THE SHORT-TERM RETENTION OF FLEXIBILITY IN VARSITY ICE HOCKEY PLAYERS

****

A Thesis

Presented to

The Faculty of University Schools

Lakehead University

****

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

in the

Theory of Coaching

****

by

Claude Daniel Chevrier

November, 1981

ABSTRACT

Title of Thesis: The Short-Term Retention of Flexibility in Varsity Ice Hockey Players

Claude Daniel Chevrier: Master of Science in the Theory of Coaching, 1981

Thesis Advisor: Dr. B. S. Rushall
Professor
School of Physical Education and Outdoor Recreation
Lakehead University

The purpose of this study was to investigate the effects of various stretching exercises on flexibility during competition-specific activities. A Leighton Flexometer was used to measure flexibility. Testing and training procedures were controlled. The subjects were 4 Lakehead University varsity ice hockey players. The research design consisted of two replications of a 3 x 3 Latin square. The subjects were tested for flexibility before an ice hockey scrimmage, during the scrimmage, and at the conclusion of the scrimmage. Data were analyzed with ANOVA and Duncan Multiple Range Test. Significance was determined at 0.05 level. Results showed: 1) flexibility training methods (3S and SS) improved ankle flexibility, 2) flexibility is specific to each joint, 3) flexibility was greater before and after the scrimmage when compared to during the scrimmage, 4) there was no difference in flexibility due to training, and 5) no significant differences between training methods on short-term flexibility retention.

ACKNOWLEDGEMENTS

The author wishes to express his thanks and appreciation to Dr. B. S. Rushall, whose help was instrumental in making this study a reality. Thanks also to Dr. T. M. K. Song for advice concerning various aspects of the research.

The author thanks the Lakehead University varsity ice hockey coach, Mr. D. Bragnalo, and the four players for their cooperation during this study.

A note of appreciation goes to Mr. W. A. M. Roaf, Mr. N. D. Brook, and Mr. M. A. Loiselle for their very helpful assistance.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF TABLES

Chapter 1

INTRODUCTION

Statement of Purpose

The purpose of this study was to investigate the effects of various stretching exercises on flexibility during competition-specific activities.

Significance of the Study

Flexibility is said by many to be useful in improving sport performance, reducing injury, and relieving some forms of muscle soreness (Corbin & Noble, 1980). If this is the case, then flexibility training should be a major component of sport training.

Studies on flexibility are numerous. The majority have been concerned with comparing the flexibility of various athletic groups (Haliski & Sigerseth, 1950; Leighton, 1957a; Leighton, 1957b; Lemiere, 1952; Pickens, 1950; Song, 1979; Sterner, 1963; Syverson, 1950; Williams, 1950). Others have measured flexibility after a period of exercise (Atha & Wheatley, 1976; Holt, Travis & Okita, 1970; Robertson, 1976). Other studies have compared levels of flexibility after various stretching techniques (de Vries, 1962; Holt, Travis, & Okita, 1970; Kusinitz & Keeney, 1958; Logan & Egstrom, 1961; Riddle, 1956; Song & Garvie, 1976).

Few studies are available concerning flexibility retention. This thesis will monitor the effects of flexibility warm-up on flexibility retention during a simulated competitive contest. This study is unique in that no other study has evaluated this phenomenon. Turner (1977) measured flexibility retention over a 10 week training period. He found that retention of flexibility was lost significantly after cessation of training. This occurred for both 3S (Scientific Stretching for Sport) and SS (Slow Stretching).

This thesis will investigate variations in the flexibility of ice hockey players during competition-specific activities. The amount of flexibility required for an ice hockey activity may be indicated. The degree of effectiveness of the training methods may suggest alterations in the warm-up activities of ice hockey.

Delimitations

1. This study was delimited to four members of the Lakehead University varsity hockey team. Their ages varied from 20 to 21 years.

2. The format of the athlete's training program was bound by the decisions of Mr. Dave Bragnalo, the Head Coach. However, appropriate amounts of time were set aside for conducting this investigation.

3. The observation period was from January 26, 1981 to March 2, 1981. The testing sessions were conducted every Monday evening.

4. The scope of this study was delimited to the ball and socket joints (hip and shoulder), and the hinge joints (knee and ankle).

5. The independent variables were the 3S and SS stretching methods (Holt, 1973).

6. The dependent variables were the changes in flexibility and the retention of flexibility in the hip, shoulder, knee, and ankle joints during competition-specific activities.

Limitations

1. This paper was limited by the effort put forth by the four varsity ice hockey players.

2. It is assumed that these athletes were able to understand and perform the various stretching exercises.

3. It is assumed that the athletes performed during a scrimmage as they do during an ice hockey contest. Thus, the conditions of a scrimmage were deemed to be similar to those of a competitive game.

Definitions

Flexibility: This is the range of extent of motion possible in a given joint (Holt, 1973).

Flexion refers to the bending or decreasing of an angle between two bones (Jacob & Francone, 1974).

Extension is the increase of the angle between two bones (Jacob & Francone, 1974).

Abduction is moving the bone away from the midline (Jacob & Francone, 1974).

Adduction is moving the bone toward the midline (Jacob & Francone, 1974).

Dorsi-Flexion is the raising of the foot toward the anterior surface of the leg (Rasch & Burke, 1978).

Plantar-Flexion is the lowering of the foot so as to bring its long axis in line with that of the leg (Rasch & Burke, 1978).

Isometric Contraction is defined as a muscular effort which does not result in joint movement; the force does not move the resistance (Holt, 1973).

Concentric Contraction: This is a muscular effort that results in a joint moving due to the shortening of the contracting muscle tissue (Holt, 1973).

Flexibility Retention refers to the difference in the flexibility of a specific joint, measured in degrees, between the pre-test and follow-up test sessions (Turner, 1977).

Joint: This is the junction of two bones. There are three major groups of joints. They are synarthrodial (immovable), amphiarthrodial (slightly movable), and the diarthrodial joint (freely moveable) (Rasch & Burke, 1978).

3S (Scientific Stretching for Sport): This is a method of increasing flexibility by a series of isometric contractions of the muscles to be stretched (muscles in a lengthened position to start), followed by concentric contractions of the opposite muscle group together with light pressure from a partner (Holt, 1973).

SS (Slow Stretching): This is a method of increasing flexibility by slow active contraction of the agonist muscles while relaxing the antagonist muscle group (Jacobs, 1976).

PNF (Proprioceptive Neuromuscular Facilitation): This is a stretching technique based on the principles of successive induction, muscle relaxation, and reciprocal innervation. It involves a maximal contraction of the agonist (muscles to be stretched) followed immediately by a concentric contraction of the antagonists (Holt, Travis & Okita, 1970).

Chapter 2

REVIEW OF LITERATURE

Flexibility

Flexibility is an important component of physical fitness (Buxton, 1957; Corbin & Noble, 1980). Improved flexibility is an integral part of physical fitness as is strength and cardiovascular endurance. This relative importance of flexibility has led coaches and trainers to make flexibility an important aspect of the training regime.

Studies on Flexibility

Flexibility has been shown to be an important aspect in performance as far back as the sixteenth century. St. Archange Tuccaro (1589) pointed out the benefits of flexibility on jumping, and he also designed a technique to increase the suppleness of the spine and the anterior thigh.

Flexibility studies were numerous during the 1940's and 1950's. The first studies dealt mostly with measuring various athletic groups, establishing norms, and comparing the results with other's data (Haliski & Sigerseth, 1950; Leighton, 1957; Lemiere, 1952; Pickens, 1952, Syverson, 1950; Williams, 1950). This type of study has continued into the 1960's and 1970's but has been less frequent (Song, 1979; Sterner, 1963). Other studies have attempted to correlate anthropometry, somatotypes, and flexibility (Broer & Galles, 1958; Fieldman, 1968; Harris, 1969; Harvey & Scott, 1967; Laubach & McConville, 1966; Mathews, Shaw & Bohnen, 1957; Mathews, Shaw & Woods, 1959; Sinelkinoff & Gugorowitsch, 1931; Tyrance, 1958). Some recent studies have attempted to show which type of exercise would be most beneficial for flexibility (Holt, Travis & Okita, 1970; Logan & Egstrom, 1961; Song & Garvie, 1976; Tanigawa, 1972; Turner, 1977). No study has been performed on short-term flexibility retention in a competitive contest. It is important to study the level of flexibility during a contest so that one may understand and find a correlation between performance and flexibility at any moment during an event.

Flexibility has been asserted to be important in performance. Early studies dealt mostly with measuring of flexibility and comparing results. Studies on flexibility are becoming more specialized. No studies have been initiated on flexibility retention during a competitive contest.

Factors Affecting Flexibility

Flexibility is specific to each joint of the human body (Dickinson, 1968; Fleishman, 1964; Harris, 1969; Munroe & Romance, 1975; Song, 1979; Travers & Evans, 1976). In 1979, Song found that flexibility was specific to each joint in each athletic group. The type of specialized flexibility varied significantly amongst different sports groups.

Flexibility has been shown to be affected by various factors. Physiologically, the body can only reach a maximum level of flexibility or dismemberment will occur. Joint mobility is limited by the bony and fleshy masses that block movements in the end position, by the muscles, tendons, ligaments and capsules that act as ties and which are put on stretch in the limiting position (Billig & Lowendahl, 1949). Other physiological factors are the shape of the bones, the elasticity of ligaments and muscles (Rathbone, 1949), strength of the antagonist muscles, and the effort of movement (Scott & French, 1959). Weight training and calisthenics can affect flexibility (Counsilman, 1955; Denk, 1971; de Vries, 1962; Kingsley, 1952; Kusinitz & Keeney, 1958; Massey & Chaudet, 1956; Meyers, 1971; Schmidt, 1967; Warden, 1962; Wickstrom, 1963). Sport participation (Skvortsov & Sermeev, 1964), heat treatment (Grobaker & Stull, 1975), preliminary exercises, short wave diathermy, hot showers (Asmussen & Boje, 1945), muscle soreness, tolerance for pain, ability to relax, and room temperature (Scott & French, 1959) affect flexibility.

Age is an important determinant of an individual's range of motion. Generally, humans become progressively more flexible from childhood to adolescence and then become progressively less flexible (Forbes, 1950; Hupprich & Sigerseth, 1950; Miller, 1954; Phillips, Bookwalter, Denman, McAuley, Sherwin, Summers & Yeakel, 1955). Leighton (1957) found that 16 year old boys were more flexible than high level swimmers, baseball and basketball players and track athletes (throwers). Skvortsov and Sermeev (1964) found that although flexibility peaks at different ages, it is usually maximal between the fourteenth and fifteenth year. Other studies have found flexibility to peak much later. Greey (1955) found that most flexible subjects were 23 years of age. Jervey (1962) supported this claim. Thus, the relationship between age and flexibility is not clearly established.

Aspects of anthropometry that can affect flexibility are body widths, girths, heights, and somatotypes. Tyrance (1958) found that neck flexion, neck rotation, lateral neck flexion, hip abduction, hip extension, knee flexion and elbow flexion correlated significantly with body type. His study showed that ectomorphs were the most flexible, followed by the mesomorphs and then endomorphs. Sinelkinoff and Gugorowitsch (1931) produced similar results. Laubach and McConville (1966) found that 25 of 84 correlations between 6 skinfold measurements and 14 flexibility measurements were significant beyond the .01 level. They concluded that the greater the amount of body fat, the smaller the range of motion. However, they concluded there was a general lack of relationship between flexility measurements and somatotype components. The greater proportion of studies have found that there is no significant relationship between selected aspects of flexibility and various anthopometric measurements (Broer & Galles, 1958; Fieldman, 1968; Harris, 1969; Harvey & Scott, 1967; Mathews, Shaw & Bohnen, 1957; Mathews, Shaw & Woods, 1959).

Various exercises have been shown to increase flexibility. Kingsley (1952) took flexibility measurements before and after a 20 week tumbling exercise program. He found that participation in the tumbling classes increased the flexibility of the subjects. Campbell (1944) found similar results after a dance program, but that the flexibility only increased to a certain level and then stopped. Moore (1954) tested teenage boys before and after a warm-up and found the warm-up to increase flexibility. Myers (1971) found that flexibility increased due to hatha yoga. Denk (1971) showed that a competitive gymnastic season aided in increasing flexibility in trunk flexion and back extension. However, this had no effect on ankle flexibility and shoulder elevation. Flexibility has been shown to increase due to exercise and a competitive season. However, increases tend to occur only in activity specific joints and to optimum levels that are accommodated by the activity.

Warm-ups increase the elasticity and contractility of the muscles making them function better and, therefore, have the potential to reduce the incidence of athletic injuries (Asmussen & Boje, 1945; Karpovich, 1956; Morehouse & Miller, 1959). Warm-ups are used extensively in athletic events. Many studies have shown that warm-ups are beneficial in improving the performance (Asmussen & Boje, 1945; Blank, 1955; Carlile, 1956; de Vries, 1955; Jervey, 1962; Karpovich, 1956; Pacheco, 1957; Pacheco, 1959; Thompson & Stull, 1959). Other studies assessing the effect of warm-ups found no difference in performance (Hipple, 1955; Hodgkins & Skubic, 1957; Karpovich & Hale, 1956; Lotter, 1959; Mathews & Snyder, 1959; Michael, Skubic & Rochelle, 1957; Sills & O'Riley, 1956). Schultz (1979) stated that static stretching safely improves flexibility, offers prevention and therapy for muscular distress, and may reduce the risk of injury. Worthington (1965) stated that the danger period for hamstring pulls is early in an activity session, particularly following an inadequate warm-up.

Muscle strains are a frequent occurrence in ice hockey. They can be due to uneven muscle strength and/or inflexibility (Davis, Logan & McKinney, 1961; Klafs & Arnhein, 1973).

Some joints are injured more frequently than others. Hastings, Cameron, Evans and Parker (1974) studied hockey injuries in Ontario. They found that more than half the ligament injuries occurred in the knee joint. Knee injuries were responsible for the greatest period of prolonged disability and the major proportion of hospitalizations and operations. Ankle injuries were second to knee injuries but generally were less severe, with shoulder injuries being next. MacIntosh, Skrien & Shephard (1972) studied sport injuries from 1951 to 1968 at the

University of Toronto. They found that sprains occurred most frequently in the ankle, next the knee, then the shoulder, and lastly in the hip. Muscle strains occurred mostly in the thigh. It was found also that the highest injury rates were seen towards the end of the playing season. A proper level of flexibility could be proposed as being required to prevent the occurrence of injuries.

The research on flexibility is controversial. Some researchers have shown flexibility to help in an athlete's performance while others found no such benefits. Those that support the claim that flexibility is important would acknowledge that a lack of flexibility would be a severe setback. Travers (1973) stated that a lack of flexibility has three consequences. They are: 1) it is impossible to perform skills properly, 2) there is an increased risk of muscle injury, and 3) there will be a loss of power in the range of movement. Cureton (1941) suggested that flexibility exercises, if built up to sufficient dosage, may condition muscles, tendons, ligaments, and bones to greater tensile strength and elasticity. Generally, the effects of lack of flexibility on performance are confined to opinions rather than valid data.

Excessive flexibility could cause many problems. Davis, Logan and McKinney (1961) stated that extreme flexibility may be a predisposing cause of injury to joints. Individuals with excessive flexibility may not have the structural qualities to provide adequate stability (Cureton, 1941).

The researches on flexibility have produced few conclusive statements. The firmest positions appear to support activity specific and optimal ranges of movement. Factors which affect flexibility are varied and controversial. The benefits from flexibility activities are supported more by opinions rather than controlled studies. A major absence of research is in the area of the amount of flexibility that is retained during an activity after a warm-up. Several assertions of flexibility warm-up benefits are dependent upon the demonstration of warm-up retention. This thesis assesses such retention in ice-hockey.

Reliability of the Leighton Flexometer

When Leighton first developed the flexometer, he performed a reliability check on all the tests he constructed and found a reliability coefficient of $\underline{r}$ = .994 (Leighton, 1942). In later years, Leighton tested various athletic groups and found reliability coefficients ranging from .86 to .999 (Leighton, 1957a) and .94 to .99 (Leighton, 1957b). Other researchers have observed similar trends. Broer and Galles (1958) measured the flexibility of 100 university physical education women and found through repeated measures a reliability coefficient of .971. Forbes (1950) found varying levels of reliability ranging from .901 to .983 depending on the joint measured. Mathews, Shaw and Bohnen (1957) had retests performed by other individuals and found an objectivity coefficient of .88. Laubach and McConville (1966) found reliability coefficients of .956 on the shoulder flexion-extension test, .955 on knee flexion-extension, and .982 on ankle flexion-extension. Munroe and Romance (1975) attempted to reduce the number of flexibility tests used by Leighton. They selected four of Leighton's tests which they thought would give an appropriate indication of an athlete's flexibility. They found a reliability coefficient of .95 on their selected tests. More recently, Song (1979) measured the flexibility of ice hockey players and found reliability coefficients ranging from .901 to .996 for a variety of tests.

The Leighton flexometer has been used extensively and has been shown to be reliable in measuring flexibility.

3S Exercises

The 3S type of flexibility exercises were developed by Holt (1973). This type of exercise is based on proprioceptive neuromuscular facilitation (PNF) exercises for paralysis patients (Kabat, 1952).

Very few studies have been done comparing various types of exercises and their effects on flexibility. Holt et al. (1970) tested subjects before and after doing various exercises. These were fast stretch, slow stretch, and a form of 3S. They found that all three improved flexibility but that the 3S exercises had greater gains while the other two were similar. Tanigawa (1972) found similar results. Turner (1977) on the other hand, found that 3S and SS forms increased flexibility over a control group but that neither method was superior. Song and Garvie (1976) found that during a five week program, the 3S group improved 20% while the control group improved 10%. Other studies have compared ballistic, slow and fast stretching exercises (de Vries, 1962; Kusinitz & Keeney, 1958; Logan & Egstrom, 1961; Riddle, 1956). More studies are needed to have a better understanding of 3S flexibility exercises and to see if they are superior or not to other forms.

SS Exercises

Very few studies have been performed on slow stretching (SS) exercises. De Vries (1962) tested the flexibility of individuals after doing static and ballistic stretching. He found that there was no difference between the two groups. These results agreed with Kusinitz and Keeney (1958) and Riddle (1956) who found that these exercises increased flexibility. Logan and Egstrom (1961) found no difference between fast and slow stretching on flexibility gains. Turner (1977) found no difference in flexibility gains between 3S and SS flexibility exercises.

The data on SS exercises show that flexibility gains are similar to those obtained with other methods. More studies are needed to find the best exercise for flexibility development.

Flexibility Retention

Few studies have been initiated regarding the retention of flexibility. Turner (1977) found, after a six week flexibility program, that retention tests taken two and four weeks after the conclusion of the program, showed no significant changes in flexibility between trained and untrained subjects at that point in time as compared to before training. Trained flexibility was not retained or had been lost in a short period of time. This is in contrast with McCue (1953) who found that improvements in flexibility were long lasting. Turner also found that there was no difference between 3S and SS exercises in the amount of flexibility loss during the two week period following the cessation of flexibility training. Tanigawa (1972) found that PNF type exercises showed a greater loss in flexibility than subjects using passive mobilization exercise and a control group. This occurred in less than one week. This may have been due to greater gains in flexibility using the PNF type exercises. Other studies have attempted to find the retention levels in a much shorter time period. Hansen (1962) measured a group of secondary school students, three, six and twenty-four hours after doing stretching exercises. He found that the original gain was very high after three hours, less after six hours and that a significant increase in flexibility still existed after 24 hours. Atha and Wheatley (1976) found that the effects of a single 15 minute mobilizing treatment persisted for 24 hours. No studies have been located with flexibility retention during a competitive event. Flexibility is proposed as an important component of athletics. Studies thus far have not shown the optimum range of flexibility. Studies of this type must be increased if this is to be found. If this optimum range is not found, the importance of flexibility may diminish because the research is quite divided as to whether or not flexibility aids in increasing performance.

Chapter 3
METHODS AND PROCEDURES

Hypothesis

There is no difference in the flexibility retention of subjects using 3S and SS flexibility training methods on the shoulder, hip, knee, and ankle joints during competition-specific activities.

Subjects and Setting

Four varsity hockey players from Lakehead University of Thunder Bay, Ontario served as subjects. Their ages ranged from 20 to 21 years.

The subjects conducted their training programme under the direction of the experimenter. Training and testing sessions were conducted in the Port Arthur Arena in Thunder Bay, Ontario.

Research Design

This study consisted of two replications of a 3 x 3 Latin square which was used to evaluate the effects of 3S, SS, and a control group (no exercises) on the shoulder, hip, knee and ankle joints. Subject 1 received 3S training on all four joints during session I. Subject II received SS training on all four joints during session I. Subject III received no training during session I. Subject IV repeated one of the training schedules to give a balanced effect (Figure 1).

Each subject was measured on two different occasions which constitutes a further replication. Thus, the experimental design is a total within-subjects factorial study (Winer, 1962, p. 349).

Design of the Study

Subject \ Testing Session	1	2	3
I	3S Training	SS Training	C No Training
II	SS Training	C No Training	3S Training
III	C No Training	3S Training	SS Training

Figure 1. Latin square used in this study.

Data Analysis

Data were analysed using the computer program SALTA which is part of the ANOV88 Statistical Package (Butler, Kamlet & Monty, 1970). A separate error term is computed for each source of variance in the design. Individual analyses were conducted for each of the four joints. A total analysis was made of all the pooled data. Consistent findings were assessed across all analyses. A significance level of .05 was set for the declaration of true effects. The analyses yielded the main effects of joints, time of measurement, method of training, and replications. The interaction of time of measurement and method is of most interest. It will indicate whether or not one method of flexibility warm-up produces better retention of effects than the others. This consideration is the primary test of the research hypothesis.

When the main effects were significant a Duncan Multiple Range Test was conducted to determine which means were significantly different from one another. When interactions were significantly different, graphical representations were made to demonstrate the difference.

Reliability

Two series of measurements were taken on each of four Lakehead University Residence male students. The flexibility tests were the same as those used in this thesis. Leighton's procedures were followed in all tests. The tester was helped by one assistant, who also was present during the testing for this study. The order of the subjects was the same for all tests. The tests were performed in the following order: shoulder flexion-extension, hip adduction-abduction, knee flexion-extension and ankle flexion-extension. The second replication was taken using the same order of subjects and tests at the completion of the first sets of testing. Test - retest reliabilities were established through the computation of a Pearson Product-moment Correlation Coefficient. All obtained statistics were significant ($p < .05$) indicating that the measurement techniques were reliable (see appendix A).

Testing and Training Schedule

Subjects were paired according to their exercise regimen. The observation period was from January 26, 1981 to March 2, 1981. The testing and training sessions were held once per week on Monday evenings between 1900 hours and 2100 hours. The control group was tested when they arrived in the locker room. The exercise groups commenced the stretching exercises (3S, SS) 15 minutes before they stepped on the ice surface. For the 3S and SS groups, the first testing session was at the conclusion of the exercise routine. The exercises were performed in the following order. First they did the shoulder exercises, then the hip, the knee, and finally the ankle exercises. The same order was followed for the testing sessions.

The first retention test for the groups occurred at the midpoint of the activity. The subjects were tested in a random order. The second retention test was at the conclusion of the competition simulation task. The subjects were again tested in a random order.

Testing Apparatus

One Leighton Flexometer (Leighton, 1966) was used for measuring the range of motion. This instrument is made of a weighted 360 degree dial and a weighted pointer mounted in a case. The dial and pointer operate freely and independently from each other but both are controlled by gravity. The flexometer records movement when it is in any position 20 degrees or better off the horizontal. Independent locking devices are provided for the dial and the pointer which stops the movement of the dial and pointer in any given position. The flexometer must be strapped to the segment next to the joint being tested. An example of the use of the flexometer is the knee flexion-extension test. The subject is in a prone position on a bench. The knees extend beyond the end of the bench. The arms are at the sides of the body and they are grasping the bench. The flexometer is fastened to the outside of the right ankle. The knee is flexed to its maximum. The dial is then locked. The subject extends the knee maximally and the pointer is locked. The subject is instructed to relax and the reading is taken.

All measurements were taken on the right side of the body. The subjects wore stockings and one piece underwear.

Testing Procedures

Leighton's procedures for flexibility measurements were used for all tests (Leighton, 1966). One tester administered all the tests, and he was assisted by one of two assistants, both of whom had experience with Leighton's flexibility measurement procedures. There was only one measurement for each joint at each testing session. This was done to avoid a practice effect. The assistant held various body segments stationary, and recorded all data. When testing for shoulder flexibility, the assistant added pressure on the subject's shoulders and chest. For knee flexibility, the assistant added pressure to the thigh and hip regions of the subject. In the hip flexibility test, the assistant's foot was used as a brace for the subject's right leg. The ankle flexibility test saw the assistant add pressure on the thigh, knee and lower leg of the subject. This stabilizing role ensured the reliability of measurements.

Teaching Methods

Before the start of the study, the subjects were given a demonstration of the testing procedures and the exercises. The SS subjects performed their exercises individually. The investigator supervised and was available for consultation if the subjects had problems understanding the procedures. Instructions with diagrams were posted in the locker room in a visible area to serve as constant cues for correct execution.

Flexibility Tests

Leighton's procedures were followed (individual pictures are in appendix B).

Shoulder flexion-extension. The subject was in a standing position at a projecting corner of a wall. The arm to be measured was extended just beyond the projecting corner. The back was to the wall, with the shoulder blades, buttocks and the heels touching the wall. The instrument was fastened to the side of the upper arm. The arm was moved upward and forward in an arc as far as possible. The palm of the moving hand was sliding against the wall. Once the maximum movement occurred, the dial was locked. The arm was then moved downward and backward as far as possible. The palm of the hand was sliding against the wall. The pointer was then locked. The subject relaxed and the reading was taken.

Hip adduction-abduction. The subject was in a standing position, feet together, knees straight and the arms at the sides. The flexometer was fastened to the back of the right leg just above the ankle. This was the starting position. The dial was locked. The subject moved the left leg sideways as far as possible. The pointer was locked when the maximum movement occurred. The subject relaxed and the reading was taken.

Knee flexion-extension. The subject was in a prone position on a bench. The knees were extended beyond the end of the bench. The arms were at the sides of the body and they were grasping the bench. The flexometer was fastened to the outside of the right ankle. The knee was flexed to its maximum. The dial was then locked. The subject extended the knee maximally and the pointer was locked. The subject was instructed to relax and the reading was taken.

Ankle flexion-extension. The subject was in a sitting position on a bench. The right foot was projecting beyond the edge of the bench. The left foot was resting on the floor. The right knee was kept straight. The flexometer was fastened on the inside of the right foot. The arms of the subject were slightly behind him, grasping the bench. The subject plantar-flexed the ankle as much as possible. The dial was locked. The ankle was dorsi-flexed to the maximum and the pointer was locked. The subject relaxed and the reading was taken.

Training Methods

3S flexibility exercises. This is a method of increasing flexibility by a series of isometric contractions of the muscles to be stretched (muscles in a lengthened position to start), followed by concentric contractions of the opposite muscle group together with light pressure from a partner (Holt, 1973).

For example, an athlete wanting to stretch the hip adductors performed as follows. The athlete (A) is sitting with his back straight and legs straight and as far apart as possible. The helper (H) is positioned in front of A, resting on one knee with the opposite foot on the floor, holding both A's legs above the ankles. A attempts to bring his legs together, with the knees remaining straight. The helper (H) resists. H holds A's position to produce a six second isometric contraction. A moves the legs further apart to a new position so that the legs are forcibly extended. H assists A's movement with light pressure. A attains his maximum range of motion without straining then relaxes.

When each exercise is completed, the following repetition is performed from the new lengthened position. The isometric contraction is a gradual increase in effort and not an explosive one.

SS flexibility exercises. This is a method of increasing flexibility by slow active contraction of the agonist muscles while relaxing the antagonist muscle group (Jacobs, 1976).

For example, an athlete (A) wanting to stretch the hip adductors performed as follows. The athlete (A) is sitting with his back straight and legs straight and as far apart as possible. A moves the legs slowly apart, knees remaining straight, so that the hips are forcibly extended. A holds this position for 10 seconds, without straining and then relaxes. Upon completion of each exercise the next repetition is performed from the starting position. The stretching movement made by A is overtly controlled only by the agonist muscle group and without additional assistance from any external force (e.g., hands pulling the legs to a greater range of motion).

Helpers for 3S Training Exercises

At each session, two different subjects did the 3S exercises. One was the helper while the other subject performed the exercise. They reversed roles after each exercise. If injuries occurred and only one subject was able to perform the 3S exercises, the tester became the helper.

Training Procedures

The flexibility exercises were carried out at the same time at every session. The control group was measured after undressing. No warm-up was permitted for this group. When the exercise groups finished their training, they were tested. The training period was synchronized to end as closely as possible to the start of the hockey scrimmage.

3S Exercises

Shoulder flexors. The subject (S) was in a long sitting position, with his legs straight, back straight, the arms straight and back from his sides, and the shoulders were stretched as far back as possible.

The helper (H) was standing behind the subject, one foot near the subject's body, with the knee resting against the subject's spine. H held S's forearms. S attempted to pull his arms towards his legs. The elbows remained straight. H resisted S's movement. H held S's position to produce a six second isometric contraction. S moved the arms slowly backward and toward the ceiling, elbows remaining straight, so that the shoulders were forcibly extended. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Shoulder extensors. The subject (S) was in the long sitting position with his legs and back straight, arms straight above his head, and the shoulders stretched back as far as possible. The helper (H) stood behind S, with the right foot near S's body, the right knee resting against S's spine, and holding S's forearms. S attempted to move his arms forward and toward the ceiling, elbows remaining straight. H resisted S's movement. H held S's position to produce a six second isometric contraction. S moved the arms slowly backward and toward the floor, elbows remaining straight, so that the shoulders were forcibly flexed. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Knee extensors. The subject (S) was in the prone position on a bench, knees and lower legs extended beyond the end of the bench, with the lower legs close to the buttocks, the arms at his sides, and the hands grasping the edge of the bench. The helper (H) stood behind S, and held S's lower legs. S attempted to move his legs backward and toward the ceiling. H resisted S's movement. H held S's position to produce a six second isometric contraction. S moved the legs slowly forward and toward the floor so that the knees were forcibly flexed. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Knee flexors. The subject (S) was in the prone position on a bench, the knees and lower legs extended beyond the end of the bench, with the knees straight, the arms at his sides, and the hands grasping the edge of the bench. The helper (H) stood behind S, and held S's lower legs. S attempted to move the legs forward and toward the ceiling. H resisted S's movement. H held S's position to produce a six second isometric contraction. S moved the legs slowly backward and toward the floor so that the knees were forcibly extended. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Ankle extensors. The subject (S) was in the long sitting position on the floor, with his knees and back straight, his feet inside the towel, and the hands grasping the ends of the towel. S attempted to move the feet downward and toward the floor. S resisted his movement with the use of a towel. S held his position to produce a six second isometric contraction. S moved the feet slowly upward and toward the ceiling so that the ankles were forcibly flexed. S assisted his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Ankle flexors. The subject (S) was in the long sitting position on the floor, with his knees and back straight, the hands straight down at his sides, and his feet pointed toward the floor. The helper (H) was kneeling in front of S, and held S's feet down. S attempted to move the feet upward and toward the ceiling. H resisted S's movement. H held S's position to produce a six second isometric contraction. S moved the feet slowly downward and toward the floor so that the ankles were forcibly extended. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

Hip adductors. The subject (S) was in the long sitting position with his back straight, the legs straight and as far apart as possible. The arms were resting at his sides with the hands touching the floor. The helper (H) was positioned in front of S, resting on one knee with the opposite foot on the floor, and holding both S's legs above the ankles. S attempted to bring his legs together, with the knees remaining straight. H resisted S's movements. H held S's position to produce a six second isometric contraction. S moved the legs slowly apart so that the hips were forcibly abducted. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix c for diagrams).

Hip abductors. The subject (S) was in the long sitting position with his back straight, the legs straight and crossing over one another. The arms were resting at his sides with the hands touching the floor.

The helper (H) was positioned in front of S, resting on one knee with the opposite foot on the floor, and holding both S's legs above the ankles. S attempted to spread his legs apart, with the knees remaining straight. H resisted S's movement. H held S's position to produce a six second isometric contraction. S crossed the legs slowly so that the hips were forcibly adducted. H assisted S's movement with light pressure. S attained his maximum range of motion by straining to some extent, and then relaxed. This was repeated 2 more times from the new lengthened position (see appendix C for diagrams).

SS Exercises

Shoulder extensors. The subject (S) was in the long sitting position on the floor with his legs and back straight, arms straight above his head, and the shoulders stretched back as far as possible. S moved the arms slowly backward and toward the floor, elbows remaining straight, so that the shoulders were forcibly flexed. S held this position for 10 seconds without straining and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Shoulder flexors. The subject (S) was in the long sitting position on the floor with his legs and back straight, arms straight down from his sides, and the shoulders stretched back as far as possible. S moved the arms slowly backward and toward the ceiling, elbows remaining straight, so that the shoulders were forcibly extended. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Knee extensors. The subject (S) was in the prone position on a bench, the knees and lower legs were extending beyond the end of the bench, with the legs straight, the arms at his sides, and the hands grasping the edge of the bench. S moved the lower legs slowly forward and toward the ceiling, so that the knees were forcibly flexed. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Knee flexors. The subject (s) was in the prone position on a bench, the knees and lower legs extending beyond the end of the bench, with legs bent, the arms at his sides, and the hands grasping the edge of the bench. S moved the lower legs slowly backward and toward the floor, so that the knees were forcibly extended. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Ankle extensors. The subject (S) was in the long sitting position on the floor, with his knees and back straight and the hands straight down at his sides. S moved the feet slowly upward and toward the ceiling, so that the ankles were forcibly dorsi-flexed. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Ankle flexors. The subject (S) was in the long sitting position on the floor, with his knees and back straight and the hands straight down at his sides. S moved the feet slowly downward and toward the floor, so that the ankles were forcibly plantar-flexed. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Hip adductors. The subject (S) was in the long sitting position on the floor, with his back straight, legs straight and spread apart. The hands were straight down at his sides. S moved the legs slowly apart, so that the hips were forcibly abducted. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagram).

<u>Hip abductors</u>. The subject (S) was in the long sitting position on the floor, with his back straight, legs straight with one crossed over the other. The hands were straight down at his sides. S crossed one leg over the other slowly, so that the hips were forcibly adducted. S held this position for 10 seconds without straining, and then relaxed. This was repeated 2 more times (see appendix D for diagrams).

Chapter 4

RESULTS

Flexibility Analysis of Various Joints

Hip Joint. The amount of flexibility retention was determined for each joint. Data were analysed by analysis of variance. The ANOVA indicated no significant difference occurred between means in the main factors, method of training ($F = 0.595$; df = 2, 6; $P > .05$), time of measurement ($F = 2.8924$; df = 2, 6; $P > .05$), and replication of measurement ($F = 1.9314$; df = 1, 3; $P > .05$). No significant differences were found in all first order interactions and the second order interaction. Table 1 indicates the ANOVA table for this analysis. The raw data for the analysis are included in appendix E.

Knee Joint. The ANOVA indicated no significant differences between means for the main factors. No differences were found in all first order interactions and the second order interaction. The results of the analysis are summarized in Table 2. The raw data for the analysis are included in appendix E.

Ankle Joint. The ANOVA indicated a significant difference between means occurred in the main factor, method of training ($F = 6.0257$; df = 2, 6; $P < .05$). However, time of measurement ($F = 2.2984$; df = 2, 6; $P > .05$), and replication of measurement ($F = 1.065$; df = 1, 3; $P > .05$) revealed no significant differences. The ANOVA indicated no significant difference in all the first order interactions and the second order interaction.

Table 1. SUMMARY OF ANALYSIS OF VARIANCE FOR THE HIP JOINT

Source	DF	SS	MS	F	P
Subjects	3	2131.11			
Methods (M)	2	24.33	12.17	0.4981	0.63076
Error Within (EW)	6	146.56	24.43		
Time of Measurement (T)	2	39.00	19.50	0.5321	0.61273
EW	6	219.89	36.65		
Replication (R)	1	26.89	26.89	2.0983	0.24331
EW	3	38.44	12.81		
MXT	4	305.17	76.29	2.8437	0.07176
EW	12	321.94	26.83		
MXR	2	38.11	19.06	0.7092	0.52910
EW	6	161.22	26.87		
TXR	2	80.78	40.39	2.0673	0.20751
EW	6	117.22	19.54		
MXTXR	4	147.22	36.81	2.3232	0.11594
EW	12	190.11	15.84		
Total	68	1856.89			

a significant at .05 level

Table 2. SUMMARY OF ANALYSIS OF VARIANCE FOR THE KNEE JOINT

Source	DF	SS	MS	F	P
Subjects	3	1351.82			
Method (M)	2	187.86	93.93	0.5950	0.58110
Error Within (EW)	6	947.14	157.86		
Time of Measurement (T)	2	845.44	422.72	2.8924	0.13197
EW	6	876.89	146.15		
Replication (R)	1	517.35	517.35	1.9314	0.25878
EW	3	803.60	267.87		
MXT	4	1171.22	292.81	0.9859	0.45156
EW	12	3563.78	296.98		
MXR	2	512.19	256.10	2.5341	0.15930
EW	6	606.36	101.06		
TXR	2	1170.11	585.06	2.0856	0.20527
EW	6	1683.11	280.52		
MXTXR	4	270.22	67.56	0.1350	0.96630
EW	12	6004.56	500.38		
Total	68	19159.83			

a significant at .05 level

Table 3. SUMMARY OF ANALYSIS OF VARIANCE FOR THE ANKLE JOINT

Source	DF	SS	MS	F	P
Subjects	3	3678.49			
Methods (M)	2	253.69	126.85	6.0257	0.03672 a
Error Within (EW)	6	126.31	21.05		
Time of Measurement (T)	2	57.69	28.85	2.2984	0.18152
EW	6	75.31	12.55		
Replication (R)	1	396.68	396.68	1.0650	0.37798
EW	3	1117.38	372.46		
MXT	4	289.31	72.33	1.1450	0.38199
EW	12	758.03	63.17		
MXR	2	330.03	165.01	2.9084	0.13090
EW	6	340.42	56.74		
TXR	2	89.36	44.68	1.8185	0.24133
EW	6	147.42	24.57		
MXTXR	4	19.31	4.83	0.1344	0.96656
EW	12	430.92	35.91		
Total	68	4431.83			

Comparison of Means

Control	SS	3S
57.708[b]	61.417	61.917

a-significant at .05 level
b-underlined comparisons are not significant

A Duncan Multiple Range Test using mean differences was conducted for the main factor, method of training. This test revealed that flexibility for the 3S and SS training groups were significantly different when compared to the no exercise group. It also indicated no significant difference between 3S and SS training exercise on ankle flexibility. The results of the ANOVA and the Duncan Multiple Range Test are summarized in Table 3. The raw data for this analysis are included in appendix E.

Shoulder joint. The ANOVA indicated no significant differences occurred in the main factors. A significant difference occurred in the first order interaction, time of measurement and replication of measurement ($F = 26.2818$; df = 2, 6; $P < .05$). This indicates that the magnitude of the second flexibility measurement for the shoulder joint was dependent upon the time of measurement in the testing session. The three measures per session were markedly different for each replication (see Figure 2). The ANOVA indicated no significant differences in the other first order interactions and the second order interaction.

A Duncan Multiple Range Test was conducted on the first order interaction, time of measurement and replication of measurement. This indicated that flexibility was significantly different between the first replication during the competition and all other measurements. The first replication of the post-test was not significantly different only to the second replication during the competition. The results of the analysis are summarized in Table 4. The raw data for the analysis are included in appendix E.

Figure 2.

Mean replication of measurement flexibility scores against time of measurement on the shoulder joint.

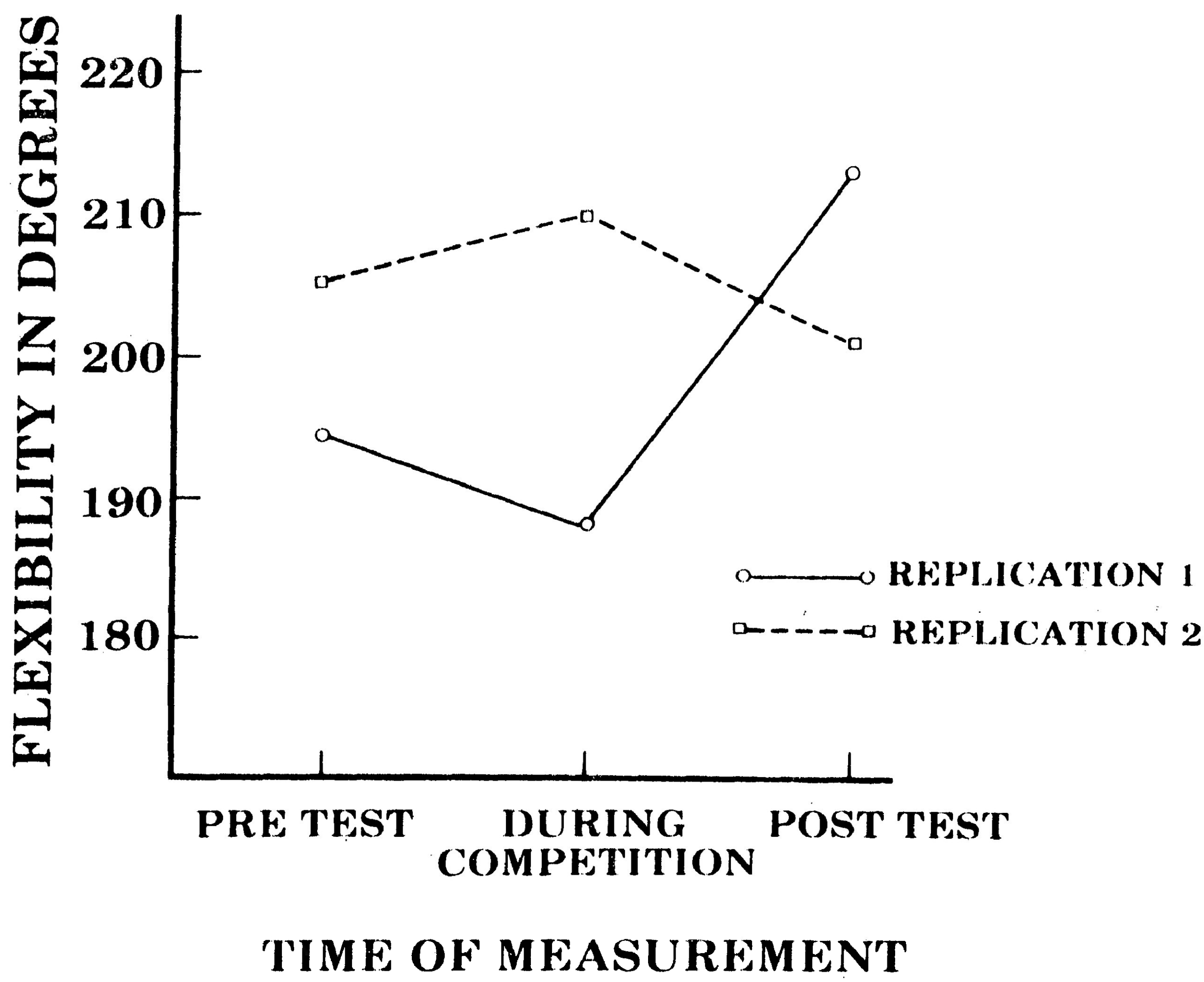


Table 4. SUMMARY OF ANALYSIS OF VARIANCE FOR THE SHOULDER JOINT

Source	DF	SS	MS	F	P
Subjects	3	2416.72			
Methods (M)	2	586.03	293.01	0.5332	0.61215
Error Within (EW)	6	3297.19	549.53		
Time of Measurement (T)	2	826.78	413.39	3.2041	0.11307
EW	6	774.11	129.02		
Replication (R)	1	242.00	242.00	0.9438	0.40296
EW	3	769.22	256.41		
MXT	4	210.06	52.51	0.2478	0.90547
EW	12	2542.72	211.89		
MXR	2	576.08	288.04	0.5140	0.62221
EW	6	3362.03	560.34		
TXR	2	3464.33	1732.17	26.2818	0.00108 a
EW	6	395.44	65.91		
MXTXR	4	180.83	45.21	0.1724	0.94835
EW	12	3147.06	262.25		
Total	68	20373.89			

Comparison of Means

During Competition 1	Post-Test 2	Pre-Test 1	Pre-Test 2	During Competition 1	Post-Test 1
188.083	201.082[b]	204.417	205.417	209.917	212.917

a-significant at .05 level
b-underlined comparisons are not significant

Total joint analysis. The ANOVA indicated no significant differences in the main factors, method of training (F = 0.9125; df = 2, 6; $P > .05$), and replication of measurement (F = 0.0218; df = 1, 3; $P > .05$). However, significant differences were found in the main factors, joints (F = 465.6085; df = 3, 9; $P < .05$), and time of measurement (F = 6.3947; df = 2, 6; $P < .05$). The first order interaction, joint and replication, was significant, thus indicating that the magnitude of the flexibility reading of the second replication depended upon the joint (F = 4.5527; df = 3, 9; $P < .05$) (see Figure 3). The ANOVA indicated a significant difference in the first order interaction, time of measurement and replication of measurement (F = 11.122; df = 2, 6; $P < .05$) (see Figure 4). No significant differences were found in all other first order interactions. The ANOVA indicated a significant difference in the second order interaction, joint, time and replication (F = 4.5916; df = 6, 18; $P < .05$) (see Figure 5). All other second order interactions were non-significant as well as the third order interaction.

A Duncan Multiple Range Test was conducted on all significant findings. Comparing means for the main factor, joints, showed that the ankle and hip flexibility measures were not significantly different. The knee and shoulder joints flexibility were significantly different to each other and to the ankle and hip joints. The main factor, time of measurement, indicated that the pre-test and post-test measurements were not significantly different. However, the measurement taken during competition was significantly different to the pre-test and post-test measurements. The first order interaction, joint and replication, indicated that only the ankle and knee joints varied

Figure 3.

Mean joint flexibility scores against replication of measurement.

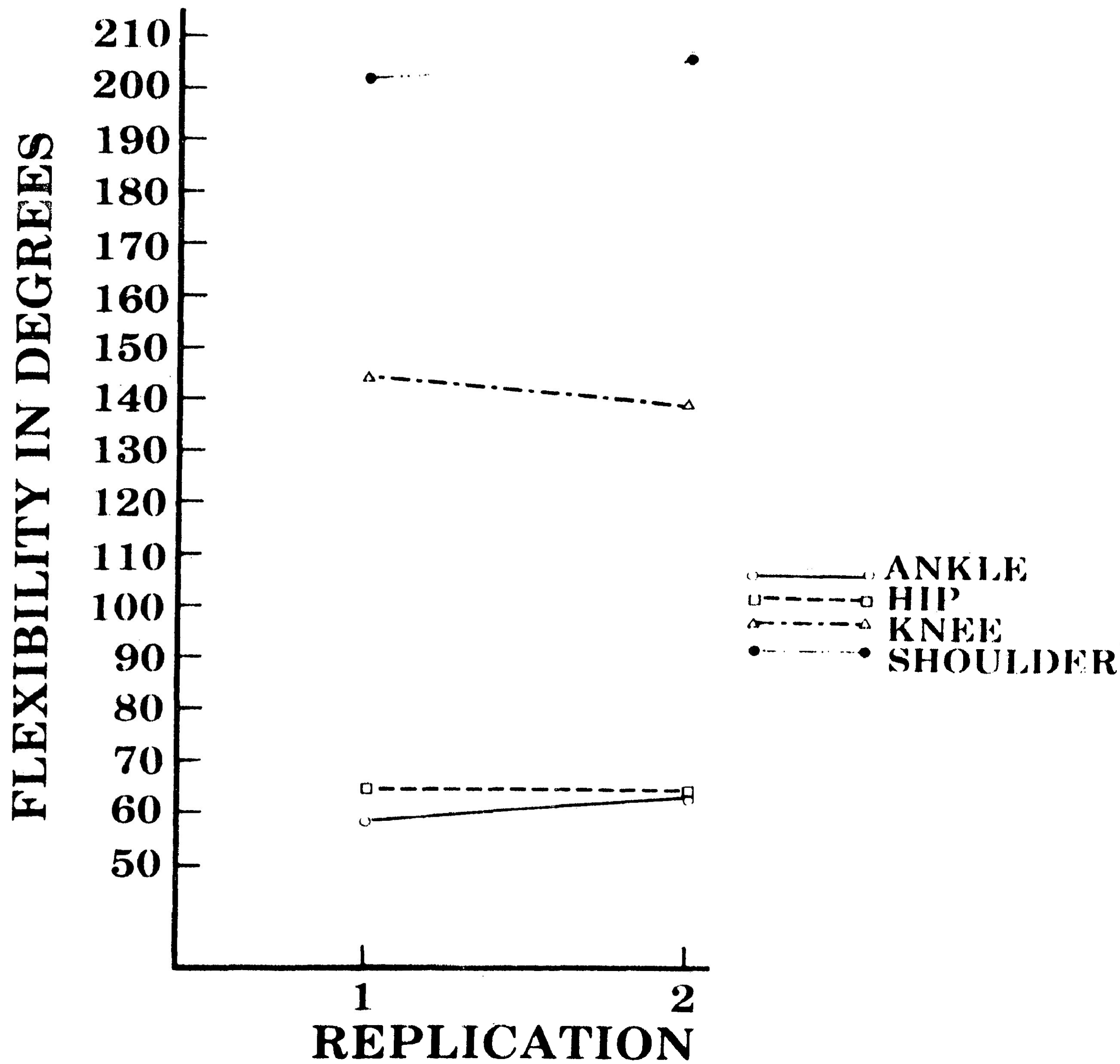


Figure 4.

Mean joint flexibility scores against time of measurement.

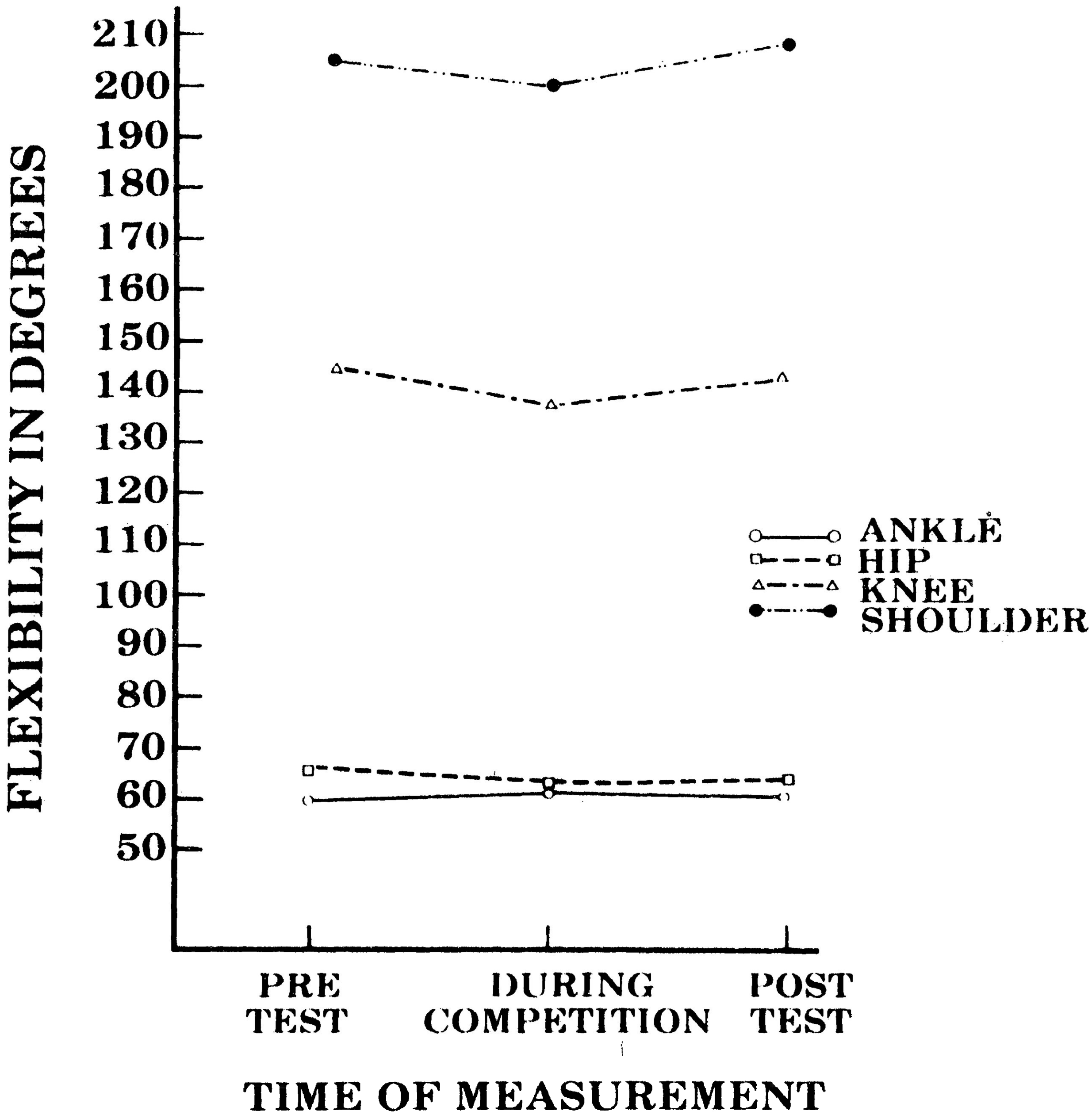
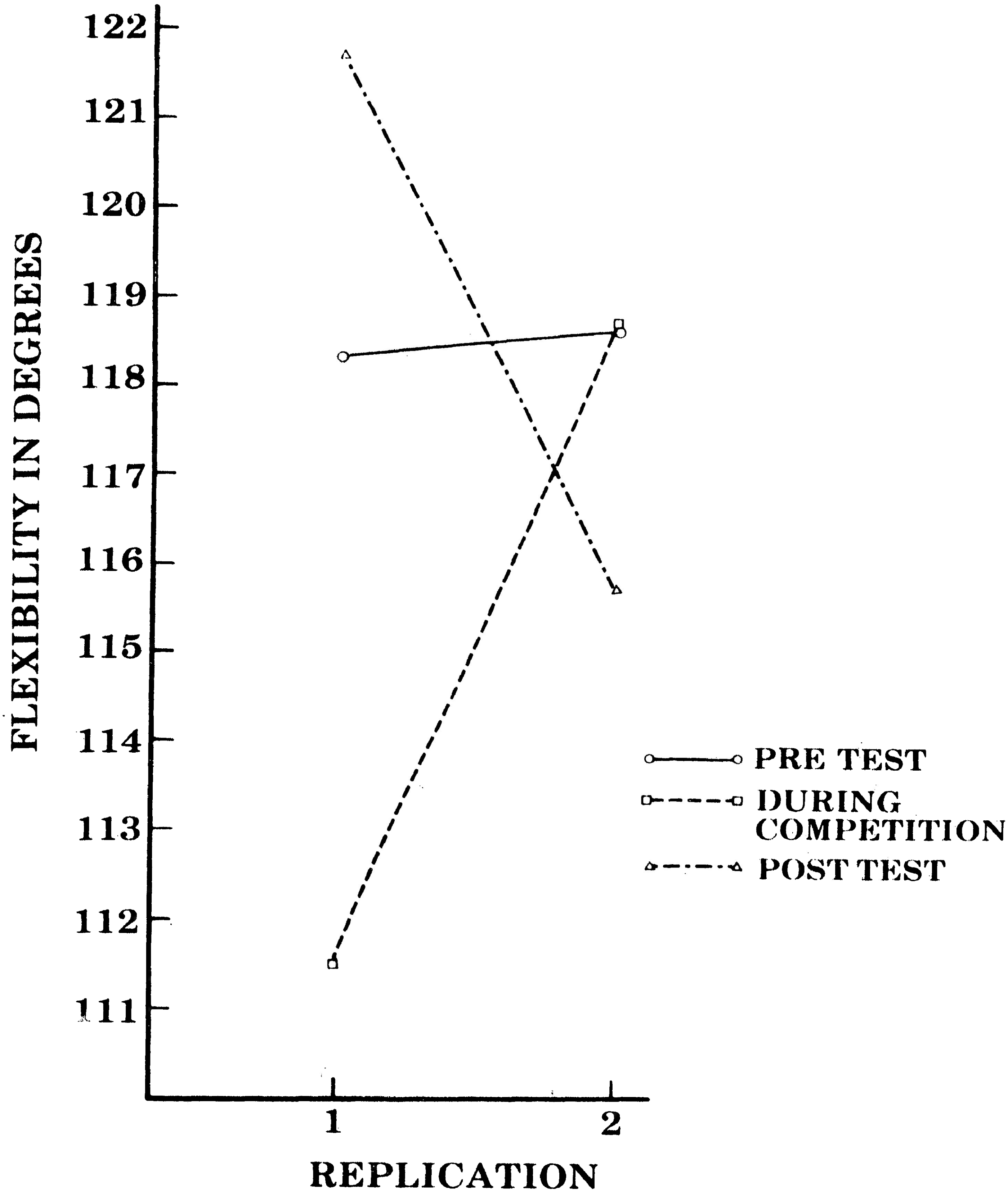


Figure 5. Mean time of measurement flexibility scores against replication of measurement.



significantly from the first to the second replication. The first order interaction, time of measurement and replication of measurement, indicated that only the pre-test measurement did not vary significantly from the first to the second replication. However, the first replication during the competition was significantly different to all other measurements. The first replication of the post-test was significantly different to the second replication of the post-test. The second order interaction, joint, time and replication, indicated a significant difference only on the shoulder joint. In this case the first replication during the competition was not significantly different to the second replication of the post test. The results are summarized in Table 5. The raw data are included in appendix E.

Summary

The results of the five analyses indicated only seven significant <u>F</u> values. No significant factor was robust across all or the majority of analyses. The significant sources of variance were idiosyncratic to three of the five analyses. This lack of consistency suggests that the data contained no marked trends or differences. The research hypothesis, there is no difference in the flexibility retention of subjects using 3S and SS flexibility training methods on the shoulder, hip, knee, and ankle joints during competition specific activities, was supported in this study.

Table 5. SUMMARY OF TOTAL ANALYSIS OF VARIANCE

Source	DF	SS	MS	F	P
Subjects	3	3046.12			
Joints (J)	3	1013787.07	337929.02	465.6085	0.00000 a
Error Within (EW)	9	6532.01	725.78		
Methods (M)	2	220.13	110.07	0.9125	0.45082
EW	6	723.73	120.62		
Time (T)	2	788.63	394.32	6.3947	0.03256 a
EW	6	369.98	61.66		
Replication (R)	1	14.22	14.22	0.0218	0.89202
EW	3	1958.53	652.84		
JXM	6	831.78	138.63	0.6578	0.68409
EW	18	3793.47	210.75		
JXT	6	980.28	163.38	1.8658	0.14249
EW	18	1576.22	87.57		
JXR	3	1168.69	389.56	4.5527	0.03331 a
EW	9	770.11	85.57		
MXT	4	871.33	217.83	1.0872	0.40594
EW	12	2404.23	200.35		
MXR	2	351.17	175.59	0.7974	0.49308
EW	6	1321.24	220.21		

. . cont'd

Table 5. (cont'd)
Summary of Total Analysis of Variance .

Source	DF	SS	MS	F	P
TXR	2	2074.84	1037.42	11.1220	0.00959 a
EW	6	559.66	93.28		
JXTXT	12	1104.42	92.04	0.6928	0.74730
EW	36	4782.24	132.84		
JXMXR	6	1105.24	184.21	1.0530	0.42523
EW	18	3148.78	174.93		
JXTXR	6	2729.74	454.96	4.59.16	0.00538 a
EW	18	1783.53	99.09		
MXTXR	4	429.95	107.49	0.3729	0.82354
EW	12	3458.88	288.24		
JXMXTXR	12	187.63	15.64	0.0892	0.99996
EW	36	6313.76	175.38		
Total	284	1066141.53			

a-significant at .05 level

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Main Factor, JOINTS.

JOINT			
Ankle	Hip	Knee	Shoulder
Mean	Mean	Mean	Mean
60.347	64.333	141.319	203.639

Key: A = Ankle Joint

H = Hip Joint

K = Knee Joint

S = Shoulder Joint

Comparison of Means

A	H	K	S
<u>60.347[b]</u>	<u>64.333</u>	141.319	203.639

b - Underlined comparisons are not significant.

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Main Factor, TIME OF MEASUREMENT.

TIME OF MEASUREMENT		
PRE-TEST	DURING COMP.	POST-TEST
MEAN	MEAN	MEAN
118.469	115.073	118.688

Key: PRE = Pre-Test

D = During Competition

POS = Post-Test

Comparison of Means

D	PRE	POS
115.073	118.469[b]	118.688

b - Underlined comparisons are not significant

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the First Order Interaction, JOINT AND REPLICATION OF MEASUREMENT.

JOINT							
ANKLE		HIP		KNEE		SHOULDER	
REPLICATION		REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
58.000	62.694	64.944	63.722	144.000	138.639	201.806	205.472

Key: A = Ankle Joint 1 = 1st Replication
H = Hip Joint 2 = 2nd Replication
K = Knee Joint
S = Shoulder Joint

<u>Comparison of Means</u>

A1	A2	H2	H1	K2	K1	S1	S2
58.00	<u>62.694</u>	<u>63.722[b]</u>	<u>64.944</u>	138.639	144.00	<u>201.806</u>	<u>205.472</u>

b - Underlined comparisons are not significant.

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the First Order Interaction, TIME OF MEASUREMENT AND REPLICATION OF MEASUREMENT.

TIME OF MEASUREMENT					
PRE-TEST		DURING COMP.		POST-TEST	
REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean
118.333	118.604	111.521	118.625	121.708	115.667

Key: PRE = Pre-Test   1 = 1st Replication

D = During Competition   2 = 2nd Replication

POS = Post-Test

Comparison of Means

D1	POS2	PRE1	PRE2	D2	POS1
111.521	115.667[b]	118.333	118.604	118.625	121.708

b - Underlined comparisons are not significant.

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Second Order Interaction, JOINT, TIME OF MEASUREMENT, AND REPLICATION OF MEASUREMENT FOR THE ANKLE JOINT.

ANKLE JOINT					
TIME OF MEASUREMENT					
PRE-TEST		DURING COMPETITION		POST-TEST	
REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean
57.250	61.083	60.083	62.583	56.667	64.417

Key: PRE = Pre-Test; DC = During Competition; POS = Post-Test; 1 = 1st Replication; 2 = 2nd Replication

Comparison of Means

POS1	PRE1	DC1	PRE2	DC2	POS2
56.667[b]	57.250	60.083	61.083	62.583	64.417

b - Underlined comparisons are not significant

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Second Order Interaction, JOINT, TIME OF MEASUREMENT, AND REPLICATION OF MEASUREMENT FOR THE KNEE JOINT.

KNEE JOINT					
TIME OF MEASUREMENT					
PRE-TEST		DURING COMPETITION		POST-TEST	
REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean
145.833	143.583	135.333	137.917	150.833	134.417

Key: PRE = Pre-Test
DC = During Competition
POS = Post-Test
1 = 1st Replication
2 = 2nd Replication

Comparison of Means

POS2	DC1	DC2	PRE2	PRE1	POS1
134.417[b]	135.333	137.917	143.583	145.833	150.333

b - Underlined comparisons are not significant

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Second Order Interaction, JOINT, TIME OF MEASUREMENT, AND REPLICATION OF MEASUREMENT FOR THE HIP JOINT.

HIP JOINT					
TIME OF MEASUREMENT					
PRE-TEST		DURING COMPETITION		POST-TEST	
REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean
65.833	64.333	62.583	64.083	66.417	62.750

Key: PRE = Pre-Test   1 = 1st Replication

DC = During Competition   2 = 2nd Replication

POS = Post-Test

<u>Comparison of Means</u>

DC1	POS2	DC2	PRE2	PRE1	POS1
62.583[b]	62.750	64.083	64.333	65.833	66.417

b - Underlined comparisons are not significant

Table 5. (cont'd)
Results of a Duncan Multiple Range Test on the Second Order Interaction, JOINT, TIME OF MEASUREMENT, AND REPLICATION OF MEASUREMENT FOR THE SHOULDER JOINT.

SHOULDER JOINT					
TIME OF MEASUREMENT					
PRE-TEST		DURING COMPETITION		POST-TEST	
REPLICATION		REPLICATION		REPLICATION	
1st	2nd	1st	2nd	1st	2nd
Mean	Mean	Mean	Mean	Mean	Mean
204.417	205.417	188.083	209.917	212.917	201.083

Key: PRE = Pre-Test; DC = During Competition; POS = Post-Test

1 = 1st Replication; 2 = 2nd Replication

Comparison of Means

DC1	POS2	PRE1	PRE2	DC2	POS1
188.083	201.083[b]	204.417	205.417	209.917	212.917

b - Underlined comparisons are not significant

Chapter 5

DISCUSSION

This study used two types of stretching exercises (3S, SS) and assessed the characteristics of flexibility retention.

Both methods (3S, SS) and a no exercise group were found to produce no differing effects prior to, during, or following an ice hockey scrimmage activity. This is surprising because the literature indicated that pre-exercise flexibility was needed and has lasting effects during a performance. These two positions were not supported by these data.

Statistically significant findings were isolated and inconsistent across the individual joint analyses and the overall analysis. A slight suggestion could be made that replication was the most important variable since it was involved in four significant interactions. Perhaps some weak change occurred between the first and second repeated measurement sessions. This appeared to be the only finding involving changed scores in the data.

Of greater significance were the findings which supported the acceptance of various null hypotheses. They pertain to a number of positions supported or expanded in the literature and are as follows:

1) The flexibility values obtained for two stretching methods and a no exercise control group were not significantly different.

2) There was no reduction or increase in flexibility during a hockey scrimmage that was associated with either of the exercise methods or the no exercise control group.

3) The above findings were supported on each of the replications of the experience.

Flexibility is specific to each joint of the human body (Dickinson, 1968; Fleishman, 1964; Harris, 1969; Munroe & Romance, 1975; Song, 1979; Travers & Evans, 1976). This study found that there were significant differences in the amounts of flexibility between the joints. This is due to the nature of the joint and one would expect this to occur. The reason for using different joints was to see if any hypothesis was joint specific. This study found that this was not the case.

The literature showed that exercise increases flexibility (Campbell, 1944; Denk, 1971; Kingsley, 1952; Meyers, 1971; Moore, 1954). Ankle joint flexibility was found to be improved due to 3S and SS warm-up when compared to the no warm-up condition. The fact that the two methods produced significant warm-up effects when compared to the control condition showed that improvement in flexibility measures would be facilitated by deliberate exercise. The second and third measurements indicated that the treatment condition groups did not increase flexibility but the control group did to a level similar to the two experimental groups. This suggests that the exercise involved in the scrimmage stimulated an increase to a level of flexibility which was similar to that of the experimental groups. Turner (1977) found similar effects with basketball players. All other main factors and all interactions associated with the ankle joint were non-significant. This finding may be due to the ankle movements involved in ice hockey. In the skating stride, some plantar-flexion occurs but the equipment prevents dorsi-flexion. This may have produced a restriction on possible improvement during the activity.

No significant differences were found in the main factors and interactions involving the knee joint. This suggests that the flexibility measurements in the knee joint may not be influenced by the exercises performed or participation in the activity. It could be that the range of motion of the knee joint is altered in trained athletes and that neither training nor competition will enhance or decrease that flexibility. However, the ice hockey activity rarely causes hyper-extension of the knee joint. Hyper-flexion may occur in some cases, such as in a contact situation. It is difficult to understand or explain these findings.

No significant differences were found in the main factors and the interactions involving the hip joint. This may have been due to the type of action and range of motion measured in this study. The hip movement during skating is not adduction-abduction or flexion-extension. The action involves both these movements but neither to extremes. The overall pre-test measurements on hip flexibility were slightly higher than during and after the competition. This suggests that the exercises were related to the measurement techniques. Ice hockey most probably does not demand the adduction-abduction required for the procedural techniques for Leighton's flexibility tests that were used in the study. It is assumed that the results support this interpretation.

The shoulder joint analysis revealed one significant interaction. It was found that there was a significant difference in the first order interaction, time of measurement and replication of measurement. In the first replication, flexibility was at its lowest level but at its highest at the same moment in the second replication. The pre-tests in both replications were similar, thus showing that the initial levels of flexibility were not influenced by the method of training. All main factors and all other interactions were non-significant. This could be due to the varying intensity of the scrimmage activities. The level of intensity could affect flexibility. When it is very intense, flexibility may be stimulated and when it is low, flexibility may be suppressed. Varying reactions could be expected for intermediate intensity levels. This is a purely speculative reason. It may be a factor that needs to be controlled in future studies.

The most interesting results involved the time of measurement. It was found that flexibility was lower during the scrimmage as compared to before and after the scrimmage. It is difficult to explain this phenomenon as possible reasons are few. It is not in concert with any of the popular notions involving flexibility. It is possible that the measurements obtained were due to chance or some transitory extraneous variable. Only further investigations or replications of this study are likely to shed light on this unusual result.

The method of training had no effect on flexibility. There was no change after the warm-up due to training. Neither method (3S, SS) produced superior ranges of motion. The control group results were no different to those of the training groups. Therefore, there was no effect or loss of flexibility during the scrimmage. This is difficult to explain in view of the literature. It has been shown that flexibility increases due to exercise. It has also been shown that 3S training is superior to other types of flexibility training (Holt, Travis & Okita, 1970; Song & Garvie, 1976; Tanigawa, 1972). This did not occur in this study. Turner (1977) found that 3S exercises were superior to SS exercises for increasing flexibility. However, neither method was superior for flexibility retention over a long period. More research is needed to clarify the findings of this study with regard to short-term retention.

Replication of measurements allowed for the verification of specific findings. The analysis found four significant interactions dealing with replication. The replication showed confusing results. In some cases the measurements decreased from the first to the second replication, while in other cases, they increased. This was true of all joints and training methods. This was not likely due to specificity of training because the subjects were at the onset in a trained state. The replications on the ankle joint showed a definite trend. The measurements on the ankle joint increased in the second replication. The three other joints were not consistent in their flexiblity measurements. In some cases, the first replication was greater than the second replication, in other cases, the opposite was true.

The controls of the subjects during the testing sessions may have been a problem. Human error may have occurred. The assistant held various body segments and so technique changes may have developed. However, such a possibility was not readily observable. Changes may have also occurred in the subjects. There was no control of the subjects' movements before arriving at the testing site. This may have precipitated the variation in the flexibility scores. Other extraneous variables may have had an effect. Such variables may have been heat (Grobaker & Stull, 1975), muscle soreness, tolerance for pain and ability to relax (Scott & French, 1959). A totally controlled study of the subjects' lifestyles is suggested for future researchers.

This study found no significant findings concerning flexibility retention for both 3S and SS flexibility training. Turner (1977) found no significant difference in long-term flexibility retention at the conclusion of a training program using either 3S or SS flexibility training. Tanigawa (1972) found that PNF exercises had a greater loss of flexibility than other passive exercises and no exercises. Hansen (1962) found that flexibility due to exercise persisted for over 24 hours. This was supported by Atha and Wheatley (1976). This study is the only one that investigated short-term flexibility. Comparison with other studies are difficult because long-term and short-term flexibility may be completely dissimilar in nature. This study found no flexibility retention. Song and Garvie (1976) found that top level Canadian wrestlers with high pre-test flexibility scores improved less than those who had low pre-test flexibility scores. This indicated that athletes may have higher initial levels of flexibility and improvements due to stretching exercises may be limited. The subjects in this study were highly skilled in their sport. The hockey players' initial levels of flexibility may have been high, thus causing high scores on the pre-test measurements. Exercises and the competition would not increase or decrease the flexibility of the subjects. This would explain the strange results of this study.

This thesis was a statistical study with four subjects. The power of some tests of significance may have been weakened by the small sample size. However, in the contrasts that were of interest to the central hypotheses surrounding flexibility, its time of measurement, and method of developing, consistent but statistically significant trends were not indicated. The power of a test determines statistical significance. When the data do not even hint at trends, the sample size is not a plausible factor for explaining the results that were obtained. This study was limited to ice hockey players. There is a possibility that hockey players have different "conditions" of flexibility than non-athletes.

The reliability analyses were conducted on untrained students. The methods of measurement were shown to be reliable in all joints. There is a possibility that the flexiblity status of an untrained and trained individual are different. If the athlete in training is maintaining an increased amount of flexibility that is near optimum or maximum for the individual, one would not expect any changes due to exercise types or forms. The possibility further arises that if the athletes in this study were already at high levels of flexibility, the reliability of their measures may be different to those obtained for untrained individuals. Further research needs to be conducted on this latter item. Thus, it is proposed that the negative conclusion of this study may have been due to the nature of the subjects. This hypothesis is purely speculative.

This study found no significant difference in short-term flexibility retention using 3S or SS training. This disagrees with the literature which has found that exercise increases flexibility (Campbell, 1944; Denk, 1971; Holt, Travis & Okita, 1970; Kingsley, 1952; Moore, 1954; Myers, 1971; Tanigawa, 1972; Turner, 1977) and that 3S training is superior (Holt, Travis & Okita, 1970; Song & Garvie, 1976; Tanigawa, 1972).

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Flexibility retention is a relatively new concept in physical education. Few studies have been initiated on this subject. The literature does not discern which type of training is most beneficial for flexibility retention. The research on 3S and SS flexibility training does not show any clear tendencies of one method being superior to the other.

This study tested the effects of two training methods, 3S and SS, on flexibility retention of the shoulder, hip, knee, and ankle joints during a competition simulated task.

The subjects were four Lakehead University varsity ice hockey players. Their ages ranged from 20 to 21 years. An ice hockey scrimmage was deemed to be similar to an ice hockey game.

The research design consisted of two replications of a 3 x 3 Latin square. Three measurements were taken per session: a pre-competition test, a during competition test, and a post-competition test. A Leighton Flexometer was used for measuring flexibility. An assistant was responsible for holding various body segments of the subjects during the testing periods. Data were analyzed using ANOVA and a Duncan Multiple Range Test. A significance level of .05 was set for the declaration of true differences.

Conclusions

This study indicated the following conclusions:

1) the ankle joint was affected positively by the training methods

when compared to the control group. However, there was no significant difference in flexibility retention between 3S and SS flexibility training.

2) Flexibility was specific to each joint.

3) Flexibility was greater before and after the scrimmage when compared to during the scrimmage.

4) There was no difference in flexibility due to flexibility exercises.

5) There was no significant difference between training methods on flexibility retention.

Recommendations

If more research is to be performed on this topic, the following features are recommended:

1) Replication of this study should be performed on the same sport group as well as other sport groups.

2) Subjects of various athletic ability should be used.

3) The number of subjects, replications, and testing sessions during competition should be increased.

4) A flexibility measurement technique should be devised that resembles more closely the movements in the sport.

5) Strict control of subjects' activities on the day of testing should be achieved.

REFERENCES

Asmussen, E. & Boje, O. Body temperature and capacity for work. Acta Physiologica Scandinavica, 1945, 10, 1-22.

Atha, J., & Wheatley, D. W. Joint mobility changes due to low frequency vibration and stretching exercise. British Journal of Sports Medicine, 1976, 10(1), 26-34.

Bierman, W. Influence of cycloid vibration massage on trunk flexion. American Journal of Physical Medicine, 1960, 39, 219-224.

Billig, H. E., & Lowendahl, E. Mobilization of the human body. Stanford: Stanford University Press, 1953.

Blank, L. B. Effects of warm-up on speed. Athletic Journal, 1955, 35(6), 10; 45-46.

Broer, M., & Galles, N. Importance of relationship between various body measurements in performance of the toe-touch test. Research Quarterly, 1958, 29(3), 253-263.

Butler, D. H., Kamlet, A. S., & Monty, R. A. A multi-purpose analysis of variance fortran IV computer program. Maryland: Aberdeen Research and Development Center, 1970.

Buxton, D. Extension of the Kraus-Weber test. Research Quarterly, 1957, 28(3), 210-217.

Campbell, R. E. A study of factors affecting flexibility. Unpublished master's thesis, University of Wisconsin, 1944.

Carlile, F. The effects of preliminary passive warming on swimming performance. Research Quarterly, 1956, 27(2), 246-247.

Corbin, C. B., & Noble, L. Flexibility, a major component of physical fitness. Journal of Physical Education and Recreation, 1980, 51(3), 23-24; 57-60.

Counsilman, J. E. Does weight training belong in the program? Journal of Health, Physical Education, and Recreation, 1955, 26(1), 17-18.

Cureton, T. Flexibility as an aspect of physical fitness. Research Quarterly, 1941, Supp. 12, 381-390.

Davis, E. C., Logan, G. A., & McKinney, W. C. Biophysical values of muscular activity with implications for research. Dubuque, Iowa: Wm. C. Brown Company, 1961.

Denk, G. M. The changes occurring in strength and flexibility during a competitive gymnastics season involving high school boys. Master's thesis, University of Kansas, 1971.

de Vries, H. A. Effects of various warm-up procedures on one hundred yard times of competitive swimming. Research Quarterly, 1955, 26(1), 11-20.

de Vries, H. A. Evaluation of static stretching procedures for improvement of flexibiltiy. Research Quarterly, 1962, 33(2), 222-229.

de Vries, H. A. Prevention of muscular distress after exercise. Research Quarterly, 1961, 32(4), 468-479.

Dickinson, R. V. Flexibiltiy measurement: range of motion vs. limitation of movement in one direction. Master's thesis, University of California (Los Angeles), 1963.

Fieldman, H. Relative contribution of the back and hamstring muscles in the performance of the toe-touch after selected extensibility exercises. Research Quarterly, 1968, 39(3), 518-523.

Fleishman, E. A. The structure and measurement of physical fitness. Englewood Cliffs, New Jersey: Prentice-Hall, 1964.

Forbes, J. Characteristics of flexibility tests of 4-H club members. Doctoral dissertation, University of Oregon, 1950.

Greey, G. W. A study of flexibility in five selected joints of adult males, age 18-71. Unpublished doctoral dissertation, University of Michigan, 1955.

Grobaker, M. R., & Stull, G. A. Thermal applications as a determiner of joint flexibility. American Corrective Therapy Journal, 1975, 29(1), 3-8.

Haliski, C. C., & Sigerseth, P. O. The flexibility of football players. Research Quarterly, 1950, 21(4), 394-398.

Hansen, T. O. Selected effects of stretching on flexibility. Unpublished master's thesis, University of California (LA), 1962.

Harris, M. L. A factor analytic study of flexibility. Research Quarterly, 1969, 40(1), 62-70.

Harvey, V. P., & Scott, G. D. Reliability of a measure of forward flexibility and its relation to physical dimensions of college women. Research Quarterly, 1967, 38(1), 28-33.

Hastings, D. E., Cameron, J., Evans, J., & Parker, S. M. A study of hockey injuries in Ontario. Ontario Medical Review, 1974, 41(11), 686-692.

Hays, W. L. Statistics, Toronto: Holt, Rinehart and Winston, 1963.

Hines, W. W., & Montgomery, D. C. Probability and statistics in engineering and management science. New York: Ronald Press Company, 1972.

Hipple, J. E. Warm-up and fatigue in junior high school sprints. Research Quarterly, 1955, 26(2), 246-247.

Hodgkins, J., & Skubic, V. Effect of warm-up activities on speed, strength and accuracy. Research Quarterly, 1957, 28(2), 147-152.

Holt, L. E. Scientific stretching for sport. Dalhousie: Dalhousie University Press, 1973.

Holt, L. E.,Travis, T. M., & Okita, T. Comparative study of three stretching techniques. Perceptual and Motor Skills, 1970, 31, 611-616.

Hupprich, F. L., & Sigerseth, P. O. The specificity of flexibility in girls. Research Quarterly, 1950, 21(1), 25-33.

Jacob, S. W., & Francone, C. A. Structure and function in man. Toronto: W. B. Saunders Company, 1970.

Jacobs, M. Neurophysiological implications of slow active stretching. American Corrective Therapy Journal, 1976, 30(5), 151-154.

Jervey, A. A. A study of the flexibility of selected joints in specified groups of adult females. Unpublished doctoral dissertation, University of Massachusetts, 1962.

Kabat, P.H. Studies of neuromuscular dysfunction XV - the role of central facilitation in restoration of motor function in paralysis. Archives of Physical Medicine and Rehabilitation, 1952, 33(9), 521-533.

Karpovich, P. V. Physiology of muscular activity. Philadelphia: W. B. Saunders Company, 1956.

Karpovich, P. V., & Hale, C. J. The effect of warming-up upon physical performance. Journal of the American Medical Association, 1956, 142, 1117-1119.

Kingsley, D. B. Flexibility changes resulting from participation in tumbling. Master's thesis, University of Oregon, 1952.

Klafs, C. E., & Arnheim, D. D. Modern principles of athletic training. St. Louis: C. V. Mosby Company, 1973.

Kos, B. The influence of warming up, a hot shower and massage upon the breadth of lumbar movement. France, Acta, Univ. Catholinae Gymnike 2, 1966.

Kusinitz, I., & Keeney, C. E. Effects of progressive weight training on health and physical fitness of adolescent boys. Research Quarterly, 1958, 29(3), 294-301.

Laubach, L. L., & McConville, J. T. Relationships between flexibility, anthropometry, and the somatotype of college men. Research Quarterly, 1966, 37(2), 241-251.

Leighton, J. R. A simple objective and reliable measure of flexibility. Unpublished Master's thesis, University of Oregon, 1942.

Leighton, J. R. Flexibility characteristics of four specialized skill groups of college athletes. Archives of Physical Medicine and Rehabilitation, 1957a, 38(1), 24-28.

Leighton, J. R. Flexibility characteristics of three specialized skill groups of champion athletes. Archives of Physical Medicine and Rehabilitation, 1957b, 38(9), 580-583.

Leighton, J. R. The Leighton flexometer and flexibility test. Journal of the Association for Physical and Mental Rehabilitation, 1966, 20(3), 86-93.

Lemiere, O. Flexibility of shot-putters and discus throwers. Unpublished master's thesis, University of Oregon, 1952.

Logan, G. A., & Egstrom, G. Effects of slow and fast stretching on sacro-femoral angle. Journal of Association for Physical and Mental Rehabilitation, 1961, 15, 85-86.

Lotter, W. S. Effects of fatigue and warm-up on speed of arm movements. Research Quarterly, 1959, 30(1), 57-65.

MacIntosh, D. L., Skrien, T., & Shephard, R. J. Physical activity and injury, a study of sports injuries at the University of Toronto, 1951 - 1968. Master's thesis, University of Toronto, 1972.

Massey, B., & Chaudet, N. L. Effects of systemic, heavy resistance exercise on range of joint meovement in young male adults. Research Quarterly, 1956, 26(1), 41-51.

Mathews, D. K., Shaw, V., & Bohnen, M. Hip flexibility of college women as related to length of body segments. Research Quarterly, 1957, 28(4), 352-356.

Mathews, D. K., Shaw, V., & Woods, J. B. Hip flexibility of elementary school boys as related to body segments. Research Quarterly, 1959, 30(3), 297-302.

Mathews, D. K., & Snyder, A. J. Effects of warm-up on the 440 yard dash. Research Quarterly, 1959, 30(4), 446-451.

McCue, B. F. Flexibility measurements of college women. Research Quarterly, 1953, 24(3), 316-324.

Meyers, E. J. Effects of selected exercise variables on ligament stability and flexibility of the knee. Research Quarterly, 1971, 42(4), 411-422.

Michael, E., Skubic, V., & Rochelle, R. Effect of warm-up on softball throw for distance. Research Quarterly, 1957, 28(4), 357-363.

Miller, C. J. The relationship of flexibility in boys to age. Master's thesis, University of Maryland, 1954.

Moore, K. M. The effect of warm-up exercises on the flexibility of boys twelve, fourteen, and sixteen years of age. Master's thesis, University of Oregon, 1954.

Morehouse, L. E., & Miller, A. T. Physiology of exercise, St. Louis: C. V. Mosby Company, 1959.

Munroe, R. A., & Romance, T. T. Use of the Leighton flexometer in the development of a short flexibility test battery. American Corrective Therapy Journal, 1975, 29(1), 22-25.

Pacheco, B. A. Effectiveness of warm-up exercise in junior high school girls. Research Quarterly, 1959, 30(2), 202-213.

Pacheco, B. A. Improvement in jumping performance due to preliminary exercise. Research Quarterly, 1957, 28(1), 55-63.

Phillips, M., Bookwalter, C., Denman, C., McAuley, J., Sherwin, H., Summers, D., & Yeakel, H. Analysis of results from the Kraus-Weber test of minimum muscular fitness in children. Research Quarterly, 1955, 26(3), 314-323.

Pickens, W. L. A study of flexibility in swimmers. Unpublished master's thesis, University of Oregon, 1950.

Rasch, P. J., & Burke, R. K. Kinesiology and applied anatomy. Philadelphia: Lea & Febiger, 1978.

Rathbone, J. L. Corrective physical education, Philadelphia: W. B. Saunders Company, 1949.

Riddle, K. S. A comparison of three methods for increasing flexibility of the trunk and hip joints. Doctoral dissertation, University of Oregon, 1956.

Robertson, L. D. The effect of two exercise routines on the movement of medial rotation of the leg. Medicine and Science in Sports, 1976, 8(4), 253-257.

Schmidt, R. A. Effects of positional tensioning and stretch on reaction latency and contraction speed of muscle. Research Quarterly, 1967, 38(3), 494-501.

Schultz, P. Flexibility: day of the static stretch. The Physician and Sportsmedicine, 1979, 7(11), 109-117.

Scott, G. M., & French, E. Measurement and evaluation in physical education. Dubuque, Iowa: William C. Brown Company, 1959.

Sills, F. D., & O'Riley, V. E. Comparative effects of rest, exercise and cold spray upon performance in spot running. Research Quarterly, 1956, 27(2), 217-219.

Sinelkinoff, E., & Gugorowitsch, M. The movement of joints as a secondary sex and constitutional-characteristics. Zeitsch. Fur Konstilutionslehre, 1931, 15, 679-693.

Skvortsov, B. L., & Sermeev, B. V. Joint mobility compared in young swimmers. Rev. Analyl. Educ. Phys. Sport, 1964, 7, 1-92.

Song, T. M. K. Flexibility of ice hockey players and comparison with other groups. In J. Terauds & H. Josef Gros (Eds.), Science in skiing, skating and hockey. Del Mar: Academic Publishers, 1979.

Song, T. M. K., & Garvie, G. T. Wrestling with flexibility. Canadian Association of Health, Physical Education and Recreation, 1976, 43(1), 18-26.

Sterner, J. M. A study of flexibility in wrestlers as compared with other sport groups. Master's thesis, South Dakota State College of Agriculture and Mechanic Arts, 1963.

Syverson, M. A study of flexibility in basketball players. Unpublished master's thesis, University of Oregon, 1950.

Tanigawa, M. C. Comparison of the hold-relax procedure and passive mobilization on increasing muscle length. Physical Therapy, 1972, 52, 725-735.

Thompson, H. L., & Stull, A. G. Effects of various training programs on speed of swimming. Research Quarterly, 1959, 30(4), 479-485.

Travers, P. A regular warm-up is advisable. Swimming Coach, 1973, 66, 12.

Travers, P. R., & Evans, P. G. Annotation limitation of mobility in major joints of 231 sportsmen. British Journal of Sports Medicine, 1976, 10(1), 35-36.

Tuccaro, Saint Archange. Trois dialogues de l'exercise de sauter et voltiger en l'air, Paris: 1589.

Turner, A. A. The effects of two training methods on flexibility. Master's thesis, Lakehead University, 1977.

Tyrance, H. J. Relationship of extreme body types to ranges of flexibility. Research Quarterly, 1958, 29(3), 349-359.

Warden, C. A study of the effects of relaxation on selected elements of skill. Unpublished master's thesis, South College, Massachusetts, 1962.

Wickstrom, R. L. Weight training and flexibility. Journal of Health, Physical Education and Recreation, 1963, 34(2), 61-62.

Williams, E. T. A study of flexibility in basketball players. Unpublished master's thesis, University of Oregon, 1950.

Worthington, A. J. Causes and prevention of hamstring injuries. Track Technique, 1975, 61, 1950-1951.

Appendix A

RESULTS: LU RESIDENCE STUDENTS

Ss	REPS	SHOULDER	HIP	KNEE	ANKLE
1	1	214	45	148	61
	2	218	44	149	59
2	1	262	44	135	72
	2	240	46	137	70
3	1	210	47	119	74
	2	216	46	119	77
4	1	199	50	160	70
	2	205	49	159	78

CORRELATION: LU RESIDENCE STUDENTS: SHOULDER					
Ss	Test 1	Test 2	1X2	$(1)^2$	$(2)^2$
1	214	218	46652	45796	47524
2	262	240	62880	68644	57600
3	210	216	45360	44100	46656
4	199	205	40795	39601	42025
Total	885	879	195687	198141	193805

$\Sigma X \Sigma Y = 777915$

$(\Sigma X)^2 = 783225$

$N = 4$

$(\Sigma Y)^2 = 772641$

$r = .9847838922$ **

$r^2 = 96.97993143$

* Pearson Product Momemt Correlation

** $P < .05$

CORRELATION: LU RESIDENCE STUDENTS: HIP					
Ss	TEST 1	TEST 2	1X2	$(1)^2$	$(2)^2$
1	45	44	1980	2025	1936
2	44	46	2024	1936	2116
3	47	46	2162	2209	2116
4	50	49	2450	2500	2401
TOTAL	186	185	8616	8670	8569

$\Sigma X \Sigma Y = 34410$

$(\Sigma X)^2 = 34596$

$N = 4$

$(\Sigma Y)^2 = 34225$

$r = .8250286473$ **

$r^2 = 68.06722689$

* Pearson Product Moment Correlation

** $P < .05$

CORRELATION: LU RESIDENCE STUDENTS: KNEE					
Ss	TEST 1	TEST 2	1X2	$(1)^2$	$(2)^2$
1	148	149	22052	21904	22201
2	135	137	18495	18225	18769
3	119	119	14161	14161	14161
4	160	159	25440	25600	25281
TOTAL	562	564	80148	79890	80412

$\Sigma X \, \Sigma Y = 316968$

$(\Sigma X)^2 = 315844$

$N = 4$

$(\Sigma Y)^2 = 318096$

$r = .9975021898$ **

$r^2 = 99.50106187$

* Pearson Product Moment Correlation

** $P < .05$

CORRELATION: LU RESIDENCE STUDENTS: ANKLE					
Ss	TEST 1	TEST 2	1X2	$(1)^2$	$(2)^2$
1	61	59	3599	3721	3481
2	72	70	5040	5184	4900
3	74	77	5698	5476	5929
4	70	78	5460	4900	6084
TOTAL	277	284	19797	19281	20394

$\Sigma X \Sigma Y = 78668$

$(\Sigma X)^2 = 76729$

$N = 4$

$(\Sigma Y)^2 = 80656$

$r = .862602837$ **

$r^2 = 74.40836544$

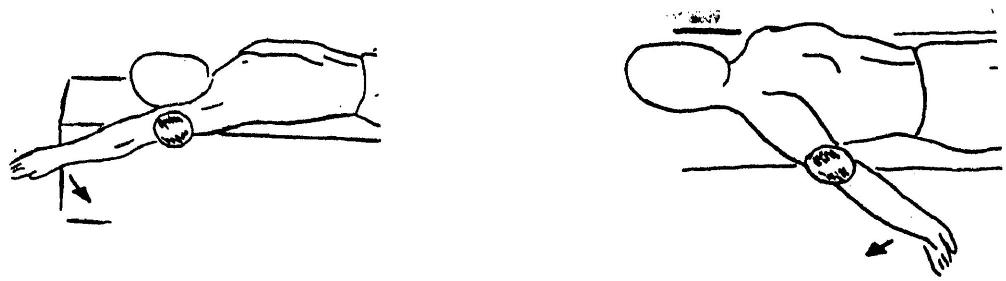
* Pearson Product Moment Correlation

** $P < .05$

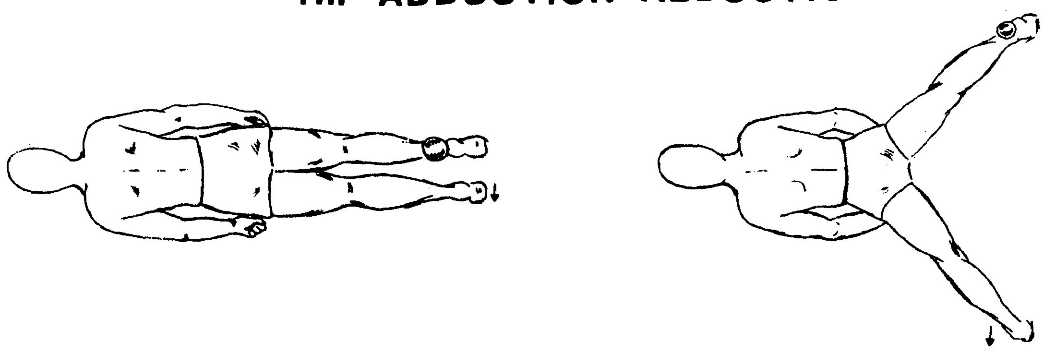
Appendix B

Flexibility Tests

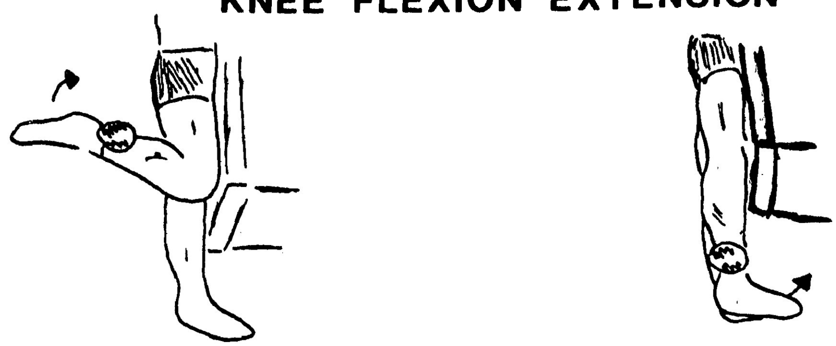
SHOULDER FLEXION EXTENSION



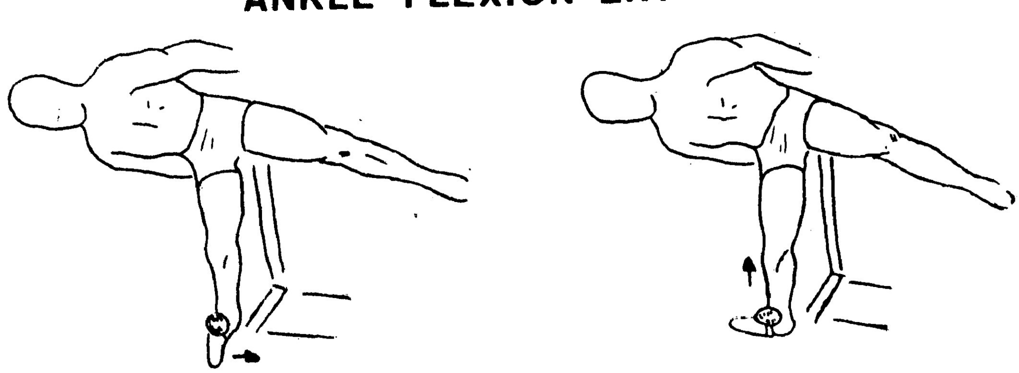
HIP ADDUCTION ABDUCTION



KNEE FLEXION EXTENSION



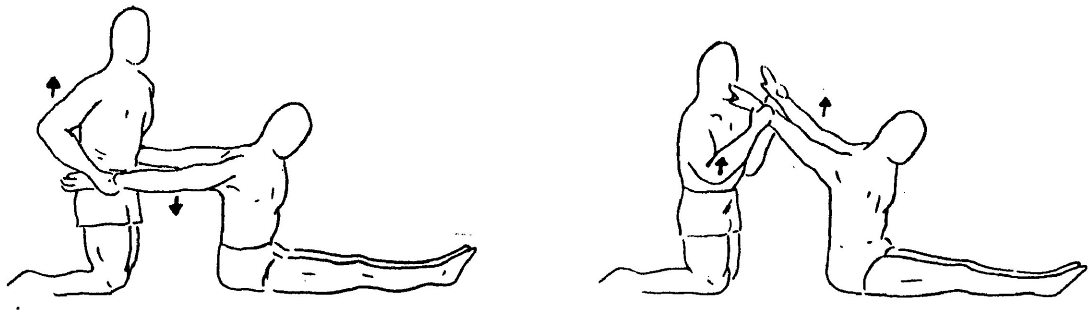
ANKLE FLEXION EXTENSION



Appendix C

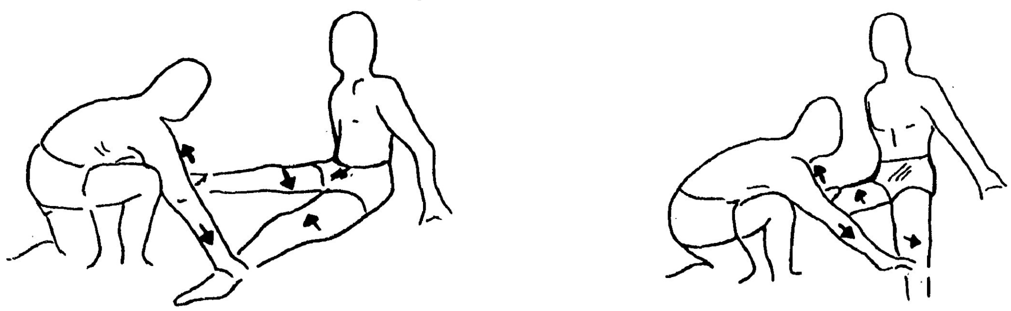
3S Exercises

Shoulder Flexors

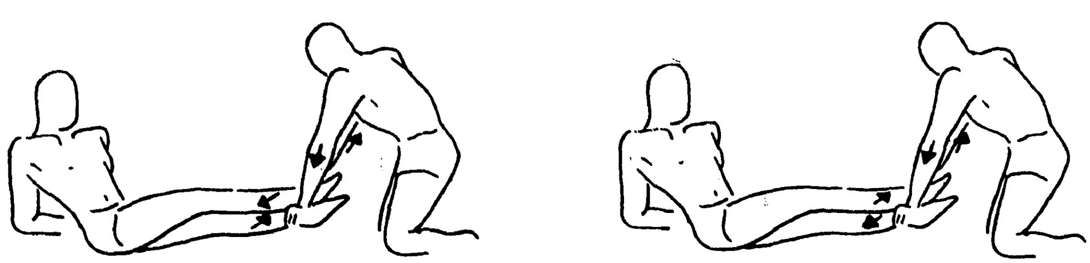


Shoulder Extensors

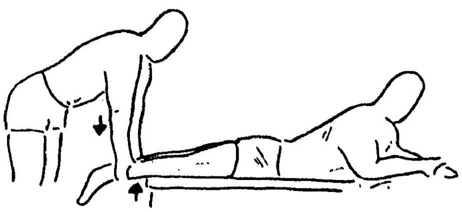
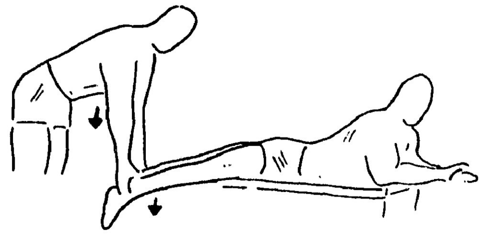
Hip Adductors



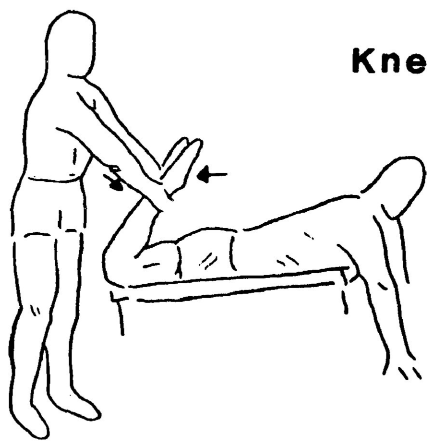
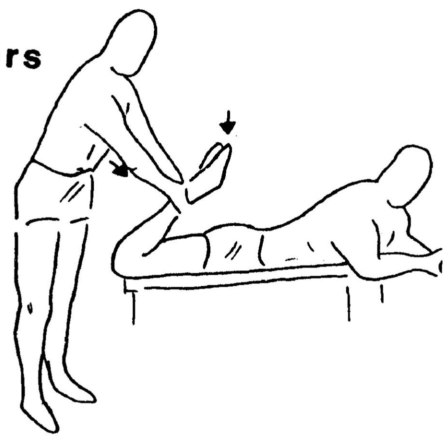
Hip Abductors



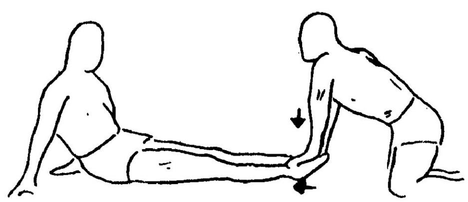
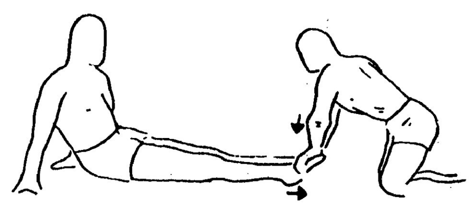
Knee Flexors

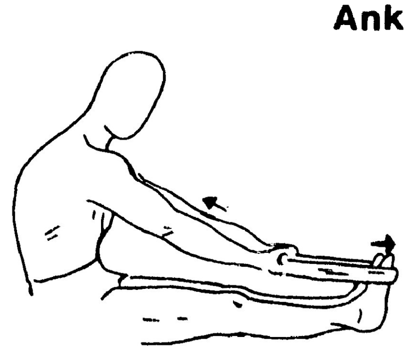
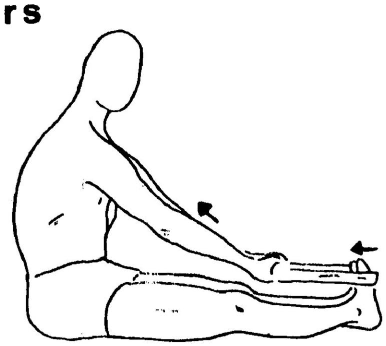
Knee Extensors

Ankle Flexors

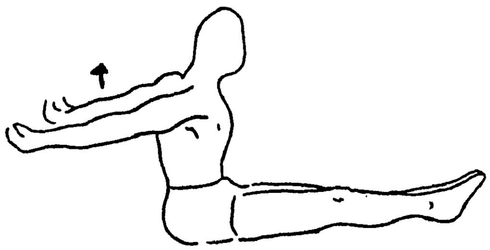
Ankle Extensors

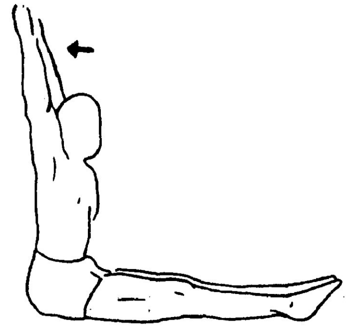
Appendix D

SS Exercises

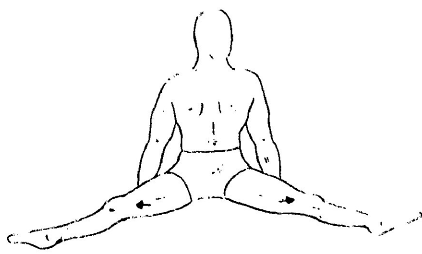
Shoulder Flexors



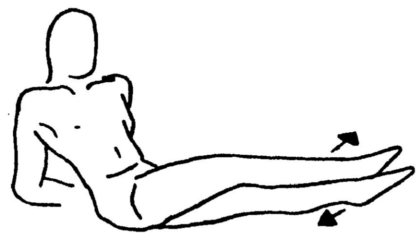
Shoulder Extensors



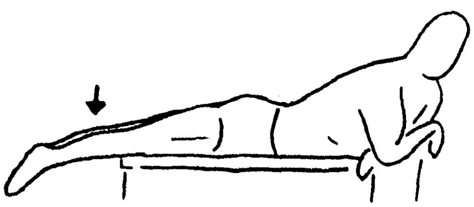
Hip Adductors



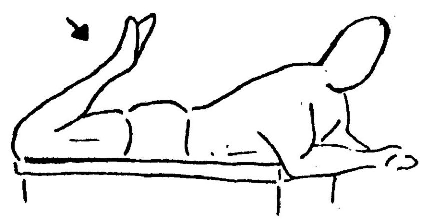
Hip Abductors



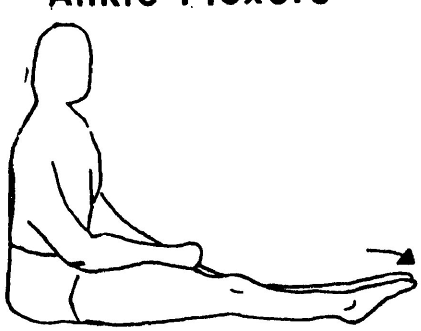
Knee Flexors



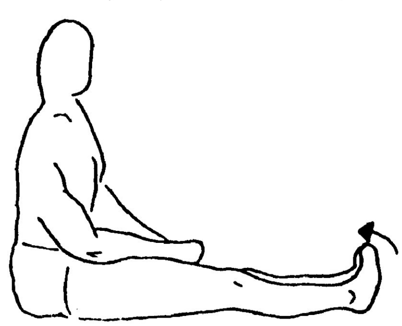
Knee Extensors



Ankle Flexors



Ankle Extensors



Appendix E

JOINT: ANKLE

Ss	REPS	CONTROL			3S			SS		
		TIME			TIME			TIME		
		START	MIDDLE	END	START	MIDDLE	END	START	MIDDLE	END
1	1	48	45	57	55	65	44	55	57	54
	2	49	51	51	55	50	53	56	49	52
2	1	33	63	51	52	53	45	53	40	43
	2	44	60	69	66	70	70	79	63	75
3	1	72	76	64	70	67	66	76	70	75
	2	65	63	67	74	80	81	72	77	79
4	1	63	61	67	62	60	64	48	64	50
	2	49	63	54	63	63	58	61	62	64

JOINT: KNEE

		CONTROL			3S			SS		
		TIME			TIME			TIME		
Ss	REPS	START	MIDDLE	END	START	MIDDLE	END	START	MIDDLE	END
1	1	133	127	187	131	127	137	157	141	136
	2	132	128	123	138	132	127	126	128	126
2	1	133	149	137	166	104	160	172	121	164
	2	149	125	144	153	160	159	148	152	148
3	1	138	104	166	135	175	110	134	157	185
	2	136	144	127	137	148	112	170	113	121
4	1	152	141	149	145	140	147	154	138	131
	2	138	145	147	150	143	139	146	137	140

JOINT: HIP

		CONTROL			3S			SS		
		TIME			TIME			TIME		
Ss	REPS	START	MIDDLE	END	START	MIDDLE	END	START	MIDDLE	END
1	1	62	63	67	68	54	66	56	63	72
	2	61	69	54	65	59	57	56	55	69
2	1	60	62	61	65	62	48	54	45	56
	2	57	67	51	62	61	54	54	61	54
3	1	75	71	79	73	75	70	78	68	72
	2	62	68	71	74	64	74	80	71	77
4	1	64	61	69	73	65	67	62	62	70
	2	73	71	62	66	59	65	62	64	65

JOINT: SHOULDER

		CONTROL			3S			SS		
		TIME			TIME			TIME		
Ss	REPS	START	MIDDLE	END	START	MIDDLE	END	START	MIDDLE	END
1	1	194	187	224	185	182	214	223	209	240
	2	212	210	210	181	202	199	199	216	185
2	1	191	206	220	213	197	207	185	135	182
	2	199	212	206	194	207	182	206	214	211
3	1	224	183	222	203	195	197	191	182	200
	2	192	207	190	213	189	199	196	198	209
4	1	209	198	208	230	155	219	205	228	222
	2	215	221	187	212	214	202	247	229	233