Aquatic Therapy for Conditioning and Treatment of Tendon and Ligament Injuries

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Aquatic therapy for rehabilitation and conditioning purposes has been available for several years. Most of the purported benefit is due to the ability to maintain or improve conditioning without unnecessarily overstressing a particular injury. The most common forms to achieve this effect are via underwater treadmill or swimming pool. Both are safe when used properly; however, devastating results may occur if used by untrained individuals or treating conditions in which these modalities are contraindicated. Proper diagnosis of the condition, having properly trained personal, acclimation of the horse, and having specific treatment protocols are necessary for optimum results to be obtained. Author's address: University of Tennessee, College of Veterinary Medicine, Department of Large Animal Clinical Science, 2407 River Drive, Knoxville, TN 37996-4545; email: sadair@utk.edu.

1. Introduction

Equine aquatic therapy primarily encompasses swimming and underwater treadmill. Whirlpools, salt water spas, and recovery pools are also examples but will not be addressed in this article. Equine swimming pools have been available for 25 to 30 years; however, prior to that, oftentimes ponds, lakes, or the ocean have been used. Many of the pools are located at tracks or barns. A few veterinary hospitals and equine rehab centers also have these pools. The main drawback of pools is the expense on construction and the costs of maintenance.

More recently, equine underwater treadmills have been developed to overcome the expense of construction and maintenance of in-ground pools. These units also provide a more controlled environment than do pools, with a decreased possibility of injury.

Benefits of Swimming and Underwater Treadmill

Swimming and underwater treadmill may provide several benefits. They primarily provide cardiovascular conditioning without the stresses on the musculoskeletal system.[1] They also provide a different type of muscle exercise because the muscles are either fully unloaded (i.e., swimming) or partially loaded (underwater treadmill). Additionally, they may work different groups of muscles than when working on land. Resistance to joint movement is also a benefit by increasing the muscle contraction required to move the joint without having excessive force placed on the bone or joint surface.

The use of swimming and the underwater treadmill in the rehabilitation of musculoskeletal injuries is becoming more common. Their use allows maintaining cardiovascular fitness, muscle tone, and improved joint movement without undue stresses occurring on the injured limb. The reason

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for the decreased stress placed on the limb is the buoyancy that the water provides. Depending on the height or depth of water, a certain amount of this depends on the amount of water in relation to the body mass of the horse. That is to say that a horse that is placed in a small area will require less water to get to the level of the point of the shoulder. Because of the reduced amount of water, there is less buoyancy and thus more weight being borne.

Mechanical Effects of Water

Buoyancy

Buoyancy is the force experienced as an up-thrust, which acts in the opposite direction to the force of gravity.[2] A body immersed in the water appears to lose weight, and the weight loss is equal to the weight of water displaced.[2] Immersion in water allows for unweighting of tendons, ligaments, bones, and joints within the distal limb.[3] There is a reduction in ground reaction forces leading to reduced concussive stresses on joints and tendons, allowing for exercise without further trauma induced by weight-bearing or concussive forces.[4] Reduced body weight decreases postoperative and convalescent complications. McClintock et al.[3] determined the weight reduction for a horse in a flotation tank filled with saline. They found approximately a 10% reduction in the weight borne by the limbs when the saline was at the level of the olecranon. When the saline was raised to the level of the tuber coxae, there was approximately a 75% reduction in weight.

Hydrostatic Pressure

Immersion causes water displacement and increased hydrostatic pressure. Hydrostatic pressure is the sum pressure exerted on all surfaces of a body immersed in water, for any given depth.[2] In humans, this can cause redistribution of blood flow from the peripheral limbs due to an isotonic fluid shift from extravascular space.[5] It can also lead to a decrease in hemoglobin and hematocrit level within 25 to 60 minutes of water immersion.[5] Hydrostatic pressure will affect lung volumes; hence, care must be taken with patients with respiratory distress or compromise.[2]

Water Viscosity

Viscosity is the resistance of a fluid to motion.[2] Viscosity of water increases as speed increases. This is due to increased turbulence and drag. This in turn increases the amount and intensity of work being preformed. The addition of hydrojets to the pool or treadmill can increase the drag on limb movement. Viscosity decreases as water temperature increases.[2] This means weaker and smaller muscles move more easily in warmer water.[2]

Density

Relative density and specific gravity of an object will depend on the composition of the object and will determine whether an object will float or sink.[2] Therefore lean animals and heavily muscled animals have a tendency to sink, and animals with a greater amount of body fat will float more easily.[2]

Physiological Effects of Aquatic Therapy

Cardiovascular and Hematological Effects

Both swimming and underwater treadmill exercise are forms of aerobic exercise and help develop cardiovascular fitness. With water immersion, there is a decrease in systemic vascular resistance, and the changes in total peripheral resistance are dependent on water temperature.[5]

After underwater treadmill exercise there is a moderate but nonsignificant increase in blood lactate and plasma creatine phosphokinase levels.[6] Hemoglobin concentration is significantly increased as a result of the physical exercise.[7] Voss et al.[7] concluded that underwater treadmill training after their training protocol represents a medium-sized aerobic work load for horses.[7]

Swimming causes a significant increase in blood pressure.[8] However, the maximum heart rate obtained while swimming is less than that obtained during ground exercise.[9,8] There appears to be no relationship between heart rate and duration of swimming.[9] There also appears to be increased cardiovascular benefits while working at slower speeds.[9,10]

Respiratory Effects

Water pressure on the horse's body during swimming prevents adequate ventilation.[10–12] Hobo et al.[10] found an increase in respiratory rate and an increase in both inspiratory and expiratory pressure, and that the expiratory time was roughly doubled the inspiratory time.[10] This suggested that a longer expiratory time may limit sudden collapse of airways by water pressure during swimming and prevent a marked decrease in air space volume, thus maintaining buoyancy.[10] There are no studies available on the effects of underwater treadmill exercise on the respiratory function in horses.

Musculoskeletal and Locomotor Effects

Walking in water at the level of the carpus or ulna resulted in a lower stride frequency and greater stride length compared with walking in water at hoof height.[13] Water provides a resistance to movement of the limb in the sagittal plane; therefore an increase in height of the flight arc may also minimize the resistance experienced in swinging the limb back and forth.[13] When moving in water between carpal and ulna height, the horse may find it easier to adopt a rounder flight arc by increasing flexion of the hip, stifle, and hock joints. Water treadmill exercise may increase activity of muscles that flex the hip, flex the stifle, and protract the hind limb.[13] Borgia et al.[14] found no effect of water treadmill training on the properties of the gluteal and

superficial digital flexor muscles and on cardiocirculatory response to a standardized exercise test. However the authors state that a more strenuous water treadmill conditioning protocol may be needed to induce a training effect in gluteal and superficial digital flexor muscle and heart rate response.[14]

Misumi et al.[15] evaluated the effects of swimming on 2-year-old Thoroughbreds in race training and found that fast-twitch, high-oxidative fibers increased. There was an increase in aerobic capacity of muscles and a decrease in fast-twitch, low-oxidative fibers. There was no change in slow-twitch fibers. They suggested that a training program including swimming training is useful for improvement in performance capacity because it can reduce locomotor diseases in young horses and allow for smooth progress in future training.[4,15]

Horses use their forelimbs to regulate their lateral balance, and their rear limbs function in propulsion.[9] The propulsive action of the rear limbs is much exaggerated. Also, during swimming, the equine back is lordotic. Because of the exaggerated rear limb action and lordotic back, horses with rear limb injuries or back pain should not swim.

There is an increased range of joint motion in both forelimbs and hind limbs, depending on water height. Joint angle in horses decreases as water approaches the carpus or hock. Once the level of the carpus or hock is reached, joint flexion and limb height will vary little. This may be used to target specific joints and aid in re-establishment of joint range of motion after joint surgery. In dogs, there is increased flexion and range of motion during swimming compared with walking in both normal and operated stifle joints after CCL surgery.[16] The increased range of motion was due to increased joint flexion. Ground treadmill walking produces greater stifle extension than swimming.[16]

Strength

Water density is 12 times greater than air.[2] During aquatic therapy there is increased resistance to limb or body movement and increased energy costs compared with walking at similar speeds on land as the result of this increased density. This provides better muscle development and muscle tone due to working against resistance and provides better balance of muscle groups working against increased resistance while maintaining a symmetrical gait.[17]

Temperature and Salinity

Cold salt water hydrotherapy has been reported to benefit several problems of the equine lower limb.[18] Conditions that may benefit from this type of therapy include tendonitis, desmitis, wounds, arthritis, synovitis, bruising, and bucked shins.[19] Additionally, the water temperature achieved by some units may aid in treatment or prevention of laminitis.[20] Cold salt water is purported to exert its effects by one or more of the following properties:[19,20]

- Water density increases with salt concentration, which in turn increases pressure to aid fluid and waste dispersal.
- Water aeration has a massaging effect on the leg and increases the dissolved oxygen content of the spa solution.
- The depth of the water is proportional to the pressure exerted on the leg, which aids fluid and waste dispersal.
- Water at temperatures below 6°C (48°F) has a higher ability to carry oxygen.

There is limited research available in the horse to either support or refute the use of cold salt water for lower-limb injuries in the horse. Much of the reported benefit is anecdotal and historical in that for many years individuals have swum, floated, or exercised in oceans and reported beneficial effects for numerous maladies.

Precautions

Safety is a paramount importance when using swimming or an underwater treadmill. It is very important that the handlers be thoroughly familiar with the equipment and must be able to read the horse's temperament. The handler should be able to anticipate and correct problems with the horse or equipment before they develop.

Swimming pools should be constructed so that two handlers can easily walk 360° around. Depth should be adequate so that the horse cannot touch the bottom. Most are 12 to 15 feet deep. The sides should be sloped to prevent injury. Some type of ramp system should be used that allows easy entry and exit from the pool. The filtration system is very important. The water becomes quickly contaminated with dirt and feces, so a good filtration system is a necessity. Most horses are good swimmers but do require training. Usually an introductory period is required, with increasing time intervals in the pool. The time is slowly increased to a period of approximately 15 minutes. Little research has been done on proper protocols. There has been a protocol described using a swimming test to determine the level of fitness a horse has achieved after conventional training. However, it is not applicable for determining swimming protocols.

There are two types of underwater treadmills, in-ground and above-ground. The in-ground type allows for a greater amount of water to be used; thus there is greater buoyancy. Both have variable speeds that range from 0 to 15 mph. This is much lower than the high-speed treadmill, which is capable of achieving speeds of 45 to 50 mph. Horses require training to this equipment also. Some may require sedation until they are familiar with the routine. Both units require filtration, and most have the ability to provide both heated and unheated water. These units are expensive, but the prices are becoming more reasonable.

Acclimation to water treadmill exercise requires a minimum of two 15-minute, nonsedated, acclimating runs.[21] Sedation can be used to prevent horses from panicking during the first exposure but thereafter does not affect the time taken to acclimate.

Water temperature should be adjusted to provide maximize comfort. For active exercise and swimming, use 65° to 75°F. For less vigorous exercise, 96° to 104°F is acceptable. The least adverse physiological effects occur at 97°F.[12]

Summary of Important Safety Considerations

1. Horses are not natural swimmers
   - May panic and attempt to jump out of the unit
   - Often cannot breathe or swim efficiently
   - Excessive lordosis may be induced, which may induce back pain or muscle soreness
   - Stifle injuries may be caused by exaggerated kicking motion

2. Reconditioning of muscles or cardiovascular or mental status before full skeletal recovery
   - Increased risk of over-eager horses that produce more forces than bones, joints, ligaments, or tendons can withstand
   - Increased risk of catastrophic musculoskeletal injuries 30 to 60 days after return to work
   - Transient osteoporosis

Monitoring

Unfortunately, most of the facilities do not monitor any parameters either during or after a session. Because of this, recommended protocols are empirical. Two easy parameters that can be measured include heart rate and blood lactate levels. Heart rate can be used to monitor the level of stresses that are being placed on the cardiovascular system. Maximum heart rate in the horse is approximately 200 bpm. By using a heart rate monitor, a target rate and a time to stay in the target range can be set. Blood lactate is used to determine if the horse has progressed into the aerobic metabolism stage. This is a desired state to achieve adequate conditioning. Respiratory rate can also be used but is not as reliable as heart rate.

Indications for Aquatic Therapy

- Rehabilitation after injury or surgery
- Tendon injuries (suspensory desmitis, etc.)
- Post-arthroscopic surgery
- Replacement for hand-walking
- Nondisplaced fractures
- Joint stiffness, osteoarthritis
- Increase in muscle development
- Encourages symmetric gait and back development
- Cardiovascular conditioning
- Reconditioning after a lay-up

Contraindications for Aquatic Therapy

- Acute joint inflammation
- Skin infections
- Open wounds
- Upper limb lameness (made worse with swimming, underwater treadmill OK)
- Back pain (made worse with swimming, underwater treadmill OK)
- Acute myositis
- Cardiovascular compromise
- Respiratory disease

Protocol Variables

The following are variables that must be considered when developing a protocol for an individual patient. Of upmost importance is the disposition of the horse. Some horses may never acclimate to aquatic therapy. In these individuals, another therapeutic plan must be developed.

- Injury and condition of patient
- Water level
  - Amount of buoyancy and limb weight-bearing
  - Degree of joint flexion desired
- Water temperature
  - Warm versus cold
- Treadmill speed
- Hydrojets: On or off (if equipped)
- Warm-up period
- Duration of exercise: 5 to 30 minutes
- Exertion during exercise
- Frequency of exercise
- Cool-down period

Sample Underwater Treadmill Protocol

The following is an example of an underwater treadmill program that is used at the University of Tennessee for a mild to moderate tendon injury. It is only begun after an ultrasound evaluation has shown significant healing has occurred and that the horse can have a significant amount of hand-walking. It is important that the horse be evaluated before each treadmill session for any increased heat or swelling of the affected tendon or ligament. It also should be evaluated weekly for change in the degree of lameness. Ultrasonography should be repeated at monthly intervals so that the rehabilitation program can be adjusted or terminated, if necessary.

Acclimation Period (1 to 2 Days)

- Walk in and walk out of underwater treadmill
- Walk in unit and add 6 inches of water, drain, and walk out to acclimate to sounds of unit filling

- Walk in, add water, turn on treadmill, stop treadmill, drain unit, walk out
- May use sedation during acclimation, if needed

Rehabilitation Program (Days 3 to 7)

- Water level at olecranon
- Speed: Walk at 2 mph
- Warm-up: 2 to 3 minutes
- Duration: 5 minutes
- Cool-down: 2 to 3 minutes
- Frequency: Once per day, 5 days per week
- Outcome measures
  - Walking comfortably for 5 minutes' duration at 2 mph
  - If successful, proceed to next level

Rehabilitation Program (Weeks 2 to 5)

Week 2

- Increase duration of walk-up to 10 minutes
- May begin lowering or raising water level
- May increase speed to 2 to 3 mph
- Frequency: Once per day, 5 days per week
- Outcome measures
  - Walking comfortably for 10 minutes' duration at 3 mph
  - If successful, proceed to next level

Week 3

- Increase duration of walk-up to 15 minutes
- Adjust water level to best address specific injury and goals
- May increase speed to 4 mph
- Frequency: Once per day, 5 days per week
- Outcome measures
  - Walking comfortably for 15 minutes' duration at 3 to 4 mph
  - If successful, proceed to next level

Week 4

- Increase duration of walk-up to 20 minutes
- Increase speed to 5 mph
- Frequency: Once per day, 5 days per week
- Outcome measures
  - Walking comfortably for 20 minutes' duration at 4 to 5 mph
  - If successful, proceed to next level

Week 5

- Maximum exercise intensity of 5 mph for 20 minutes
- May introduce cross-training activities
- Frequency: Once per day, 3 to 5 days per week
- Outcome measures
  - Walking comfortably for 20 minutes' duration at 4 to 5 mph

Warm up and cool down for each session

- At least 5 minutes each at 2 mph

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