calm exercises, such as slow leash walks and weight-shifting exercises. Then, only when the strength has improved enough, can hydrotherapy be started (Henderson *et al*., 2015).

Although having the possibility to surgically treat the rupture of the cranial cruciate ligament, conservative management is still the most popular choice in small dogs (Comerford *et al*., 2013). A questionnaire study examining conservative treatment of this impairment in the United Kingdom was made by Comeford *et al*. (2013). Out of 113 responses from veterinarians only 15,5% would have chosen immediate surgical management for a small dog (<15 kg). The individual factors considered crucial were severity and duration of lameness and the age of the patient. Of the respondents, 53,6% recommended hydrotherapy as a form of rehabilitation for these patients (Comerford *et al*., 2013). The study examined only the treatment of small dogs and thus cannot be applied to bigger breeds.

Neurological conditions

Neurological patients are often quite severe cases. They may experience difficulties trying to move limbs or change their body position. Even basic bodily functions such as urinating and defecating may be troublesome to these patients. This is also why treating these animals often requires broad multimodal therapy instead of just physiotherapy. While not being the only treatment, aquatic therapy can be a helpful addition for treating dogs experiencing neurological problems. Standing assisted in water is a comfortable stance even for the nonambulatory patients. Hydrotherapy is also known to trigger limb movements earlier in the rehabilitation process than just exercising on dry land (Marcellin-Little *et al*., 2015).

Neurological impairments

There are numerous different neurological impairments that occur in dogs. Some conditions may even make the dog completely nonambulatory. Starting rehabilitating early in the recovery process is important for these patients (Drum, 2010). According to Drum (2010) the appropriate time for starting is within the first two weeks of the recovery period. This has at least been shown to improve motor function in people suffering from spinal cord injury. The early rehabilitation period is also known as the acute phase of rehabilitation. The goal for nonambulatory patients during this phase is to get the patient to concentrate on basic functional tasks and maintaining musculoskeletal health. Individually tailored hydrotherapy is a possible tool in this phase (Drum, 2010).

Supported exercise in the form of hydrotherapy can be helpful to dogs with spinal problems. Patients seem to experience less exhaustion in comparison with assisted exercise on dry land. The added dorsal pressure caused by the water increases dogs' proprioceptive skills. Sensory awareness of the eventual paretic limbs can also be trained due to the same mechanism (Prankel, 2008). A study on fibrocardilaginous embolism in dogs by Cizinauskas *et al*. (2003) states that

introducing physiotherapy and hydrotherapy in the early recovery period has a significant positive effect on the recovery rate. In fibrocardilaginous embolism some fibrous tissue from intervertebral discs has gotten into the spinal arteries. In the study all severely affected dogs underwent hydrotherapy for ten minutes for a minimum of twice a day. If the dog was plegic, passive limb movement exercises were done in the water. The individually planned treatments were begun within the first 24 to 48 hours after disease onset (Cizinauskas *et al*., 2003). The type of hydrotherapy was not mentioned in the study.

In some cases a specific function has to be trained for the sake of the neurological patient's recovery. A publication by Doyle *et al*. (2015) suggests that for example strengthening hock flexion is important for dogs suffering from complications after intraoperative compression of specific nerves in the hind leg. This can be done for example by walking on an underwater treadmill with the water reaching the height of the hock (Doyle *et al*., 2015).

Postoperative rehabilitation

Hydrotherapy may be indicated for postoperative rehabilitation in neurological patients (Veenman, 2006) such as after spinal surgery, in dogs with intervertebral disc disease (Veenman, 2006; Hady & Schwarz, 2015). Hady and Schwarz (2015) made a retrospective study in 113 dogs to analyse the effects of postoperative rehabilitation after this condition. Physical therapy was initiated after the surgery in the hospital and the owners got instructions to further continue the rehabilitating at home. The exercises at the hospital and home included for example neuromuscular electrical stimulation, range of motion and sling walking. Underwater treadmill therapy was started ten to 14 days postoperatively and done weekly. Additional exercises for improving power and balance were added progressively to the rehabilitation protocol. In this study the average recovery time was 16 days and an average of 40 days were spent in formal physical rehabilitation. A scoring system called the modified Frankel score (MFS) was also used to evaluate the outcome of the therapy. This is simply an evaluating scale that varies between zero and five. A higher score indicates higher motor abilities. It was found that more time in formal rehabilitation and more underwater treadmill sessions affected the dog's chances of improvement positively (Hady & Schwarz, 2015). Again, it is impossible to say which of the methods – or all together – improved the outcome.

Other indications

Conditioning

Besides treating present problems, aquatic therapy can also be used for conditioning which can prevent health issues (Gross Saunders, 2007). Hydrotherapy helps to condition the cardiovascular system, the musculoskeletal system and increase endurance (Levine *et al*., 2005b; Veenman, 2006; Prankel, 2008). For example a study of eight markedly obese dogs by Chauvet *et al*. (2011) shows that by exercising on an underwater treadmill on a regular basis the dogs could travel significantly longer distances over the course of the study. Also the median speed and duration could be increased significanty (Chauvet *et al*., 2011). It is also suggested that water-based exercises are more efficient in conditioning than land based ones (Monk, 2007: see Tomlinson 2012 p. 626). Preventative conditioning and avoiding deconditioning is especially important for competing canine athletes such as sled dogs and herding dogs (Steiss, 2002; Levine

et al., 2005b). This can decrease the risk for injuries, for example muscle disorders (Steiss, 2002). The benefits that can be gained from conditioning include lower resting heart rate and blood pressure, increased stroke volume as well as stiffer cartilage and ligament and stronger bones, muscles and tendons. This is something hydrotherapy can provide (Levine *et al*., 2005b).

In addition weight-related issues can often be managed with hydrotherapy (Prankel, 2008). Physical activity, such as swimming or walking on an underwater treadmill, can contribute to negative energy balance and improve the rate of weight loss. Simultaneous caloric restriction is important for the outcome. Further studies on the effect of exercise on weight loss are needed. While the effects of water buoyancy reduce energy expenditure, the resistance due to viscosity increases it. Altering the treadmill speed also allows changing the intensity of the exercise (Chauvet *et al*., 2011). The study by Chauvet *et al*. (2011) resulted also in weight loss and decreasing of the thoracic and abdominal girth in all the participating dogs. The dogs that especially benefit from weight management are ones suffering from concomitant degenerative joint disease (Veenman, 2006). According to Brundell (2011) weight loss can significantly reduce lameness in dogs with osteoarthritis. Although exercise can help with weight loss, overloading joints should be avoided particularly in osteoarthritic dogs. Hydrotherapy, specially swimming, is a form of exercise that often works with these patients as it efficiently helps to unload the joints (Levine & Millis, 1997).

Others

Other indications for hydrotherapy named in literature are for example palliative care and managing behavioural issues (Prankel, 2008). Palliative care can in aquatic therapy's case include analgesia and minimizing dysfunction in degenerative conditions (Veenman, 2006; Prankel, 2008.

Contraindications

There are times when hydrotherapy is contraindicated for dogs. Even before casual swims with the dog it would be advised to seek a veterinarian’s opinion (Prankel, 2008). Sometimes a veterinary surgeon may refer a normally contraindicated case for hydrotherapy believing the benefits are more significant than the risks. With patients like these monitoring becomes even more important than usually: the possible signs of fatigue and distress must be recognized early in order to be able to discontinue the exercise in time (Tomlinson, 2012). With hydrotherapy it is important to remember that sometimes even just a particular water level is contraindicated. For example a water level below the greater trochanter should be avoided in arthritis patients as it will provide too much resistance (Prankel, 2008). Sometimes only one of the methods – swimming or the use of an underwater treadmill – is contraindicated (Tomlinson 2012).

Orthopaedic conditions

Even though used for rehabilitation of many orthopaedic conditions, hydrotherapy should in some cases be avoided. Different joint disruptions, such as shoulder, elbow and hip luxation, can become worse if a too aggressive and uncontrolled form of exercise is used. This includes swimming. The joint should instead be healed first, which can take about one to three months. Swimming should also be avoided in some cases where the tissue will not be able to handle

much stress. An example is the mineralization of tendons where swimming after surgery should be avoided for several months to protect the tendon (Davidson *et al*., 2005). Some of the contraindications are fractures and in some cases external fixators (Connell & Monk, 2010; Brundell, 2011). Avoiding hydrotherapy when having an external fixator is due to open wounds which cause a risk of infection (Connell & Monk, 2010).

While providing some of the benefits of hydrotherapy, the hydrostatic pressure of water may also contraindicate the use of aquatic therapy for some patients. For example, the use of a jet stream can make some orthopaedic conditions worse. The dogs may experience localised pressure especially when performing tight turns and this may place unnecessary strain on convalescent joints or the spine (Prankel, 2008).

Chronic diseases

Some conditions such as uncontrolled epilepsy may in some cases contraindicate the use of hydrotherapy (Prankel, 2008; Connell & Monk, 2010). Other conditions, for example diabetes, require adjustments in medication prior to starting rehabilitation with swimming or an underwater treadmill. It has also been noticed that sometimes hydrotherapy can be very challenging for severely affected dogs with cervical myelopathies. These patients are more commonly known as wobblers as they are suffering from ataxia. These dogs may easily lose their balance and this may make aquatic therapy an unsuitable form of rehabilitation for these patients (Prankel, 2008). In an article by Ciuperca and Millis (2015) it is also discussed that physical therapy, which can include hydrotherapy, is considered controversial in human patients with muscle dystrophy. A study by Ambrósio *et al*. (2014) has studied the condition in dogs. In the study two dogs received active physical therapy consisting of active walking exercise while the other two just maintained their active routine of daily living. The active physical therapy led to slower velocity of gait while the control dogs had a better preservation of motor function (Ambrósio *et al*., 2014).

Systemic conditions

Cardiovascular and respiratory compromise are considered as contraindications to hydrotherapy (Prankel, 2008; Connell & Monk, 2010). The hydrostatic pressure affects also the respiratory system of the dog. The pressure slightly compresses the thorax and during exercise the oxygen demand is higher. This can lead to dyspnoea and hypoxia in patients that already have trouble breathing, such as brachycephalic breeds (Prankel, 2008). Other systemic conditions that may result in avoiding the use of aquatic therapy are for example cardiac, liver and kidney diseases – especially if being untreated (Connell & Monk, 2010). It is said that the use of and underwater treadmill causes less respiratory distress than swimming and that it is the method of choice if the respiratory system is compromised (Tomlinson, 2012).

Infections

If the dog is suffering from an infection, hydrotherapy is not recommended (Connell & Monk, 2010; Brundell, 2011). An example would be an ear infection if there is a possibility for the ears to become immersed at some point (Connell & Monk, 2010). Infections of the skin and skin irritations are also contraindicating factors (Connell & Monk, 2010). Having an infected dog in

the facilities could lead to infecting other patients (Brundell, 2011).

Other contraindications

Vomiting and diarrhoea are often mentioned as contraindications for hydrotherapy (Prankel, 2008; Connell & Monk, 2010; Brundell, 2011). In human studies it has been suggested that aquatic therapy might help spreading tumour metastasis due to the increased blood and lymph flow (Curties, 2000: see Tomlinson, 2012 p. 626). It is possible that this applies also on canine patients although more research is required (Tomlinson, 2012).

Open wounds are considered as a contraindication due to a risk of infection (Connell & Monk, 2010).

Fear of water is a contraindication to hydrotherapy as it may have more negative than positive outcome (Brundell, 2011). It should though be noted that many dogs can be trained out of the fear. Many dogs find it comforting if for example while getting on an underwater treadmill the chamber is not initially closed entirely (Davis *et al*., 2015). It has been noted in rats that already four days of exposure to the pool decreased the signs of stress in the animals. One session of four minutes was used daily (Baldini *et al*., 2006a).

Aggressive behaviour of the dog can sometimes be a problem. Handling these kinds of patients can be challenging, especially in the water. The safety of the therapist, owner and dog should never be compromised. Many times it is safe to stand on the side of the pool or to use an underwater treadmill instead of swimming. It should still be kept in mind that a fearful or aggressive animal may among other things get overly stressed, swallow too much water and develop fatigue. Pain may worsen aggressive behaviour (Tomlinson, 2012).

Equipment

Underwater treadmill

An underwater treadmill often occupies less space than a swimming pool and the temperature of the water can be changed faster. An underwater treadmill consists of more moving parts than a swimming pool and is therefore more prone to mechanical problems (Prankel, 2008). The limb movement is easier to evaluate than when using a swimming pool because of the glass walls allowing visualization of the dog from the side (Prankel, 2008). Patients should be able to get on and off the treadmill easily: ramps are usually being used for this (Prankel, 2008; Davis *et al*., 2015). Sometimes the whole treadmill is at floor level. Steps are not recommended as they can be troublesome for many patients (Davis *et al*., 2015).

Swimming pool

In addition to the pool itself most pools contain steps to enter the pool. They can also act as a rest station or as a surface for the therapist to stand on and possibly perform other exercises when the dog is taking a pause from swimming (Davis *et al*., 2015). Frequent breaks are recommended to avoid exhaustion and overheating. The ramp should lead down into the water. The pool should be be designed such that it allows the dog being removed quickly from the

water if needed (Prankel, 2008).

The water

Depth

When using an underwater treadmill the depth of the water is easy to alter (Prankel, 2008). Adjusting the depth is basically adjusting the amount of weight the patient is carrying by itself; when the water reaches the level of the greater trochanter, the weight the dog is carrying is reduced by over 50%. A water level up to the midthorax promotes walking while deeper water encourages swimming (Hodges & Palmer, 1993: see Budsberg *et al*., 2008 p. 1463). Different motor skills can also be trained by adjusting the depth of the water (Doyle *et al*., 2015).

Temperature

The recommended temperature of the water varies in the literature. In the literature used for this study the recommended temperature was always around 30 ºC: for example a temperature between 26-30 ºC is suggested in a book chapter by Sharp (2008), while the paper by Gross Saunders (2007) mentions a temperature between 25 and 27 ºC. Prankel (2008) states that the temperature should be kept at about 30 ºC. It was noted in a study by Boonchai *et al*. (2014) that toy breed dogs swimming in 25 ºC water had higher heart rate and serum glucose levels than dogs swimming in 33 ºC or 37 ºC water. Meanwhile the respiratory rate was highest in dogs swimming in 37 ºC water. 33 ºC is recommended to prevent tachycardia, hyperventilation and hyperthermia. (Boonchai *et al*., 2014).

Chlorine

Chlorinating the water used during hydrotherapy can cause problems. A study by Ngan-vongpanit & Yano (2012) showed the following side effects in dogs that were swimming in a chlorinated pool: dry fur and skin, abrasion wounds at the armpit, red eye, otitis and even a small amount of respiratory issues. In the study, the incidence of side effects increased when the frequency of swimming was greater. A total of 412 dogs were evaluated in the study. If chlorinated water is used, the owners should be informed about the possible side effects (Ngan-vongpanit & Yano, 2012).

Additional aids

Additional aids can be used during hydrotherapy as a safety measure, motivation or to increase the effectivity of the exercise (Gross Saunders, 2007; Prankel, 2008; Davis *et al*., 2015). For example buoyancy can be enhanced with the help of a flotation device whereas toys can encourage a wider range of motion and to increased turning in the swimming pool (Levine & Millis, 1997; Prankel, 2008). It is recommended to attach a flotation device on the patient – such as a life vest – when in water, especially when exercising in a swimming pool (Gross Saunders, 2007; Davis *et al*., 2015).

Outcome assessment

The outcome of the physical rehabilitation should be evaluated in walk, trot and gallop as long as it is safe for the patient (Levine *et al*., 2005a). Sometimes function during therapeutic exercises, such as cavaletti walking and change of position from sitting to standing, is included

in the assessment (Ciuperca & Millis, 2015). Function at rest should also be evaluated, for example by studying posture and balance (Levine *et al*., 2005a). Some of the quite objective measures include the range of motion, degree of lameness, state of cardiovascular fitness and the amount of muscle mass.

Many tools can be used to make the assessment more objective (Prankel, 2008). In a study by Baumhardt *et al*. (2012) tools such as a goniometer, measuring devices and x-ray were used. Physiological variables such as the dog's heart rate can also be used to evaluate the treatment (Levine *et al*., 2005a). Even a protocol can be used to help in evaluating the recovery of function (Baldini *et al*., 2006b). In addition subjective observations should be taken into account, such as assessment of everyday function done by the owner. The therapist can initially do the outcome assessment, but the success of the treatment should always be monitored by a veterinarian (Prankel, 2008). Monitoring should be performed regularly (Budsberg *et al*., 2008).

DISCUSSION

Materials and methods

This thesis was executed as a literature study, which caused its challenges during the process. The number of studies performed in the veterinary rehabilitation field is not as great as among a variety of other subjects. This led to using publications from veterinary nursing journals in addition to the scientific, peer-reviewed articles and studies. A couple of articles were even discarded from the final references due to lack of reliability which led to even fewer usable sources. Many authors of the texts used for this study – such as Kirkby and Lewis (2012), Tomlinson (2012) and Davis *et al*. (2015) – reflect on the lack of research. Information on hydrotherapy is specifically limited. Some of the information from studies done on other physical therapy methods can probably, to some extent be applied to hydrotherapy. Doing studies on animals' health is not simple because it is unethical for example to not treat a control group of a study just for the study's sake. This may be one of the factors complicating research in this field. During the research process for this text it became clear that undoubtedly most of the publications originate from the United Kingdom or the United States. Only little information can be found specifically about Sweden or many other countries and it is possible that the recommendations are not applicable to the situation in other countries.

Results

The two types of hydrotherapy methods discussed in the literature used for this study are swimming and using an underwater treadmill. The publications tend to concentrate on the activities happening in a clinical environment while possible benefits and disadvantages of these exercises in more uncontrolled settings are less studied. This probably depends on the fact that studies are easier to perform when as many factors as possible can be controlled by the researchers, and the outcome is easier to evaluate. This makes is difficult to say how for example swimming in daily life affects a dog in a more long-term perspective.

Mechanism of action

A significant part of the effects of hydrotherapy seem to be due to the properties of water: hydrostatic pressure, buoyancy, viscosity, surface tension and even the warmth of the water (Prankel, 2008; Brundell, 2011). This gives hydrotherapy properties that cannot be imitated with land-based exercises. It also sets some restrictions; hydrotherapy cannot for example be used immediately postoperatively if there is a risk of the incision to submerge at any point (Connell & Monk, 2010). Some of the effects of hydrotherapy derive from the actual exercise and because of that may provide benefits such as weight loss and conditioning (Gross Saunders, 2007; Chauvet *et al*., 2011).

Indications and contraindications

Two main groups of indications for hydrotherapy can generally be identified in the literature: orthopaedic and neurological conditions. The main goals appear to be maintaining and restoring function postoperatively or after trauma, but hydrotherapy can also be utilized for instance for preoperative conditioning (Levine *et al*., 2005a; Prankel, 2008). The conditioning use of aquatic therapy seems also widely discussed, especially in view of preventive use or weight loss (Steiss, 2002; Gross Saunders, 2007; Prankel, 2008). Hydrotherapy as palliative care is also suggested by some authors as the therapy form provides analgesia of some degree and can even help minimizing dysfunction in degenerative conditions (Veenman, 2006; Prankel, 2008). Treating behavioural issues is also brought up though it is not mentioned in which way aquatic therapy can help with these kinds of problems (Prankel, 2008). Diarrhoea and vomiting are mentioned as contraindications but the reason is not given in the publications that were used (Prankel, 2008; Connell & Monk, 2010; Brundell, 2011). This could be due to hygiene causes. It is considered controversial to use physical therapy on humans with muscle dystrophy (Ciuperca and Millis, 2015). Similarly, the study in dogs with this condition indicated that physical therapy might not be beneficial (Ambrósio *et al*., 2014). While the study was very small with only four dogs and the physical therapy did not include hydrotherapy but consisted of active walking exercises, it might be something to keep in mind when treating these patients.

In some of the publications it is not defined which method of hydrotherapy that was used or suggested for rehabilitation. This is quite peculiar as the two methods have different mechanisms of action and thus affect the patient in diverse ways. This applies especially to neurological conditions where function, such as walking, has to be retrained as it is suggested that for example swimming and overground stepping are task-specific (Angeli *et al*., 2009). The study was done on rats but could potentially be adapted to dogs. This would mean that only by swimming the walking motion cannot be completely recovered and therefore specifying the method seems important.

In many studies more than one rehabilitation method was used concomitantly in the same patient which takes the focus from a specific method and transfers it to the entirety.

Requirements for successful hydrotherapy

The effect of the therapy can be controlled by altering the level of water (Budsberg *et al*., 2008; Prankel, 2008; Doyle *et al*., 2015). Altering the depth is easier if using an underwater treadmill.

For some conditions it is good to have as little stress on the joints as possible and this is easier to fulfil by using swimming. Regarding the recommended temperature of the water, the studied literature is quite uniform and (usually/always/often?) suggests a temperature near 30 °C.

In a study by Nganvongpanit and Yano (2012) it is mentioned that many dogs need to be trained to swim while owners tend to believe that animals can do it naturally. The effect of training could also be seen in a study done with rats by Baldini *et al*. (2006a): the rats that were accustomed to swimming prior to spinal surgery inflicting spinal damage, scored better when the improvement of function was measured. The results of this study could most likely be applied on dogs. The study by Nganvongpanit and Yano (2012) showed also a variety of side effect when dogs are in contact with chlorinated water, including dry fur and skin. It is hard to say to which extent this is significant in Sweden as statistics for the substances used in the water for hydrotherapy for dogs does not seem to exist.

Evaluating the outcome

Outcome assessment of just one method turned out to be fairly complicated as most of the studies evaluated more than one rehabilitation technique at a time. This made it impossible to say which of the used methods caused the results or if it was the combination of the different methods. The study done on rats by Angeli *et al*. (2009) suggested that multimodal physical therapy is often needed, at least in the case of a spinal cord injury, as functions can be task-specific and because of that different exercises are required for as many functions as possible to recover.

CONCLUSIONS

There are several indications for using hydrotherapy as a part of the rehabilitation process of a dog. It can be a way to regain function postoperatively and even to strengthen the tissues preoperatively. Patients that have injuries affecting the musculoskeletal system, for example muscle injuries and healed fractures, can often be helped with hydrotherapy because it strengthens the different tissues. Aquatic therapy can oftentimes help neurological patients, such as dogs with different spinal problems, to regain function. Hydrotherapy can also be used to condition dogs or as palliative care due to its slight analgesic effect. Multimodal rehabilitation seems to be the key in rehabilitation in many cases to strengthen as many functions as effectively as possible. Contraindications include orthopaedic ones such as joint disruptions and unhealed fractures. Some chronic diseases can also act as contraindications. These include uncontrolled epilepsy and ataxia. Diabetes patients often need to a change in their medication routine if hydrotherapy is used. Aquatic therapy is considered controversial for dogs suffering from muscle dystrophy. Other contraindications include cardiovascular and respiratory problems, infektions, diarrhea, vomiting and fear of water.

The equipment that is needed is a swimming pool or an underwater treadmill. The temperature of the water needs to be at around 30 °C. On the underwater treadmill the depth should be adjusted to suit the needs of every individual. Other equipment that may be used are flotation devices for safety and to enhance buoyancy and toys for motivation. Equipment and

environment have to be appropriate to achieve best possible results. Therefore, the equipment should be given a lot of thought when being purchased.

Regular monitoring is important for the outcome assessment. If possible, evaluation should always be made in walk, trot and gallop as well as in rest. Specific functions may also be included in the outcome assessment. Devices such as a goniometer, a measuring tape and x-ray can be used during the evaluation. Sometimes even more subjective sources of information can be used, for example the owner can tell about his observations. The outcome assessment varies from patient to patient.

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