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The Use Of Water Rehabilitation Exercises For The Injured Athlete

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THE USE OF WATER REHABILITATION EXERCISES FOR THE INJURED ATHLETE

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BY

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THE USE OF WATER REHABILITATION EXERCISES FOR THE INJURED ATHLETE

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ABSTRACT OF THESIS

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Injury prevention and rehabilitation are vital parts of a recreational and athletic program. This study was undertaken to determine if water exercises are an appropriate and beneficial part of a rehabilitation program. The total rehabilitation program should contain components such as strength, flexibility, speed, endurance, agility, balance, coordination, quick reactions, and aerobic maintenance. The water rehabilitation program which the athletes participated in contained all of these components except balance, coordination specific to their sports, quick reactions, and agility. The changes made in range of motion and strength were measured biweekly or weekly to determine improvements or regressions during the exercise program.

The range of motion was measured by a J SKLAR MFG. CO. of Long Island New York goniometer, while strength measurements were made by a leg weight flexion and extension machine. A home made ankle weight device was used to determine the strength of planter flexion, dorsi flexion, inversion, and eversion.

Seven high school students were used in this study, six males and one female. Five males participated in the water rehabilitation, while one male and one female participated in the traditional land rehabilitation. The water rehabilitation subjects performed specific exercises for their injuries which consisted of jumping, jogging, deep knee bends, limb circles, swimming, and kicking. The non water rehabilitation consisted of exercises against gravity, walking, jogging, and weight work.

Improvements were measured in strength and range of motion in all the subjects. Every injury heals differently, so direct comparisons were not possible from subject to subject. The conclusion was made, however, that water rehabilitation is a beneficial part of a rehabilitation program aiding in joint range of motion and strength gain.

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CHAPTER ONE

INTRODUCTION

As participation in athletics as well as recreational sports increases, so does the incidence of injury. Once an injury has occurred, the need to maintain the present fitness level of the uninjured segments of the body becomes very critical to the athlete's future participation. Maintenance during the injury period, as well as rehabilitation after the injury period is very vital for total recovery. The rehabilitation program itself should include components for strength, flexibility, speed, endurance, agility, balance, coordination, quick reactions, and high capacities in the respiratory and cardiovascular systems. Fortunately, science has been applied to sports to continually improve the athletes' chances for an injury-free comeback. We are slowly deviating from traditional practices in training and trying new research ideas. Swimming, for example, is one of America's most popular sports. It can be used in many forms from recreation to lifesaving. It also is an activity which can be used by the healthy as well as the physically disabled. The injured athlete is one who can benefit from the buoyancy given to him from the water. The use of a swimming pool in an athletes' rehabilitation program is a relatively new idea.

Need for the Study

The thought of injury, or surgery is very frightening to the motivated athlete training for his particular sport. His own

success or failure depends for a large part on the proper rehabilitation techniques of his injury. Because literature and ideas about proper techniques are constantly being changed, it is important that the professional in charge possess an open mind and continuously look for new ideas. A very effective, yet often overlooked form of rehabilitation is the use of hydrotherapy. This type of therapy can be very beneficial, because it is non-weight bearing. For example, a 130 pound person immersed to the neck in water loses 90 percent of his weight (1). Thus, people can jog and jump in the water, when they could not practice such an activity on land. Scientific data is lacking about the effects of different types of physical therapy on athletic injuries (15, 20, 23). Thus, the need for further exploration of rehabilitation techniques is needed so the injured athlete can receive the optimal care.

Purpose of the Study

The purpose of this study is to determine if using water exercises in a swimming pool is an appropriate and beneficial part of a rehabilitation program.

Hypotheses

1. The use of water exercises during a rehabilitation program will aid in the increases of strength, flexibility, and range of motion of the injured body part.
2. The athlete will be able to maintain the flexibility and range of motion of the uninjured body parts during the rehabilitation program.
3. The athlete will be able to start range of motion resistance exercises sooner in the water than he would be able to on land

with a standard rehabilitation program.

Delimitations of the Study

This study involves highly motivated high school athletes. This would tend to decrease the total rehabilitation time and increase the amount of workout in the pool.

Because every injury is slightly different, total rehabilitation time comparisons hold little worth in comparison of methods. They can only act as estimated standards.

Limitations of the Study

There are a small number of subjects in this study. The reason for this is because of the small number of serious injuries requiring this type of rehabilitation.

The researcher has relatively little control over the activities of an athlete unrelated to the rehabilitation program. Therefore, the athlete could be doing things detrimental or helpful to his program without realizing it.

The motivation of the athlete will have a large influence on his actual rehabilitation time.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

Rehabilitation

Physical activity has been used for many years as a therapeutic device. The use of this activity for rehabilitation has also been used for a number of years. Rehabilitation involves "bringing an individual's strength and endurance back to normal; weakened body parts are strengthened, range of motion is increased, and in general, aiding normal functioning to return" (1). Important in this reconditioning of the injured limb, is the maintenance and reconditioning of the other parts of the athlete. The injured athlete must be viewed as a "sum of parts." Besides the injured joint or part, the psychological fitness of the subject, the cardiovascular fitness, level of coordination, and overall muscular strength, power, endurance, and flexibility also need to be considered. Although this study will not concentrate on all of these aspects, they are all intertwined in the optimal functioning of an athlete (1, 15).

Components of a Rehabilitation Program

When developing a rehabilitation program for an athlete there are certain guidelines which should be followed.

"1. In exercising apply the overload principle; the load on the muscles should be greater than what is accustomed. The overload will vary, depending upon the type and severity of the injury.

2. The progression of exercise must be gradual but continuous. This may be done by increasing intensity, duration, or repetitions, dependent upon the stage of the rehabilitation program.
3. Use specific exercises for specific injuries.
4. Each exercise must be geared to the disability of the individual, his tolerance to exercise, and the state of improvement of the disability." (1)

The Results of Inactivity on Different Parts of the Body

The Musculo-Skeletal System

One must have some understanding of what happens to the joints and musculature of an injured athlete during the "laying out" and recuperative period of the athlete. This is essential to a clearer understanding of his recuperative period. After an injury, the musculoskeletal system begins to atrophy. This happens mainly because the proprioception of the muscle fibers is decreased, due to the abrupt halt in their usage (22). As a result of this halt in usage, slow twitch muscle fibers atrophy first, followed by the fast twitch fibers (4, 22). When comparative results were taken in a research study done by Sargeant et al. (as reported by Booth and Gollnick) there were losses in the cross sectional areas of both slow twitch and fast twitch muscle fibers in immobilization periods from 53-213 days in subjects of 18-30 years old. The actual percentage of muscle fibers did not decrease, but their size and sensitivity to stimulation did (4).

The Joints

Immobilization is an insult to the joints of the body as well.

There is evidence that fibrosis and decreased range of motion has been detected in joints as soon as the fourth day (23). The DiMarlias table as reported by Smodlaka, Perkins, and Long indicates

> "When an injured shoulder is not immobilized full Range of Motion (R.O.M.) will return after 18 days; if immobilization for one week, full range will return in 52 days; if immobilization for two weeks range will return in 121 days; and if immobilized for three weeks, the range will return in 300 days."

Ligaments and Cartilage

Ligaments, bone, and cartilage are also affected in immobilization. In bone and ligament insertion studies strength was reduced significantly, there were decreases in failure properties, decreases in chondrocyte degeneration and cellular components and decreases in the matrix in articular cartilage (15). Since lengthy immobilizations may lead to adhesions and an inferior hyaline cartilage will replace the fibrocartilage, the joint will not be well suited for normal function. Other joints affected by the immobilization may also develop structural changes as well. The rehabilitation should be planned and carefully monitored. Studies have shown that early joint movement will aid in healing tendons and ligaments, and will prevent contractures when done in a non stressful and controlled environment (20).

Rehabilitation Progression

The rehabilitator should always pay close attention to pain, as an inhibiting signal.

> "Functional progression can be defined as an ordered sequence of activities enabling the acquisition or reacquisition of

skills required for the safe effective performance of athletic endeavors." (13)

The basic rehabilitative program will start with non weight bearing slow range of motion, progress to weight bearing range of motion, then after pain and swelling have subsided, fast speed work is included. If strengthening exercises are started too early, it will cause the patient more pain and effusion, he will gain less strength, have more muscle uncoordination, and rehabilitation will be prolonged. On the average, primary ligamentous repairs take 6-12 months to approach normal strength. The gains in strength depend on the type and rate of strengthening exercises. If only slow speed work is performed, the kinesthetic skills will not be redeveloped, proprioception skills will be lacking, and the athlete will not reach the limb velocity he needs for his event (13, 17, 20, 22).

Modes of Rehabilitation Training

Modes of rehabilitative training can be divided into static and dynamic training. Static training includes isometric strengthening, while dynamic exercise includes isotonic and isokinetic exercise. Eccentric and concentric movements should also be considered when making decisions for a rehabilitation program. Isometric exercise describes the function of the contracting muscle where there is no movement at the joint during the exercise. These exercises are usually done in the beginning stages of rehabilitation, when there is still very limited range of motion. There should be minimal discomfort produced during these exercises.

The next stage in a rehabilitation program would be dynamic

exercise. There is constant resistance, variable resistance, and accommodating resistance which are included in dynamic exercise. The constant resistance (isotonic) exercises are accomplished through a full range of motion of the joint where there is a set resistance or weight. These exercises are used as a crucial strengthening mode in rehabilitation. A disadvantage of this type of exercise is that because of the physiology of the lever system of the skeleton, loading occurs only at the weakest point in the system, so the force is not equal throughout. Once inertia is overcome little added work is needed to move the weight (20, 22).

Variable resistance has also been used as a rehabilitation mode. This includes such things as cam shaped machines or hydraulics, plus elastic bands and manual resistance. These systems attempt to adjust the force so that the load stays constant through the entire range of motion. An advantage of this system is that concentric as well as eccentric muscle action is used (20, 22).

The third type of exercise used is accommodating exercise. The speed of this exercise is controlled, while the resistance is varied. The big advantage of this type of exercise is that the resistance matches the exertion of the patient. The resistance can be used at either fast or slow speeds, thus the exertion needed in athletic events can be simulated. Also the risk of injury is decreased because if the muscles fatigue, or are limited in strength, the resistance of the machine will decrease (20, 22).

The Use of Water in Rehabilitation

Water rehabilitation is not a separate entity from other types

on land, but rather a complement to a sound overall program. Important factors in the use of the water include buoyancy, functional resistance, and displacement of water. Water has been used as a mode of therapy since the fifth century. A man by the name of Galius Aurelianus prescribed "natural waters" and swimming in the sea or warm springs for a patient with paralyzed parts. In England, after the First World War, poliomyelitis was treated with underwater exercises. During the second World War, orthopedic patients used the water for rehabilitative purposes (12).

It seems that since the second World War there have not been many advances in the use of water in rehabilitation. In most activities the body has to constantly work to keep itself from being pulled downward. The gravitational pull is counterbalanced by water. Water breaks the force of the landing appendages and also acts as a resistance to all of the appendages (14). Water activity can use almost every large muscle group in the body at one phase or another (1).

> "Early passive or active range of motion should be done in a pain free range. Gentle, active exercises can be started with the use of the buoyancy of water to allow pain free motion." (20)

Water exercises are presently being used with some geriatric patients (12), multiple sclerosis patients (8), and in the maintenance of cardiovascular fitness (17, 19, 25). Water activities can increase joint range of motion, flexibility, cardiovascular endurance, strength, and power of an injured body part, but there has not been much written about actual water rehabilitation programs. Aqua dynamics, a

publication put out by the government suggests using change of pace and interval training.

> "Change of pace consists of the shifting from one activity to another involving a different set of muscles or type of stress and the changing of intensity of work. Interval training is interspersing repeated periods of physical work with recovery periods during which an activity of a reduced intensity is performed." (19)

CHAPTER THREE

METHODS AND PROCEDURES

The purpose for this study is to determine if water rehabilitation exercises are a beneficial part of a total rehabilitation program.

Subjects

The study includes seven case studies of high school athletes who have had a 2°+, 3° injury, surgical repair, or bone fracture which kept the athlete from participating in a particular sport for at least two weeks.

Rehabilitation Design and Methods of Assessment

The criteria used to determine the severity of the injury were:

Table 1

Functional Grading System

1°	Minimal pain and swelling
	Stable joint (ligament)
	Full Range of Motion
	Pain free weight bearing (lower extremity)
	Slight muscle weakness compared to opposite limb
2°	Moderate pain and swelling, slight discoloration
	Moderate instability in joint or ligament
	Decreased Range of Motion
	Difficulty in weight bearing, ambulation, or against resistance

Definite muscle weakness when compared to uninjured limb

3° Severe pain and swelling

Unstable joint, ligament, or muscle instability

Minimal Range of Motion

Inability to bear weight

Inability to use musculature for limb movement

All athletes who received an injury signed a consent form, as well as his/her parent signing the form (if subject was under 18). The athlete then regularly attended the rehabilitation sessions four times a week. The sessions were held on Monday, Wednesday, Friday, and Saturday. During the week the sessions were 30-35 minutes in length. On Saturdays they were 45-50 minutes in length. After completing one week and each subsequent week of the water workout, the subject's R.O.M. and strength were measured by using a goniometer and leg weight machine. The leg weight device was used to compare the strength in flexion and extension of the injured limb, to the uninjured limb. A home made ankle weight device was used to determine the strength of plantar flexion, dorsi flexion, inversion, and eversion. The J SKLAR MFG. CO. of Long Island, New York goniometer was used to determine joint range of motion. A tape measure was used to measure limb girths.

The procedures used to make these measurements were as follows: Wednesdays and Saturdays were the days used to measure the strength and range of motion. Flexion and extension of the leg was measured in five pound increments, until the subject was within five pounds of his previous exercise maximum. After this point 2½ pound increases

were used. For the leg extension the subject sat on a table, the weight was strapped to his lower leg (Figure I A), then he slowly lifted the weight until his leg was in a fully extended position. The leg flexion involved the same weight device (Figure I A), when the subject laid on his stomach, and fully flexed his leg.

The goniometric measures involved taking measurements of the total range of motion of the particular body part at the joint angles. The mean of three measurements was taken in order to compensate for any measurement method discrepancy. The tape measure procedure used to measure limb girth was a matter of measuring a predetermined span above a predetermined point. The lower leg girth was measured five inches above the lateral maleolus, and for the upper leg, three inches above the upper ridge of the patella. Complete results of these measurements are included in Appendix A in graph and table format.

Rehabilitation Methods

The swimming pool which was used for rehabilitation was 25 yards in length and 18½ yards in width. The depth of the pool varied from 3' to 12'. The gradual decline in the depth was used as a functional part of the rehabilitation (day by day rehabilitation sessions listed in Appendix C). The deep end of the pool was used for treading water. The subjects started out in shoulder height level water, walking then jogging. As they improved, they were moved up to chest deep, below the ribs deep, and eventually 3' of water. Other exercises such as leg crosses and circle ankles were performed (see Appendix B for explanations and diagrams). Swimming laps, kicking with the

kickboard, kicking holding on to the side of the pool were some other exercises used.

The types of exercises performed by each person were specifically designed for his (her) particular injury, using a basis of several choices. Some participants used lap swimming or kicking with a kickboard as one mode of the therapy, while others did not. The determining factor in this decision was the patient's comfort/fear in the water. While these were not sessions to teach the patients how to swim, in some cases, mild modifications were made in the strokes and/or kicks to improve their efficiency. Refer to Appendix B for complete descriptions.

Methods of Data Analysis

Since every injury is slightly different, and every person will react differently to treatment, there were no direct comparisons made between people in this study. The measures which were made will be presented in graph and table form, so the progression of the athlete will be easily noted. The tables are present in Appendix A and throughout the paper.

CHAPTER FOUR

CASE STUDIES OF INJURED ATHLETES

Case Number 1

This case involved a 15 year old male who received a 3° medial collateral ligament strain during the second quarter of a Friday night football game. The young man was unable to bear any weight on the injured extremity while he was assisted off the field. Upon examination of the knee, there was discoloration, and swelling was beginning to form. The following evaluative tests were performed, with subsequent diagnosis:

1. Anterior and posterior drawer sign - Negative
2. Appleys compression and distraction tests - Positive only for pain
3. Varus stress - Negative
4. Valgus stress - Positive for instability
5. McMurray test - Negative, no clicking, but it did elicit pain
6. Bounce Home test - Positive, knee did not fully extend

After these tests the knee was packed in ice bags for the remainder of the game (approximately 45 minutes). The knee was then immobilized as much as possible with plywood pieces of board on each side of the knee and an Ace wrap. The patient was instructed to keep bags of ice on the injury, elevate it, and keep weight off of it for the remainder of the night at home. He was then instructed to visit

the clinic the following day for further treatment and evaluation. He was also instructed to bring shorts or trunks with him to begin water rehabilitation that afternoon.

At the clinic the doctor examined the patient's knee, and performed the same evaluative tests. The physician confirmed that the patient incurred a 3° medial collateral ligament strain. The possibility of a tear was present, therefore the physician prescribed to allow healing mechanisms of the body take their course for ten days before diagnosing a tear and ordering further tests. The subject was then given a Velcro Straight Leg Splint which he wore for five days after the injury, then slowly started parts of his daily walking routine without the brace. The subject also received whirlpool and ultrasound treatments during two weeks of his swimming pool rehabilitation. The day by day descriptions of his water workouts are listed on page one of Appendix C. Additional comments such as onset of pain, change in attitude, etc. have been also noted.

The results of the rehabilitation were very positive. After three weeks of the water rehabilitation, the young man was tested on flexion and extension weights. His injured limb was tested against his uninjured limb and the strength difference was only five pounds in extension and three pounds in flexion. However, in a matter of four weeks, his injured extremity was 100% of his uninjured extremity in extension and 94% in flexion. The complete progression is listed in Appendix A. Full practice and playing in the games was resumed after 4½ weeks. The young man continued to play basketball with no observed difficulties. He was instructed to continue his flexion

extension sets using large numbers of repetitions (3 sets of 20 reps with 25 pounds extension, 3 sets of 15 pounds flexion).

Case Number 2

This young man was also injured in a football game. After limping off the field he was put on the bench where he complained of very sharp pinpoint pain on the lateral border of his fibula, directly above the lateral maleolus. Upon examination, there was slight swelling, discoloration, and very tender pinpoint pain. He did not, however, have any radiating pain, or show positive results to the bump test or torsion test. He was, however, taken out of the game (3rd quarter) where his lower leg was put in ice, compressed, and elevated for the remainder of the game (approximately 25 minutes). After this he was instructed to keep ice on the injury for 45 minutes, remove the ice for 15 minutes, then replace the ice for 45 until he went to bed. He was also instructed, the following day, to visit the clinic if pain, swelling, or discomfort persisted. He did not show up at the clinic, but went to the hospital Sunday, where he received X-rays, and the diagnosis of a fracture of the fibula. His leg was then placed in a cast for 2½ weeks. On the following Monday he started on isometric exercises of the injured and uninjured extremities (10 x 10, 10 times daily) and was instructed to start lifting weights with many repetitions and lower weights. After this, the researcher did not see him again for 2½ weeks. Upon inquiry, the subject stated he had continued the program set up for him. Complete evaluation of the subject's leg circumference and strength differences are reported in Appendix A.

The rehabilitation of this subject seemed to take longer than expected. He did come to the rehabilitation sessions four times a week, but his enthusiasm during the workouts was minimal. Refer to Appendix D for complete workouts. Upon completion of the water workouts, he was set up with a program involving PRE's, ankle weight exercises, figure 8 running, and jogging.

Table 2

Subject # 2 Bi-weekly Strength Measurements

Date	Right Ankle		Left Ankle		Right Ankle		Left Ankle	
	Plantar Flexion	Dorsi Flexion	Plantar Flexion	Dorsi Flexion	Inversion	Eversion	Inversion	Eversion
11/10	8	6	15 lbs.	12½	2½	2½	8	6½
11/14	8	8½	15 lbs.	12½	2½	2½	8	6½
11/17	10	8	15 lbs.	12½	3½	2½	8	6½
11/21	12	10	15 lbs.	12½	5	3½	8	6½
11/24	12	12	15 lbs.	12½	7½	5	8	6½
11/28	14	12½	15 lbs.	12½	7½	5	8	6½

Case Number 3

This subject had a cast on his ankle for 2½ weeks. The original reason for the casting was because of continual and chronic ankle sprains which resulted in severely stretched medial ligaments and tendons. The incentive for this young man to rapidly rebuild the strength of his casted ankle and leg was high, since he was a senior basketball player who had practices beginning approximately six weeks after the removal of his cast.

In the afternoon of the first day, after the cast was removed, the water rehabilitation sessions began. Although his range of motion was minimal at the outset, it quickly improved from the work-outs which were performed in the pool. His strength improved markedly also, especially since there was no consistent program of isometric exercises while his cast was on. After 2½ weeks the injured ankle was over 80% strength in all range of motion except inversion, where it was 65%. On November 7, approximately three weeks after the cast removal, the subject was also started on a program of PRE's, Toe Raises, Running figure 8's, jogging, and finally sprinting and pivoting drills. The subject was released for full practice November 13, and has had no problems since this time.

Table 3

Subject # 3 Bi-weekly Strength Measurements

Date	Plantar flexion		Dorsi flexion		Inversion		Eversion	
	Right Ankle	Left Ankle	Right Ankle	Left Ankle	Right Ankle	Left Ankle	Right Ankle	Left Ankle
10/31	14	15	8	12½	6½	10	5½	6
11/03	14½	15	8	12½	8	10	5	6
11/07	14½	15	10	12½	8	10	5½	6
11/10	15	15	12½	12½	8½	10	6	8

Case Number 4

This athlete came to the Paris clinic January 26 complaining of

a right knee which constantly gave out whenever he jumped and tried to land. He also complained of pain and swelling when this happened. Upon examination a positive anterior drawer and a pivot shift test were observed. The athlete was referred to an orthopedic surgeon who performed an anterior cruciate repair a week later. The athlete was casted in a 20 degree flexion for six weeks. While the cast was on the athlete was instructed to do quadricep sets and leg raises on a daily basis. The athlete started out doing 10 sets of 10, ten times a day and by the end of the six weeks was doing 10 sets of 20, ten times a day.

On March 14, the orthopedic surgeon removed the cast and instructed the athlete to wear a straight leg soft splint while walking for four weeks. The athlete was to continue the straight leg raises and quadricep sets. The surgeon permitted the athlete to start the water rehabilitation March 19. At this time there was a 2 inch difference in circumference in the right leg (20") compared to the left (22"). The R.O.M. of the right leg lacked 80 degrees in flexion and 20 degrees in extension. The first days of water rehabilitation consisted of lap swimming, walking, and range of motion exercises. The workouts were 30-45 minutes in length four times a week.

By March 30, the workouts had increased in intensity and difficulty, and the athlete appeared to be responding to the treatment. The athlete was treading water, walking forward using an extended backward kicking motion in chest deep water, and improving upon his R.O.M. The athlete's leg circumference was unchanged, but his flexion had improved by 5 degrees. The extension was unchanged, since he was not permitted to reach full extension.

On April 11th, 3½ weeks later the athlete was responding well to his workouts. He had increased his leg circumference 1/4 of an inch and increased his R.O.M. in flexion 15 degrees from his original measurement. The athlete stated that he was no longer doing any other exercises than the water exercises. He was instructed to start out with 10 sets of 10 ten times a day, and progress from here. He was also to continue his water workouts, since this was the only method he was using to work on his R.O.M.

By April 25th the athlete was doing well in the water. His leg circumference had increased another 1/8 of an inch. The athlete was walking in waist deep water, and performing long stride jogging in shoulder deep water. The flexion of the leg had increased 7 degrees from the previous measurement, leaving 58 degrees which he still needed to obtain in full R.O.M. The athlete stated that he also was feeling stronger while walking around school.

May 2 the athlete was walking with powerful pushoffs in waist deep water, and performing long stride jogging in chest deep water. A new exercise was started at this time where the athlete held onto the wall and went into a knee bend as far down as he could go. This was difficult for the athlete, but he responded well to the challenge. Manual resistance was also started when he was doing the flexion and extension exercises in the water. The athlete had gained 3 more degrees in flexion, therefore he had 55 degrees to obtain for full flexion.

The modified kneebends seemed to be helping the R.O.M. and strength of the athlete. May 9th the R.O.M. had improved 5 more

degrees, so 50 degrees remained in flexion. The orthopedic surgeon also permitted the athlete to begin working on full R.O.M. The doctor also suggested that he start working with light weights with many repetitions two or three times a day, but light weights were not available for these workouts.

May 11 the athlete was tested to find out his strength for flexion and extension. His uninjured leg could extend a maximum of 80 pounds. The injured leg could extend 55 pounds for all but the last 20 degrees and flex 20 pounds for the 48 degrees of flexion which was his greatest capacity for flexion. The athlete's leg circumference was now one inch smaller than the uninjured leg.

May 21 the athlete stated that he was feeling strong in the water. He had been performing three sets of 20 flexions and extensions with the pull buoy in the water. His resistance was increased to two pull buoys, and to 3 sets of 12. His R.O.M. had improved 8 degrees in flexion and 3 degrees in extension so he needed 42 degrees of flexion and 12 degrees in extension.

May 27-29 the athlete was instructed to continue his water rehabilitation on his own, since the researcher was out of town. June 3, the athlete was again tested for strength and R.O.M. The gains in strength were 8 pounds in extension. He could lift a maximum of 63 pounds. His flexion had an even greater increase with a 10 pound gain to 30 pounds. The R.O.M. of the athlete had also increased. The flexion had increased 7 degrees while the extension had increased 5 degrees. The athlete needed 35 degrees more in flexion and 7 degrees in extension. This was the last day the

researcher had contact with the athlete. The athlete was encouraged to continue the type of water conditioning program which he had been doing for the past few months. It was also suggested he start working with the weights which were at the football stadium for his flexion and extension. He was told to do this for strength and to use the swimming pool workouts more for range of motion and aerobic training.

Table 4

Subject # 4 Strength Gain

Date	Right Leg Flexion	Right Leg Extension	Left Leg Flexion	Left Leg Extension
5/11	20	55	40	80
5/18	24	58	40	80
5/25	26	60	40	80
6/03	30	63	40	80

Case Number 5

This athlete was initially seen by the researcher April 19 with complaints of a tight left calf muscle, and sharp pains tracking down the back of his leg, down to his heel. There was no swelling or discoloration, but there was pain on palpation of the achilles gastrocnemius soleus insertion. The athlete was also unable to completely plantarflex and push his total weight. After several questions it was found that the athlete had been experiencing this

pain since the end of his basketball season, with it gradually becoming more troublesome. The athlete was a sprinter and long jumper with possible State potential, so a strategy was developed to maintain the athlete's conditioning, as well as provide some healing time. Qualifications for the State Track Meet were May 16, so the researcher had a little less than 4 weeks to work with the athlete. The athlete at this time was instructed to discontinue sprinting and running, use crutch walking at school when walking around, and to begin water rehabilitation Monday, April 22. The athlete was unable to go to Physical Therapy for treatments, so the water rehabilitation was followed by use of an ice bag for the injury after the rehabilitation session.

The athlete was a capable swimmer, and because of this it helped considerably when deciding his workouts. Because of the pain caused in plantar flexion no running was permitted in the water for the first week. The first four days of training consisted of treading water, swimming freestyle, kicking (backstroke and freestyle), and walking in the deep water. The athlete continued the water routine, and also used crutches until April 29. By this time the athlete was able to plantar flex his own weight with the use of a table for support. The athlete was also able to walk for short periods of time without his crutches so he was advised to start using his crutches less.

Tuesday, April 30 the athlete was instructed to start jogging in shoulder deep water. If pain was felt while doing this routine he was to inform the researcher. Throughout the week the athlete

increased his workouts and decreased the depth of the water where he was running. Monday, May 6, hopping on one leg was initiated in the deeper water. The hopping was also increased in repetitions and decreased in depth of the pool.

Monday, May 13 the athlete decreased his total workout in the pool and started jogging outside, followed by jogging and hopping in the shallow end of the pool. The following two days the athlete started short sprints and jumping. A 1/2 inch heel lift had been put in his left shoe to alleviate some of the stretch put on the achilles tendon.

May 16 the athlete made the preliminary State track finals in the 100 yard dash, and the semifinals in the long jump, recording personal records in both. The achilles calf muscle insertion was sore, but had not been reinjured to the severity of its previous state in the competition. After the track meet the athlete continued three more weeks of water rehabilitation. He was also encouraged to begin a rest period from running and start a light weight program with mild stretching of the affected area.

Case Number 6

A November 10, 1984 football injury was the reason that this athlete was seen at the clinic. The injury occurred to the right knee while the athlete was playing football. The athlete was tackled by several players. This athlete was unable to get up from the tackle, because of pain which was felt and joint instability of the right knee. On the field examination revealed a valgus laxity of at least 3 degrees. After the test the athlete was assisted off the

field where ice was compressed around the knee for 45 minutes. He was given a straight leg splint and crutches and was advised to go to the Paris Clinic the next day.

Upon further evaluations done at the clinic the valgus opening was noted on the medial side of the knee. The athlete also had a positive drawer test which indicated possible anterior cruciate damage. After evaluation by a doctor the athlete was referred to Champaign. A patellar tendon transfer was done on this athlete November 16.

While the athlete had his cast on he was instructed to do quadriceps sets every day. He was instructed to do 10 sets of 20 five times a day for a 10 second count.

The cast was left on the athlete with his knee in about 15 degrees of flexion for seven weeks. During this period the athlete was instructed to use the gym pack weight machine he had at home and to do flexion and extension weights with his left leg, with hopes that there would be some cross nervous stimulation taking place. The athlete also did some upper body weight lifting on his own.

The cast was removed January 5, 1985. A soft straight leg splint was put on the athlete. He was instructed to wear it at all times until the LENOX HILL brace arrived. The surgeon also would not permit the athlete to start any rehabilitation with the right leg until the LENOX HILL brace arrived. The athlete continued an upper body weight program for the weeks it took for the brace to arrive.

On February 2, the athlete started a rehabilitation program

for his right leg. Initial measurements were taken of the right leg. The athlete had lost 2½ inches of circumference. The right leg was only 15 inches in circumference 3 inches above the patella, while the left leg was 17½. There was still considerable swelling on the right knee since the right knee measurement was 16 inches and the left knee measurement was 14 inches. R.O.M. was restricted due to the long immobilization period. The athlete lacked 20 degrees for full extension and 100 degrees in flexion. Scar tissue had also built up and was visible under the right patella.

The athlete was willing to work on his rehabilitation on his own and at physical therapy, so the rehabilitation workout was as follows:

1. Tuesday, Thursday, and Saturday leg lifts on the back with weights on the ankle; 2 sets of 20 with a 20 second count. Then the same number with the athlete laying on his stomach. This was started with a 2 pound weight.

2. Monday, Wednesday, and Friday leg lifts 3 sets of 10 against manual resistance.

Upon the advice of the surgeon this flexion was joined with forced extension. February 14 the athlete's R.O.M. was again measured. He had made no gains in almost two weeks. In physical therapy, however, he was lifting four pounds in his leg lifts.

March 6 the athlete was walking stronger and responding to the forced flexion and extension. His leg circumference was measured and he had gained 3/4 of an inch since the first day of his rehabilitation. The swelling had gone in his right knee so both knees were

the same size. His R.O.M. had improved 4 more degrees in flexion and stayed the same in extension. He was also using 7 pounds on the leg lifts. The athlete had 93 degrees left in flexion and 17 degrees left in extension.

March 9-17 only one workout was completed. The athlete was started on his routine workouts March 19.

April 4 the athlete was measured and had made small gains from his previous measurements. The athlete had 3 more degrees in flexion and extension. He gained 1/4 of an inch more in circumference from his March measurement.

April 19 the athlete had made a breakthrough. It appeared that some of the adhesions had finally broken up. His R.O.M. had gained 8 degrees from his previous measures in flexion and 4 degrees in extension. At this time therapy was also started to retrain the athlete to properly walk.

April 27 the athlete was up to 15 pounds on his leg lifts. He was continuing to practice correct gait. He had also gained 3 degrees more in extension.

May 15 gains had been made in flexion and extension. His flexion measurement had increased 7 degrees while his extension increased 3 degrees. The athlete was lifting 18 pounds in his workouts.

June 4 was the last day that the researcher was to work with the athlete. He gained a total of 29 degrees in flexion and 15 degrees in extension. The athlete was advised to continue his rehabilitation at Paris Hospital.

Non Water Rehabilitation Case Number 7

January 5, 1985 this athlete arrived at the Paris clinic. January 3 she had been playing basketball, came down from a rebound, and sprained her ankle. She stated that she put ice on the area immediately after the injury, and left it on the ankle for 45 minutes. She was taken to the emergency room where x-rays were taken. The x-rays were negative for bone breakage, therefore the emergency room doctor instructed the athlete to stay on crutches for three weeks. After consultation with the emergency room physician he agreed to let the researcher work with the individual on treatments and rehabilitation. This athlete did not have access to the swimming pool.

On the initial evaluation the athlete had pain over the anterior talofibular ligament, anterior talotibial, calcaneofibular, and posterior talofibular ligaments. She also felt pain when her large toe was pulled down, showing she also injured the extensor hallucis longus tendon. There was a great amount of swelling and discoloration which allowed almost no R.O.M. in the athlete's right ankle. Initial measurements of the ankle range of motion indicated that her left ankle also lacked the full range of motion.

Left Ankle: Dorsi flexion 5 degrees, Plantar flexion 40 degrees, forefoot abduction 5 degrees, subtalar inversion 5 degrees, subtalar eversion 1 degree, forefoot adduction 5 degrees. These measurements indicate an abnormality in structural R.O.M. which could have predisposed this athlete to an ankle injury. The measurements of the injured right ankle were: Dorsi flexion 0 degrees, plantar

flexion 10 degrees, forefoot abduction 0 degrees, subtalar inversion 2 degrees, subtalar eversion 0 degrees, forefoot adduction 5 degrees.

The athlete was instructed to use an ankle whirlpool at 100-105 degrees, two times a day, for 30 minutes. While her ankle was in the whirlpool she was to attempt to draw the ABC's the entire time. After the whirlpool she was to elevate her foot for ten minutes while she received a massage from the ends of her toes to her calf. The athlete did this treatment for two days, but complained that the whirlpool was inaccessible to her. She asked for a more practical treatment. The treatments were changed to cryokinetics. This involves passive progressive exercise while the limb is still numbed from the initial ice treatment. The involved limb is moved through a range of motion which acts on the same concept as the ABC's in the whirlpool. Cryokinetics for the athlete consisted of:

1. Ice on the extremity for 20 minutes.
2. Exercise 5-7 minutes (until pain was felt).
3. Ice 10 minutes.
4. Exercise 5-7 minutes.
5. Ice 10 minutes.
6. Exercise 5-7 minutes.
7. Ice ten minutes.
8. Exercise 5-7 minutes.
9. Ice 10 minutes.
10. Exercise 5-7 minutes.
11. Ice 30 minutes.

The exercise started out with an active R.O.M. and progressed

depending on the tolerance of the athlete. The exercise was also conducted for a longer period of time as the injury became less sensitive to pain.

January 9 was the first day for the cryokinetics. The athlete started the exercise periods by performing active R.O.M. with her foot and ankle. There was no resistance applied to the foot. The athlete said she was able to perform the R.O.M. exercises for 4 minutes before pain occurred.

January 12 the athlete's ankle was once again examined. The discoloration in the area had dispersed from the previous week. The swelling, however, was unchanged and still hindered the athlete. A gain of 5 degrees was made in plantar flexion since the previous week.

January 16 the athlete added a one pound weight to her foot when she put her ankle through the ranges of motion. She was now able to go for six minutes before experiencing pain.

January 19 R.O.M. measures were taken and improvements were noted in dorsi flexion (3 degrees), plantar flexion (10 degrees), and forefoot adduction (9 degrees). The swelling around the ankle joint was dispersing, but it was still present on the lateral epicondyle and under the talofibular ligament. The athlete began using 2 pounds of weight on her foot.

January 25 the athlete started to use a 5 pound weight. She was alternating these sets of weights with slow walking. She attempted to walk without crutches, but discontinued to do so because of discomfort.

January 31 the R.O.M. of the athlete was progressively improving. Dorsi flexion was back to 5 degrees, plantar flexion 25 degrees, forefoot abduction 3 degrees, forefoot adduction 5 degrees, subtalar eversion 3 degrees, and inversion 3 degrees. The athlete was walking through the full heel toe stance and had moved up to 7 pounds using the weights. She was also starting to walk short distances without the use of her crutches.

February 9 the athlete was able to walk without a limp for short distances. She was instructed to start doing the weight workout without using the cryokinetics. She began jogging for 6-7 minutes for each exercise bout. At this time the athlete was introduced to a kinestetic sense board, which involved a board with a half of a ball underneath. The athlete would strap her foot to this board then try to balance on it. She was to use this for both feet.

February 15 the athlete was walking for most of the day without crutches and no noticeable limp. Her R.O.M. measurements were improved. Plantar flexion 30, forefoot abduction 5, forefoot adduction 10, subtalar inversion 3 (these are all degrees). She was now using 15 pounds for dorsi flexion, and 10 pounds for eversion and inversion. The cryokinetics exercises now consisted of sprints, pivots, and figure 8's.

February 20, the cryokinetics was discontinued. The athlete was now jogging up to one mile with some discomfort near the end of the workout. Her weights for inversion had increased 2 pounds (now 12 pounds).

February 26 the athlete started jogging and running figure 8's.

She was up to 15 pounds for the inversion and eversion. At this time the athlete was released for full competition.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The concept of rehabilitating the injury of an athlete or non athlete is one which is recognized as being important to the non athlete and crucial to the athlete. Once an injury has occurred the need to maintain the present level of the uninjured segments of the body become critical to future active participation. Maintenance during the injury period, as well as the rehabilitation after the injury period is vital for total recovery. One very often overlooked form of rehabilitation is the use of water rehabilitation. This type of treatment can be very beneficial, because it is non weight bearing, but still uses the water as a form of resistance. The use of a swimming pool in the rehabilitation of injured ankles and knees is a concept which many people in the sports medicine profession have ignored.

The primary purpose of the study was to determine if the use of water exercises in a swimming pool is an appropriate and beneficial part of a rehabilitation program for ankles and knees.

Each case study involved is a high school athlete who became injured or required some type of immobilization for at least two weeks. Seven high school athletes were used in the study: one female and six males. Five males participated in the water rehabilitation program. One male and one female were put through a rehabilitation program without using the water exercises.

The rehabilitation procedure consisted of post injury goniometric measures to determine the initial range of motion loss. The water rehabilitation subjects received the water treatment three to five times a week with sessions lasting 25-60 minutes. The rehabilitation sessions continued until the strength and range of motion measures indicated they had reached 90% strength and range of motion of their unaffected limb, or the school year ended. The nonwater rehabilitation athletes were subjected to the same criteria, but performed various exercises on land.

Tables and figures were prepared to show progressive range of motion and circumference measurements for most of the subjects. Since every person and every injury is slightly different, comparisons were not made between individuals.

CONCLUSIONS

Based on the results of the case studies, the following conclusions have been drawn:

1. The length of the rehabilitation program depends on the severity of the injury, and the cooperation of the subject.

2. The use of aquatherapy is a beneficial part of a rehabilitation program. Based on the range of motion and strength gains, it appears to aid in the rehabilitation of joint range of motion and strength improvement.

RECOMMENDATIONS

1. A larger number of subjects should be in included in future studies.

2. More research is needed on the physiological as well as structural advantages of using swimming pool exercises for rehabilitation.

3. A questionnaire of the patients' perceived benefit of aquatherapy would be helpful in making a subjective conclusion of the water rehabilitation program.

5. Agreement among all participating physicians regarding the specific kind of treatment would aid in future rehabilitation studies.

List of References

1. Annarino, Dr. A.A., "Reconditioning" Water Activities for Conditioning and Reconditioning, 1982, pp. 47-52.

2. Bender, Jay A., Ph.D., "The Multiple Angle Testing Method for the Evaluation of Muscle Strength" The Journal of Bone and Joint Surgery, Vol. 45-A, No. 1, January 1963, pp. 135-140.

3. Bonavilla, Edward J., D.P.M., A.A.C.F.S., "Post surgical Management of the Runner," The Journal of Foot Surgery, Volume 15, No. 2, 1976, pp. 59-60.

4. Booth, Frank W. and Gollnick, Philip D., "Effects of Disuse on the Structure and Function of Skeletal Muscle," Medicine and Science in Sports and Exercise, Vol. 15, No. 5, 1983, pp. 415-420.

5. Brewster, Clive E., MS, PT et al., "Rehabilitation for Anterior Cruciate Reconstruction," The Journal of Orthopedic and Sports Physical Therapy, Vol. 5, No. 3, 1979, pp. 121-126.

6. Cummins, Gina DiBlasio. "Getting Physical" Ohio State Medical Journal, June 1983, pp. 435-439.

7. Erikson, Ejnar, "Sports Injuries of the Knee Ligaments: Their Diagnosis, Treatment, Rehabilitation, and Prevention," Medicine and Science in Sports, Vol. 8, No. 3, 1976, pp. 133-144.

8. Gehlsen, Gale M. "Effects of an Aquatic Fitness Program on the Muscular Strength and Endurance of Patients with Multiple Sclerosis," Physical Therapy, Volume 64, No. 5, May 1984, pp. 653-656.

9. Holden, David L. et al., "The Nonoperative Treatment of Grade I and II Medial Collateral Ligament Injuries to the Knee," The American Journal of Sports Medicine, Vol. 11, No. 5, 1983, pp. 340-344.

10. Hoover, Richard L., MS, RPT, "Rehabilitation: A Functional Protocol," The Journal of School Health, April 1977, pp. 238-240.

11. Jones, Richard F., "The Games Disabled People Play," The Medical Journal of Australia, February 6, 1982, pp. 128-131.

12. Kacavas, James J. et al., "The Use of Aqua-Therapy with Geriatric Patients," American Corrective Therapy Journal, March-April, 1977, pp. 52-59.

13. Kegerreis, Sam, MS, PT, ATC, "The Construction and Implementation of Functional Progressions as a Component of Athletic Rehabilitation," The Journal of Orthopaedic and Sports Physical Therapy, July-August 1983, pp. 14-19.

14. Kupriam, Werner, Physical Therapy for Sports, (W.B. Saunders Company, 1981), pp. 154-160 and 175-186.

15. Long, James P., LPT, "Rehabilitation and Return to Activity to Sports Injuries", Primary Care, Vol. 11, No. 1, March 1984, pp. 137-150.

16. McCafferty, William B. and Horvath, Steven M., "Specificity of Exercise and Specificity of Training: A Subcellular Review," The Research Quarterly, Vol. 48, No. 2, pp. 358-367.

17. Mc Donough, Andrew L., MS, PT, "Effects of Immobilization and Exercise on Articular Cartilage - A Review of Literature," The Journal of Orthopaedic and Sports Physical Therapy, Summer 1981, pp. 2-5.

18. Perkins, George. "Rest and Movement," The Journal of Bone and Joint Surgery, Vol. 35B, No. 4, November 1953, pp. 521-539.

19. Presidents Council on Physical Fitness and Sports, Aqua Dynamics - Physical Conditioning Through Water Exercises (Washington, D.C.; Government Printing Office, 1977), pp. 1-29.

20. Scott, Steven G., D.D., "Current Concepts in the Rehabilitation of the Injured Athlete," Mayo Clinic Proceedings, Vol. 59, 1984, pp. 83-90.

21. Sjöberg, I., Swimming Medicine IV, (University Park Press 1978), pp. 59-62.

22. Smith, Michael J., M.D., "Muscle Fiber Types - Their Relationship to Athletic Training and Rehabilitation", Orthopedic Clinic of North America, Vol. 14, No. 2, April 1983, pp. 403-411.

23. Smodlaka, M.D., Sc.D., "Rehabilitating the Injured Athlete," The Physician and Sports Medicine, November 1977, pp. 43-52.

24. Sports Medicine Meets Synchronized Swimming. (The American Alliance for Health, Physical Education, Recreation, and Dance: Reston, VA, 1980)

25. Vegso, Joseph J., MS, ATC, and Harmon, Louis E. III, M.D. "Nonoperative Management of Athletic Ankle Injuries," Clinics in Sports Medicine, Vol. 1, No. 1, March 1982, pp. 85-98.

APPENDIX A

SUBJECT ARTHROPOMETRIC IMPROVEMENTS

Subject # 1

A 3° medial collateral ligament strain of the right leg was suffered on September 21, 1984. There was also significant bleeding and bruising in the general knee area. Swimming pool rehabilitation began September 22, and took place four times a week. Girth measurements and range of motion measurements were taken initially, then every Wednesday and Saturday.

Criteria used:

A. Expected knee flexion for adults 130-135°
B. Expected knee extension for adults 0-10°
C. Expected knee internal rotation 10°
D. Expected knee external rotation 10°

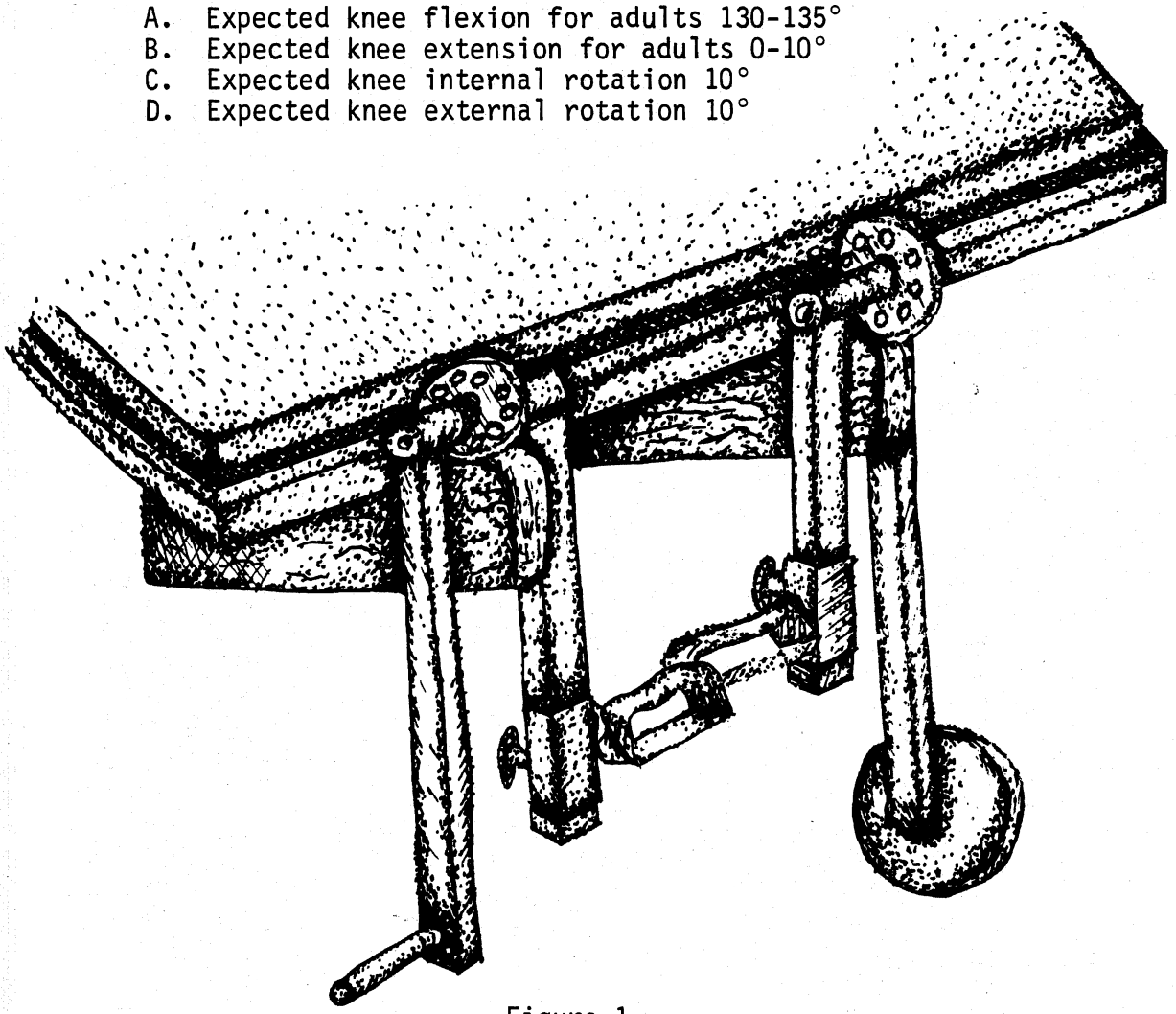


Figure 1

Flexion Extension Weight Apparatus

Table 5

Subject # 1 Bi-Weekly Progression

Date	Left leg Circum. 3" above patella	Right leg Circum. 3" above patella	Left leg Extension	Right leg Extension	Left leg Flexion	Right leg Flexion	Left Leg Internal Rotation	Right Leg Internal Rotation	Left Leg External Rotation	Right Leg External Rotation
10/22	22.5"	24"	5°	-20°	130°	70°	8°	5°	8°	0°
10/26	22"	22"	5°	-10°	130°	90°	8°	5°	8°	3°
10/29	22"	22"	5°	-10°	130°	95°	8°	3°	8°	3°
11/03	22"	22"	5°	-8°	130°	85°	8°	2°	8°	2°
11/06	22.5"	22"	5°	-5°	130°	88°	8°	6°	8°	5°
11/10	22"	22"	5°	0°	130°	92°	6°	6°	8°	6°
11/13	22"	22.5"	5°	0°	130°	95°	8°	6°	8°	6°
11/17	22"	22"	5°	0°	130°	120°	8°	8°	8°	8°
11/20	22"	22"	5°	0°	130°	126°	8°	8°	8°	8°
11/24	22"	22"	5°	0°	130°	130°	8°	7°	8°	8°

11/03 For some reason there was some swelling and tenderness over the medial collateral ligament.

11/06 The swelling and tenderness is gone.

11/17 Tested on weights:

	Left Leg	Right leg
	Extension 25 lbs.	Extension 20 lbs.
	Flexion 18 lbs.	Flexion 18 lbs.

11/20 Started lifting weights, serious running, partial practice, running figure 8's.

11/24 Started cutting and full practice.

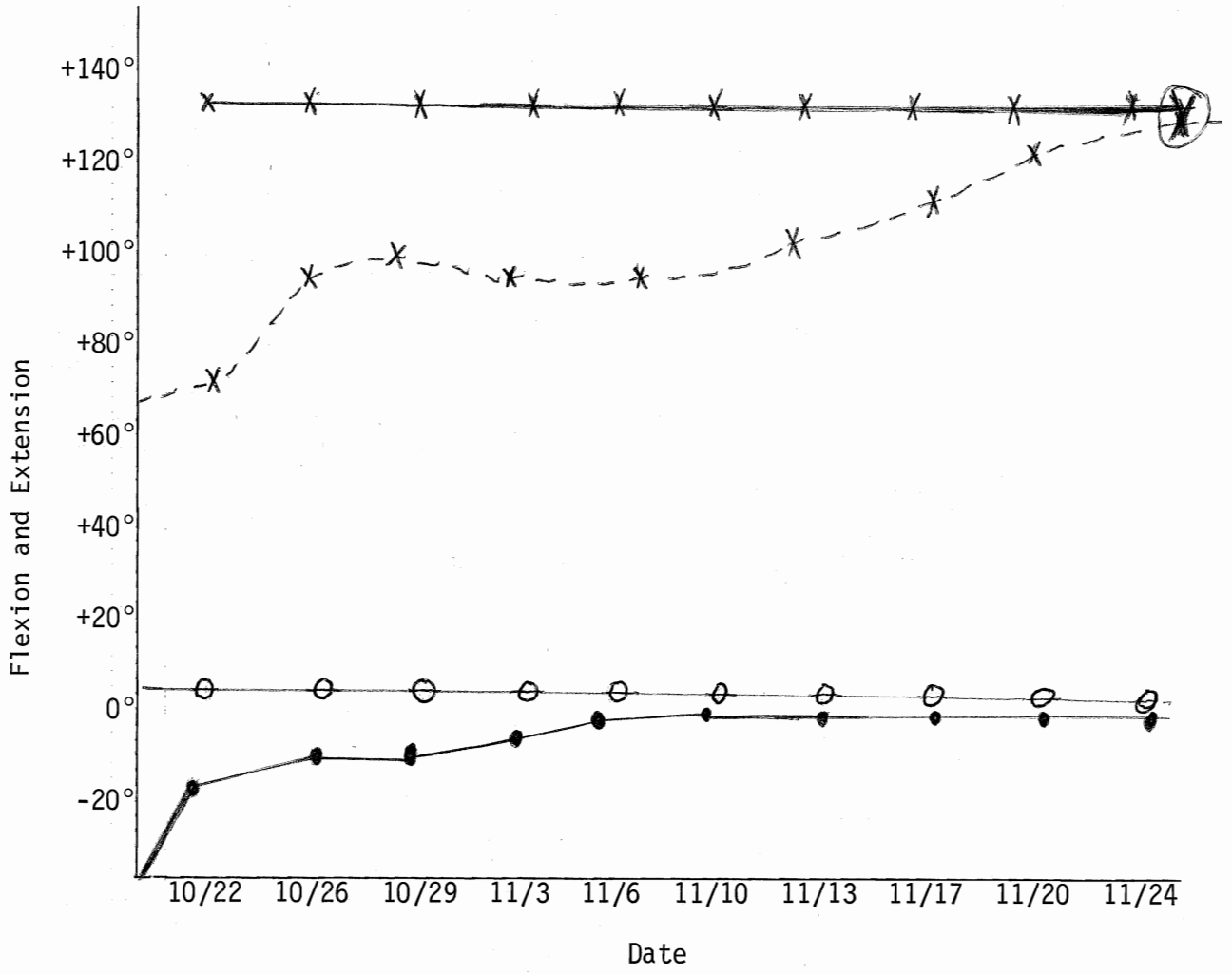


Figure 2

Comparison of the Right Leg Flexion and Extension Range of Motion
to Left Leg Flexion and Extension Range of Motion
Subject # 1

Right leg flexion° -X-

Left leg flexion° -X-

Right leg extension° -●-

Left leg extension° -O-

Subject # 2

This young man received a fracture of the fibula of his right leg October 5, 1984. As a result of this injury, he had a cast on his ankle for 2½ weeks. October 25, 1984 the cast was removed, and October 26, the water rehabilitation was started.

This criteria for comparison was used for subjects 2 and 3:

Dorsi flexion 20°	Subtalar inversion 5°
Plantar flexion 50°	Subtalar eversion 5°
Forefoot Abduction 10°	Calf circumference left leg 13"
Forefoot Adduction 20°	Calf circumference right leg 10-12"

Table 6

Subject # 2 Bi-weekly Progression

Date	Dorsi flexion		Plantar flexion		Subtalar Inversion		Subtalar Eversion		Forefoot Abduction		Forefoot Adduction		Calf Circumference	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
10/26	2°	15°	4°	40°	0°	5°	0°	5°	2°	10°	6°	15°	12"	13"
10/27	2°	15°	4°	40°	0°	5°	0°	5°	2°	10°	6°	15°	12"	13"
10/31	6°	15°	6°	40°	0°	5°	0°	5°	5°	10°	6°	15°	12½"	13"
11/03	10°	16°	10°	40°	2°	5°	0°	5°	5°	6°	8°	15°	12 3/4"	13"
11/07	10°	16°	15°	42°	2°	5°	0°	5°	3°	10°	12°	17°	12 3/4"	13"
11/10	10°	16°	20°	42°	2°	5°	0°	5°	5°	8°	10°	17°	12½"	13"
11/14	12°	17°	24°	42°	4°	5°	2°	5°	5°	10°	12°	15°	12½"	13"
11/17	15°	17°	29°	42°	4°	5°	2°	5°	8°	10°	14°	17°	12½"	13"
11/21	15°	17°	34°	42°	4°	5°	4°	5°	8°	9°	14°	17°	12 3/4"	13"
11/24	16°	17°	39°	43°	4°	5°	4°	5°	8°	10°	14°	17°	12 3/4"	13"
11/28	16°	17°	40°	43°	5°	5°	4°	5°	9°	10°	16°	17°	12 3/4"	13"

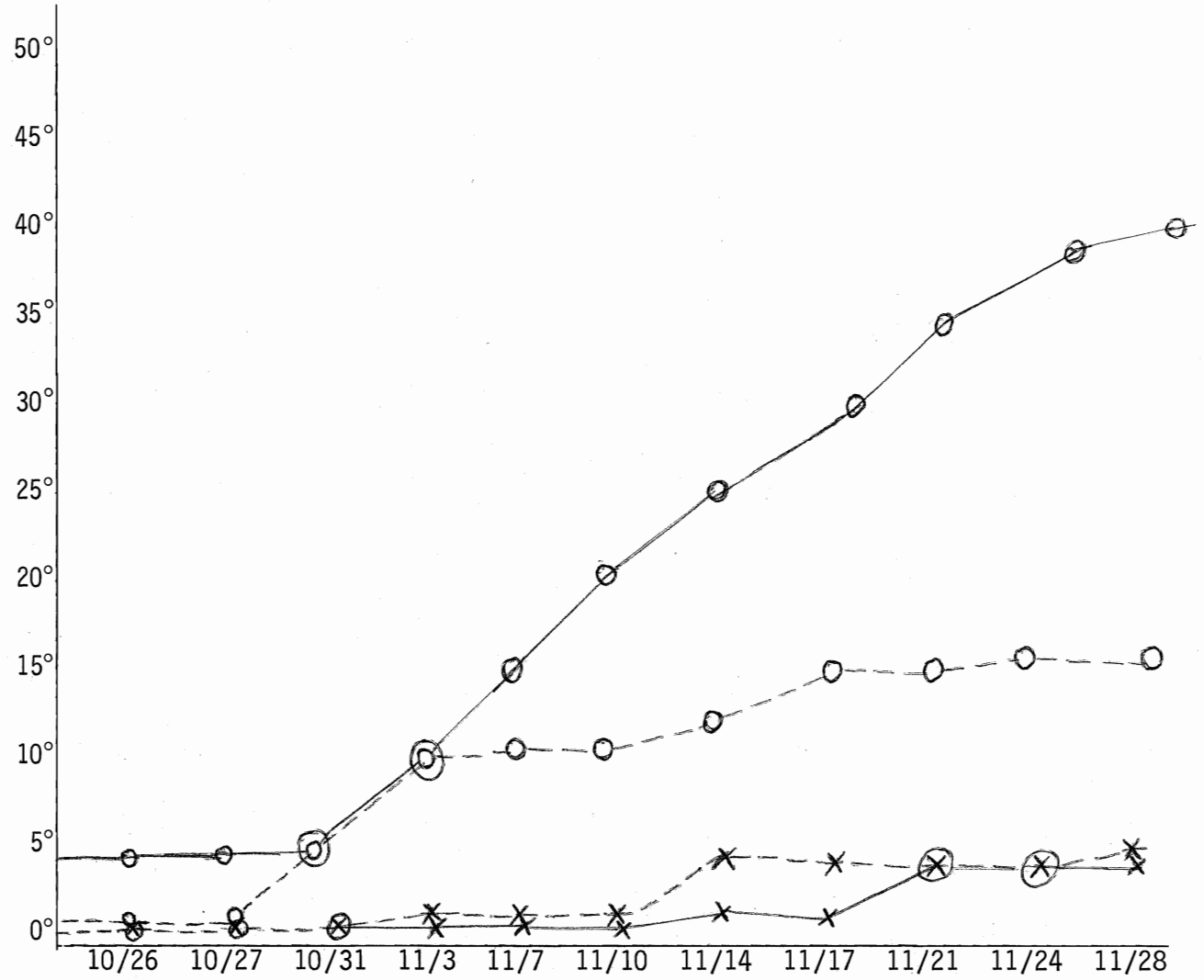


Figure 3

Right Ankle Dorsi flexion, Plantar flexion, Inversion and Eversion Improvement During Total Water Rehabilitation Time
Subject # 2

Dorsi flexion° - O - -

Plantar flexion° - O -

Inversion° - X - -

Eversion° — X —

*11/10 The ankle strengthening device was started and used four times a week.

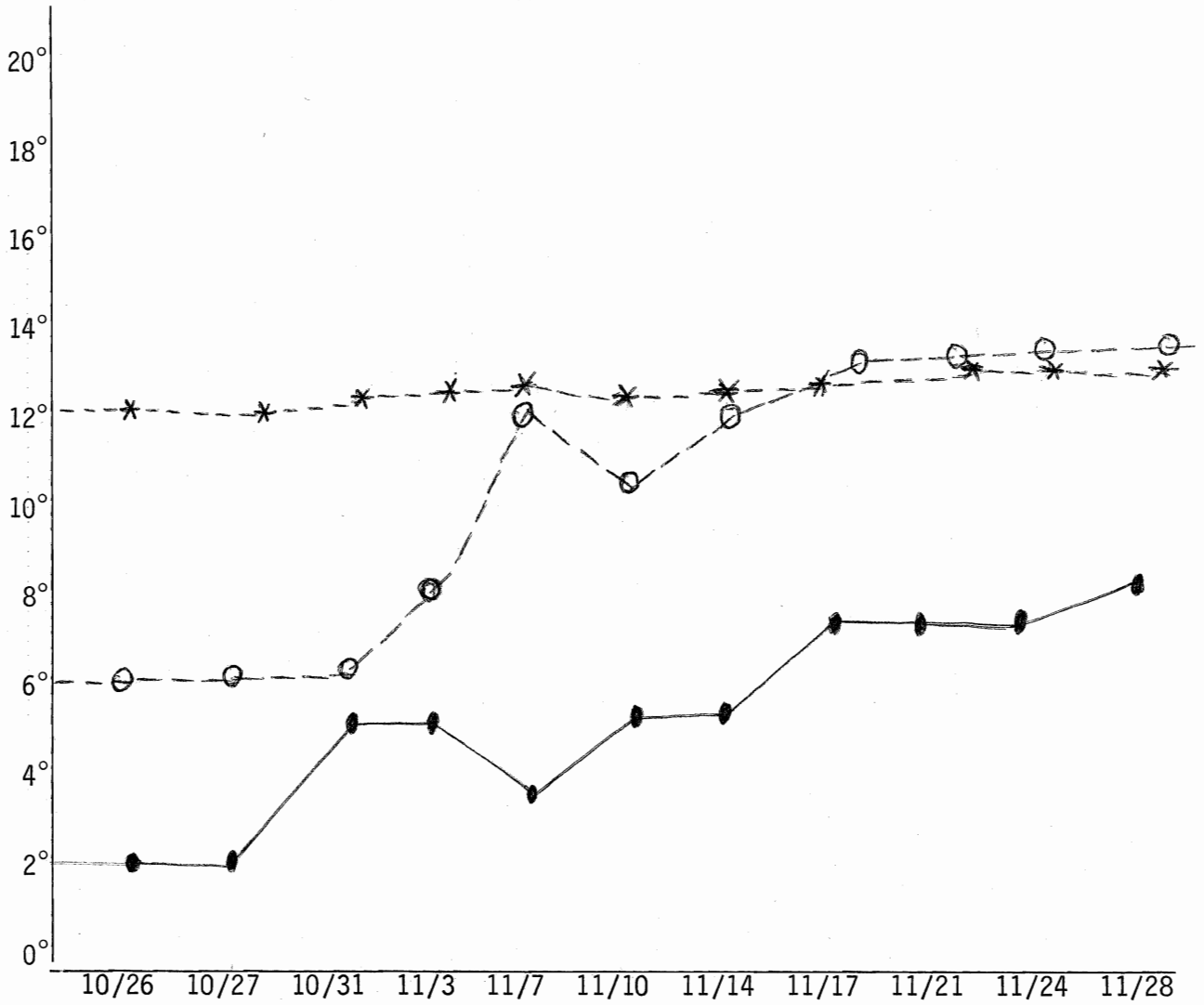


Figure 4

Increases in Right Forefoot Abduction and Adduction and Right Calf Circumference During the Water Rehabilitation Period
Subject # 2

Forefoot Abduction° —●—

Forefoot Adduction° —Θ—

Calf Circumference—✶— (inches)

Subject # 3

This young man came to me on October 10, 1984, the day that he got his cast off. It was on his right ankle for 2½ weeks. He had basketball practice starting in approximately 6 weeks, thus his motivation was high, and his workouts in the pool were vigorous.

Table 7

Subject # 3 Bi-weekly Progression

Date	Dorsi flexion		Plantar flexion		Subtalar Inversion		Subtalar Eversion		Forefoot Adduction		Forefoot Abduction		Circumference	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
10/13	6°	18°	20°	40°	0°	5°	0°	5°	0°	5°	2°	15°	10"	11"
10/17	6°	18°	22°	40°	0°	5°	2°	5°	2°	5°	2°	15°	10"	11"
10/20	10°	18°	28°	45°	2°	5°	2°	5°	2°	5°	6°	15°	10¼"	11"
10/24	10°	18°	34°	45°	3°	5°	0°	5°	4°	5°	8°	18°	10¼"	11"
10/27	14°	18°	34°	48°	3°	5°	2°	5°	5°	5°	12°	18°	10½"	11"
10/31	18°	16°	40°	48°	3°	5°	2°	5°	5°	5°	12°	18°	10½"	11"
11/03	15°	18°	38°	50°	5°	5°	3°	5°	5°	5°	15°	18°	10½"	11"
11/07	16°	18°	42°	50°	5°	5°	4°	5°	5°	4°	16°	18°	10 3/4"	11"
11/10	18°	18°	46°	50°	5°	5°	4°	5°	5°	5°	16°	18°	10 3/4"	11"

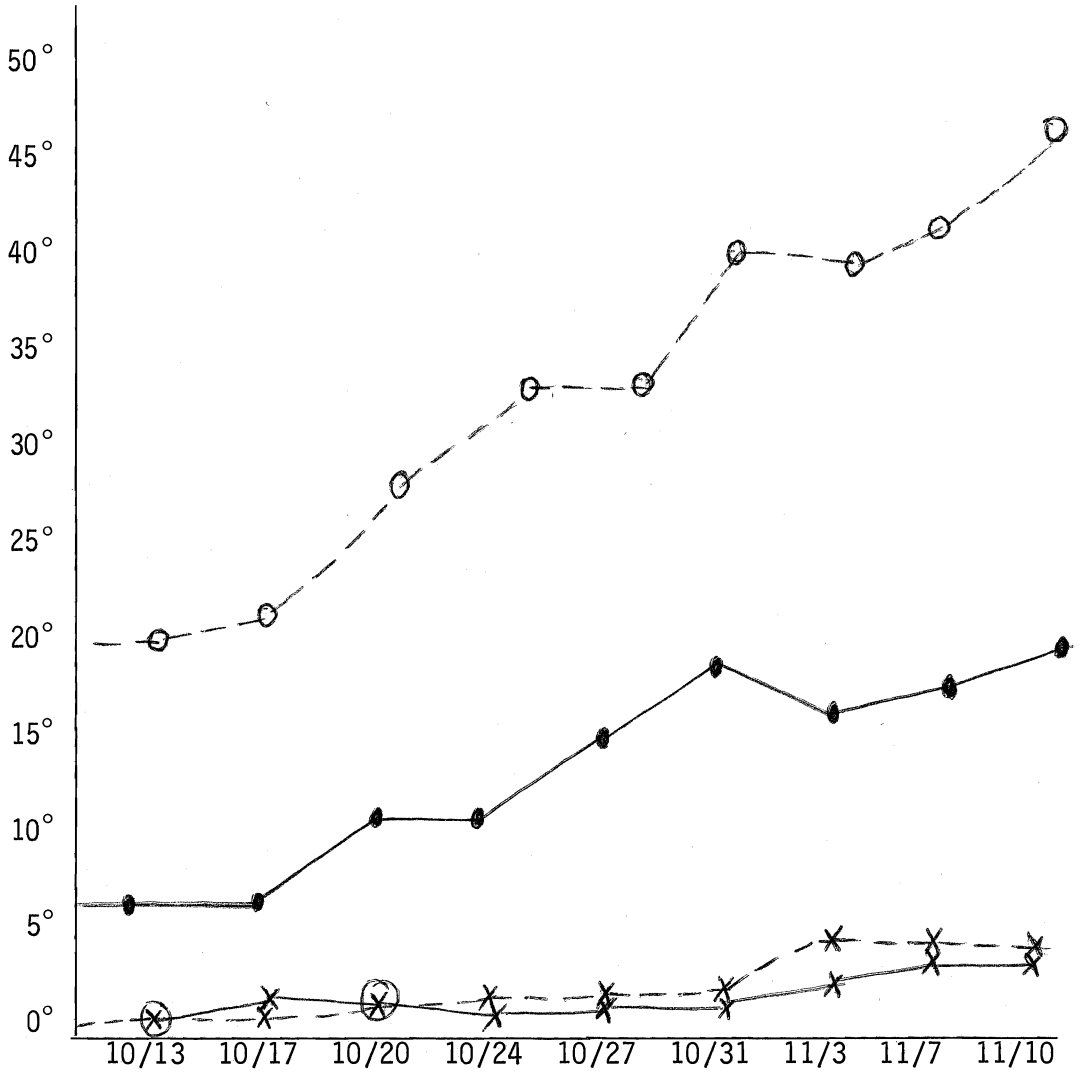


Figure 5

Right Ankle Dorsi flexion, Plantar flexion, Inversion, and Eversion Improvement During Total Water Rehabilitation Time
Subject # 3

Dorsi flexion°

Plantar flexion°

Inversion°

Eversion°

This subject started working on the ankle strengthening device on 10/31.

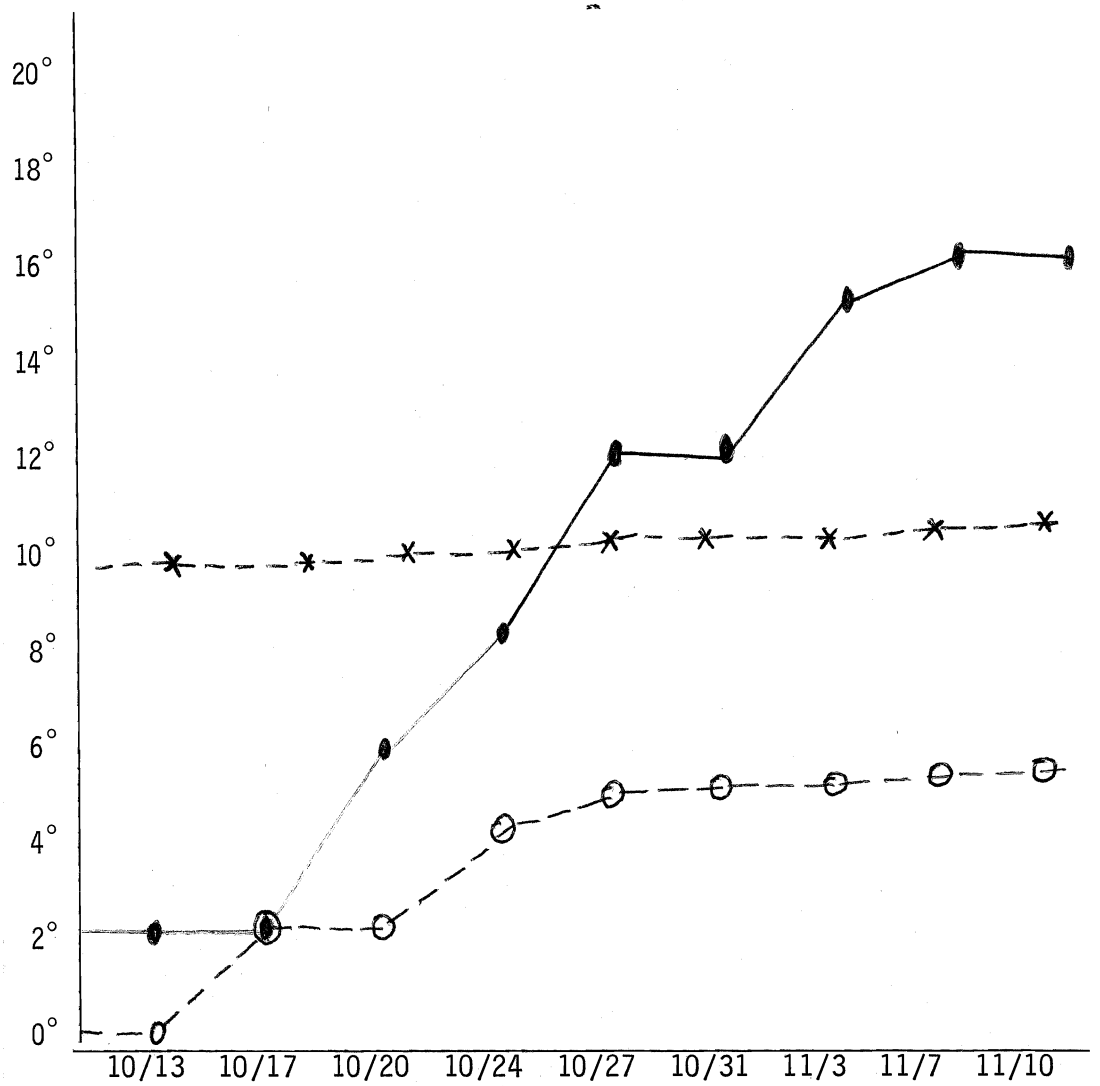


Figure 6

Increases in Right Forefoot Abduction and Adduction and Right Calf Circumference During the Water Rehabilitation Period Subject # 3

Forefoot Abduction° —●—

Forefoot Adduction° —○—

Calf circumference —✱— (inches)

Subject # 4

This athlete first complained of right knee pain January 26, 1984. After evaluative tests he was referred to an orthopedic surgeon, who performed an anterior cruciate repair.

Table 8

Subject # 4 Weekly Progression

Date	Left leg Circum. 3" above patella	Right leg Circum. 3" above patella	Left leg Extension	Right leg Extension	Left leg Flexion	Right leg Flexion	Left leg Internal Rotation	Right leg Internal Rotation	Left leg External Rotation	Right leg External Rotation
3/19	22"	20"	0°	-20°	130°	50°	+2°	0°	+5°	0°
3/26	22"	20"	0°	-20°	130°	55°	+2°	0°	+5°	0°
4/02	22"	20"	0°	-20°	130°	59°	+2°	0°	+5°	0°
4/09	22"	20¼"	0°	-20°	130°	65°	+2°	0°	+5°	0°
4/16	22"	20¼"	0°	-20°	130°	69°	+2°	0°	+5°	0°
4/23	22"	20 3/8"	0°	-20°	130°	72°	+2°	0°	+5°	0°
4/30	22"	20 3/8"	0°	-20°	130°	75°	+2°	0°	+5°	1°
5/06	22 1/8"	20½"	0°	-20°	130°	78°	+2°	1°	+5°	1°
5/13	22 1/8"	20½"	0°	-15°	130°	82°	+2°	1°	+5°	1°
5/20	22 1/8"	21"	0°	-12°	130°	86°	+2°	1°	+5°	2°
6/03	22 1/8"	21"	0°	- 7°	130°	93°	+2°	1°	+5°	2°

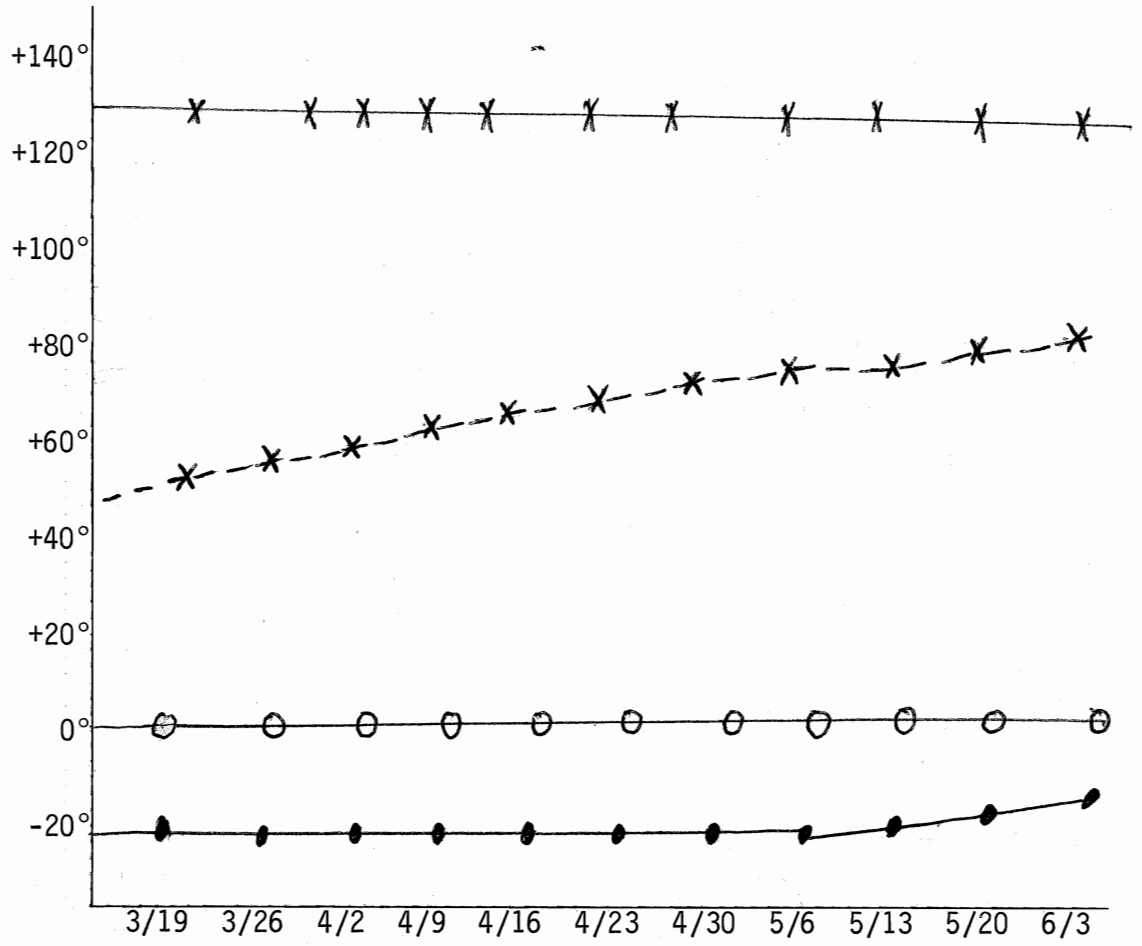


Figure 7

Right Leg Flexion and Extension Range of Motion
Compared to Left Leg Flexion and Extension Range of Motion
Subject # 4

Right leg flexion° —X—

Left leg flexion° —*—

Right leg extension° —●—

Left leg extension° —O—

Subject # 6

This athlete was injured November 10, 1984, when he was tackled while playing football. November 16, the athlete underwent a patellar tendon transfer.

Table 9

Subject # 6 Weekly Progression

Date	Left leg Circum. 3" above patella	Right leg Circum. 3" above patella	Left leg Extension	Right leg Extension	Left leg Flexion	Right leg Flexion
2/02	17½"	15"	0°	-20°	+130°	+10°
2/10	17½"	15"	0°	-20°	+130°	+10°
2/20	17½"	15¼"	0°	-17°	+130°	+13°
2/27						
3/01						
3/06	17½"	15 3/4"	0°	-17°	+130°	+17°
3/19	17½"	15 3/4"	0°	-17°	+130°	+17°
3/26	17 2/3"	15 7/8"	0°	-16°	+130°	+18°
4/04	17½"	16"	0°	-14°	+130°	+20°
4/09						
4/15						
4/19	17 3/4"	16"	0°	- 9°	+130°	+28°
4/27	17 3/4"	16"	0°	- 9°	+130°	+31°
5/04						
5/09						
5/15	17 2/3"	16 1/8"	0°	- 6°	+130°	+35°
5/22						
5/27						
6/04	17 3/4"	16 1/8"	0°	- 5°	+130°	+39°

Table 10

Subject # 6 Strength Gain

Date	Right Leg Flexion	Right Leg Extension	Left Leg Flexion	Left Leg Extension
2/02	2	2	28	40
2/14	4	4	28	40
2/20	6	5	28	40
2/26	6	5	28	40
3/05	6	7	28	40
3/14	8	9	28	40
3/21	8	9	28	40
3/29	9	10	28	40
4/04	9	12	28	40
4/11	10	14	28	40
4/18	11	15	28	40
4/27	12	15	28	40
5/05	13½	17	28	40
5/15	15	18	28	40
5/23	15	20	28	40
5/29	16	22	28	40
6/04	17	24	28	40

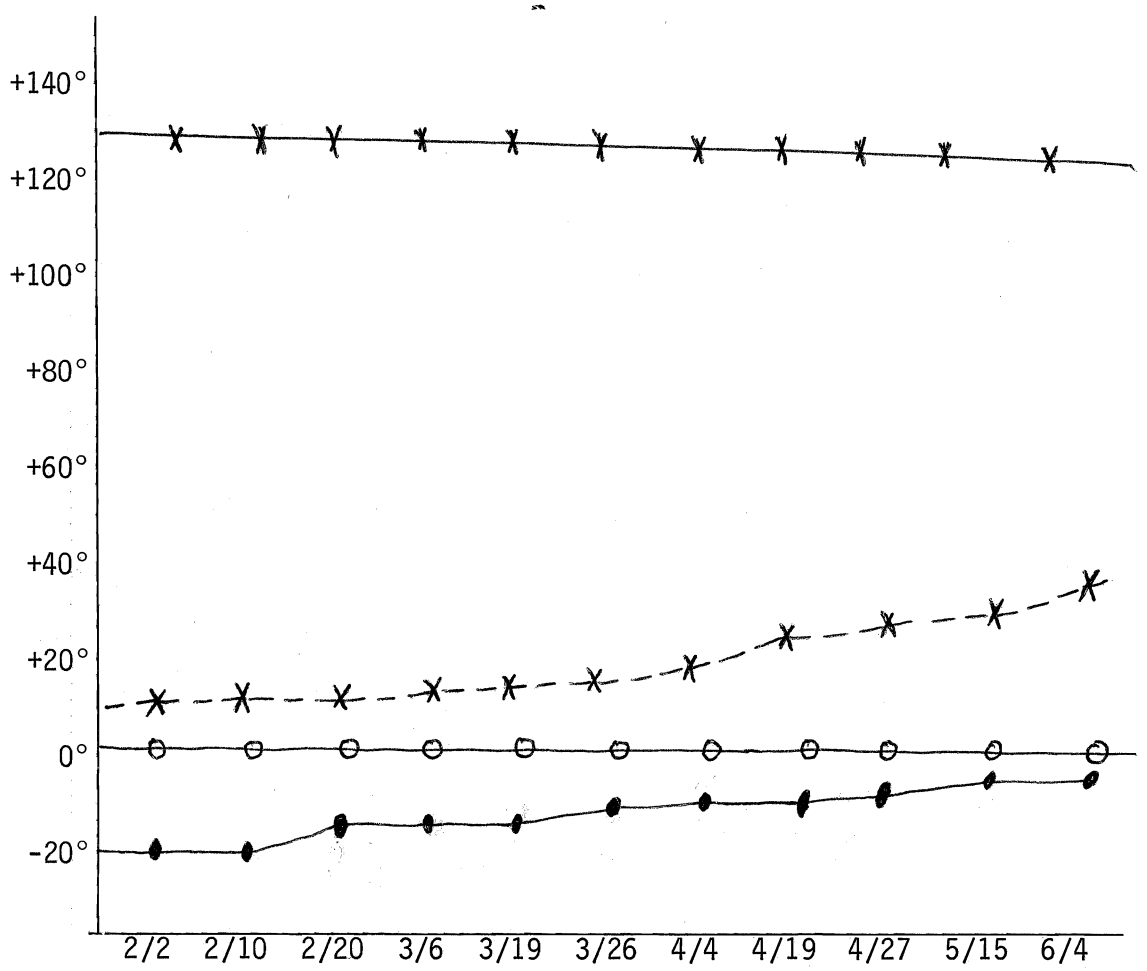


Figure 8

Right Leg Flexion and Extension Range of Motion
Compared to Left Leg Flexion and Extension Range of Motion
Subject # 6

Right Leg Flexion —X—

Left Leg Flexion —X—

Right Leg Extension —●—

Left Leg Extension —○—

Subject # 7
Non Water Rehabilitation

This athlete received a second degree sprain injuring the anterior talofibular, anterior talotibial, calcaneofibular and posterior talofibular ligaments and the extensor hallucis longus tendon.

Table 11

Subject # 7 Weekly Progression

Date	Dorsi flexion		Plantar flexion		Subtalar Inversion		Subtalar Eversion		Forefoot Abduction		Forefoot Adduction	
	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right	Left
1/05	0°	+5°	+10°	+40°	2°	5°	0°	1°	0°	5°	+5°	20°
1/12	+1°	+5°	+15°	+40°	2°	5°	0°	3°	0°	5°	+6°	20°
1/19	+3°	+5°	+10°	+40°	2°	5°	0°	3°	0°	5°	+9°	20°
1/31	+5°	+5°	+25°	+40°	3°	5°	3°	3°	3°	5°	+5°	20°
2/07	+5°	+5°	+28°	+40°	3°	5°	3°	3°	5°	5°	+6°	20°
2/15	+5°	+5°	+30°	+40°	3°	5°	3°	3°	5°	5°	+10°	20°

Table 12

Subject # 7 Bi-weekly Strength Measurements

Date	Plantar flexion		Dorsi flexion		Inversion		Eversion	
	Right Ankle	Left Ankle	Right Ankle	Left Ankle	Right Ankle	Left Ankle	Right Ankle	Left Ankle
1/16	1	15	1	20	1	12	1	12
1/19	2	15	2	20	2	13	2	12
1/25	5	15	5	20	5	15	5	13
1/31	7	15	7	20	7	15	7	15
2/07	10	16	10	24	9	17	9	17
2/15	15	16	15	24	10	19	10	18
2/20	15	17	15	25	12	20	12	20
2/26	18	18	20	25	15	20	15	20

APPENDIX B

WATER WORKOUT ILLUSTRATIONS AND EXPLANATIONS

Water Workouts

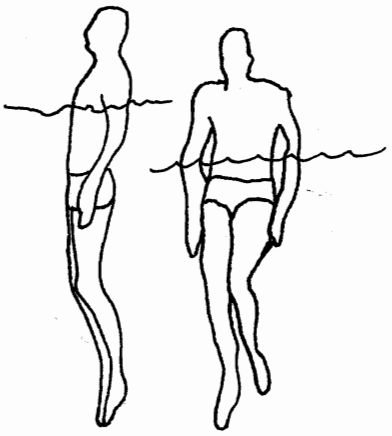
A variety of workouts and exercises were used each day. The workouts and exercises used were individualized as much as possible, in order to assure the subject was receiving a proper workout for his particular injury. Each workout was gauged for each person's tolerance. If there was any pain elicited, the particular exercise was stopped. The exercises included:

1. Alternate toe touches:

   Standing in waist deep water, bring hand toward opposite foot.

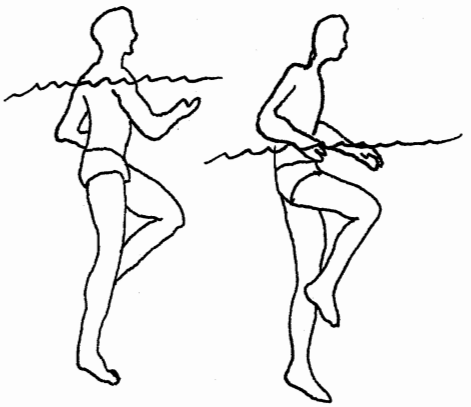
2. Toe Bounce - One foot and two feet.

   Standing in various depths of water, raise on toes and go back down.



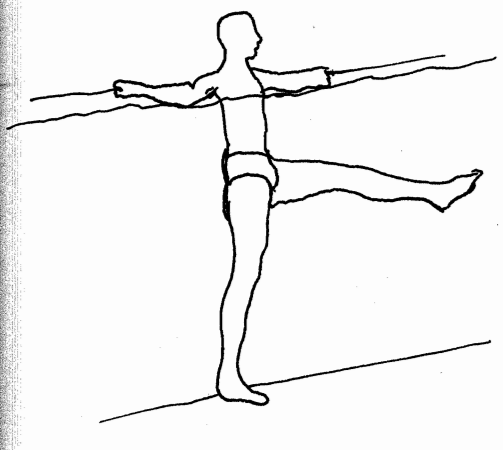
3. Jogging in place and widths of the pool.

   A. Arms bent in running position.
   B. Knees high and wide strides.
   C. Kick back with legs to work gluteals and hamstrings.
   D. Done in various depths of water, depending on strength of individual.



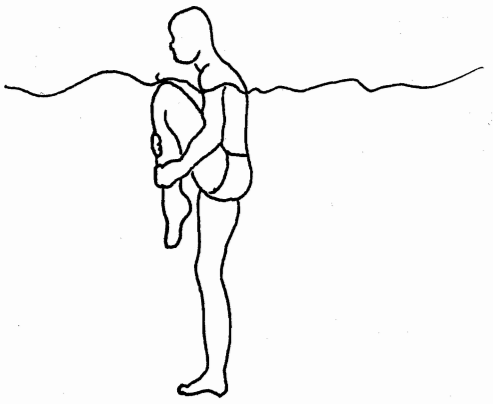
4. Leg Outs

   A. Hang on to side of pool.
   B. Extend leg straight out.
   C. Stretch leg and hold in isometric contraction.
   D. Drop leg to starting position.



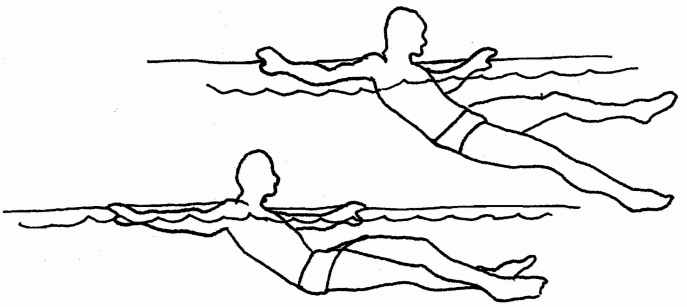
5. Pull and Stretch

   A. Raise leg and clasp calf with both arms pulling leg vigorously to chest.
   B. Repeat with opposite leg.



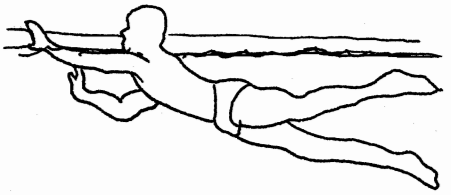
6. Leg Crosses

   A. Swing legs apart.
   B. Bring legs together, crossing one leg over the other.
   C. Swing legs apart, bring other leg over.



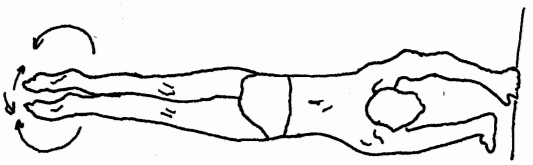
7. Wall Kicking

   A. While lying prone, holding on to the gutter with one hand flat on the wall, push legs out.
   B. Kick feet together with wide kicks.



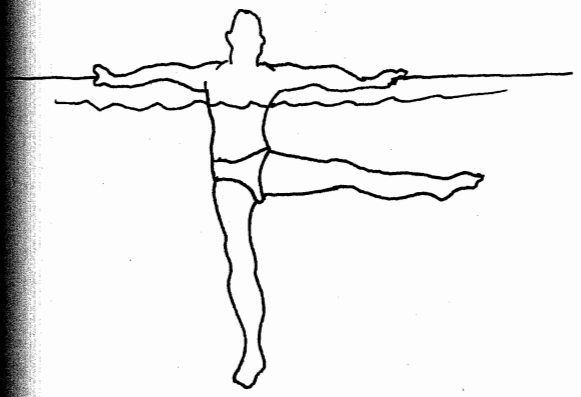
8. Ankle Circles

   Circle ankles from left to right, then right to left.



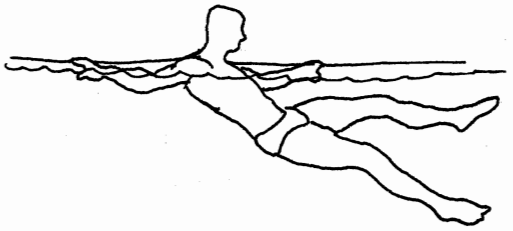
9. Knee and Ankle ABC's

   A. Stretch leg out in front of body.
   B. Trace the alphabet from A to Z twice, working on ankle and knee range of motion.



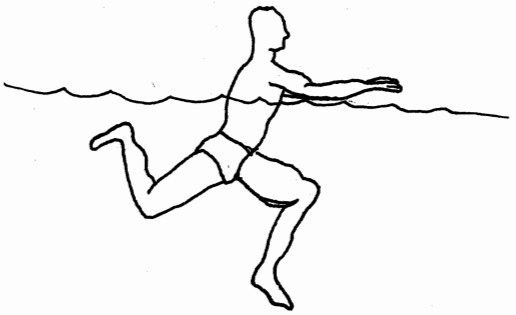
10. Back Flutter Kick

   A. Lying in the supine position, hold on to side of pool.
   B. Flutter kick, making sure knees are relatively straight.



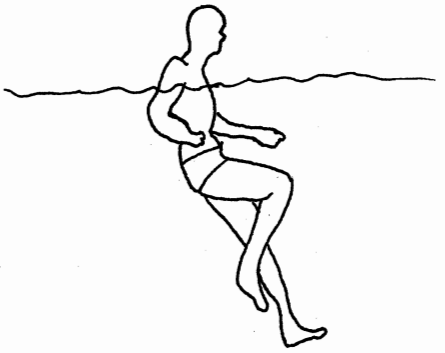
11. Deep Knee Bends

   A. Subject stands in chest deep or shallow water.
   B. He takes one leg up and bends the other knee down supporting his weight.



12. Treading Water

   A. Performed in deep water in a perpendicular position.
   B. Kick vigorously, at the same time sculling with the arms keeping head above water.
   C. Modification of this for more advanced participants, tread to keep shoulders and chest out of water.



13. Kicking holding on to kick board

   A. Hold kick board, keeping head out of water.
   B. Kick vigorously free style or breast-stroke kick, depending on injury.

14. Lap Swimming

    Swim laps using any stroke or combinations of strokes.

15. Leg Adduction/Abduction

    A. Subject hangs on to side of pool.
    B. He forces both legs out, against the resistance of the water, then brings them back together.

*Illustrations taken from Aqua Dynamics, Source # 19.

APPENDIX C

SUBJECT # 1 DAY BY DAY WATER WORKOUTS

SUBJECT NUMBER ONE

Workout # 1: 20 minutes. There was still swelling and pain elicited by some movements. The workout was stopped early because the researcher did not want the subject to associate pain with every workout.

1. Alternate toe touches, 15 on each leg.
2. Knee ABC's, 2 sets of 2.
3. Leg Abduction/Adduction, 5 minutes.
4. Leg crosses, 5 minutes.
5. Leg outs, each isometric contraction held to a count of 20, 10 on each leg.
6. Knee ABC's.

Workouts # 2 and 3: Knee felt better in these workouts, was able to complete 30 minutes.

1. Alternate toe touches, 15 on each leg.
2. Knee ABC's, 2 sets of 2.
3. Leg Adduction/Abduction, 5 minutes.
4. Leg crosses, 5 minutes.
5. Leg outs, each isometric contraction held to a count of 20, 15 on each leg.
6. Wall Kicking, 5 minutes.
7. Back flutter kick, 5 minutes.
8. Knee ABC's, 2 sets of 2.

Workout # 4: 40 minutes.

1. Alternate toe touches, 20 on each leg.
2. Leg outs, each isometric contraction to a count of 30, 15 on each leg.
3. Leg crosses.

4. Wall kicking, 5 minutes.
5. Back flutter kick, 5 minutes.
6. Jogging widths of the pool 10 widths, armpit deep water, trying to kick back as far as possible and stride out as far as possible.
7. Knee ABC's.
8. Swimming freestyle 4 lengths.
9. Wall kicking, 5 minutes.
10. Back flutter kick, 5 minutes.
11. Alternate toe touches, 15 on each leg.

Workouts # 5 and 6: 35 minutes.

1. Alternate toe touches, 20 on each leg.
2. Leg outs, same style as above.
3. Pull and stretch, to tolerance, 5 on each leg.
4. Abduction/Adduction, 5 minutes.
5. Jogging widths, armpit deep water, 12 widths.
6. Knee ABC's.
7. Wall kicking, 5 minutes.
8. Back flutter kick, 5 minutes.

Workouts # 7 and 8: 35 minutes.

1. Alternate toe touches, 20 on each leg.
2. Toe bounces both legs, chest deep water, 10 of these.
3. Jogging in chest deep water, 16 widths.
4. Knee ABC's, 2 sets of 2.
5. Leg Adduction/Abduction, 5 minutes.
6. Back flutter kick, 5 minutes.
7. Swimming 6 lengths free style.
8. Kick 3 lengths free style.
9. Leg crosses, 2 minutes.

Workout # 9: 40 minutes. Subject starting to feel much stronger, progress will probably start increasing at a faster rate.

1. Alternate toe touches, 20 on each leg.
2. Pull and stretch, 15 on each leg.
3. Leg crosses, 5 minutes.
4. Leg Abduction/Adduction, 5 minutes.
5. Leg outs, each isometric contraction to a count of 30, 18 on each leg.
6. Wall kicking, 8 minutes.
7. Back flutter kick, 8 minutes.
8. Swimming 8 lengths free style.
9. Jogging in waist deep water 16 widths.
*10. Deep knee bends, 5 on right leg, waist deep water.
11. Knee PRE's, 2 sets of 2.
12. Alternate toe touches, 10 on each side.

*These did not elicit any pain, which was a very positive sign.

Workouts # 10 and 11: 35 minutes.

1. Alternate toe touches, 15 on each leg.
2. Back flutter kick, 5 minutes.
3. Wall kicking, 5 minutes.
4. Jogging 20 widths, waist deep water.
5. Toe bouncing, 1 leg chest deep water, 10 of these.
6. Knee ABC's, 2 sets of 2.
7. Swimming laps 8 lengths free style.
8. Kicking holding on to kick board, 3 lengths.
9. Leg crosses, 1 minute.
10. Alternate toe touches, 15 on each leg.

Workout # 12: 40 minutes.

1. Alternate toe touches, 15 on each leg.
2. Back flutter kick, 6 minutes.
3. Wall kicking, 6 minutes.
4. Leg Abduction/Adduction, 3 minutes.
5. Jogging, waist deep water, 24 widths.
6. Swimming 8 lengths free style.
7. Kicking holding onto kick board, four lengths free style.
8. Toe bouncing right leg, waist deep water, 10 of these.
9. Deep knee bends, 8 on right leg.
10. Knee ABC's.

APPENDIX D

SUBJECT # 2 DAY BY DAY WATER WORKOUTS

SUBJECT NUMBER TWO

Workout # 1: 30 minutes.

1. Pull and stretch, 20 on each leg.
2. Alternate toe touches, 20 on each side } warm up
3. Leg crosses, 5 minutes.
4. Jogging (very slow), emphasis on spring off toes, 10 widths, armpit deep water.
5. Ankle ABC's.
6. Wall kicking.
7. Ankle circles.
8. Swim 6 lengths free style, 2 lengths breast stroke.

Workouts # 2 and 3: 30 minutes.

1. Pull and stretch, 20 on each leg.
2. Alternate toe touches, 20 on each side. } warm up
3. Leg Adduction/Abduction, 3 minutes.
4. Back flutter kick, 5 minutes.
5. Wall kicking, 5 minutes.
6. Jogging at same speed as previous day, spring off toes, same depth, 14 widths.
7. Ankle ABC's.
8. Jogging in place 3 minutes, chest deep water.
9. Ankle circles.
10. Swim 3 lengths free style, kicking holding onto kick board, 3 lengths.

Workout # 4: 40 minutes.

1. Leg crosses, 5 minutes.
2. Alternate toe touches, 25 on each leg.
3. Jogging 20 widths, same depth, slightly faster, chest deep water.

4. Wall kicking, 8 minutes.
5. Ankle A.B.C.'s.
6. Jogging in one place 5 minutes, chest deep water.
7. Ankle ABC's.
8. Swimming 6 lengths free style, 2 lengths breast stroke
9. Back flutter kick, 5 minutes.
10. Pull and stretch, 20 on each leg.

*Very tired after this workout.

Workout # 5: 35 minutes exactly the same as above, but no back flutter kick.

Workouts # 6 and 7: 35 minutes.

1. Leg outs, 20 on each leg.
2. Alternate toe touches, 20 on each leg.
3. Toe bounces on right ankle, armpit deep water.
4. Jogging chest deep water, 20 widths.
5. Ankle ABC's, 2 sets of 2.
6. Back flutter kick, 8 minutes.
7. Swimming 3 lengths free style, 3 lengths breast stroke.
8. Pull and stretch, 20 on each leg.
9. Leg crosses, 3 minutes.

Workout # 8: 40 minutes.

1. Alternate toe touches, 25 on each leg.
2. Swimming 8 lengths, 6 freestyle, 2 breast stroke.
3. Kicking with kick board 4 lengths, 3 freestyle, 1 breast stroke.
4. Jogging waist deep water, 20 widths.
5. Ankle ABC's.
6. Back flutter kick, 8 minutes.

7. Toe bouncing right ankle, chest deep water.
8. Ankle circles.
9. Leg Adduction, Abduction.
10. Tread water, 4 minutes.

Workout # 9: Same as above, except no back flutter kick.

Workouts # 10 and 11: 35 minutes.

1. Leg Abduction/Adduction, 3 minutes.
2. Alternate toe touches, 25 on each leg.
3. Jogging widths, waist deep water, 24 widths.
4. Hopping on right ankle, 5 minutes.
5. Ankle ABC's, 2 sets of 2.
6. Swimming 10 lengths.
7. Treading water, 8 minutes.

Workout # 12: 40 minutes.

1. Leg crosses.
2. Alternate toe touches.
3. Jogging waist deep water, 28 widths.
4. Toe bouncing, right ankle, 5 minutes.
5. Ankle ABC's, 2 sets of 2.
6. Swimming 10 lengths, 3 breast stroke, 7 free style.
7. Kicking with kick board 6 lengths, 4 free style, 2 breast stroke.
8. Tread water, 10 minutes.
9. Ankle ABC's.
10. Alternate toe touches, 15 on each leg.

APPENDIX E

SUBJECT # 3 DAY BY DAY WATER WORKOUTS

SUBJECT NUMBER THREE

This subject could not swim, and was somewhat frightened of deep water, so this limited his swimming workouts to the shallow end of the pool activities.

Workout # 1: 30 minutes.

1. Pull and stretch, 20 on each leg.
2. Alternate toe touches, 20 on each leg.
3. Leg crosses, 5 minutes.
4. Walking with bounding movements 10 widths, armpit deep water.
5. Ankle ABC's, 2 sets of 2.
6. Wall kicking, 5 minutes.
7. Back flutter kick, 5 minutes.
8. Ankle circles, 3 minutes.

Workouts # 2 and 3: 30 minutes.

1. Alternate toe touches, 20 on each leg.
2. Pull and stretch, 20 on each leg.
3. Back flutter kick, 10 minutes.
4. Jogging (slow) emphasize springing off on toes, 10 widths.
5. Wall kicking, 10 minutes.
6. Ankle ABC's, 2 sets of 2.

Workout # 4: 35 minutes.

1. Abduction/Adduction, 2 minutes.
2. Alternate toe touches, 20 on each side.
3. Jogging 14 widths, armpit deep water.
4. Ankle ABC's, 2 sets of 2.
5. Wall kicking, 10 minutes.

6. Back flutter kick, 10 minutes.
7. Ankle circles, 2 minutes.

Workouts # 5 and 6: 35 minutes.

1. Alternate toe touches, 20 on each leg.
2. Pull and stretch, 10 on each leg.
3. Back flutter kick, 10 minutes.
4. Wall kicking, 10 minutes.
5. Jogging, chest deep water, 14 widths.
6. Ankle ABC's.
7. Toe bounces off both feet 2 minutes, chest deep water.
8. Ankle ABC's.

Workout # 7: 40 minutes. Subject's attitude seems to be going slowly downhill. He is not getting the instant results which he wants.

1. Alternate toe touches, 15 on each leg.
2. Leg Abduction/Adduction, 4 minutes.
3. Jogging, chest deep water, 20 widths.
4. Toe bounces off both feet, 4 minutes.
5. Wall kicking, 12 minutes.
6. Back flutter kick for 12 minutes.
7. Ankle ABC's.

Workouts # 8 and 9: 35 minutes.

1. Alternate toe touches, 15 on each leg.
2. Toe bounces off both feet, 4 minutes.
3. Jogging chest deep water, 22 widths.
4. Toe bounces off right foot, 1 minute.

5. Ankle ABC's.
6. Wall kicking, 12 minutes.
7. Back flutter kick, 12 minutes.

Workout # 10: 40 minutes. Today the subject ventured into the deep water, with a kick board, for the first time.

1. Alternate toe touches, 15 on each leg.
2. Jogging waist deep water, 12 widths.
3. Jogging chest deep water, 12 widths.
4. Toe bounces off right foot, 2 minutes, chest deep water.
5. Ankle ABC's, 2 sets of 2.
6. Wall kicking, 10 minutes.
7. Back flutter kick, 10 minutes.
8. 2 lengths free style kick with kick board.
9. Ankle circles, 2 minutes.
10. Jogging in place, 2 minutes, chest deep water.
11. Ankle ABC's.

Workout # 11: 35 minutes. In order to enhance the subject's experience, and keep his interest, today we played water basketball for 15 minutes. There were 8 minutes from minutes 3-11 where the subject was permitted to bounce on only his right foot. This was played in chest deep water.

1. Alternating toe touches, 15 on each leg.
2. Wall kicking, 5 minutes.
3. Back flutter kick, 8 minutes.
4. Ankle ABC's, 2 sets of 2.

5. Water Basketball, 15 minutes.
6. Ankle ABC's.

Workouts # 12 and 13: 35 minutes.

1. Ankle circles, 2 minutes.
2. Pull and stretch, 15 on each leg.
3. Leg Adduction/Abduction, 3 minutes.
4. Jogging waist deep water, 18 widths.
5. Jogging chest deep water, 6 widths.
6. Wall kicking, 8 minutes.
7. Back flutter kick, 8 minutes.
8. Ankle ABC's, 2 sets of 2.

Workouts # 14 and 15: 35 minutes.

1. Ankle circles, 2 minutes.
2. Leg Adduction/Abduction, 2 minutes.
3. Jogging waist deep water, 24 widths.
4. Wall kicking, 6 minutes.
5. Back flutter kick, 6 minutes.
6. 3 lengths free style kick with kick board.
7. Toe bounces off right foot, waist deep water, 1 minute.
8. Ankle PRE's.

Workout # 16: Same as above, but

1. 6 lengths free style kick.
2. Toe bounces, 3 minutes.

APPENDIX F

SUBJECT # 4 DAY BY DAY WATER WORKOUTS

SUBJECT NUMBER FOUR

Workout # 1: 38 minutes.

1. Alternate toe touches, 10 on each leg.
2. Leg outs, 15 on each leg, 10 second counts.
3. Leg Abduction, Adduction - 2 minutes.
*4. 8 lengths freestyle swim with minimal kick.
5. Leg crosses, 1 set of 30.
6. Walking, shoulder deep water 8 widths.
7. Alternate toe touches, 10 on each leg.

Workouts # 2, 3, and 4: 40 minutes.

1. Alternate toe touches, 6 on each leg.
2. Leg outs, 15 on each leg, 30 second counts.
*3. 10 lengths freestyle, minimal kick.
4. Walking, shoulder deep water 12 widths.
5. Leg Abduction, Adduction - 8 minutes.

Workout # 5: 28 minutes.

1. Leg Abduction, Adduction - 5 minutes.
2. Alternate toe touches, 10 on each leg.
*3. 12 lengths freestyle, some kicking.
4. Walk 10 widths chest deep water.
*5. Tread water supported by kickboard under one arm, 3 minutes.

Workouts # 6 and 7: 35 minutes.

*1. Walk 12 widths, chest deep water, 6 widths walking forward using an extended backward kicking motion.

*The athlete was instructed that his kicking motions should be smooth, not rapid and jerking.

2. Alternate toe touches, 10 on each leg.

*3. 12 lengths freestyle, some kicking.

4. Abduction, Adduction - 3 minutes.

*5. Tread water, supported by a kickboard under one arm, 5 minutes.

6. Alternate toe touches, 10 on each leg.

Workouts # 8 and 9: 40 minutes.

1. Leg outs, 15 on each leg, 30 second counts.

*2. Walk 10 widths chest deep water using an extended backward kicking motion.

3. Walk 4 widths waist deep water.

*4. Swim 14 lengths, some kicking.

*5. Slow motion wall kicks, 5 minutes.

6. Abduction, Adduction - 1 minute.

Workouts # 10 and 11: 30 minutes.

1. Alternate toe touches, 10 on each leg.

*2. Slow motion wall kicks, 5 minutes.

*3. Walk 14 widths chest deep water using an extended backward kicking motion.

*4. Swim 14 lengths, some kicking.

5. Walk 6 widths waist deep water.

Workouts # 12, 13, and 14: 45 minutes.

*1. Walk 16 widths chest deep water using an extended backward kicking motion.

*2. Walk 10 widths waist deep water, 4 of these widths using an extended backward kicking motion.

*The athlete was instructed that his kicking motions should be smooth, not rapid and jerking.

*3. Swim 14 lengths, some kicking.

4. Tread water, supported by a kickboard under one arm, 8 minutes.

Workout # 15: 35 minutes.

1. Leg outs, 10 on each leg, 40 second counts.

*2. Swim 10 lengths, some kicking.

3. Walk 10 widths chest deep water using an extended backward kicking motion.

4. Walk 6 widths waist deep water, 4 of these widths using an extended backward kicking motion.

5. Abduction, Adduction - 2 minutes.

Workouts # 16, 17, and 18: 38 minutes.

1. Walk 10 widths waist deep water.

*2. Walk 16 widths chest deep water, 4 widths long stride jogging.

*3. Swim 14 lengths, some kicking.

*4. Slow motion wall kicking, 5 minutes.

5. Alternate toe touches, 15 on each leg.

Workouts # 19, 20, and 21: 40 minutes.

*1. Walk 14 widths waist deep water, 4 widths using an extended backward kicking motion.

*2. Walk 12 widths chest deep water, 6 widths long stride jogging.

*3. Swim 12 lengths, some kicking.

4. Abduction, Adduction - 4 minutes.

5. Walk 4 widths hip deep water.

Workouts # 22 and 23: 35 minutes.

1. Alternate toe touches, 10 on each leg.

*The athlete was instructed that his kicking motions should be smooth, not rapid and jerking.

*2. Wall kicking with long strides, 5 minutes.

*3. Walk 14 widths waist deep water, 6 to 8 widths using an extended backward kicking motion.

*4. Swim 10 lengths, some kicking.

*5. Walk 14 widths chest deep water, 10 widths long stride jogging.

Workouts # 24 - 27: 30-55 minutes.

1. Alternate toe touches, 10 on each leg.

2. Leg outs with resistance to flexion and extension. Resistance increased from 5 seconds to 15 seconds for a set of 10.

*3. Swim 12 lengths, some kicking.

4. Knee bends, followed by pull and stretch 2-10 on each leg.

5. Walk 6 widths hip deep water.

*6. Walk 6 widths waist deep water using an extended backward kicking motion.

*7. Long stride jog, chest deep water, 6-16 widths.

Workouts # 28 - 30: 35 minutes.

1. Abduction, Adduction - 3 minutes.

2. Jogging waist deep water, 4 widths.

3. Long stride jog, waist deep water, 6 widths.

4. Walk 10 widths hip deep water or knee bends with pull and stretch.

5. Swim 12 lengths.

6. Wall Kicking, 3 minutes.

7. Tread water, not using a kickboard for flotation, 3 minutes.

8. Walk 6 widths hip deep water.

*The athlete was instructed that his kicking motions should be smooth, not rapid and jerking.

Workouts # 31 - 34: 35-55 minutes.

1. Alternate toe touches or leg crosses, 2 minutes.
2. Knee bends followed by pull and stretch, 5-15 on each leg.
3. Swim 12 lengths.
4. Leg outs against resistance for 5-15 seconds or against weight of two pull buoys, 10-15.
5. Knee ABC's, 2 minutes.
6. Wall Kicking, 4 minutes.
7. Long stride jogging 6-10 widths in waist deep water.
8. Walk hip deep water using an extended backward kicking motion, 4-10 widths.

Workouts # 35 and 36: 40-60 minutes.

1. Leg crosses or abduction, adduction - 3 minutes.
2. Knee bends followed by pull and stretch, 8-16 on each leg.
3. Long stride jogging hip deep water, 4-8 widths.
4. Swim 14 lengths.
5. Wall Kicking 3 minutes or kickboard or back flutter kick.
6. Jogging waist deep water, 6-10 widths.
7. Treading water, not using a kickboard for floatation, 6-9 minutes.
8. Long stride jogging waist deep water, 8-14 widths.

APPENDIX G

SUBJECT # 5 DAY BY DAY WATER WORKOUTS

SUBJECT NUMBER FIVE

Workouts # 1, 2, 3, and 4: 20-30 minutes.

1. Pull and stretch, 10 on each leg.
2. Ankle circles, 3 minutes.
3. Kickboard kicking, 6 to 10 lengths.
4. Swimming 12 to 16 lengths.
5. Walk 6 widths shoulder deep water.
6. Tread water, 6 minutes.

Workout # 5: 30 minutes.

1. Pull and stretch, 10 on each leg.
2. Walk in chest deep water, 6 widths.
3. Stand up on both toes, 10 times, in shoulder deep water.
4. Swim 10 lengths.
5. Kick 4 lengths, 30 seconds per length, 15 seconds rest between each length.
6. Walk in chest deep water 6 widths.

Workouts # 6 and 7: 35 minutes.

1. Pull and stretch, 10 on each leg.
2. Jog in chest deep water, 6 widths.
3. Stand on both toes in waist deep water, 15 times.
4. Kick 8 lengths, 30 seconds per length, 15 seconds rest between each length.
5. Walk in hip deep water 10 widths.

Workout # 8: 35-40 minutes.

1. Pull and stretch, 10 on each leg.
2. Jog in chest deep water 6 widths.

3. Jog in waist deep water 4 widths.

4. Toe bounce on left leg in shoulder deep water, 15 times.

5. Kick 8 lengths, 30 seconds per length, 15 seconds rest between each length.

6. Tread water 10 minutes, alternating 1 minute with hands in the water to 30 seconds with hands out of the water.

7. Back flutter kick, 2 minutes.

Workouts # 9 and 10: 35-40 minutes.

1. Pull and stretch, 10 on each leg.

2. Jog in waist deep water, 8 widths.

3. Jog in hip deep water, 6 widths.

4. Toe bounce on left leg in waist deep water, 5-10 times.

5. Kick 10 lengths, 35 seconds per length, 15 seconds rest between each length.

6. Ankle ABC's, 1 minute.

7. Tread water 11-16 minutes, alternating 1 minute with hands in the water to 30 seconds with hands out of the water.

8. Back flutter kick, 2 minutes.

Workouts # 11 and 12: Athlete started to jog outside, then did the water workout.

1. Pull and stretch, 10 on each leg.

2. Kick 8 lengths with kickboard.

3. Jog in waist deep water, 6 widths.

4. Jog in hip deep water, 6 widths.

5. Toe bounce on left leg in waist deep water, 8-16 times.

6. Back flutter kick, 2 minutes.

APPENDIX H

SUBJECT CONSENT FORM

Consent for Participation in a Research Project

I _____, state that I am under (18)
(Name of subject)
years old and wish to participate in the water rehabilitation program conducted by Laura Lutes.

The purpose of the research is to determine if the use of a swimming pool is an effective part of a rehabilitation program for an injured athlete.

The rehabilitation involves 30-40 minute workouts in the swimming pool, 4 times a week. Each workout will be geared toward the athlete's particular injury, and will consist of various exercises, jogging patterns, and sometimes swimming. Collection of joint range of motion, and limb widths will be taken twice weekly.

The personal risks of this study are minimal, and are those associated with return to activity such as sore muscles. Benefits will include improved strength of the injured limb as well as improved range of motion.

I acknowledge that Laura Lutes has fully explained to me the risks involved and the need for the research. I have been informed that I may withdraw at any time and will be given another rehabilitation program to work with. If there are any questions which I may have at any time, Laura Lutes has offered to answer them. I have been informed that I will be given a copy of this consent form. I freely and voluntarily consent to my participation in this research project.

_____
Signature Volunteer

_____ _____
Witness to explanation Signature of Parent
(If under 18)