1993

A Comprehensive Aquatics Program for Spinal Cord Injuries

Michelle T. Fugere
University of North Dakota

A COMPREHENSIVE AQUATICS PROGRAM FOR SPINAL CORD INJURIES

by

Michelle T. Fugere

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Physical Therapy

Grand Forks, North Dakota
May
1993

This Independent study, submitted by Michelle T. Fugere in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Graduate School Advisor, and Chairperson of Physical Therapy under whom the work has been done and hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)

PERMISSION

Title A Comprehensive Aquatics Program for Spinal Cord Injuries

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this independent study in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the library of this University shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my independent study work or, in her absence, by the chairperson of the department or the dean of the Graduate School. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of North Dakota in any scholarly use which may be made of any material in my independent study.

Signature Michelle D. Tugre

Date April 1, 1993

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

Water provides a new challenge in the rehabilitation of those with spinal cord injuries. An aquatics program specific to the individual can give invaluable physical, psychological, and therapeutic effects. The inherent properties of water, such as its buoyancy, turbulence, and resistance, give the spinal cord injured person a new freedom of movement and an ideal environment for increasing confidence and learning skills which can be carried over to daily activities.

Spinal cord injury aquatics programs in the past have proved successful in several aspects. Goals which are attainable through an aquatics program include increasing respiratory function, range of motion, and muscle strength and improving coordination and mobility while at the same time decreasing spasticity and pain. Social benefits, such as a sense of achievement, self-respect, and self-confidence arise from the experience as the water provides the spinal cord patient with a higher functioning level which is physically and economically beneficial to the individual and ultimately to society.

A comprehensive aquatics program for spinal cord injured patients is necessary for outlining components which will enable the physical therapist to design a treatment program which will provide for the optimal independence of the patient. This program can then be tailored to the individual to meet the specific functional needs and goals of the patient.

CHAPTER I

INTRODUCTION

Approximately 11,000 new cases of spinal cord injuries occur each year from either traumatic or nontraumatic causes. Common traumatic causes are motor vehicle accidents, falls, diving accidents, or gunshot wounds. Nontraumatic causes are the result of a disease process or other pathology such as tumors, hemorrhages, or vertebral subluxations. These traumatic and nontraumatic causes may result in bruising or stretching of the cord, bleeding or swelling around the cord, pressure against the cord, or tearing of the spinal cord.[1] Therefore, the return of function is variable depending on the type and extent of injury of the spinal cord. This variability must be taken into consideration when planning an individualized treatment program for the spinal cord injury patient.

Demographics of spinal cord injuries reveal that 82% are male with almost half of the total injuries occurring in the 15 to 24 year old age group. It is estimated that for the rehabilitation of a spinal cord injury patient from initial onset to discharge from the facility, the average cost is $75,300 for a 184 day stay with complete quadriplegia and $45,400 for a 123 day stay with complete paraplegia.[1] Time must be used wisely in order to provide the patient with the best care and therapy so that he will be able to function at his maximal physical potential once discharged.

When looking at the spinal cord itself, it is composed of a bundle of nerve pathways enclosed within and protected by the vertebral column which is divided into the cervical (C), thoracic (T), lumbar (L), and sacral (S) regions. When the body receives sensory stimulation, sensory pathways of the spinal cord carry the afferent

nerve impulses produced from the stimulus from the part of the body stimulated up the spinal cord to the brain. The response of the brain is carried by motor pathways down the spinal cord, causing the muscles to react to the stimulus. When an injury occurs to the spinal cord, an interruption of the nerve pathways results so that the messages aren't able to get through or across the injured area. This results in losses or changes in sensory and/or motor functioning of the innervated area. If the spinal cord is injured in the cervical area, partial or total loss of upper extremity function as well as motor and sensory function below the level of injury occurs. This is quadriplegia. A spinal cord injury occurring at the T2 (second thoracic) level or below results in paraplegia, the paralysis of the lower extremities and the trunk, with the extent of the paralysis depending on the injury level (See Table 1, page 4). Quadriplegia and paraplegia can further be classified as complete or incomplete which is determined by the amount of damage to the spinal cord. A complete lesion means that all the nerve pathways at the injured level have been damaged, resulting in a permanent and total loss of muscle movement and sensation below the level of lesion. An incomplete lesion results in sparing of some nerve pathways, retaining some motor and/or sensory function. In an incomplete lesion, neurological recovery of muscle function or sensation may continue to occur a few years after the injury.[2] Whether a quadriplegic or paraplegic, no two spinal cord injuries are the same as they are variable in regards to the level of and extent of the injury which necessitates that the treatment program be individualized to meet each patient's specific needs and goals.

Every spinal cord injured person endures weeks and even months of rehabilitation to maximize his/her functional and physical potential. The physical therapy treatment program for the spinal cord injury person should be designed around increasing endurance, strength, mobility, balance, and coordination. This is

accomplished through a regular exercise program which may include such activities as range of motion exercises, mat classes, mobility and transfer training, breathing exercises, and therapeutic pool activities or an aquatics program. In every person comes the desire to swim, even those with physical limitations, along with the motivation to strive toward the highest level of independence possible. Water provides invaluable physical, psychologic, and therapeutic effects which the spinal cord injury person may not even be aware of as they adjust to dealing and living with their disability.

The purpose of this review is to develop a comprehensive aquatics program for spinal cord injuries which can be tailored to meet the individual needs and level of functioning to provide the patient with an alternate treatment program to assist in achieving optimal independence. Discussions in this project will begin with a brief overview of existing literature on the rehabilitation of spinal cord injury patients and lead into the properties of the water and the goals, effects, and benefits which are possible through the use of an aquatics program versus routine exercise programs. Examples of aquatic exercises which can be utilized to achieve the goals of the individual will be outlined according to the level of injury and how the patient can be progressed to his maximal potential. Finally, two clinical situations, one of a quadriplegic and the other of a paraplegic, will be described to demonstrate adjustments necessary to the tailoring of individualized programs to meet specific functional needs and goals.[1-15]

TABLE 1 Levels of Innervation[3,4,5]

Last intact spinal level	Muscles innervated	Function available
C1,C2,C3	Facial muscles	Facial movement
	Sternocleidomastoid	Cervical motion
C4	Diaphragm	Respiration
	Levator scapulae	Scapular elevation
C5	Deltoid	Shoulder abduction, flexion, horizontal abduction
	Supraspinatus	Shoulder abduction
	Infraspinatus, Teres minor	Shoulder external rotation
	Subscapularis	Shoulder internal rotation
	Pectoralis major	Shoulder horizontal adduction,internal rotation
	Biceps, Brachialis,Brachioradialis	Elbow flexion
	Supinator	Supination
C6	Coracobrachialis	Shoulder flexion, adduction
	Teres major	Shoulder adduction, extension, internal rotation
	Latissimus dorsi	Shoulder extension, adduction, internal rotation
	Serratus anterior	Scapular abduction, upward rotation
	ECRL, ECRB	Wrist extension
	Pronator teres	Pronation
C7	Triceps	Elbow extension
	Flexor carpi radialis	Wrist flexion
	Extensor pollicis longus & brevis	Thumb extension
	Extensor digitorum	Finger extension
	Flexor digitorum	Finger flexion (weak)
C8, T1	Flexor digitorum	Finger flexion
	Flexor carpi ulnaris	Wrist flexion
	Flexor pollicis longus & brevis	Thumb flexion
	Finger intrinsics	Fine hand movements
T1 & below	Erector spinae	Trunk extension, trunk control

T4 to T6	Top half of intercostals	Respiration
T8 & below	Abdominals	Trunk flexion, trunk control
T9 to T12	All intercostals	Respiration, trunk control
T12	Quadratus lumborum	Pelvic elevation
L2	Iliopsoas	Hip flexion
	Sartorius	Hip flexion, abduction, external rotation
	Quadriceps	Knee extension
	Adductors	Hip adduction
	Gracilis	Hip adduction
L3	Obturator externus	Hip external rotation
L4, L5	Gluteus minimus, TFL	Hip internal rotation, abduction
	Gluteus medius	Hip abduction
	Gemelli, Obturator internus	Hip external rotation
	Tibialis anterior	Dorsiflexion, inversion
	Tibialis posterior	Inversion
L5	Hamstrings	Knee flexion, hip extension
	Gluteus maximus	Hip extension
	Peronei	Eversion
S1	Gastrocnemius, Soleus	Plantarflexion

CHAPTER II

REVIEW OF LITERATURE

Review of the literature on the rehabilitation of spinal cord injuries abounds with information on the physical and physiological management of the spinal cord injury. Exercise programs for improving mobility status, strength, and endurance are also abundant. Tetraplegia and Paraplegia by Bromley, for example, provides thorough and complete details of how the physical therapist can help facilitate the patient in learning transfers of all kinds, wheelchair mobility, sitting activities, rolling, positional changes (like supine to sitting), weight shifting, and gait training, when appropriate.[6] O'Sullivan and Schmitz in Physical Rehabilitation: Assessment and Treatment also outline a physical therapy treatment program for the spinal cord injury patient, like Bromley, the focus of this treatment program is with mat activities and exercise.[3] While this is a necessary part of the spinal cord injury rehabilitation process, it can be taken one step further to also include an aquatics program.

Information on aquatics programs for the rehabilitation of spinal cord injury patients outlining different techniques which can be implemented are sparse. Medical facilities working with spinal cord injuries may have a policy on an aquatics program. However, the consistency and regularity of the use of these programs are variable. Often these policies are limited to goals and a few specific exercises. Literature on the individualization of a program according to the patient's goals, the level of injury, medical stability, his/her motivation, and the physical therapist's own knowledge and experience in working with spinal cord injury patients in the water is limited. For

instance, in "A hydrotherapy program for high cervical cord lesion," Farrell published a program in which his facility, the Spinal Injuries Unit at Shaughnessy Hospital in Vancouver, British Columbia, uses for C4, C5, and C6 spinal cord injury patients, including the goals of treatment and further discussing an example of different methods of treatments and exercise activities which can be carried out in the pool.[7] While the program described in the article provides an excellent beginning to therapeutic aquatics exercises, it is specific to higher level cervical lesions and there is no instruction or suggestions of further exercises as the patient progresses to a higher level of functioning in the water.

Aquatics programs and books full of exercises in the water are also abundant for the able-bodied person to get in shape and improve his/her aquatics abilities, such as The W.E.T. Workout by Katz.[8] Books such as this contain exercises which can be easily adapted to the those with physical limitations according to the ability level and goals of the individual.

CHAPTER III

THE WATER

Water provides physical, psychological, and therapeutic effects which may aid in the rehabilitation process of the spinal cord injury patient. The many properties of water give the spinal cord injury person a new freedom of movement. Buoyancy, as stated by Archimedes principle, is when a body is fully or partially immersed in a fluid, a buoyant force or upward force equal to the weight of the fluid which is displaced is experienced.[9] This buoyancy and the elimination of gravity is the key to flotation for any person and may also allow the spinal cord injury person the ability to execute movements in the water which may not be possible out of the water. Turbulence, or the movement of the water itself, is used both to assist and resist movement during pool therapy.[9] Slower movements in the water require control, coordination, and balance to overcome the effects of turbulence. Control, coordination, and balance are neuromuscular properties often requiring rehabilitation after a spinal cord injury. The resistance or push of the water against the patient as he/she performs the exercises helps with strengthening of muscle groups while at the same time slowing down activities, enabling the spinal cord injury person more time to react to the movement, facilitating proprioceptors and thus initiating body awareness.

The newly founded freedom of movement experienced in an aquatics program provides substantial psychological effects. The experience can give the patient a new confidence in himself/herself and his/her abilities and opens up

possibilities of further independence and achievement as the patient becomes motivated to try new and different activities as he/she progresses through the rehabilitation process. Oftentimes, mobility in the water is the only unaided movement within the environment that the spinal cord injury patient may be capable of accomplishing. Thus a sense of accomplishment, self-achievement, self-respect, self-expression, and social benefits arise as the water provides the new environment in which the spinal cord injury patient can compete with others who aren't disabled and can succeed in reaching some of his/her goals. An aquatics program must be positive, rewarding, fun, and safe for the spinal cord injury patient to receive optimal benefit.

The therapeutic effects of an aquatics program for the spinal cord injury person are numerous and important in the development of his maximal level of independence. Being in the water can bring about such results as relief of pain, stiffness, and muscle spasms through the promotion of relaxation and improvement of balance, posture, and coordination. Also an increase in body awareness, kinesthetic awareness, and spatial orientation develop as the spinal cord injury person becomes more aware of where his/her extremities are in relation to the rest of the body through the facilitation of proprioceptors as he/she learns how to coordinate and move his/her body in the new environment.[4,7,9,10,11]

Other goals are possible through the use of an aquatics program. Because the spinal cord injured person often has some abdominal muscle involvement, which is important in respiratory function, a decrease in inspiratory force and vital capacity is a frequent complication.[4] A repetitive swimming therapy program may help not only to strengthen these muscles and coordinate breathing control but also improve cardiovascular and respiratory endurance to help increase respiratory function. The resistance provided by the water aids in enhancing or strengthening the motor

power of remaining muscle groups. An increase in range of motion is also possible as the warmth of the water promotes relaxation and relief from the normal amounts of stresson the joints and muscles in the body, thus allowing passive stretching to be done to maintain or increase joint range of motion more easily and prevent contractures.[4,12]

A very important aim of treatment of the spinal cord injury patient through an aquatics program is to safely attain an upright position or posture. This has several effects on the patient. First, there is the psychological one as the patient is standing and is able to complete activities at a more natural eye-to-eye level as the physical therapist and thus creates a sense of well-being. This position also stretches and provides weight bearing on the Achilles tendon, a region of frequent tightness and spasticity in the spinal cord injured person.[4] Finally, osteoporosis can be slowed down when longitudinal stress is put on the skeletal system while the patient is standing.[7] Because of the positive effects which an aquatics program can provide the spinal cord injury patient, versus a regular exercise program, it seems only logical that an aquatics program be included in the rehabilitation process and treatment of the spinal cord injury patient.

CHAPTER IV

SPECIAL CONSIDERATIONS AND COMPLICATIONS

There are special considerations which must be factored in when working with a spinal cord injury patient in a pool setting. Patients with pressure sores are not candidates for an aquatics program until after the sore has completely healed because of the increased risk of infection from bacteria present in the water. Another contraindication to an aquatics program is an open tracheotomy as there is an increased risk of infection and possibility of inhalation of water. Some may experience respiratory distress in the water as the water pressure causes some resistance to breathing, causing an initial apprehension when getting into the water for the first time post-injury. This should eventually be overcome, but the physical therapist should make certain that the spinal cord injury person has good, controlled, and stable respiratory function out of the water prior to initiating an aquatics program.[4,10]

Incontinence may also present a problem as bladder and bowel function are frequently impaired in the spinal cord injury patient. Pool therapy can be timed appropriately with the patient's normal bladder and bowel schedule or program. Catheterized patients can clamp the catheter and wear a leg bag in the water. Ear infections are a risk as the patient may spend much time floating and thus accumulate water in the ears. Combined with the decreased mobility status, inadequate drainage of the ears may result, causing an acute inflammation. Wearing earplugs while in the water is the easy solution to what may become a problem. Spinal cord

injury people above a T6 lesion level results in difficulties with temperature control, either overheating or sudden loss of body heat are possible when they are introduced into or taken out of the water. If the temperature of the water is too cool, an increase in muscle spasm may be the result or if it is too warm, the rate of fatigue may be increased.[4,10,12] The water temperature of the pool should be between 94 and 100 degrees Fahrenheit[13] with the air in the pool area also being warmer (about 78 degrees Fahrenheit) than the other areas of the physical therapy department.[14] To keep the patient from getting cold when taken out of the pool, towels or bath blankets most often are put on top of the person and some facilities are equipped with heat lamps around the pool and dressing areas. Care must be taken to prevent any adverse reactions which may lead to further complications.

Safety is the key in and out of the water. Hazards are possible around a pool and preventative measures should be taken. Debris on the bottom of the pool can cut feet, water around the edge causes a slick and dangerous surface, and objects scattered around the edge of the pool may not be in plain sight for everyone. A personal flotation device may be necessary for some spinal cord injury patients. This depends again on the patient's level of injury, ability, security in the water, and the physical therapist's handling. Constant supervision is a must when anyone is in the pool. All staff should be trained in resuscitation techniques. Being familiar with the patient and his/her abilities and being prepared for any situation is the best prevention.

CHAPTER V

THE EXERCISES

Entry and Exit

Depending on the design of the pool and equipment available, there are several methods for entering and exiting the pool.

1. Steps- If the spinal cord injury person has ambulation abilities, it is possible for the person to walk into the pool using handrails.

2. Ramp- A ramp allows the patient to be wheeled directly into the pool in a wheelchair.

3. Sitting entry- First a transfer is done from the wheelchair to the side of the pool with the type of transfer determined by the level of lesion and the patient's abilities. Once on the edge of the pool as the patient may need to scoot forward using his/her arms, he/she leans and reaches forward to the physical therapist in front of him in the pool. The physical therapist then places his/her hands at the lower level of the scapulae to control the entry into the water.

4. Hoist- Probably the most common entry method is the use of an electrical, pneumatic, or hydraulic lift. The patient is transferred into a specially designed sling which is then hooked onto four clamps at the corners. It lifts the patient up and out of the wheelchair, swings around so that the patient is over the water, and then lowers down to the awaiting physical therapist in the water.[15]

Methods for exiting the pool are the same for the steps, ramp, or hoist. Exiting the pool by way of the side requires modification. If the spinal cord injury

person has normal or good triceps strength, once he/she is at the edge of the pool, he/she can lift himself/herself up onto the side by placing both hands palm down on the edge and extending the elbows. He/she then can either lift his/her body and turn so that the buttocks are placed on the edge or can wiggle forward using the arms until he/she is completely out of the pool.[9,15]

Breathing Control

Good breathing control is necessary for all water activities and is a precursor for prone flotation. As mentioned earlier, the spinal cord injury patient may experience respiratory distress when first introduced to the water, so it is essential that he/she have normal, stable respiratory function out of the water before beginning an aquatics program. He/she may also be somewhat apprehensive to the new environment as they may be unsure of their abilities, and this in turn may cause some breathing difficulties. As mentioned earlier, patients with open tracheotomies (frequently done with C4 lesion levels) or who are respirator dependent, such as those with C1, C2, and C3 levels of lesion, are not candidates for an aquatics program.There are several exercises performed in the water to help the patient relax in the water and develop good breathing control.

1. Blowing- The patient is encouraged to breathe out or blow out at the surface of the water and blow bubbles so he/she can get a feel for exhaling into the water without inhaling water which can be a frightening experience when the patient is not yet accustomed to the water.[9]

2. Holding breath- Once the patient feels comfortable with the water, putting the face or the entire head underwater is the next step. At first the face is momentarily placed in the water, and this will eventually progress to putting the head underwater for several seconds as the lung's vital capacity increases.

3. Bobbing- The final step in the progression is bobbing up and down in the water. This requires the individual to quickly alternate inhaling and exhaling as his/her head goes in and out of the water.

Flotation

Archimedes principle comes into play here since the relative density of water is one. If a body has a relative density less than one, it will float since the weight of the body is less than the weight of the water. But if it is greater than one, it will sink instead.[15] With spinal cord injuries, there is often a loss of density in the extremities which leads to high floating of the extremities.[9] Thus this low buoyancy individual will require the use of flotation devices such as a neck collar, pelvic float, and ankle floats for safety when he/she is in the pool when first beginning until his/her skill level demonstrates that he/she is no longer in need of the extra support.

1. Rolling- The spinal cord injury patient must be able to control lateral rotation for flotation and other swimming activities. Control of lateral rotation is taught by having the patient lift one arm slightly out of the water, turning the head to the opposite side, and moving the free arm back and forth (sculling) to correct the rotation caused by the lifted arm.[8]

2. Supine floating- Along with any flotation devices for assistance, the physical therapist may position himself/herself with the patient's head on his/her shoulder and with support being given at the scapulae. As the patient progresses to being able to independently float, the physical therapist may then position himself/herself at the patient's feet and while grasping the ankles, move the patient in an arc in the water to help the patient maintain more dynamic flotation movement.

3. Prone floating- Good breathing control is essential before the more advanced prone floating can be attempted. With the patient prone in the water, with the extremities hanging down, the physical therapist supports the abdomen to

encourage flotation of the trunk. From this prone position, the patient can achieve rolling to supine by rotating the head to one side and extending the same side shoulder with sculling with one or both hands to complete the roll.[4]

Upper and Lower Extremity Range of Motion and Stretching

The properties and warmth of water create an ideal environment which permits range of motion exercises that might not be possible outside the water because of limitations of pain and contractures. There is less stress on the joints, and the warmth of the water helps to alleviate muscle spasticity and reduce pain.[12] In the water, all joints of the upper and lower extremities can be moved through their available range of motion with sustained stretching at the end range.

Upper Extremity Strengthening Exercises

Strengthening of functional muscle groups according the level of lesion (See Table 1, page 4) is possible as the resistance of the water pushes against the arms as they move through the water. Greater resistance can be given by special equipment such as hand paddles or pull-buoys. The following are upper extremity strengthening exercises suggested for the spinal cord injury patient which can be adapted in accordance with the level of functioning. Each can be done in a supported standing or sitting position with the patient submerged in the water to shoulder level. Repetitions are determined by the patient's strength and fatigue level.

1. Shoulder flexion/extension- The patient lifts his/her arms forward to the surface of the water and then brings the arms back down to his/her sides.

2. Shoulder abduction/adduction- The patient raises his/her arms straight out to the sides to the surface of the water and then brings the arms back down to his/her sides.

3. Shoulder internal/external rotation- Starting with the arms tucked into the sides and the elbows bent to 90 degrees, the patient pushes the forearms out and then brings them back in to the abdomen.

4. Shoulder horizontal abduction/adduction- With the shoulders forward flexed to 90 degrees, the patient crosses the arms in front of him/her as if hugging himself/herself and then sweeps the arms out and back as if trying to squeeze the shoulder blades together.

5. Arm swirls- With the arms abducted to 90 degrees, the patient rotates the arms in forward and backward circles.[8]

6. Bicep curls- This can be done in two different ways. The first method is having the patient bend the elbows up with the arms hanging straight down at the sides. Another method is to have the patient hang onto the edge of the pool and starting with the arms straight out in front of him/her, have him/her pull himself/herself to the side of the pool by bending up at the elbow.

7. Tricep push-ups- The patient stand facing the wall of the pool with the hand on the edge of the pool. He/she then straightens the elbows, lifting his/her body out of the water. This can also be done with the back against the wall of the pool.[8]

8. Water push- With the elbows bent up in front and the palms facing down, the patient pushes the water down toward the bottom of the pool by extending the elbows and then pulls the arms back up to chest level.

9. Punching- With the arms forward flexed to 90 degrees, the patient alternately moves the arms forward in a punching motion.[8]

10. PNF patterns- Any of the upper extremity PNF patterns can be incorporated into the strengthening program as needed. The combination of upper extremity movements and variety of muscle groups facilitated within the PNF

patterns is excellent therapeutic exercises for the coordination of the arms, balance, trunk motions, and stability of the proximal to distal muscle groups.

Lower Extremity Strengthening Exercises

As with the upper extremity strengthening exercises, the purpose of these exercises is strengthening of the remaining muscle groups of the lower extremities (See Table 1, page 4) of the spinal cord injury patient. Paraplegics may also have the ability to ambulate, and this can be facilitated in an aquatics program. The following are lower extremity strengthening exercises which can be adapted to the level of functioning of the patient. Resistance can be added through the use of fins or pull-buoys. These exercises are to be performed with the patient in a supported standing position or with the patient hanging onto the edge of the pool for support. The repetitions are determined by the patient's strength and fatigue level.

1. Hip flexion- The patient alternately lifts one leg straight forward to the surface of the water and then returns it back down to standing.[8]

2. Hip extension- With the patient facing the wall of the pool, keeping the leg straight, he/she alternately lifts the leg straight back and then returns it to standing.

3. Hip abduction/adduction- The patient lifts one leg straight out to the side and then returns it to standing.

4. Hip internal/external rotation- With the hip and knee flexed up to 90 degrees, the patient crosses the foot over toward the other knee and then rotates it out in the other direction.

5. Hamstring curls- With the patient facing the wall of the pool, he/she alternately bends the knee up toward the buttock while keeping the hip straight and then back down to standing.

6. Quad kicks- With the hip and knee flexed to 90 degrees, the patient straightens the leg at the knee and then bends the knee back down.

7. Leg lunge- Begin with taking a large step with the right foot. Keeping the right knee bent and the left one straight, weight shift forward onto the right leg and then back onto the left. This can also be done by side stepping. Repeat on the other side.[8]

8. Plie squeeze- With the heels together, the patient performs a deep knee bend and then contracts the buttocks as he straightens up.[8]

9. Treading- Using the arms on the edge of the pool for support and to lift the legs off of the bottom of the pool, the patient alternately bends and straightens the legs as if bicycling.

10. PNF patterns- Any of the lower extremity PNF patterns can be included in the strengthening program as needed. Again, the combination and variety of muscle groups used to perform the different PNF patterns helps to facilitate trunk motions and pelvic support, strengthen several muscle groups at the same time from proximal to distal, and coordinate balance reactions in the water.

11. Ambulation- With lower level lesions, the use of the abdominal musculature is present and there is thus a greater chance at ambulation. The buoyancy of the water allows the patient to lift his/her body up easier. A patient who requires the use of braces for ambulation on land may be independent in the water. The patient is first taught a swing-to and later a swing-through gait with facilitation and control being provided at the pelvis by the physical therapist and parallel bars may be used if the pool is equipped with them.[15]

Trunk Strengthening

The following exercises are designed for spinal cord injury patients with a level of lesion at the thoracic level or lower to facilitate the strengthening of functional abdominal musculature (See Table 1, page 4). Support may be given by either the physical therapist or by the patient hanging onto the edge of the pool.

1. Sit-ups- With the patient floating on his/her back and hanging onto the edge of the pool, he/she bends the knees up toward the chest and then straightens the legs back out.[11]

2. Leg tuck- Using the edge of the pool for support, the patient lifts his/her legs up or tucks them up under him/her and then straightens them back out to standing.

3. Trunk twist- With the hands on the hips, the patient twists his/her body in one direction and then the other.[8]

4. Leg swing- Using the edge of the pool for support, the patient lifts his/her legs up so that the hips are both at 90 degrees with the knees straight. He/she then swings the legs from side to side in a slow, controlled manner.[8]

Balance

Balance and trunk control again depend on the level of lesion and are generally less affected if the abdominal muscles are not involved. As the patient's balance improves, the position of the patient can be varied to provide increased complexity. However, caution must be exercised when working with the spinal cord injury patient with decreased balance as the turbulence from quick movement in the water may cause him/her to topple over.

1. Supine floating- In this more advanced activity, as the patient floats supine, the physical therapist moves the trunk from side to side as the patient tries to maintain his/her steady, floating balance without rolling over.[15]

2. Sitting- With the patient seated in the pool, balance is first taught with him/her hanging onto the edge of the seat with the physical therapist manually challenging his/her balance. The next step is for the patient to slowly lift one arm forward and then out to the side while maintaining his/her balance. Once this is mastered, both arms are lifted forward and then out to the sides at the same time.

The last progressional step for sitting balance is if the patient is able to keep his/her balance when turbulence is introduced to the water.[15]

3. Standing- Standing balance is first practiced in the parallel bars if the pool is equipped with them. The patient is taught to stand by extending the hips and locking the knees. Pelvic support is provided by the physical therapist as the patient goes through the movements of bringing his/her arms forward and then out to the sides.[15] Standing balance is further challenged by the physical therapist manually shifting the patient forward and backwards and to the sides and again creating turbulence as the final stage of achievement.

The Swimming Strokes

Several different swimming strokes can be used as an added challenge in an aquatics program for the spinal cord injury patient depending on his abilities, any range of motion limitations, and muscle strength. The most common strokes taught are the crawl, back, and breast strokes with their corresponding kicks. Paraplegics should be able to do any of the upper extremity strokes with the assistance of fins or buoys around the ankles to help keep the lower extremities afloat or he/she may be able to perform the kicks if he/she has the ability. The quadriplegic is often able to perform only the upper extremity portion of the swimming stroke with pelvic and ankle flotation devices necessary until he/she is proficient with the upper extremity motions and balance.

1. Crawl- Since this is a unilateral stroke, the patient must be able to maintain the prone position instead of allowing rolling by sculling the nonstroke arm as the stroking arm pulls down through the water.[11] This stroke can first be practiced with the patient hanging onto the edge of the pool and alternately lifting and pulling the arms down to perform the upper extremity part. The flutter kick, if appropriate, can also be practiced with the patient hanging onto the edge of the pool and kicking the legs up

and down. The crawl stroke with the flutter kick is good for strengthening of hip and knee flexion and extension and all shoulder, elbow, and hand motions.[4]

2. Back- Again, floating and balance must be mastered before learning this stroke as rolling may occur. As the patient rotates his/her head to the opposite side, he/she lifts his/her arm up and out of the water, extending the elbow and then bringing the arm down through the water. This motion pushes the body upwards as the arms are brought back down to the sides.[9] The flutter kick is used with the back stroke also and is good for strengthening of the hip and knee flexion and extension and all shoulder, elbow, and hand motions.[4]

3. Breast- The patient is initially taught the breast stroke with the head out of the water as there is a tendency for him/her to keep the head submerged with the buttocks floating. Support by the physical therapist is given under the chin and pressing down on the buttocks and the support gradually being released as the patient is able to hold his/her head up and becomes aware of his/her body position.[11] The frog kick used is good for strengthening of hip flexion, extension, abduction, and adduction,knee flexion and extension, and ankle plantarflexion with the upper extremity movement helping with all shoulder, elbow, wrist, and hand motions.[4]

Recreation Activities

Recreation activities not only promote swimming skills that the spinal cord injury patient has learned, but they also include the psychological effects of socialization among patients and increasing self-confidence. Water activities may include snorkeling, water polo, volleyball, and basketball to just name a few. Snorkeling is an excellent activity in helping to develop good breathing control along with prone flotation. It is possible for any spinal cord injury patient to participate in group water sports activities like water polo, volleyball, and basketball as special

equipment is available to help the person maintain a vertical position. Water activities such as these are an excellent way to improve control, balance reactions, strength, and speed of reaction without the patient really even realizing that it is a form of physical therapy. Early participation in sporting activities helps the patient realize that many different recreation opportunities exist for those with physical disabilities and he/she should not have any limitations if the motivation and desire to broaden his/her involvement in society is endless.

CHAPTER VI

CLINICAL SITUATIONS

In each of these clinical situations presented, a sample aquatics program is outlined from first starting with pool therapy to a more advanced level according to the patient's level of lesion and abilities.

1. C7 complete quadriplegic- This spinal cord injury person will have innervation of all shoulder and scapular musculature along with elbow flexion, extension, supination, and pronation, wrist flexion and extension, and weak finger extension.[4] With functioning triceps, the patient may be able to enter and exit the pool by way of the side of the pool, but a hoist may be used until he/she becomes more accustomed to the water. Breathing control exercises come first with the blowing bubbles, holding the breath, and bobbing. The quadriplegic will be able to float whether supine or prone but will initially require flotation devices and manual support until he/she feels more comfortable and are able to float. Rolling is also taught at this stage as the patient is able to effectively use his/her arms to complete the lateral rotation. Lower extremity passive range of motion and stretching exercises are facilitated by the water along with stretching of the fingers. Upper extremity exercises may include any of the mentioned exercises which may help in the strengthening of the functioning muscle groups. These exercises include shoulder flexion, extension, abduction, adduction, internal rotation, external rotation and horizontal abduction and adduction, arm swirls, bicep curls, tricep push-ups, the water push, punching, and PNF patterns. Sitting balance is an important next step as the

quadriplegic first learns to resist the properties of water by hanging onto the edge of the seat and progresses from there.Finally, any one of the three mentioned strokes, the crawl, back, and breast, can be taught to the quadriplegic.

2. L3 complete paraplegic- This spinal cord injury person has innervation of all upper extremity and abdominal musculature along with pelvic elevation, hip flexion, adduction, and weak external rotation, and knee flexion and extension.[4] Entry and exit into the pool can easily be done over the side of the pool by this patient. An aquatics program designed for this kind of paraplegic can again begin with the breathing exercises and flotation. Any or all of the upper extremity strengthening exercises can be incorporated into the aquatics exercise routine along with passive range of motion and stretching of hip abduction, extension, and internal rotation, and of the ankles and toes. Lower extremity strengthening exercises which are appropriate include hip flexion, abduction, and external rotation, ham curls, quad kicks, leg lunges, the plie squeeze, treading, and PNF patterns. Ambulation in the pool is also possible with this low level paraplegic after the patient has mastered standing balance. The trunk strengthening exercises of the sit-ups, leg tucks, trunk twist, and leg swings also are beneficial in trunk control. Any of the swimming strokes can be taught along with their corresponding kicks according to the patient's abilities.

CHAPTER VII
CONCLUSION

An aquatics program should be an integral part to the rehabilitation process of any spinal cord injury person. The physical, psychologic, and therapeutic effects and benefits which the water provides are invaluable in helping the patient maximize his/her functional and physical potential, achieve optimal independence, and eventually be a productive member of society. Even though the physical therapist plays an important role in the development of the treatment program and in motivating the patient to strive toward his/her maximal abilities, it is really the self-motivation and personal goals of the patient that are the keys which determine the potential to which he/she is able to achieve.

A regular aquatics program gives the spinal cord injury patient an environment in which he/she is able to achieve or perform activities which may not be possible out of the water, providing him/her with a sense of accomplishment, self-achievement, and the motivation to keep trying new and different activities and to explore his/her maximal potential. The innate properties of the water, such as buoyancy, turbulence, and resistance, assist the patient with movements in the water while at the same time providing valuable therapeutic effects. Through the elimination of gravity, buoyancy facilitates motion as the patient is able to perform exercises or ambulate with more ease and independence. The turbulence taxes balance, improving on this necessary function. The resistance the water gives as the patient exercises in the water is valuable for strengthening of remaining muscle groups.

Because the therapeutic pool is heated, the warmth promotes relaxation of the muscles, allowing range of motion exercises to be performed with less pain and limitations.

The addition of an aquatics program is an effective and fun method of physical therapy which incorporates the physical, psychological, and therapeutic effects necessary as the spinal cord injured person progresses through the rehabilitation process.

BIBLIOGRAPHY

1. Young JS and Northrup NE. Statistical information pertaining to some of the most commonly asked questions about SCI. National Spinal Cord Injury Data Center, Phoenix, 1979.

2. Samaritan Rehabiliation Institute. Handbook for spinal cord injuries. 1990: 10-12.

3. Schmitz TJ. Traumatic spinal cord injury. In: Physical Rehabilitation: Assessment and Treatment. Philadelphia: F.A. Davis Company;1988: 545-583.

4. Campion M. Adult Hydrotherapy. Oxford, Great Britain: Heinemann Professional Publishing;1990: 104-121.

5. Daniels L and Worthingham C. Muscle Testing. Philadelphia: W.B. Saunders Company; 1986: 54,90,92,110,112,116,122.

6. Bromley I. Tetraplegia and Paraplegia. Edinburgh: Churchill Livingstone; 1976: 82-184.

7. Farrell RJ. A hydrotherapy program for high cervical cord lesion. Phys Can. 1976; 28: 8-12.

8. Katz J. The W.E.T. Workout. NewYork, NY: Facts on File Publications; 1985: 16, 20, 22, 38, 42, 52, 60-64.

9. Campion M. Hydrotherapy in Pediatrics. Rockville, Maryland: An Aspen Publication; 1986: 7, 8, 15, 42-49.

10. Garvey LA. Spinal cord injury and aquatics. Clinical Management. 1991; 11: 21-24.

11. Medical Center Rehabilitation Hospital & Clinics Physical Therapy Department Policies and Procedures Manual. Spinal cord injured pool program. 1991: 526.

12. Smith R. Kids take the plunge. Rehab Management. 1992; 5: 31-36.

13. Bolton E and Goodwin D. An Introduction to Pool Exercises. Edinburgh: E. & S. Livingstone Ltd; 1967: 17.

14. Atkinson G and Harrison R. Implications of the health and safety at work act of relationship to hydrotherapy dept. Phys Ther. 1981; 67: 263

15. Skinner AT and Thomson AM. Duffield's Exercise in Water. 3rd ed. London: Bailliere Tindall; 1983: 6-12, 138-141.