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The Effects of an Underwater Treadmill Physical Therapy Program on Two Dogs with Osteoarthritis

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Appendix D - UNIVERSITY HONORS PROGRAM
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PROJECT TITLE: The Effects of an Underwater Treadmill Physical Therapy Program on Two Dogs with Osteoarthritis

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

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The Effects of an Underwater Treadmill Exercise Program on Two Dogs with Osteoarthritis

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ABSTRACT: This study attempts to determine the effects of exercise on increasing the mobility and activity in two dogs affected with osteoarthritis of the hip joints. In this study, an underwater treadmill was used for exercise twice a day, five days a week, for a period of approximately eight weeks. The changes in mobility and activity were evaluated via pedometer measurements, force plate analysis, range of motion measurements, percent body fat measurements, lameness scores, video kinematics, and owner evaluation. Following the exercise program, significant improvement was noted in the owner evaluations and lameness scores, but a negative progression was revealed in percent body fat measurements. The pedometer, force plate, range of motion, and video kinematics evaluations yielded inconsistent results.

Introduction

Osteoarthritis (OA) is a very common disorder in the dog. The bone and cartilage damage of osteoarthritis and the associated pain and reduced joint mobility decreases the dog's activity level and its quality of life. Physical therapy is new to veterinary medicine and is being investigated for its potential as a treatment for osteoarthritis. A major physical therapy modality, controlled exercise, aids the patient by reducing stress in the joints and promoting more normal physiological function of the affected joint tissues. Traditional treatments for osteoarthritis in animal patients have focused on anti-inflammatory medication and/or surgery. Through a more natural process, exercise therapy benefits the arthritic patient by increasing strength and endurance, decreasing body fat, increasing range of joint motion, and stimulating better joint tissue repair. All of these beneficial effects promote an increased level of activity and an increased quality of life in the patient.

The two dogs in this study exercised for a period of approximately eight weeks. The effects of the underwater treadmill exercise program on the dogs after this period of time were hypothesized to be as follows: the patients' physical activity will increase, their percentage of body fat will decrease, and their percentage of body weight placed on the affected limbs will increase. The degree of observed lameness was hypothesized to decrease and the range of motion of the affected joints was expected to increase. It was also hypothesized that the combination of these factors would contribute to improved performance in functional ability, which would be revealed in the video kinematics and owner evaluation.

Osteoarthritis

The Disease

OA, also known as degenerative joint disease, is a highly prevalent disorder among dogs. A survey of 200 veterinarians in 1996 conducted by Pfizer Animal Health proprietary market research estimated that osteoarthritis affects as much as 20% of the canine population over 1 year of age (Johnston, *Veterinary Clinics* 1997). While the cause of the disease is unknown, much is known concerning the clinical signs of osteoarthritis. It has been described as a joint disorder involving cartilage deterioration, bone deformation, changes in tissues surrounding the joint, and low-grade inflammation (Johnston, *Veterinary Clinics* 1997). The clinical signs frequently exhibited by dogs with OA include decreased physical activity, decreased range of motion in the affected joints, weight gain due to lack of exercise and/or pain exhibited upon manipulation of the arthritic joints.

Traditional Treatments

Following diagnosis, dogs have traditionally been limited to treatments such as pharmaceuticals and surgery. Pharmaceutical treatment aims to reduce the pain and inflammation caused by the arthritis. Tissue damage in osteoarthritis causes the production of inflammatory products such as prostaglandins and leukotrienes, which are indirectly responsible for the associated pain by causing hyperalgesia. The administration of corticosteroids or non-steroidal anti-inflammatory drugs (NSAIDS), which interrupt the metabolic pathways of these products, is the predominant method of treatment for osteoarthritis (Johnston et. al., *JAVMA* 1997). However, these drugs are not ideal treatments in that they posses a variety of negative side effects including gastrointestinal disturbances and cartilage degeneration.

Surgery may be used in cases where the joint mobility is severely inhibited by the arthritis or in other cases that provide difficulties beyond the scope of anti-inflammatory medications. Surgical procedures are meant, ideally, to restore normal joint function and minimize pain by removing bone malformations like bone spurs and osteophytes. However, such procedures are very unlikely to completely correct the problematic joint.

In a study that evaluated the effects of various surgical procedures on dogs with osteoarthritis of the stifle joint, it was found that while limb use was improved in the patients, "surgical correction did not prevent progression of osteoarthritis in [the] stifles of dogs" Roy et. al., 1992). Such results suggest that surgery is by no means a cure for the disease.

Physical Therapy

The Objectives and Benefits of Physical Therapy

Physical therapy is presently being explored as an additional treatment for animals with osteoarthritis. Physical therapy, sometimes referred to as physical rehabilitation, may be described as that area of medicine which is "concerned with health promotion, with prevention of physical disabilities, and with rehabilitation of persons [or animals] disabled by pain, disease, or injury; ...through the use of physical therapeutic measures as opposed to medicines, surgery, or radiation" (Millis &Levine, 1997).

As it relates to osteoarthritis, exercise in physical therapy consists of a regimen of increased activity that is used to promote the physical fitness of the joint while alleviating the signs of the disease. The increased exercise serves to promote the development of lean muscle tissue around the joint and to decrease the patient's body weight by reducing the percentage of body fat. Improved muscle conditioning increases joint strength and decreased body weight reduces the amount of joint-borne stress during normal activities such as walking, running and jumping. Reduced stress decreases cartilage damage, allowing relief to the affected joint. This process slows the progression of osteoarthritis and reduces inflammation and the signs of edema, inflammation and pain. Consequently, the patient's range of joint motion and overall activity level increase, enhancing the patient's quality of life (Millis & Levine, 1997).

Precautions must be taken, however, in order to ensure that the chosen method of therapy does not worsen the condition instead of improving it. It was believed prior to 1980 that any type of stress would be detrimental to a joint affected by osteoarthritis, therefore patients were discouraged from exercising (Millis & Levine, 1997). Yet the very different view that "physical therapy is very helpful in animals having acute joint injury" is commonly held today (Hulse, 1998). Certainly, there is a given level of exercise which subjects the joint to unneeded stress and therefore serves to promote osteoarthritis. This is especially true if the type of exercise exposes the joint to high-impact activity (Hulse 1998). The solution, therefore, is to utilize a low-impact form of exercise that is also physically demanding enough to promote the development of muscle tissue. The underwater treadmill can provide the desired exercise. The treadmill utilizes water to provide varying degrees of buoyancy to the exercising patient. Unpublished research, previously completed by Dr. David Levine of the University of Tennessee, shows that this added buoyancy can reduce the weight borne by the legs by over 60%. This weight reduction greatly decreases the stress on the affected joints during exercise. The water also provides increased resistance to the normal walking motions of the animal, helping to facilitate muscle development. Furthermore, by controlling the speed of the treadmill, the patient's activity can be gradually increased as the patient's physical condition improves.

Materials and Methods

This study was conducted on two patients. Case one is a ten-year-old, neutered male English setter with mild osteoarthritis in both hips who exhibited a gradual decline in activity, increased weakness when climbing stairs and increased difficulty when standing from a lying position. Case two is a ten-year-old, neutered male Newfoundland with osteoarthritis in both hips who had undergone bilateral triple pelvic osteotomy as a puppy in order to treat hip dysplasia, but has become increasingly sedentary and reluctant to rise from a lying position and to climb stairs.

Both patients were exercised on the underwater treadmill with the water level high enough to submerge the greater trochanter of the femur. According to previous experimentation, a water level at this height will unload approximately 60% of the patient's total body weight. The patients were exercised twice daily, five times a week, for approximately eight weeks unless illness or other absence prevented them from doing so. Each exercise period lasted between 10 and 40 minutes, depending upon the physical ability of the patient during a particular period. Both the speed of the treadmill and the duration of each exercise period were gradually increased throughout the study. These increases were determined by the experimenters in an attempt to provide a moderately strenuous workout to the patients at each exercise period while taking into account the patients' changing level of physical fitness and stamina.

The patients' level of physical activity and the percentage of body weight placed on each limb during a trot were measured before the study began, and then at mid-study and post-study. The patients were also evaluated concerning their degree of observed lameness and the range of motion of the arthritic joints at these three times. The patient's percentage of body fat was also measured but this data was not collected at mid-study. A video recording was made at the beginning and at the end of the study to record each patient performing functional activities. These functional activities included walking, trotting, standing from a lying position and climbing stairs. In addition to these measures, an owner of each patient was asked to carefully observe their pet, reporting any changes in physical activity or mobility. The patients' level of physical activity was also measured using a pedometer, which was strapped to the patient's front leg in order to measure the number of steps taken during a given period of time. The amount of time over which the number of steps was recorded was 48 hours. Percentage of body fat was measured using a Dual Energy X-ray Absorptiometry (DEXA) Scanner. A force plate, which is a pressure sensitive plate that is flush with the surface of the floor, was used to measure the percentage of the patient's body weight that is placed on each leg.

Figure 1. Lameness Score

Orthopedic Lameness Posture (At Stance)

- 0 = Normal Stance
- 1 = Slightly Abnormal Stance (favors limb but remains on floor)
- 2 = Moderately Abnormal Stance (holds limb off floor)
- 3 = Severely Abnormal Stance (holds limb off floor)
- 4 = Not Able To Stand

Orthopedic Lameness (At Walk or Trot)

- 0 = No Lameness and Weight-Bearing on All Strides Observed
- 1 = Mild, Subtle Lameness With Partial Weight-Bearing
- 2 = Obvious Lameness With Partial Weight-Bearing
- 3 = Obvious Lameness With Intermittent Weight-Bearing
- 4 = Full Non-Weight-Bearing Lameness

Table 1.
Study Data on Case 1 (Neutered Male English Setter, 10yrs.)

Pedometer Readings (# Steps Taken)

	Trial #1	Trial #2
Pre-Study 48 hrs.	18,435	16,622
Mid--Study 48 hrs.	17,129	12,437
Post-Study 48hrs.	*	*

* data not available

Force Plate Data (% Body Weight Put on Leg)

	Left F.	Right F.	Left R.	Right R.
Day 0	110.32	113.24	68.43	69.26
Day 16	111.46	116.31	74.33	73.52
Day 39	115.65	117.57	71.06	72.06

Lameness Score

	Day 0	Day 16	Day 34
Stance:	0	0	0
Walk:	1	1	0
Trot:	1	1	0

Range of Motion (Degrees)

	L. Knee	L. Hip	R. Knee	R. Hip
Day 0				
Flex.	WNL*	45	WNL	45
Ext.	WNL	160	WNL	160
Day 16				
Flex.	27	WNL	25	WNL
Ext.	155	150	160	150
Day 34				
Flex.	30	WNL	30	WNL
Ext.	155	150	160	150

* WNL = Within Normal Limits

Dexa Scan (% Body Fat)

Day 0	27
Day 65	28

Table 2.
Study Data on Case 2 (Neutered Male Newfoundland, 10 yrs.)

Pedometer Readings (# Steps Taken)

	Trial #1	Trial #2
Pre-Study 48 hrs.	10,918	11,640
Mid–Study 48 hrs.	20,650	8,000
Post-Study 48hrs.	14,683	*

* data not available

Force Plate Data (% Body Weight Put on Leg)

	Left F.	Right F.	Left R.	Right R.
Day 0	106.68	104.08	52.13	58.16
Day 16	102.7	106.78	49.98	52.16
Day 52	107.33	105.79	45.64	50.8

Lameness Score

	Day 0	Day 16	Day 34
Stance:	1	1	0
Walk:	1	1	0
Trot:	1	1	0

Range of Motion (Degrees)

	L. Knee	L. Hip	R. Knee	R. Hip
Day 0				
Flex.	28	WNL	34	WNL
Ext.	135	90	140	100
Day 10				
Flex.	30	WNL	35	WNL
Ext.	155	120	156	120
Day 50				
Flex.	30	WNL	35	WNL
Ext.	145	130	156	110

* WNL = Within Normal Limits

Dexa Scan (% Body Fat)

Day 0	32
Day 56	35

The degree of lameness observed in the patient was subjectively scored using the lameness score method presented in Figure 1. The range of motion of the affected joints was measured using a goniometer, which measures maximum flexion and extension angles.

Results and Discussion

The original design of the study was occasionally interrupted due to various causes. The English setter (Case 1) was absent for three days due to failure by the owner to arrive with the patient. The Newfoundland (Case 2) missed several days of exercise due to a fungal infection of the rear feet as well as periodic refusal to exercise. Both patients missed approximately five exercise periods due to mechanical difficulties with the treadmill. The final data represents results for a total of 34 days of exercise for case 1 and 29 days for case 2. The final data from all measurements taken pre, mid and post-study, as well as the percentage of body fat measurements, concerning Case 1 and Case 2 are presented in Table 1 and Table 2, respectively. The final pedometer trial information is absent from the Case 1 data because this information was not submitted by the owner.

The results of the pedometer readings from both patients were unclear. The final data reveals a high degree of variability between measurements, with no clear indication of either increasing or decreasing physical activity as the study progressed. This variability can most clearly be seen when comparing the number of steps taken in trials #1 and #2 at the same point in the study. It was expected that these numbers would be similar; however, they show great variation. Also, when using the pedometer, there is no effective way to distinguish between steps taken at a walking gait and steps taken at faster speeds.

Therefore, the use of a pedometer to measure the physical activity of these patients is of questionable reliability and may not be a suitable method for use in future studies.

The final force plate data shows interesting results. The data for Case 1 reveals an increase in weight bearing in all four legs, an improvement that is consistent with our hypotheses. However, the data for Case 2 shows a slight (and probably insignificant) increase in weight bearing in the front legs, but a gradual decrease of about 7% of body weight borne in the rear legs. Knowing that Case 2 underwent surgical correction of the rear hips at an early age, it is probable that the increased exercise caused increased discomfort in the rear legs. The exercise may have also exacerbated the fungal infection of the rear feet, adding to the patient's discomfort. This information may also provide an explanation as to why this patient periodically refused to exercise during the study. While this result is contrary to our hypothesis, it provides evidence that not all dogs with arthritis can benefit from a physical therapy program with a set degree of difficulty. Further research will have to be done in order to determine which types of patients will respond favorably to programs of varying intensities.

The observed lameness in both patients improved significantly, with no lameness being shown at stance, walk or trot at the end of the study. Such a progression agrees with our hypotheses. This result may be due to increased use of the limbs during the study, which allowed the patients to grow more accustomed to any pain that was causing the initial lameness. The decrease in lameness may also be due to improved joint function and overall joint health, resulting from the use of the underwater treadmill.

The range of motion data for Case 2 showed a positive progression, especially in the increased extension of the left hip and right knee. Extension in other joints and flexion in all joints showed less-significant improvements. Case 1 showed insignificant changes in both flexion and extension of all joints. These results are inconclusive and lack a clear explanation. It is especially interesting that the joints that improved in Case 2 were a single knee and a single hip, instead of both hips (which were affected by osteoarthritis) as was hypothesized.

The percentage of body fat (as shown by the DEXA Scanner) increased at the end of the study in both patients, but only significantly so in Case 2. This result runs directly counter to our hypotheses and is difficult to explain given that the dogs' exercise levels were dramatically increased with no corresponding changes in diets. One possible explanation for such results in Case 2 is that this patient was positioned differently on the DEXA Scanner at the post-study measurement and the pre-study measurement. Such differences in positioning may have resulted in machine error in the determination of percentages of various body tissues.

The video recordings, which were used as a means of measuring any changes in the ability of each patient to perform everyday activities, showed little to no marked change in functional ability for Case 1. Case 2 did show improvement in climbing stairs during the post-study recording; however, the slope of the stairs that were climbed post-study was not as great as the slope of the stairs climbed during the pre-study recording. In addition, the post-study stairs provided better traction than the original set of stairs. Another factor of interest concerning the video kinematics evaluations is that the floors that were used by the patients to perform functional ability exercises may not have provided sufficient traction. This may have led to the compounding of any abnormalities in function already possessed by the patients.

Perhaps the most encouraging results were the comments made by the owners as the study progressed. Both dogs were reported as being much more active. Case 2 was reported to be running more and standing more, while developing the ability to stand on a tile floor without assistance. Case 1 was also reported to be running and playing more while gaining the ability to walk down steps without difficulty and to jump into the rear of a sport utility vehicle that is 34" off the ground. While these reports are somewhat subjective and not easily measured, they do provide very positive feedback in support of the treadmill therapy.

Conclusions

Overall, the study did not provide clear results as to whether or not the underwater treadmill physical therapy program was able to significantly benefit these two dogs with osteoarthritis of the hips. However, the significant decreases in the lameness scores of both dogs and the positive owner evaluations provide encouragement that the exercise program did facilitate some improvement in these patients.

It is evident that more research is needed to accurately assess the effects of such treatment; however, much was gained from the study that can be applied to further research. The questionable validity of the use of a pedometer in assessing the physical activity of a dog should negate its function as a tool to evaluate this variable in future studies. The reliability of DEXA Scanner results when dogs are positioned differently between readings will be another factor that will require further consideration. Improvements, such as a more consistent exercise schedule and a less-slippery surface when evaluating functional ability exercises, can be implemented in the future to reduce the number of variables that might alter the final results. Furthermore, an increase in patient number will be needed in future studies in order to provide a larger data set, helping to more accurately evaluate any correlation between the use of the treadmill and the outcomes in various data.

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