The Effects of Two Training Methods on Flexibility

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Master of Science

in the

Theory of Coaching

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by

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ABSTRACT

Title of Thesis: The Effects of Two Training Methods on Flexibility

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The purpose of this study was to examine the effects of two different flexibility training methods, 3S (Scientific Stretching for Sport) and SS (Slow Active Stretching). Warm-up effects, differential joint responses, and the standardization of training procedures were controlled. Ss were 12 school girl basketball players, aged 12 to 14. The research design consisted of four replications of a 3x3 Graeco-Latin square. Ss were assessed for flexibility at the beginning of a six week flexibility training program, at the conclusion of training and then after two two-week retention periods. Data were analyzed with ANOVA and Orthogonal Comparisons. Significance was determined at 0.05 level. Results showed: 1) flexibility training methods (3S and SS) improved flexibility, 2) the shoulder joint acquired more flexibility than either the knee or ankle joint, 3) neither flexibility training method was superior to the other, 4) within two weeks of training cessation, both 3S and SS effects were lost to a significant degree when compared to control effects,

5) after two weeks of training cessation, there was no difference between changes of the control and two training groups, and 6) there was no difference in loss of flexibility between the shoulder, the knee and ankle joints.

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Chapter 1

INTRODUCTION

Statement of the Problem

The purpose of this study was to examine the effects of two different training methods on the flexibility of three specific joints, the shoulder, the knee, and the ankle.

Significance

Flexibility is important in sports for its beneficial effects in terms of the reduction of injuries due to tearing of muscle tissue, the increase in amplitude of movements inherent in activity, the promotion of muscle relaxation, and the increase in metabolism in muscles, joints, and associated connective tissues (warm-up) (Holt, 1973). As a result, it has been a principal concern in the training of athletes. There are at present several flexibility training methods each purporting to enable the trainee to achieve these benefits. These methods include Slow Stretch (SS), Bounce, Scientific Stretching for Sport (3S), Constant Resistance, Held Stretch, Passive Mobilization, and Proprioceptive Neuromuscular Facilitation (PNF).

From a coaching perspective, one needs to discern which training method is most effective and efficient in terms of achieving for the athlete the greatest range of flexibility in the shortest time with the most enduring effects. This is valuable information for the coach who wants to decide which flexibility training method is to be incorporated in his/her program of training. However, there is little information either from the laboratory or the field, concerning the relative merits of different flexibility training methods.

A review of recent research shows that information of this sort is at best scanty (Holt, 1973) or not directly relevant or useful for the practicing coach (Song and Garvie, 1976).

An observation of trends reveals that coaches from all sporting disciplines within all age groups and ability levels increasingly are incorporating some form of flexibility training into their programs. Opinions vary as to which developmental method is most effective. For example, during the 1976/77 year two leading coaches have used different methods of flexibility in their practice sessions. Olympic coach Don Talbot and coach of the Thunderbolts Swim Club, utilized the 3S Method of Flexibility at the beginning of the season. Since the second half of this season he has also started to employ the SS Method in addition to the 3S Method. Olympic coach Gordon Garvie and coach of the Lakehead University Wrestling Team utilizes 3S, SS, and Bounce methods of flexibility development in his practices. It seems that Garvie uses the 3S Method since he found it effective on the basis of a previous study (Song and Garvie, 1976). However, he also uses the SS Method as well as the Bounce Method even though he is apparently aware of Holt's criticism of this method that it "often causes injury to the athlete prior to training or competition, or predisposes the athletes to injury when he/she does perform" (Holt, 1973, p. 1).

In view of the above considerations, this study anticipated to provide data that will clarify which of the two methods of flexibility training (3S and SS) is more effective, and which method achieves results that persist the longest over time (retention).

Delimitations

1. One type of flexibility instrument was used, Leighton's Flexometer (Leighton, 1966). Three tests were selected from the battery of tests Leighton offers: shoulder flexion-extension, knee flexion-extension, and ankle flexion-extension.

2. Subjects were 12 members of an elementary girl's basketball team (12 to 14 years of age).

3. Subjects with joint impairment would be excluded from the study.

4. There was a possibility that certain subject(s) would be removed from the study before the investigation ended, for example, due to injury.

5. Independent variables for the study were the 3S and SS flexibility methods, and the shoulder, knee, and ankle joints. These independent variables were selected because of past achievements in improving flexibility.

6. The total time period for this investigation was ten weeks, which included a six-week training period and a two-week and four-week follow-up retention test periods.

7. The assignment of independent variables was random.

8. Joints selected were of the synovial type including the shoulders (ball and socket), the knees (hinge), and the ankles (gliding).

9. All joint movements occurred in the sagittal plane (two directions) for both the training and testing situations.

10. The dependent variables were: changes in flexibility of the various joints (shoulder, knee, and ankle) and the retention of these changes.

Limitations

1. The study was based on the following assumptions:
(a) the subjects were representative of an elementary school girl's basketball team because of their phylum specific physiology;
(b) instructions were understood and performers performed the instructions as described; and
(c) statistical significance was at the 0.05 alpha level.

Definitions

Flexibility refers to the range or extent of motion possible in a given joint (Holt, 1973).

Strength refers to the maximal amount of force that an individual can produce in one contraction (Holt, 1973).

Relaxation refers to the lowering or elimination of muscular effort (Holt, 1973).

Isometric Contraction refers to the muscular effort which does not result in joint movement; the force does not move the resistance (Holt, 1973).

Concentric Contraction refers to the muscular effort that results in joint movement, due to the shortening of the contracting muscle tissue (Holt, 1973).

Joint refers to a connection between two or more separate segments or parts of the skeleton. Joints are variously classified, and the official classification is according to the material which joins the long parts. Classification of joints are: fibrous joint, cartilaginous joint, and synovial joint. The synovial type will be chosen for this study. This type permits a variable amount of movement. It consists of a series of investing ligaments, a true joint cavity, and hyaline cartilage over the articulating surfaces of the bones forming the joint. Synovial joints may be subdivided according to the type of movement: gliding, pivot, hinge, biaxial, and ball and socket joints. For the purpose of this study three sub-types of joints will be chosen; shoulder (ball and socket), knee (hinge), and ankle (gliding) (Francis, 1968).

Flexion refers to the movement of a body segment which decreases the angle of the joint (Francis, 1968).

Extension refers to the movement of a body segment which increases the angle of the joint (Francis, 1968).

Effect refers to the change and retention at a specific joint measured in degrees.

Change refers to the difference in angular movement of a specific joint, measured in degrees, between the pre-test and post-test periods.

Retention refers to the difference in angular movement of a specific joint, measured in degrees, between the post-test and follow-up test periods.

Sagittal refers to an imaginary line pertaining to the median vertical plane of the body.

Straining refers to the movement of a joint in a testing or an exercising situation which produces pain in that joint or the associated muscle tendon apparatus.

3S Scientific Stretching for Sport (3S) refers to a flexibility method used in sport training (Holt, 1973).

SS Slow Stretch (SS) refers to a flexibility method used in sport training (Jacobs, 1976).

Chapter 2

REVIEW OF LITERATURE

Flexibility

Physical Fitness Research Digest devoted a recent issue, Joint, and Body Range of Movement (Clarke, 1975) to joint flexibility as a physical trait with potential values for physical fitness and performances in sports. The article was a comprehensive overview of the bulk of research completed on the nonmedical, nonorthopedic aspects of flexibility. The following were areas of major discussion: research reviews (history), measurement (testing), specificity of flexibility, sex and age differences, body dimensions and physique, flexibility patterns of athletes, motor fitness items, muscle-bound, warm-up and exercise and flexibility.

Clarke (1975), in his investigation into these areas on the basis of available research studies, made these summarizations:

1. Orthopedists, physiatrists and physical therapists some 75 years ago originated the earliest flexibility testing method consisting of a goniometry measurement of a single-joint. Leighton, within the last 40 years, invented the Leighton Flexometer which has undergone extensive use by flexibility researchers. In addition to this method, tests based on trunk flexion while the subject is sitting or standing have been used by a number of investigators.

2. The flexibility of a person is not a general characteristic, but is specific to each joint.

3. Researchers using different methods to test trunk-hip forward-bend flexibility found the correlation among these tests to be in the vicinity of $\underline{r}$ = .80.

4. Investigators have shown age and sex differences in flexibility when employing the 19 Leighton Flexometer tests. The results of some studies conveyed that flexibility generally increases from age 6 to 10 in boys and 6 to 12 in girls. Upon reaching their peak, both sexes declined in flexibility as they approached age 16. However, this same pattern was not observed in all flexibility studies. To account for this inconsistency, Clarke suggested that individuals of the same sex and age partake in different types and amounts of physical activity. Clarke also believed that this reasoning could account for individual differences for opposite sexes, within the same age group.

5. The Kraus-Weber toe touch test studies compared boys and girls between the ages 6 to 12 and the results revealed that girls were more flexible at any age than boys with the exception of the girls in one study. Research examining girls and boys between the ages 6 to 17 indicated that 12 year olds are the least flexible.

6. It is indicated that there is no correlation between flexibility and anthropometric measures for males or females.

7. There is a significant correlation between physique-related measures and flexibility. Studies on college women disclosed that overweights had greater hip flexion than underweights. However, underweights had greater lumbar extension than overweights. Data on junior high school girls revealed that tall-overweights were most flexible. Short-overweights and short-underweights were least flexible on the floor-touch test. Material on college men indicated that endomorphs had greater flexibility in the neck, knee, and big joints than mesomorphs and ectomorphs. In addition, six skinfold measurements had negative correlations with right and left knee flexion-extension and neck flexion-extension and rotation.

8. Athletes indulging in long and continuous sporting activity will result in a unique pattern of flexibility for that sport. Some studies compared athletes in different sport environments to normal 16 year old boys on specific joint flexibility. Results showed that swimmers and baseball players had the greatest flexibility, surpassing the normal boys on 25 of 30 tests. The basketball players, track athletes, weight lifters and gymnasts had the next highest degree of flexibility, exceeding the boys on 14 to 15 of 30 tests. The wrestlers were the least flexible of the groups listed, surpassing the boys on 8 of 30 tests.

9. College women and boys 6 to 13 years of age possessing high flexibility in the hip and trunk performed

better in the standing broad jump, softball distance throw, and an obstacle race or sprint, respectively. In boys, high flexibility in neck rotation and trunk lateral flexion facilitated their performance in the softball distance throw.

10. During a competitive gymnastics season, gymnasts displayed an increased flexibility in specific joints and no improvement in others. Boys, during a high school gymnastics season increased their trunk flexion and back extension movements; however, ankle flexion and shoulder elevation did not improve. Ninth grade boys participating in tumbling programs increased their flexibility on 18 of 30 Flexometer tests. College women gymnasts improved in shoulder extension and arch-up flexibility while there was no significant change in right and left splits.

11. Weight trainers, athletes and body builders of international calibre did not suffer from a muscle-bound condition (loss of flexibility). Studies showed that these types of individuals generally had greater flexibility than normal groups of 16 year-old boys.

12. The results of experiments on the effect of weight-training on flexibility are discordant. Generally, studies indicated an increase in flexibility on the index finger and that both isometric and isotonic exercise increased joint flexibility for shoulder flexion-extension and abduction movements. However, the isometric exercise showed more substantial improvement at the 0.01 level. This effect may be

attributed partly to the stretching nature of the isometric exercise.

13. Warm-up exercises increase joint flexibility. In a test situation for specific joint flexibility, performing even a single preliminary trial results in a higher flexibility score for a given test.

14. Stretching exercises intended to increase joint flexibility produce substantial improvement and lasting retention. The effects of these exercises lasted at least eight weeks upon cessation of exercise. College women performing the spring-stretch exercises improved flexibility of the trunk and hip joints the greatest. The hold-stretch method increased hip joint flexibility the second best and a combination method of exercises was least effective for both joints. A different study conveyed that retention of hip joint flexibility was longer than that for the trunk and hip joints combined.

In summary, an overview of the bulk of the literature on flexibility has made apparent the different aspects that influence flexibility development, notably types of flexibility exercise, warm-up and retention.

Flexibility Exercises

The Physical Fitness Research Digest (January, 1976) dealt with an article entitled, Exercise and the Knee Joint which drew the reader's attention to the inadequate exercises that appear in the literature (journals, popular magazines, and professional textbooks), schools (physical education), fitness organizations (health spas), and professional practices (athletic trainers, cardiologists and physicians). Clarke (1976) pointed out that just because a particular exercise has been frequently used in physical education, sports and fitness environments, it did not mean that that exercise was necessarily beneficial. Clarke referred to a paper written by Flint (1964). It supported Clarke's assertion and stipulated that exercises must be based on principles of joint dynamics, must fulfill their objectives, and must be within the physical capabilities of the subject performing the exercises.

The 3S method of flexibility training. Kabat (1952) originally designed the PNF technique for patients that suffered from paralysis. PNF exercises were used to increase the range of motion of specific joints. His method was based on neurophysiological principles. Knott and Voss (1965) continued the practice of the PNF technique for patients suffering from paralysis and other joint impairments. Holt (1973), being interested in athletic performance, promoted the 3S Method of Flexibility development, using the principles of PNF. He advocated the utilization of the 3S Method because it was firmly based on accepted neurophysiological facts.

Holt, in his publication, Scientific Stretching for

Sport (1973), stated, "To date, [only] two studies [Holt et al., 1970; Tanigawa, 1972] have been done comparing facilitation stretching [3S] with other methods of increasing range of motion." (pp. 40-41). Holt, Travis and Okita (1970) investigated the effect of three techniques for increasing the range of motion. Fast stretch (ballistic), slow stretch, and IA-CA, a modified version of PNF, were compared using 24 normal male subjects. IA-CA refers to an isometric contraction of the agonist (IA), followed by a concentric contraction of the antagonist (CA). Six groups of four subjects received the treatments. Serial order effects were controlled for and pre-tests were performed on subjects to measure the effect each had on specific joint flexibility. Multiple regression analysis showed that the IA-CA flexibility method produced the greatest effect on flexibility. Holt referred to the IA-CA Method as being synonymous with the 3S Method of Flexibility.

Tanigawa (1972) compared the effects of the PNF and passive mobilization on tight hamstring muscles. A goniometric measurement method was used. The study showed that the PNF Method of Flexibility development resulted in a greater and faster degree of improvement in flexibility than did passive mobilization.

Song and Garvie (1976) compared the flexibility performance of wrestlers using the 3S Flexibility Method with that of a control group receiving no 3S exercise. Those receiving the 3S Method of Flexibility increased their flexibility in 18 of 19 Flexometer tests, with the exception of the shoulder horizontal abduction test. The group not receiving 3S Method improved on 11 of 19 tests. However, the two groups were only significantly different on two of the 19 tests, a frequency no better than chance.

Consider the statement made by Holt (1973) that at present there are only two studies (Holt et al., 1970; Tanigawa, 1972) comparing with other flexibility training methods. Examining the methods in those studies, it can be seen that the 3S Method was not strictly followed. Holt et al. (1970) stated, E [experimenter] when assisting, did not push or apply force to the leg in any direction, but served merely as a stationary object against which S could apply force for contraction of the hip extensors." (p. 614). This study did not follow the 3S procedures. The 3S flexibility training method, according to Holt (1973), required the E, after a six second isometric contraction to aid the subject with "light pressure" in the direction the subject is concentrically contracting the opposite muscle group to be stretched.

Tanigawa's (1972) procedures for exercising for joint flexibility required the person to perform multiple joint movements through multiple planes for one specific exercise. For example, the subject was told to relax the limb being exercised as E passively elevated the subject's limb into hip flexion, adduction and external rotation, dorsi-flexion with inversion, and toe extension; the knee was kept in extension. E instructed the person to indicate to him when pain was felt in the injured joint. When the subject experienced pain the subject was asked to push his leg down toward E as hard as he could. The experimenter served as an immovable object so that the subject would produce a six second isometric contraction. Tanigawa's procedures did not adhere to the steps required in the 3S Method: one joint being employed in one exercise, in one plane, gradual effort to maximum isometric contraction, followed by a concentric contraction of opposite muscle group to be stretched, and with slight assistance from the experimenter.

Song and Garvie (1976) to date have made the only study on the 3S flexibility training method. However, their description of the 3S Method omitted an integral part of the exercise. In their study they stated that the 3S Method was used and

> This method of increasing range of motion involves passively extending a muscle group close to the maximum and then, against a fixed resistance, isometrically contracting this muscle group while in the extended position for a 5 to 7 second period. Following this contraction the muscle group is relaxed and once relaxed, further extension of the particular group is possible. (Song and Garvie, 1976, p. 18).

It was not indicated here that following isometric contraction of the muscle group to be stretched, "<u>concentric contractions</u>

of the opposite muscle group together with light pressure from a partner" (Holt, 1973, p. 5) was performed. The concentric contraction of the agonist (opposite muscle group to that being stretched) is necessary to ensure physiological relaxation within the antagonist muscles (muscle group to be stretched).

In light of the above observations, these different flexibility studies (Holt, et al. 1970; Tanigawa, 1972; and Song and Garvie, 1976) cannot credit their findings to the 3S flexibility training method. Their methods may well be based on PNF principles, but they did not follow standard 3S procedures.

The SS method of flexibility training. No information has been obtained ascertaining the origin of the Slow Stretch (SS) method for flexibility development. Jacobs (1976) reported that slow active stretching should be used to acquire optimal flexibility in joints requiring exercises. He offered neuroanatomical and neurophysiological reasons to support this contention.

There are few studies reporting on the Slow Active Stretching Method (a form of SS). Weber and Kraus (1949) reported that the use of bounce stretching was superior to slow active or slow passive stretching. Logan and Egstrom (1961) found no significant difference between the mean differences of the final measures of fast and slow stretch methods for either men or women. Jacobs (1976) reported that slow active stretching is a more superior method than slow passive stretching. There are other studies, e.g., Holt et al. (1970); Tanigawa (1972), which examined slow passive stretching and not slow active stretching. The present author believes that the former method cannot be generalized to indicate the active stretching method of flexibility training and their results are not directly relevant to the present study. For this reason they will not be discussed here.

To date there are no studies providing data to compare the SS and 3S Methods of flexibility training.

Retention of Flexibility

There is little documentation on the retention of flexibility. McCue (1953) reported that upon the cessation of a stretching program the improvement effects in flexibility were long lasting (at least eight weeks). She also revealed that the flexibility of certain joints would persist longer than others. For example, the increased flexibility of the hip joint was retained longer than for the ankle joint. Unfortunately, McCue's investigation did not use a control group receiving no flexibility exercises. This rigorously restricts the usefulness of her conclusions on the retention of specific joint flexibility. Tanigawa (1970) indicated in his study that within one week following cessation of exercise the group that had undergone PNF hold-relax exercise had greater loss in flexibility than the group receiving the passive mobilization exercises and the control group receiving no flexibility exercises.

The Effects of Warm-Up on Flexibility

None of the experimental studies on 3S and SS Methods of flexibility have used (when measuring joint flexibility) warm-up activities before collecting data. Atha and Wheatly (1976) reported that an individual's flexibility score will increase over a series of trials. Unfortunately, the studies examining the superiority of PNF or SS Methods did not control for this variable. Atha and Wheatly (1976) stated their findings "throw serious doubt upon the wisdom of this practice." (p. 24). Fieldman (1966) supported their claims.

Summary

Flint (1964) has warned that the principle of standardization from one type of exercise to another is vitally important for both identification and evaluation purposes. As indicated by Devries (1976) and Clarke (1975), there has been no study to date concerning specific retention of 3S and SS Methods on the shoulder, knee, or ankle joints. Atha and Wheatly (1976) revealed that past research had used testing procedures without a warm-up. Future studies must account for this important variable if their data are to be useful.

The present study employed standardized procedures on the 3S and SS Methods of flexibility development. It controlled for the important variable of warm-up during testing sessions and secured data on the retention of flexibility so that both the practitioner and theorist may profit from the findings.

Chapter 3

METHOD

Hypothesis

There is no difference in the flexibility performance of subjects using the 3S and SS flexibility training methods on the shoulder, knee, and ankle joints.

Subjects

Subjects were 12 elementary school girl basketball players at Agnew H. Johnston Elementary School, Thunder Bay, Ontario, ranging from 12 to 14 years of age. The team members were students who voluntarily play in inter-school competitions. Clarke's (1975) review of literature showed that subjects 12 years old are "least flexible."

Design

This study consisted of four replications of a 3x3 Graeco-Latin square which was used to evaluate the effects of 3S, SS, and control (no exercise) on the shoulder, knee, and ankle joints. The Graeco-Latin square design only allowed for each condition to occur once in each column and row. No two subjects had the same order of presentation for the three conditions in each square. Subject I received 3S training on the shoulder, SS training on the knee, and no training on the ankle (control). Subject II received no training on the shoulder (control), 3S on the knee, and SS on the ankle.

Subject III received SS training on the shoulder, no training on the knee (control), and 3S on the ankle. Subjects were randomly assigned to each row in each square (Figure 1).

DESIGN OF THE STUDY

Joint / Subject	Shoulder	Knee	Ankle
I	3S Method	SS Method	Control (no exercise)
II	Control (no exercise)	3S Method	SS Method
III	SS Method	Control (no exercise)	3S Method

Figure 1. The Graeco-Latin square element sequence used in this study.

Analysis of Data

An analysis of variance (Edwards, 1968) was used to analyze the data collected. A Priori Orthogonal Comparisons (Hays, 1963) were used to determine if a significant difference had occurred between treatment conditions: 1) the flexibility trained and the untrained groups and 2) the 3S Method and SS Method of flexibility training.

Testing and Training Schedules

Pre-training testing was undertaken before the first flexibility training session. Flexibility training sessions were held three times per week (Monday, Wednesday, and Friday) for six consecutive weeks, between 3:40 and 4:00 p.m. The flexibility training program was held in conjunction with the basketball practice sessions which occurred on the same days as the training program between 3:30 and 5:00 p.m. Post-training testing occurred following completion of the last training session. The first retention test was undertaken two weeks after the post-training test. The second retention test took place four weeks after the post-training test.

Testing Apparatus

All testing was carried out in a centrally heated gymnasium. The testing room was at a constant temperature (20° C) on all testing days. The room was equipped with two portable benches (100x38x43 cm) and one portable wall. A total of 10 adjustable straps were used by three testers for strapping subjects into the proper testing positions. Subjects wore standard basketball gym clothing consisting of a pair of shorts, a T-shirt, and stockings.

Two Leighton Flexometers (Leighton, 1966) were used for measuring joint (shoulder, knee, and ankle) flexibility. The Leighton Flexometer is comprised of a weighted 360 degree dial and a weighted pointer housed in a case. The dial and pointer function freely and independently from each other, though each is controlled by gravity. The Flexometer, when positioned within 20 degrees off the horizontal, will record accurate angular movement. Independent locking mechanisms are furnished for the dial and the pointer which stopped angular movement of either at any position. The flexometer must be strapped to the segment next to the joint being tested. The dial was locked at one position (e.g., full flexion of the ankle); the angular movement was performed and the pointer locked at the opposite extreme position (e.g., full extension of the ankle). The exact reading of the pointer on the dial was the angular movement through which motion had taken place. (Leighton, 1966) (Appendix A).

In Leighton's test

> A correlation coefficient between a first and the second measurement was derived for each of thirty measures recorded. These coefficients of correlation for 120 boys ranged between 0.913 and 0.996, sufficiently high for individual comparisons.
> (Leighton, 1966, p. 86).

Testing Procedures

Leighton's rules for flexibility testing (Leighton, 1966) were followed as standard procedure for all tests. The pre-training, post-training, first retention, and second retention tests each followed the same procedures. During each session, three subjects were randomly called for testing at a time. They changed into their basketball clothing and went directly to the testing room. Upon completion of the shoulder, knee, and ankle tests the subjects left the testing room and three more subjects were called. This pattern continued until all subjects had been tested.

The same three testers collected all the data for this study. Tester A collected all data on the shoulder, tester B the knee, and tester C the ankle. Each tester was helped by two assistants. Assistant 1 prepared the subject for each test by strapping her to the testing apparatus. Assistant 2 recorded the subject's full name and all measurements for the joint being tested. All subjects performed five consecutive maximum movements for each specific joint tested as instructed by the tester.

Flexibility Tests

The flexibility tests administered to each subject are outlined in Appendix B.

Training Apparatus

All training was carried out in a large centrally heated school gymnasium. The temperature of the training gymnasium was at a constant of 20° C during all training sessions. The gymnasium was equipped with four portable wooden benches (250x25x30 cm) and four skipping ropes (100x.5 cm). Two projectors were used to present training exercises on slides for subjects to follow while performing the exercises. Three coloured slides were shown for each 3S flexibility exercise and two coloured slides for each SS flexibility exercise.

Subjects wore standard basketball clothing consisting of a pair of shorts, T-shirt, a pair of socks, and/or a pair of tennis shoes.

The flexibility training program was administered by one male and one female basketball team coach who were also knowledgeable in flexibility training.

Training Methods

3S training method. This is a method of increasing flexibility whereby an isometric contraction of the muscles to be stretched (muscles in a lengthened position to start) are followed by a concentric contraction of the opposite muscle group together with light pressure from a partner performed in series until the scope of movement cannot be increased without pain. (Holt, 1973, pp. 5-7).

For example, an athlete wanting to stretch the shoulder flexors will perform the following exercise: athlete (A) assumes a long sitting position on the floor with her legs and back straight, arms straight and back from her sides, and the shoulder stretched back as far as possible. Helper (H) stands behind A, with the right foot near A's body, the right knee resting against A's spine, and holding both A's forearms. A attempts to move the arms forward and toward the floor, elbows remain straight. H resists A's movement. H holds A's position to produce a six second isometric contraction. A moves the arms slowly backward and toward the ceiling, elbows remaining straight, to a position so that the shoulders are forcibly extended. H assists A's movement with light pressure. A attains her maximum range of motion, without straining then relaxes.

Upon completion of each exercise the next repetition will be performed from the position last attained by the athlete. The isometric contraction performed by the exercising subject must be a gradual increase in effort and not an explosive one.

SS training method. This is a method of increasing flexibility by slow active contraction of the agonist muscles while relaxing the antagonist muscle group (the muscle to be stretched) (Jacobs, 1976, pp. 151-152). A maximal range of motion is attained for each repetition of the exercise, and the final position is held for 10 seconds.

For example, an athlete wanting to stretch the shoulder flexors will perform the following exercise: athlete (A) assumes a long sitting position on the floor with her legs and back straight, arms straight down from her sides, and the shoulders stretched back as far as possible. A moves the arms slowly backward and toward the ceiling, elbows remaining straight, so that the shoulders are forcibly extended. A holds this position for 10 seconds, without straining and then relaxes.

Upon completion of each exercise the next repetition will be performed from the starting position. The stretching movement made by the athlete is overtly controlled only by the agonist muscle group and without additional assistance from any external force (i.e., hands pulling the segment to a greater range of motion).

Training Procedures

The flexibility training program consisted of 18 identical sessions.

The gymnasium was divided into two stations, 3S and SS. The distance between the stations was great enough so that subjects exercising at each station were not distracting one another during their set of exercises. All exercises were performed eight times with the subject relaxing two to five seconds between each exercise.

During Set one (shoulder exercises), Subject 1 (athlete) and Subject II (helper) moved to the 3S station and performed two exercises (Exercise I and Exercise II). Subject III (athlete) moved to the SS station and performed two exercises (Exercise VII and Exercise VIII).

During Set two (knee exercises) Subject I (athlete) moved to the SS station and performed two exercises (Exercise IX and X). Subject II (athlete) and Subject III (helper) moved to the 3S station and performed two exercises (Exercise

III and Exercise IV).

During Set three (ankle exercises), Subject I (helper) and Subject III (athlete) moved to 3S station and performed two exercises (Exercise XI and Exercise XII). Subject II (athlete) moved to the SS station and performed two exercises (Exercise V and Exercise VI).

During each set of exercises the instructor for each station controlled the exercises by standard verbal instructions. However, in sessions I and II of the flexibility training program coloured slides demonstrated standard procedures at each station as well as verbal instructions. On alternate days instructors controlled a different method of exercises. Both instructors were synchronized so that movement from station to station occurred rapidly and smoothly.

3S and SS Exercises

The 3S and SS flexibility exercises are described in Appendix C and D respectively.

Chapter 4

RESULTS

Immediate Training Effect

Pre-training test to post-training test (T1 - T2). The amount of improvement from the pre-training to post-training tests was determined for each subject on each joint. Data were analysed by analysis of variance. There was no significant difference revealed among subjects (F = 1.51, $p>0.05$). The analysis showed a significant difference among joints (F = 117.40, $p<0.01$) and among treatments (F = 4.96, $p<0.05$).

A Priori Orthogonal Comparisons using mean difference scores were conducted on the treatments. For the first orthogonal comparison the combined treatments were shown to be significantly different from the control (F = 6.01, $p<0.05$). The second comparison revealed no significant difference between the 3S and SS treatments (F = 3.90, $p>0.05$). The results of the above analyses are summarized in Table 1 and Figures 2, 3, 4 and 5.

Retention Effect

Pre-training test to first retention test (T1 - T3). Differences between pre-training and the first retention were determined. The ANOVA among the joints indicated a significant difference (F = 41.98, $p<0.01$). However, subjects (F = 1.24, $p>0.05$) and treatments (F = 0.04, $p>0.05$) analyses revealed no significant difference. Orthogonal Comparisons between the flexibility trained groups and control group revealed no significant difference (F = 0.07, p>0.05). Analysis between the two training methods (3S and SS) indicated there was no significant difference (F = 0.02, p>0.05). The results are summarized in Table 2 and Figures 2, 3, 4, and 5.

Table 1. Summary of the analysis of variance of the immediate training effect between the pre-training and the post-training test periods (T1 - T2) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	773.22	11	70.29	1.51
Joints	10935.06	2	5467.53	117.40**
Treatments	461.56	2	230.78	4.96*
Trained to Control	280.06	1	280.06	6.01*
3S to SS	181.50	1	181.50	3.90
Residual Error	931.34	20	46.57	
Total	13101.22	35		

* = significant at 5% level

** = significant at 1% level

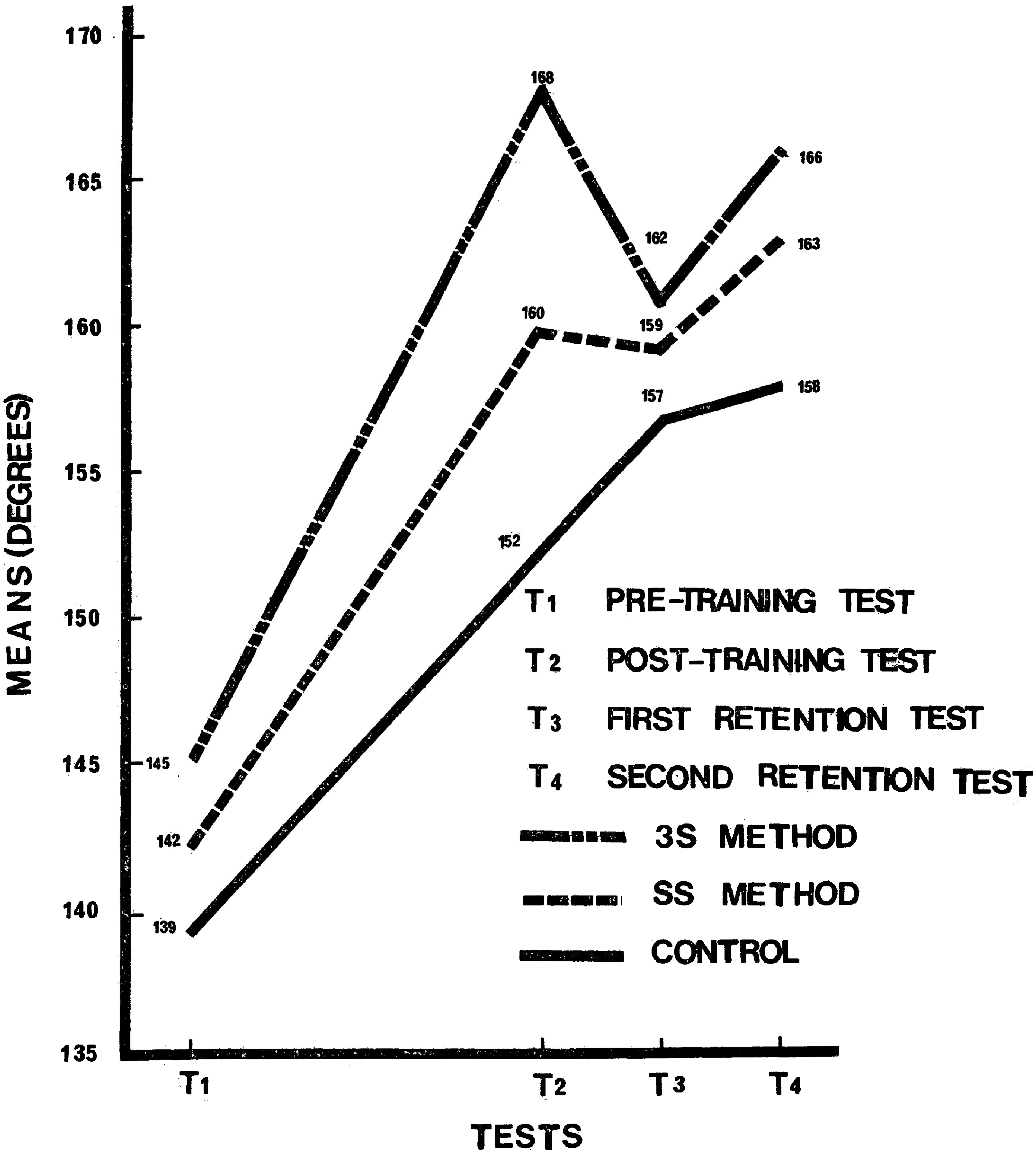


Figure 2 Mean treatment flexibility scores against tests.

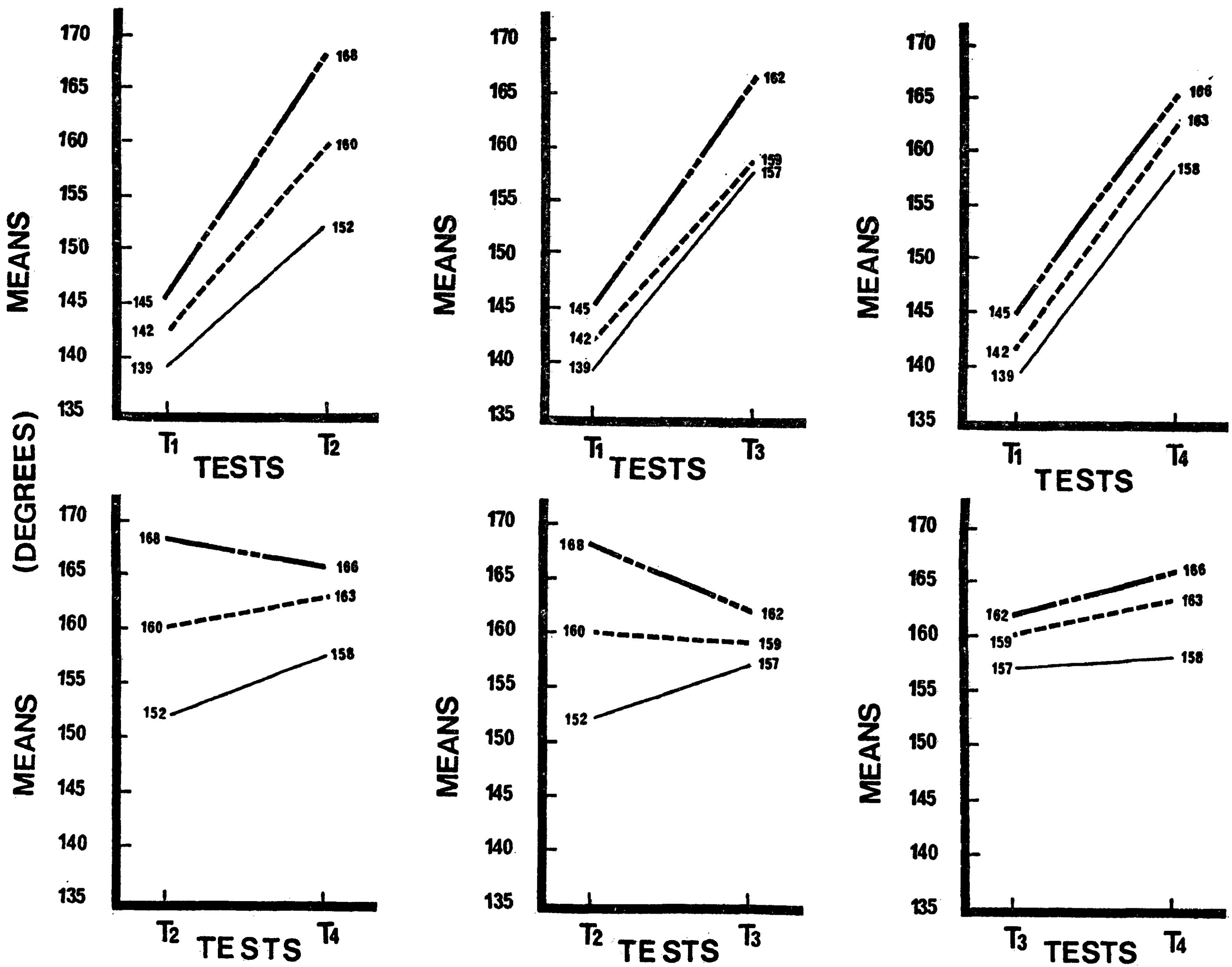


Figure 3 Mean treatment flexibility scores against tests.

LEGEND: SEE FIGURE 2

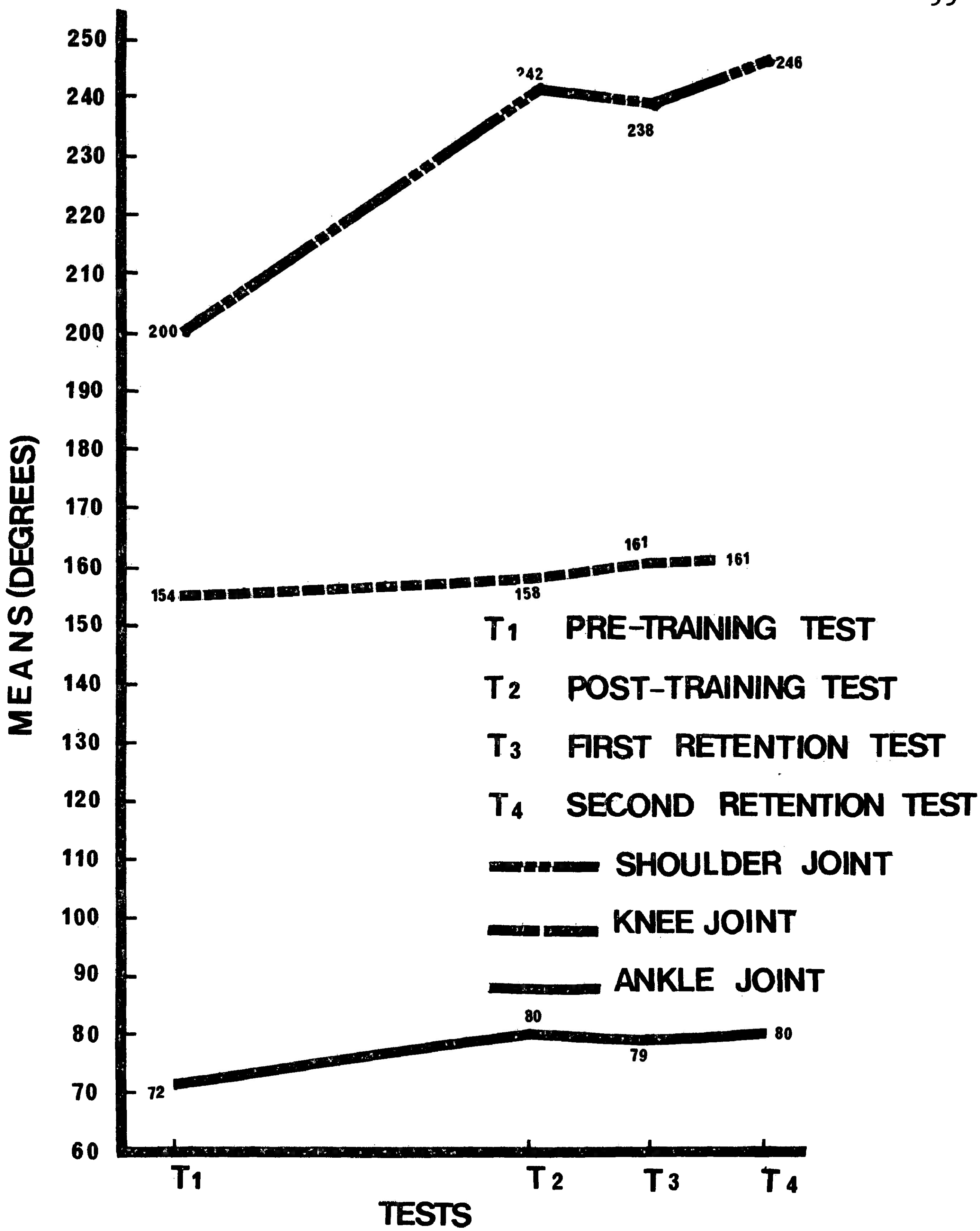


Figure 4 Mean joint flexibility scores against tests.

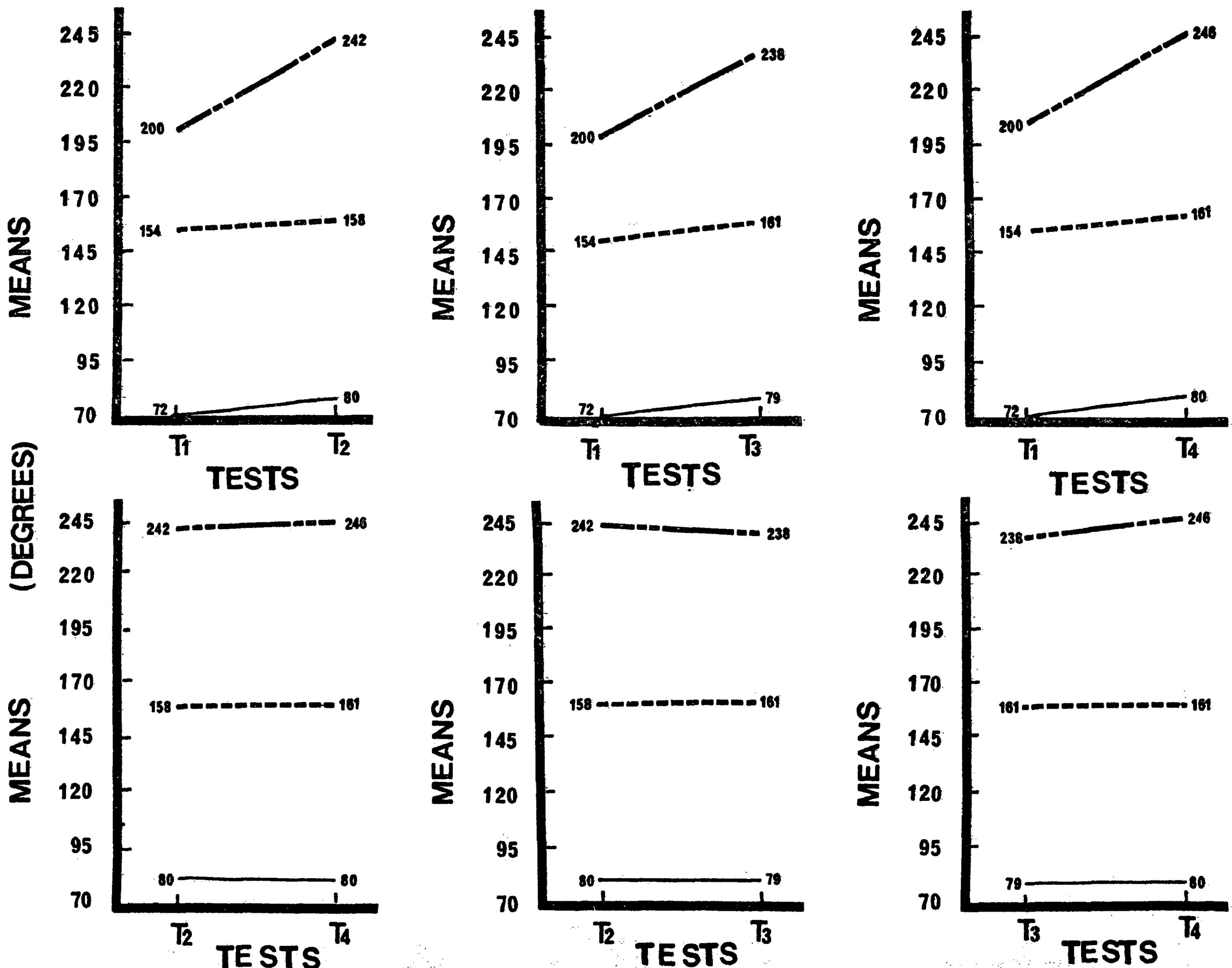


Figure 5 Mean joint flexibility scores against tests.

LEGEND: SEE FIGURE 4

Table 2. Summary of the analysis of variance of the retention effect between the pre-training and the first retention test periods (T1 - T3) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	1282.67	11	116.61	1.24
Joints	7875.12	2	3937.56	41.98*
Treatments	8.17	2	4.09	0.04
Trained to Control	6.13	1	6.13	0.07
3S to SS	2.04	1	2.04	0.02
Residual Error	1876.05	20	93.80	
Total	11042.00	35		

* = significant at 5% level

** = significant at 1% level

Pre-training test to second retention test (T1 - T4). The differences between the pre-training and the second retention period test scores were determined. The ANOVA showed a significant difference within joints (F = 58.59, $p<0.01$). However, among subjects (F = 0.67, p 0.05) and treatments (F = 0.12, $p>0.05$) no significant difference was found. Orthogonal Comparisons revealed no significant difference between trained and untrained treatments (F = 0.23, $p>0.05$) or between 3S and SS treatments (F = .000, $p>0.05$). The results of the above analysis are summarized in Table 3 and Figures 2, 3, 4, and 5.

Table 3. Summary of the analysis of variance of the retention effect between the pre-training and the second retention test periods (T1 - T4) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	792.75	11	72.07	0.67
Joints	12568.17	2	6284.09	58.59**
Treatments	24.67	2	12.34	0.12
Trained to Control	24.50	1	24.50	0.23
3S to SS	0.17	1	0.17	0.00
Residual Error	2145.17	20	107.26	
Total	15530.75	35		

* = significant at 5% level

** = significant at 1% level

Post-training test to second retention test (T2 - T4).

Difference scores between the post-test and the final retention period test were determined. The ANOVA and Orthogonal Comparisons revealed no significant difference between subjects, joints, or treatments. The results are summarized in Table 4 and Figures 2, 3, 4, and 5.

Table 4. Summary of the analysis of variance of the retention effect between the post-training and the second retention test periods (T2 - T4) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	962.75	11	87.52	1.50
Joints	110.17	2	55.09	0.94
Treatments	392.67	2	196.34	3.36
Trained to Control	200.00	1	200.00	3.42
3S to SS	192.67	1	192.67	3.30
Residual Error	1169.17	20	58.46	
Total	2634.75	35		

* = significant at 5% level

** = significant at 1% level

Post-training test to first retention test (T2 - T3). Difference scores were determined for the post-treatment and the first retention tests. The mean difference scores were analysed. There was no significant difference between subjects (F = 1.25, $p>0.05$) or joints (F = 2.32, $p>0.05$). A between treatment analysis revealed a significant difference (F = 4.32, $p<0.05$).

Orthogonal Comparisons were conducted on the treatments using mean difference scores. The combined flexibility trained groups were significantly different from the control group (F = 5.84, $p<0.05$). The comparison between flexibility trained groups did not produce a significant difference ($\underline{F}$ = 2.79, $p > 0.05$). The results of the above analysis are summarized in Table 5 and Figures 2, 3, 4, and 5.

Table 5. Summary of the analysis of variance on the retention between the post-training and the first retention test periods (T2 - T3) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	1098.0	11	99.82	1.25
Joints	368.67	2	184.34	2.32
Treatments	687.17	2	343.59	4.32*
Trained to Control	465.12	1	465.12	5.84*
3S to SS	222.04	1	222.04	2.79
Residual Error	1592.17	20	79.61	
Total	3746.00	35		

* = significant at 5% level

** = significant at 1% level

<u>First retention test to second retention test</u> (T3 - T4). Difference scores between the second and third retention tests were determined. The ANOVA and Orthogonal Comparisons indicated no significant difference within subjects, joints or treatments. The results are summarized in Table 6 and Figures 2, 3, 4, and 5.

Table 6. Summary of the analysis of variance on the retention effect between the first retention and the second retention test periods (T3 - T4) with orthogonal comparisons on the treatments.

Source of Variance	Sums of Squares	d.f.	Mean Squares	F
Subjects	650.08	11	59.10	0.58
Joints	550.50	2	275.25	2.71
Treatments	56.17	2	28.09	0.28
Trained to Control	55.12	1	55.12	0.54
3S to SS	1.04	1	1.04	0.01
Residual Error	2032.00	20	101.60	
Total	3288.75	35		

* = significant at 5% level

** = significant at 1% level

Hypothesis

The present study accepted the null hypothesis. The data showed that there was no difference in the acquiring or retaining of flexibility performance of subjects using the 3S and SS flexibility training methods on the shoulder, knee, and ankle joints.

Chapter 5

GENERAL DISCUSSION

The major findings of this study were:

1) The immediate effects of the 3S and SS flexibility training methods over six weeks were increased flexibility for the trained groups as compared to controls receiving no flexibility training. This finding is in accord with the general assumption in the field of athletic training concerning the effectiveness of flexibility training programs (Devries, 1976; Holt, 1973). Specifically, as the result of training, the shoulder acquired more flexibility than the knee or the ankle. The fact that different joints acquired different amounts of flexibility is not surprising, since they are of a different anatomical and physiological constitution (Devries, 1976; Francis, 1968).

2) Neither specific method of flexibility training was shown to be superior to the other. This is in disagreement with claims made by Holt (1973) and Jacobs (1976) that their methods, 3S and SS respectively, are superior to other methods of training.

3) The retention tests at two and four weeks after the cessation of training showed no significant changes in flexibility between the trained and untrained subjects at that point in time as compared to before training. This indicated that the flexibility training effects were not

retained or had been lost during these short periods of time after training had ceased.

The above issues will be considered in further detail under the following headings: immediate training effect, retention effect, joint effect, research procedures, and techniques.

Immediate Training Effect

The field. It has been generally assumed in the sport training field that flexibility training is useful and effective. Observations in the practical sport world have produced these findings. Don Talbot and Gordon Garvie, Olympic coaches, and coaches of the 1976/77 Thunderbolt Swim Club and Thunder Bay Wrestling Club respectively, employed flexibility exercises in their daily programs. Moreover, these coaches also utilized the SS and 3S Methods. Both these elite coaches did not seem to be satisfied that one method is superior to the other, despite the results obtained by Song and Garvie (1976) who stated that 3S (actually a modified form of 3S) produced significant increases in flexibility. These coaches believed that both methods are effective under different conditions. For example, 3S flexibility exercises stretch the joints considerably more than SS exercises. Each 3S exercise takes twice as long to perform than an SS exercise, because the 3S Method requires a partner and the SS Method does not. The two questions raised that were pertinent to this study were:

1) Is flexibility training better than no training? 2) Is one method of flexibility training (3S or SS) superior to the other in developing specific joint flexibility?

Proprioceptive neuromuscular facilitation (PNF). Holt (1973) claimed that 3S is a superior method because it is the only flexibility training method based on Herman Kabat's proprioceptive neuromuscular facilitation (PNF) principles. Jacobs (1976) claimed that the SS Method is the most efficient stretching technique because it is based on sound current anatomical and neurophysiological facts. The terms proprioceptive neuromuscular facilitation principles (PNF) and anatomical and neurophysiological facts deal with the same aspects of physiology. This deduction can be made by reading Herman Kabat (1952) and Jacobs (1976) and the physiological principles discussed. However, to judge the superiority of one method over another and their relation to PNF principles is beyond the scope of this research.

Nevertheless, empirical data from the present study showed no difference between the effectiveness of the two methods. This did not support the claims of Holt or Jacobs concerning the superiority of their methods. The data showed that the trained group did acquire more flexibility than the untrained.

Retention Effect

The field. It has been postulated generally in the sport training field that flexibility is lost very quickly, if exercise is stopped. The question is raised: Does one method (3S or SS) retain flexibility development longer than the other?

Proprioceptive neuromuscular facilitation (PNF). The present study found no difference between the 3S and SS Methods in the loss of flexibility during the period of two weeks following cessation of training. Neither Holt (1973) nor Jacobs (1976) made any claims about the retention of flexibility due to their training methods.

If the proprioceptive and neurophysiological principles (PNF) were involved in the acquired flexibility, possibly they are also involved in the retention of flexibility. If so, it was not surprising to show that the rate of change in the loss of flexibility was the same for both the 3S and SS training methods, during the first retention period. Tanigawa (1972) also found that flexibility was lost very quickly within one week following cessation of a flexibility training program.

Joint Effect

The three specific joints used in this study were of the synovial type, but each was of a different classification: the shoulder (ball and socket), the knee (hinge), and the ankle (glide). Each synovial joint is classified differently in the amounts of movement, direction of movement, series of investing ligaments, joint cavity, cartilage, and articulating surface (Francis, 1968). The shoulder, the knee, and the ankle are indeed very different anatomically and physiologically. Thus, the present experimental findings that the shoulder joint acquired more flexibility over six weeks of training as compared to the knee or the ankle could be expected to have happened.

The results also showed that there was no difference across the joints in the retention of flexibility. These findings refute the claims made by McCue (1953) that specific joints retain flexibility longer in some joints than in others. The retaining of joint flexibility could not be compared to the acquiring of specific joint flexibility, because the data had been collected over two time periods of different duration.

Research Procedures

Standardized procedures. There seemed to be no real experimental research providing empirical data to support flexibility development with either the 3S and SS Method of flexibility training. The studies that Holt (1973) used in support of the 3S Method (Holt *et al.*, 1970; Tanigawa, 1972) did not follow the standard 3S procedures set down by Holt (1973, pp. 40-41). The IA-CA Method used by Holt *et al.* (1970) omitted a concentric contraction followed by slight assistance from the partner. The Hold-Relax Method chosen by Tanigawa (1972), which consisted of multiple planes for one specific exercise, did not even resemble the 3S standard procedures. Song and Garvie (1976) conducted the only study to date that closely adhered to the 3S procedures. However, even in that study, one important requirement was absent, namely, the concentric contraction of the opposite muscle group to be stretched, though the method followed all other aspects of the standard procedures.

Jacobs (1976), as well, had not produced experimental research to support the SS Method as the best method of training. There have been two studies on the effects of slow stretch exercises (Logan and Egstrom, 1961; Weber and Kraus, 1949). The SS procedures used were not clearly defined in operational terms and thus, it cannot be ascertained as to whether or not the SS standard procedures were followed accurately.

Warm-up. Warm-up is another important factor which has not been adequately considered in the design of experimental studies in flexibility training methods. Atha and Wheatley (1976) and Harris (1969) found that most investigators used no warm-up activities before collecting their data. Atha and Wheatley's (1976) experimental research findings "throws serious doubt upon the wisdom of this practice" (Atha and Wheatley, 1976, p. 734). They tested the maximum range of hip flexion using 20 measures from a cold start over a two-day period. Subjects were measured 10 times with one minute intervals between each test. Their results showed that flexibility increased within the first four trials of each day and then levelled off.

Fieldman (1966) tested the flexibility of the hip joint after no pre-exercise one pre-trial, a battery of four exercises, a battery of six exercises, and a battery of eight exercises. The results showed that the warm-up exercises used were a definite aid in increasing the range of motion.

In the sport world it is generally believed that flexibility exercises immediately prior to competition help athletes to attain their true level of flexibility. Thus, they are encouraged to perform pre-game flexibility exercises so that full range of motion may be achieved before entering competition. It is clear that in order to measure actual change in flexibility, a more or less stable baseline has to be obtained through the execution of warm-up exercises, since any effective flexibility training "should be expected to produce a mobility change significantly greater than this [level]." (Atha and Wheatley, 1976, p. 24).

The present study used standard procedures for the 3S and SS Methods of flexibility training and employed a standard test warm-up condition. Past research has failed to adhere to these vitally important controls that are needed in collecting flexibility data. Thus, the data in this investigation was considered to be more reliable than the data of most other studies.

<u>Control</u>. There are two experimental studies (McCue, 1953; Tanigawa, 1972) of flexibility training which reported data on retention. It should be noted that neither study incorporated warm-up test procedures and consequently, the reliability of their data must be suspect. McCue (1953) stated that increases in flexibility by the use of the Bounce Method lasted 8 weeks. However, McCue's study used no untrained control group, which severely limits the generality of her interpretation since subjects could have increased in specific joint flexibility over time without any previous training in a manner similar to that shown by Tanigawa (1972). The present study controlled for this variable through intra-subject replications in the inter-group design. If the subjects increased, decreased and/or stayed the same in flexibility over time it could be detected.

It was shown that in the present study that the control group receiving no flexibility exercises continued to increase in flexibility throughout the entire 10 weeks. Two weeks following the cessation of training, the results showed a difference in the rate of change between the flexibility trained and untrained groups. During this retention period, both the groups receiving 3S and SS training dropped in flexibility, but the control group continued to increase in flexibility.

The results at the second retention test seemed to indicate that the treatment groups had dropped in flexibility to a level equal to that of the control group. It is true that four weeks after the cessation of exercise the rates of change among the 3S, SS, and control groups were the same, but the rates did not reveal that all the flexibility development achieved by these methods had been lost. On the contrary, the 3S Method actually increased in flexibility to a level that closely approximated the post-test measurement. Furthermore, the SS Method group increased in flexibility, surpassing the post-test mark. Clarke (1975) reported that athletes partaking in long and continuous sporting activities will result in a unique pattern of flexibility for that sport. The present study's findings seemed to support this claim. The control group also continued to rise still further exceeding its previous levels. In fact, it increased steadily throughout the entire investigation.

Tanigawa (1972) observed the same improvement phenomenon in controls, which he attributed to "be a result of the physical act of passively elevating the subject's limb" during test procedures and "the result of the halo effect" (p. 734). Firstly, it was suggested in his study that the experimental test conditions had caused a flexibility training effect on the hip joint, since the control group was required to have its leg moved to the maximum range of motion for each testing occasion. Secondly, he suggested that flexibility had become a major concern for all subjects during the investigation. This very probably had motivated all subjects including the controls to make a strong effort to improve in flexibility throughout the experiment.

In the present study there are three additional explanations for the control effect. Firstly, though the control group did not receive any flexibility training, it did receive the basketball training. The nature of the sport required the subjects to stretch the three joints through a wide range of movements; for example, stretching their hands above their shoulders as far as possible in reaching for a rebound. Therefore, the basketball training effect may have been the external variable that produced an increase in the control's flexibility score from the pre- to post-tests.

Secondly, during the retention period, the control group which had received no training steadily improved over time. Perhaps there was a normal extraneous variable in the subject athletes' life styles which influenced the development of flexibility. Athletes tend to lead very active lives, and their daily activities may well include exercises that contribute to flexibility development. It was known that all subjects participated in physical education gymnastic instruction throughout the retention period. Thus activity was not pursued during the retaining phase of the study. Clarke (1975) revealed that the physical activity of gymnastics can improve a subject's flexibility.

Thirdly, the present researcher believes that possibly the subjects used for this study, ranging from 12 to 14 years of age, may not have adhered strictly to the instructions given to them. The control group might have realized that flexibility exercises were helping their team-mates' general athletic performance and thus were tempted to perform flexibility exercises on their own. The retention results may not have produced data that are realistic for a non-trained control group.

Technique

Since both the 3S and SS Methods produced no differences in terms of immediate training effects, or in retention, and both appear to be based on PNF principles, then possibly the two methods are more similar than is claimed in the literature. The similarities between the methods are:

1) exercises are performed in two directions in the same plane for each joint.

2) the same number of repetitions are carried out during each exercise and,

3) the same amount of time is spent on each set of exercises.

The difference between the methods is that the 3S training requires that a partner further stretches the subject's joint whereas this step is not performed by the SS Method.

The methods do appear to be more similar than different. It seems logical then, that the 3S and SS Methods would not be different in their effects as well, because they are basically similar.

This investigation on the effects of two flexibility training programs (3S and SS) has contributed to the understanding of the immediate training effect, retention effect, joint effect, research procedures, and techniques. However, it is clear that much information is still lacking and many inconsistencies (standardized training procedures, test warm-up, and experimental design) must be resolved for future investigations. More research is also needed to clarify the possible superiority of other methods of flexibility training.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The phenomenon of flexibility has been widely investigated in connection with the science of sport training. One of the areas that has been implicated as playing an important role in sport is the effect training has on joint flexibility. However, it is unclear from the field or the literature whether the 3S (Scientific Stretching for Sport) Method or SS (Slow Active Stretch) Method is superior in effectively improving and retaining joint flexibility. The present study examined the effects of the two training methods, 3S and SS, on the flexibility of the shoulder, the knee, and the ankle joints.

Subjects were 12 elementary school girl basketball players, ranging from 12 to 14 years of age. Experimental procedures were implemented in a practical competitive basketball training situation.

The research design consisted of four replications of a 3x3 Graeco-Latin square. A pre-training test was followed by a six week flexibility training program, and then post-training, first retention and second retention period tests. The Leighton Flexometer was used for measuring flexibility. Adjustable straps and the best reading in a five trial test were used for control purposes. Data were analyzed using ANOVA and A Priori Orthogonal Comparisons methods in which an alpha level of 0.05 was adopted for statistical significance.

Conclusions

The results of this experiment indicated that within the limitations and delimitations of this thesis, the following statements could be made:

1) Flexibility training methods (3S and SS) improve flexibility.

2) The shoulder joint acquired more flexibility than either the knee or ankle joint.

3) Neither flexibility training method was superior in training effect after 3 days, 14 days, and 28 days.

4) Within two weeks of training cessation, both 3S and SS effects were lost to a significant degree when compared to control effects.

5) After two weeks of training cessation, there was no difference between flexibility changes of the control and two training groups.

6) There was no difference in loss of flexibility between the shoulder, the knee, and ankle joints.

Recommendations

If further investigation on this topic were undertaken, it is recommended that:

1) rigorous standardized training procedures, test

procedures, and control group be employed,

2) the present study be replicated using different age levels, ability levels, and sport groups,

3) subjects be restricted to not participating in any physical activity except the experimental training, and

4) subjects be tested more frequently during the acquisition and retention periods of flexibility training so that the efficiency of each method may be examined more thoroughly and,

5) the joints studied by the shoulder, the hip, and the back; and the immediate (10 sec.) effects, and long range effects of day one and two be examined.

REFERENCES

Atha, J. and Wheatley, D.W. The mobilizing effects of repeated measurement on hip flexion. British Journal of Sport Medicine, 1976, 10 (1), 22-24.

Clarke, H. Joint and body range of movement. Physical Fitness Research Digest, 1975, 5 (4), 1-22.

Clarke, H. Exercise and the knee. Physical Fitness Research Digest, 1976, 6 (1), 1-17.

Devries, H.A. Physiology of Exercise. Iowa: W.M. C. Brown Company Publishers, 1976.

Edwards, A.L. Experimental Design in Psychological Research. New York: Holt, Rinehart and Winston Inc., 1968.

Fieldman, H. Effects of selected extensibility exercises on the flexibility of the hip joint. Research Quarterly, 1966, 37, 326-331.

Flint, M.M. Selecting exercise. Journal of Health, Physical Education, Recreation, 1964, 35 (2), 19-25.

Francis, C.C. Introduction to Human Anatomy. Saint Louis: The C.V. Mosby Company, 1968.

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

Harris, M.L. Flexibility. Physical Therapy, 1969, 49, 591-601.

Holt, L.E. Scientific Stretching for Sport. Halifax: Dalhousie University, 1973.

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

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

Kabat, 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.

Knott, M. and Voss, D. Proprioceptive Neuromuscular Facilitation. New York: Harper and Row Publishers, 1965.

Leighton, J.R. The Leighton Flexometer and flexibility test. American Corrective Therapy Journal, 1966, 20 (3), 86-93.

Logan, G.A. and Egstrom, G.H. Effects of slow and fast stretching on the sacro-femoral angle. American Corrective Therapy Journal, 1961, 30 (5), 85-89.

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

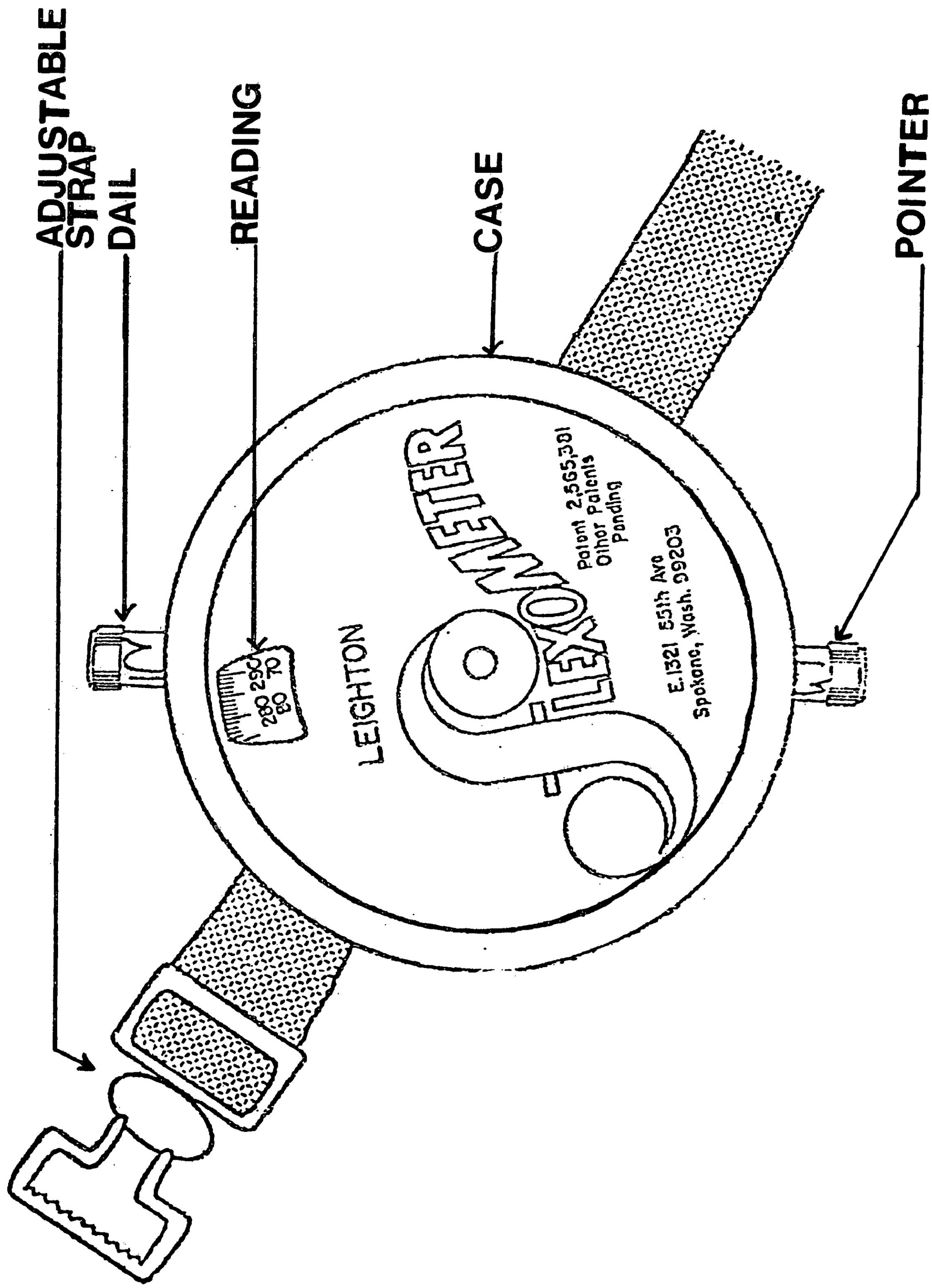
Song, T.M.K. and Garvie, G.T. Wrestling with flexibility. Cahper Journal, 1976, 43 (1), 18-26.

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

Weber, S. and Kraus, H. Passive and active stretching of muscles. The Physical Therapy Review, 1949, 29, 407-410.

Appendix A

THE LEIGHTON FLEXOMETER



Appendix B

FLEXIBILITY TESTS

Shoulder Flexion and Extension Test

The athlete stands at the projecting corner of a wall, the right shoulder to be measured extending just beyond the projecting corner, with the arms at her sides, her back to the wall, the shoulder blades, the buttocks and the heels touching the wall. The flexometer is strapped to the outside of the upper part of the right arm.

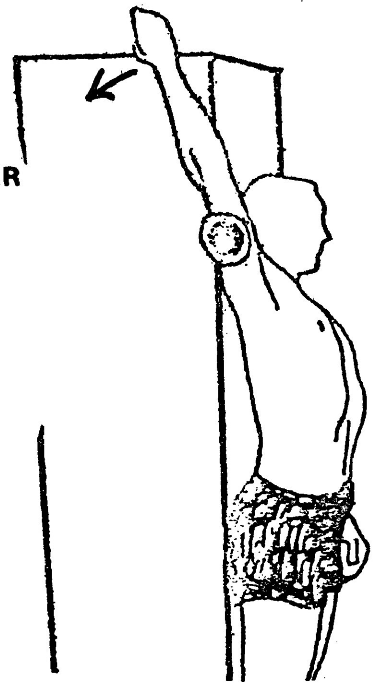
The athlete is instructed that her heels, buttocks and shoulders must touch the wall, and the elbow of the right arm must be kept straight during the test. The palm of her right hand must be against the wall when the dial and the pointer are locked.

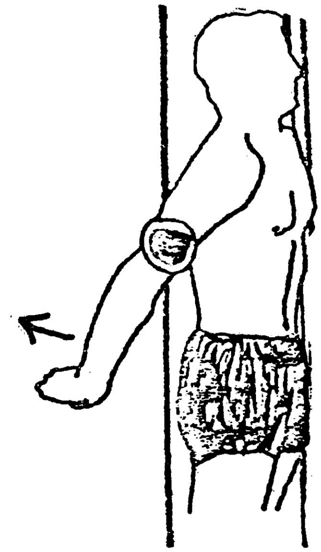
The athlete is strapped to the wall. The first strap is placed over the chest and under the right arm pit, the second strap over the hips, and the third strap over the lower legs.

The athlete's first movement is to bring the right arm forward and upward, the palm of the right hand sliding against the wall, in an arc as far as possible, without straining, holding thus for three seconds. The dial is locked, the reading is taken, and the athlete relaxes. The athlete's second movement is to bring the right arm downward and backward, the palm of the right hand sliding against the

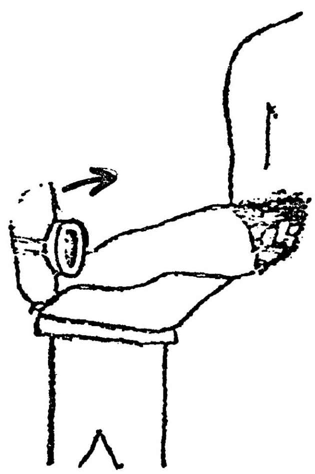
FLEXIBILITY TESTS

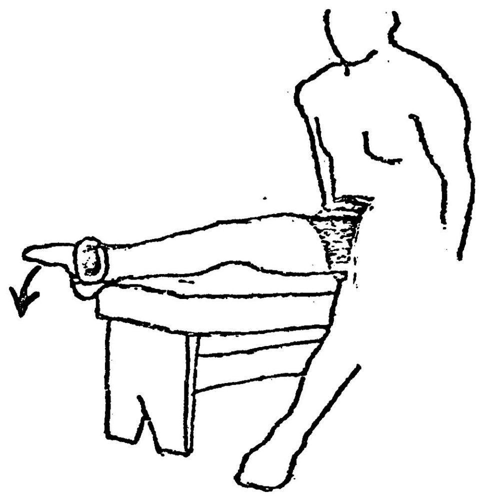
SHOULDER



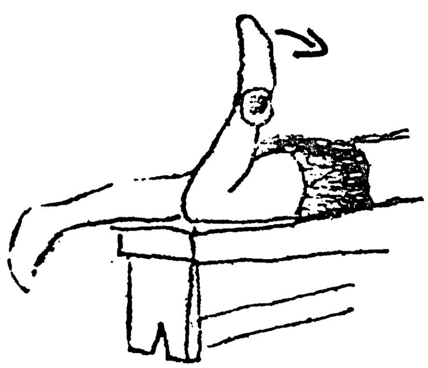


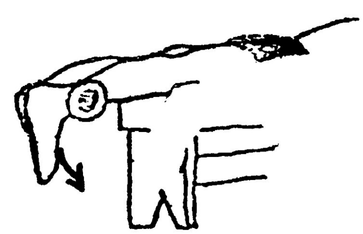
ANKLE





KNEE





TESTS FLEXION EXTENSION

* STRAPS ARE NOT SHOWN

wall, in an arc as far as possible, without straining, holding thus for three seconds. The pointer is locked, the reading is taken and the athlete relaxes.

Knee Flexion and Extension Test

The athlete lies on the bench with her knees at the end and the lower legs extending beyond the end of the bench, with the arms at her sides and hands grasping the edge of the bench. The flexometer is strapped to the outside of the lower right leg.

The athlete is cautioned that the trunk and upper leg must remain in contact with the bench during the test.

The athlete is strapped to the bench. The first strap is placed over the upper back, the second strap over the buttocks, and the third strap over the upper leg.

The athlete's first movement is to bring the right lower leg upward and backward in an arc to a position as near the buttocks as possible, without straining, holding thus for three seconds. The dial is locked, the reading is taken, and the athlete relaxes. The athlete's second movement is to bring the right lower leg forward and downward, in an arc to a position as far from the buttocks as possible without straining, holding thus for three seconds. The pointer is locked, the reading is taken and the athlete relaxes.

Ankle Flexion and Extension

The athlete sits on the bench, with the right leg resting on the bench, the right foot extended over the end of the bench, and the right knee straight. The left leg extending downward with the left foot flat on the floor. The flexometer is strapped to the inside of the right foot.

The athlete is cautioned that the lower leg, upper leg, and the buttocks must touch the bench, the left foot must remain flat on the floor, the right foot must not turn and that the right knee must be kept straight during the test.

The athlete is strapped to the bench. The first strap is placed over the upper part of the upper leg, second strap over the lower part of the upper leg, third over the upper part of the lower leg, and the fourth over the lower part of the lower leg.

The athlete's first movement is to bring the right foot upward in an arc to a position as near to the knee as possible without straining, holding thus for three seconds. The dial is locked, the reading is taken, and the athlete relaxes. The athlete's second movement is to bring the right foot downward, in an arc as far as possible, without straining, holding thus for three seconds. The pointer is locked, the reading is taken and the athlete relaxes (Leighton, 1966).

Appendix C

3S EXERCISES

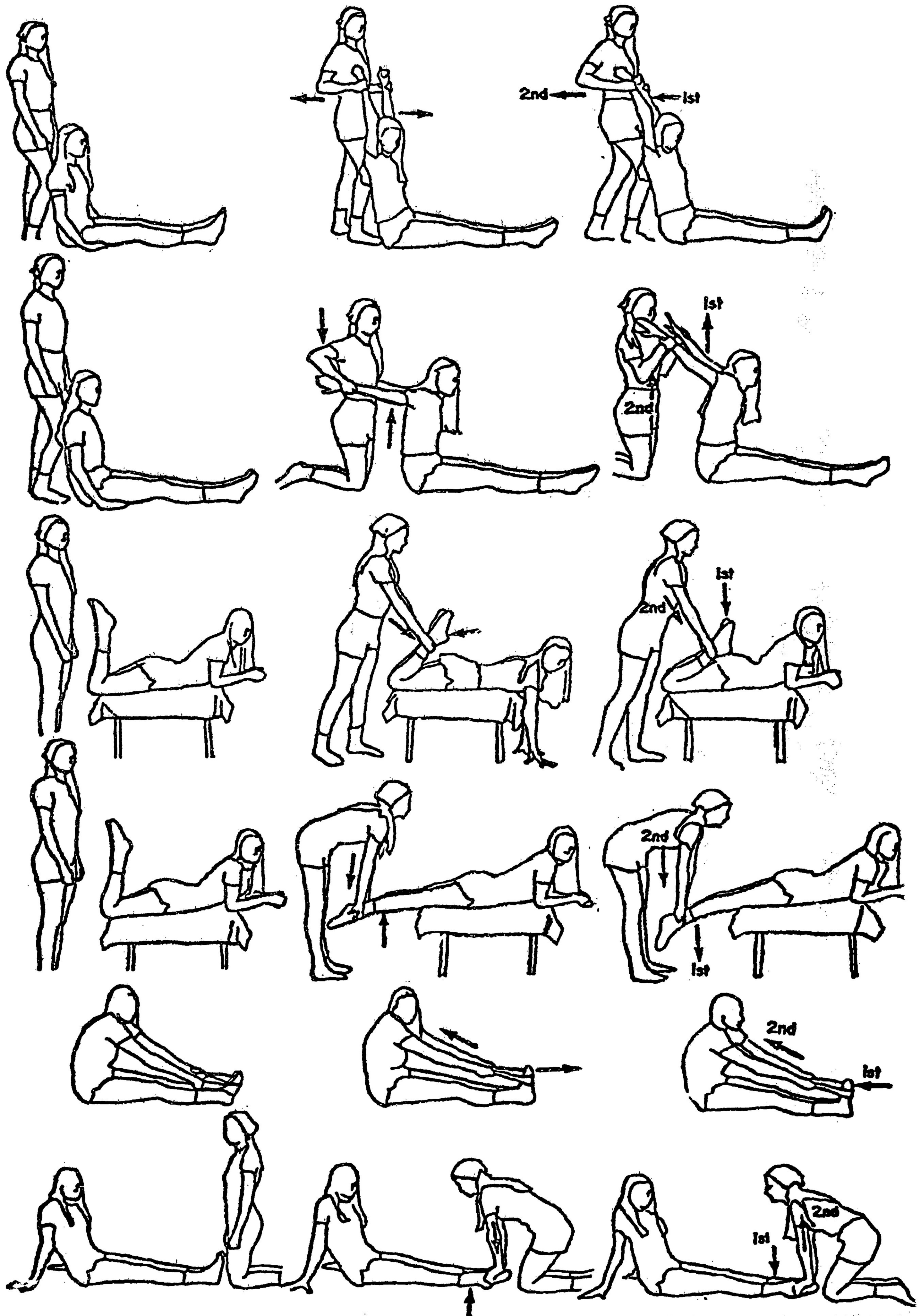
Exercise I (Shoulder Extensors)

Athlete (A) assumes a long sitting position on the floor with her legs and back straight, arms straight above her head, and the shoulders stretched back as far as possible. Helper (H) stands behind A, with the right foot near A's body, the right knee resting against A's spine, and holding A's forearms. A attempts to move the arms forward and toward the ceiling, elbows remaining straight. H resists A's movement. H holds A's position to produce a six second isometric contraction. A moves the arms slowly backward and toward the floor, elbows remaining straight, so that the shoulders are forcibly flexed. H assists A's movement with light pressure. A attains her maximum range of motion without straining, and then relaxes.

Exercise II (Shoulder Flexors)

Athlete (A) assumes a long sitting position on the floor with her legs and back straight, arms straight and back from her sides, and the shoulders stretched back as far as possible. Helper (H) stands behind A, with the right foot near A's body, the right knee resting against A's spine, and holding both A's forearms. A attempts to move the arms forward and toward the floor, the elbows remaining straight. H resists

3S EXERCISES



I

II

III

IV

V

VI

EXERCISES RELAXATION ISOMETRIC CONTRACTION FLEXION OR EXTENSION

A's movement. H holds A's position to produce a six second isometric contraction. A moves the arms slowly backward and toward the ceiling, elbowssremaining straight, so that the shoulders are forcibly extended. H assists A's movement with light pressure. A attains her maximum range of motion without straining, and then relaxes.

<u>Exercise III (Knee Extensors)</u>

Athlete (A) lies prone on the bench, knees and lower legs extending beyond the end of the bench, with the lower legs close to the buttocks, the arms at her sides, and the hands grasping the edge of the bench. Helper (H) stands behind A, and holds A's lower legs. A attempts to move the legs backward and toward the ceiling. H resists A's movement. H holds A's position to produce a six second isometric contraction. A moves the legs slowly forward tnd toward the floor so that the knees are forcibly flexed. H assists A's movement with light pressure. A attains her maximum range of motion without straining, and then relaxes.

<u>Exercise IV (Knee Flexors)</u>

Athlete (A) lies prone on the bench, knees and lower legs extending beyond the end of the bench, with the knees straight, the arms at her sides, and the hands grasping the edge of the bench. Helper (H) stands behind A, and holds A's lower legs. A attempts to move the legs forward and toward the ceiling. H resists A's movement. H hold A's position to produce a six second isometric contraction. A moves the legs slowly backward and toward the floor so that the knees are forcibly extended. H assists A's movement with light pressure. A attains her maximum range of motion without straining, and than relaxes.

Exercise V (Ankle Extensors)

Athlete (A) assumes a long sitting position on the floor, with her knees and back straight, her feet inside the rope, and the hands grasping the ends of the rope. A attempts to move the feet downward and toward the floor. A resists her movement with the use of the rope. A holds her position to produce a six second isometric contraction. A moves the feet slowly upward and toward the ceiling so that the ankles are forcibly flexed. A assists her movement with light pressure by the use of the rope. A attains her maximum range of motion without straining, and then relaxes.

Exercise VI (Ankle Elexors)

Athlete (A) assumes a long sitting position on the floor, with her kness and back straight, the hands straight doen at her sides, and her feet pointing toward the floor. Helper (H) kneels in front of A, and holds A's feet down. A attempts to move the feet upward and toward the ceiling. H resists A's movement. H holds A's position to produce a six second isometric contraction. A moves the feet slowly downward and toward the floor so that the ankles are forcibly extended. H assists A's movement with light pressure. A attains her maximum range of motion without straining, and then relaxes.

Appendix D

SS EXERCISES

<u>Exercise VII (Shoulder Extensors)</u>

A assumes a long sitting position on the floor with her legs and back straight, arms straight above her head, and the shoulders stretched back as far as possible. A moves the arms slowly backward and toward the floor, elbows remaining straight, so that the shoulders are forcibly flexed. A holds this position for 10 seconds without straining, and then relaxes.

<u>Exercise VIII (Shoulder Flexors)</u>

Athlete (A) assumes a long sitting position on the floor with her legs and back straight, arms straight down from her sides, and the shoulders stretched back as far as possible. A moves the arms slowly backward and toward the ceiling, elbows remaining straight, so that the shoulders are forcibly extended. A holds this position for 10 seconds without straining, and then relaxes.

<u>Exercise IX (Knee Extensors)</u>

Athlete (A) lies prone on the bench, knees and lower legs extending beyond the end of the bench, with the lower legs close to the buttocks, the arms at her sides, and the hands grasping the edge of the bench. A moves the lower legs slowly forward and toward the ceiling, so that the knees

SS EXERCISES

VII

VIII

IX

X

XI

XII

EXERCISE RELAXATION FLEXION OR EXTENSION are forcibly flexed. A holds this position for 10 seconds without straining, and then relaxes.

Exercise X (Knee Flexors)

Athlete (A) lies prone on the bench, knees and lower legs extending beyond the end of the bench, with the knees straight, the arms at her sides, and the hands grasping the edge of the bench. A moves the lower legs slowly backward and toward the floor, so that the knees are forcibly extended A holds this position for 10 seconds without straining, and then relaxes.

Exercise XI (Ankle Extensors)

Athlete (A) assumes a long sitting position on the floor, with her knees and back straight and the hands straight down at her sides. A moves the feet slowly upward and toward the ceiling, so that the ankles are forcibly flexed. A holds this position for 10 seconds without straining, and then relaxes.

Exercise XII (Ankle Flexors)

Athlete (A) assumes a long sitting position on the floor, with her knees and back straight and the hands straight down at her sides. A moves the feet slowly downward and toward the floor, so that the ankles are forcibly extended. A holds this position for 10 seconds without straining, and then relaxes.

Appendix E

RAW DATA

Raw Scores (in degrees) of Subjects' Flexibility According to Treatment

Subjects	3S Method				SS Method				Control			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
I (square 1)	204	270	252	263	185	231	227	230	206	236	226	242
I (square 2)	209	258	250	263	210	255	260	264	181	211	200	230
I (square 3)	209	261	251	266	208	250	225	238	177	215	242	230
I (square 4)	215	270	246	256	206	231	239	232	185	220	236	239
II (square 1)	158	166	165	160	150	157	157	170	151	158	165	161
II (square 2)	156	154	157	155	158	163	172	170	163	171	174	172
II (square 3)	152	150	153	155	152	162	163	160	169	160	162	162
II (square 4)	140	142	151	144	158	159	158	157	143	150	155	160
III (square 1)	76	86	76	73	78	81	87	85	70	78	78	75
III (square 2)	70	84	82	78	64	68	73	73	84	84	85	75
III (square 3)	80	94	85	99	61	76	76	73	71	66	78	73
III (square 4)	71	81	73	75	75	82	76	102	66	79	80	74
Mean	145	168	162	166	142	160	159	163	139	152	157	158

T1 Pre-training test T3 First retention test

T2 Post-training test T4 Second retention test

Appendix E

RAW DATA

Raw Scores (in degrees) of Joint Flexibility

of Subjects For Each Test

Subjects	Shoulder Joint				Knee Joint				Ankle Joint			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
I (square 1)	204	270	252	263	150	157	157	170	70	78	78	75
I (square 2)	209	258	250	263	158	163	172	170	84	84	85	75
I (square 3)	209	261	251	266	152	162	163	160	71	66	78	73
I (square 4)	215	270	246	256	158	159	158	157	66	79	80	74
II (square 1)	206	236	226	242	158	166	165	160	78	81	87	85
II (square 2)	181	211	200	230	156	154	157	155	64	68	73	73
II (square 3)	177	215	242	230	152	150	153	155	61	76	76	73
II (square 4)	185	220	236	239	140	142	151	144	75	82	76	102
III (square 1)	185	231	227	230	151	158	165	161	76	86	76	73
III (square 2)	210	255	260	264	163	171	174	172	70	84	82	78
III (square 3)	208	250	225	238	169	160	162	162	80	94	85	99
III (square 4)	206	231	239	232	143	150	155	160	71	81	73	75
Mean	200	242	238	246	154	158	161	161	72	80	79	80

T1 Pre-training test T3 First retention test

T2 Post-training test T4 Second retention test