THE EFFECT OF COLD APPLICATION AND FLEXIBILITY TECHNIQUES ON HIP EXTENSORS AND THEIR INFLUENCE ON FLEXIBILITY IN COLLEGE MALES

DISSERTATION

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The purpose of this study was to measure flexibility at the hip joint under four techniques of stretching, passive stretch-concentric contraction-passive stretch (PCP), passive stretch-three seconds isometric contraction of hip extensors-concentric contraction of hip flexors-passive stretch (3-PI_eCP) and passive stretch-three seconds isometric contraction of hip flexors-concentric contraction of hip flexors-passive stretch (3-PI_fCP) based on proprioceptive neuromuscular facilitation (PNF) and passive static stretch (P). Further, this study was designed to ascertain the effect of cold application (ice) in joint range of motion of the hip extensors measured with the Leighton Flexometer.

The related literature indicates the advantage of PNF techniques over the conventional methods such as dynamic and static. Cornelius (1981), and Holt (1976) indicate the advantage of PNF techniques is due, perhaps, to isometric and concentric contraction of extensor and flexor muscles used in PCP, 3-PI_eCP and 3-PI_fCP techniques in this study. The related literature indicates the purpose effect of cold

application for reducing pain, spasm, nerve conduction and increasing endurance. Knight (1978), Chambers (1969), and Sapega (1981) recommend the use of cold application when pain and spasticity interfer with the range-of-motion.

A sample of one hundred and twenty male college students were randomly assigned and tested under one of the eight different conditions to see if there were differences between four stretching techniques, P, PCP, 3-PI_eCP, and 3-PI_fCP used under cold and no-cold conditions.

The findings indicated there are no significant differences between cold and no-cold conditions used during stretching maneuver. The result of two-way ANOVA revealed significant differences among P, PCP, 3-PI_eCP, and 3-PI_fCP techniques at the 0.05 level of significance. The result of (Tukey's) test indicated that the PCP, 3-PI_eCP, and 3-PI_fCP based on PNF technique were superior over the P technique.

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CHAPTER I

INTRODUCTION

Flexibility is one of the most important elements of good physical fitness and health. It is a quality which allows individuals to perform their everyday movements. Without flexibility individuals would be limited in basic fundamental movement patterns, such as walking, bending, sitting, running, hopping, jumping, and skipping. Flexibility involves two major components. The first component includes the anatomical parts such as bones, muscles, ligament, tendon, and cartilage. Corbin and Dowell (1978) state that an individual's flexibility is determined by (1) the shape of bones, (2) cartilage in the joint, and (3) length of the ligament and muscles that crøss the joint. It should be recognized that the joint is very complicated and its function depends on how the joint is constructed. Humphrey (1981) also recognizes the role of bone, muscle, ligament, joint capsul, tendon, and skin on range of motion at the joint. He further states that about 88 percent of the resistance to the joint motion is because of structures such as bone and muscle.

The second component involved in flexibility is the physiological qualities of the muscles, bones, ligaments,

tendons, and cartilage. These qualities such as muscle's elasticity, condition of ligaments, shape of bones and fascia surrounding the joint, are all important in order to perform a desired maneuver at the joint. Sapega, Quedenfeld, Mayer and Butler (1981) advocate the important role of tendon, ligament, joint capsul and fascial sheath which are predominantly made of connective tissue as the primarily motion-limiting structures in most body joints. Sapega (1981) indicates that muscle, also, is a motion-limiting structure even though the muscle itself is not made of connective tissue, but the extensive connective tissue framework and sheathing within and around the muscle are resistant to stretch. Sapega further believes that connective tissue is the major structure limiting joint motion. These qualities are the properties of the human body but they vary with individuals. Also there is an increase or decrease in these qualities and functions depending upon how each individual is trained and performs exercise.

To acquire flexibility requires long periods of training time because its acquisition is a slow process. In addition, flexibility is an isolated quality which means that range of motion of one joint does not contribute to flexibility in another joint. Allsen, Harrison and Vance (1977) state that "...flexibility tends to be specific to a particular movement and also to particular joints of the body. This means that a person might be flexible in the shoulder girdle, but

inflexible in the lower limbs" (p. 66). Clarke (1975) also states that extensive and prolonged participation in sports and activities will result in the development of unique patterns of joint flexibility.

Factors such as age, sex, height, and weight have been considered to have a substantial effect on overall flexibility. Corbin and Dowell (1978) state that flexibility has been found to be influenced by age and sex. For example, females are more flexible than males. Also, it is believed that there is a negative correlation between increasing age and the degree of joint range of motion. Cureton (1941) claims that elasticity difference between a one-year-old child and a 74-year-old adult is 80 percent. He further believes older individuals are particularly susceptible to rupturing muscle fibers. However, the rate of this decrease in flexibility caused by the increase in age can be reduced by daily exercise. Other factors such as strength and body composition contribute to flexibility. Allsen (1977) states that a proper strength program does contribute to many components of fitness such as range of movement and agility. Tyrance (1958) conducted a study on the relationship between body composition and range of motion. He found significant flexibility differences between the three extreme body compositions (thin, fat, muscular) on neck, hip and elbow flexibility.

Statement of the Problem

This study examined the influence of cold application (cryotherapy) on hip extensors (agonist) of the dominant leg under four techniques of stretching.

Purposes of the Study

This study was designed to measure flexibility at the hip joint under four techniques of stretching. These four techniques of stretching were used under two conditions, cold and no-cold application. Further it was the purpose of this study to ascertain the effect of cold application in joint range of motion of the hip extensor muscle group on male college students.

This study also determined if there was a significant relationship between two conditions (cold and no-cold) using: passive stretch (P), passive stretch - concentric contraction - passive stretch (PCP), passive stretch - isometric contraction of hip extensors (3 sec.) - concentric contraction - passive stretch (3-PI_eCP), passive stretch - isometric contraction of hip flexors (3 sec.) - concentric contraction - passive stretch (3-PI_fCP).

Definition of Terms

The following terms have been defined for this study:

Agonist (AGO) is a muscle directly involved in a given joint action.

Antagonist (ANT) is a muscle on the opposite side of the joint axis from the agonist which causes the opposite joint action.

Anthropometric measurement is measurement of different segments of the body (length, girth).

Concentric contraction (C) is when a muscle visibly shortens to move a body part in spite of a given resistance.

Cryotherapy is the utilization of cold (ice-water-spray) as the treatment prior to the examination of each subject.

Dynamic stretch (ballistic stretch) is a type of stretching exercise involving a bouncing or jerking motion to gain momentum in the body part in order to stretch farther (Corbin, 1978).

Flexibility is a quality which refers to the ability to move body parts at the joint.

Flexometer is an instrument which measures the degree in the range of motion at the joint.

Hamstring is a group of muscles consisting of biceps femoris, semitendinosus, and semimembranosis.

Hip extensors (e) is a group of muscles which move the leg away from the upper body at the hip joint.

Hip flexors (f) is a group of muscles which elevate the leg toward the upper body at the hip joint.

Isometric contraction (I) is a contraction in which the muscle length remains the same but there is increased tension.

Isotonic contraction is a contraction in which tension remains the same but there is change in the length of the muscle.

Maximum voluntary isometric contraction (MVIC) is a voluntary contraction of the hip flexors in which muscle length remains constant with no joint motion.

Passive static stretch (PSS)--Subject's hip extensor muscles are stretched passively by help of the examiner until the point at which tension is felt behind the knee.

Quadriceps is a group of muscles consisting of rectus femoris, vastus medialis, vastus lateralis, and vastus intermedius.

Stretch is elongation or a linear deformation that increases length.

Static stretch is slow, sustained stretching exercise that places a muscle in a lengthened position and holds the position for a few seconds (Corbin, 1978).

Tension is the point during which maximum stretching of the muscle is felt before the pain is perceived.

Techniques of Stretching

Passive stretch (P)--Subject's hip extensors are stretched by help of the examiner to the point where tension is perceived behind the knee of the subject.

Passive stretch-concentric contraction-passive stretch PCP)--The subject's hip extensors are stretched by help

of the examiner to the point where tension is perceived behind the knee, then subject voluntarily contracts by flexing his hip to the maximum point, followed by further passive static stretch (PSS) of hip extensors by the help of the examiner until the tension is perceived behind the knee.

Passive stretch-isometric contraction (e)-concentric contraction-passive stretch (3-PI$_e$CP)--Passive stretch of hip extensors by help of the examiner until the point of tension is reached, followed by maximum voluntary isometric contraction (MVIC) of hip extensors for three seconds, followed by concentric contraction of hip flexors, followed by passive static stretch (PSS) of hip extensors to the point tension is perceived behind the knee of the subject.

Passive stretch-isometric contraction (f)-concentric contraction-passive stretch (3-PI$_f$CP)--Passive stretch of hip extensors by help of the examiner to the point of tension, followed by maximum voluntary isometric contraction (MVIC) of hip flexors for three seconds, followed by concentric contraction of hip flexors, followed by passive static stretch (PSS) of hip extensors to the point tension is perceived behind the subject's knee.

Limitation of the Study

The limitations of this study were as follows.

1. The subjects of this study will constitute a convenient sample restricted to college male students.

2. The subjects were free of injury or other physical defects which might have had an influence on the results of the experiment.
3. The hip joint was the only joint tested in the experiment.
4. The techniques of stretching in this study took place around the frontal axis in the sagital plane.

Hypotheses of the Study

The following hypotheses were investigated.

1. There are differences among techniques in flexibility as measured under P (m_1), PCP (m_2), 3-PI_eCP (m_3), 3-PI_fCP (m_4).
2. There are differences in flexibility as measured under two conditions, cold and no-cold.

Probable Value of the Study

The importance of good flexibility has been recognized for a long time and there has been much emphasis by doctors, coaches, trainers, and physical educators on good flexibility as a vital part of overall physical fitness and health among athletes and non-athletes. There are numerous methods and techniques presented by investigators to improve flexibility not only for better range of motion, but also as a factor in overcoming some of the postural problems and joint problems which exist among individuals.

Use of cold application is known as an effective preventive and treatment device and it is the main purpose of this study to look at whether or not cold application has any effect on flexibility since cold does cause many physiological changes in the body.

Knight (1978) states that several physiological changes in the muscle result from cryotherapy (cold application). He further indicates decrease of muscle metabolism, muscle pain, muscle spasm, and both decrease and increase of circulation as a result of cold application. According to Knight, cold decreases stretch reflexes and prolongs relaxation. Whether or not cold could be a positive factor in flexibility is unknown, but the last two factors, decrease in stretch reflex and prolonged relaxation, are two important factors enhancing flexibility since both factors help muscles to be stretched to their maximum for a longer period of time.

CHAPTER II

REVIEW OF LITERATURE

The study of joint range of motion as an important element of physical fitness received most attention during the middle of the 1950's when a study by Hans Kraus and Ruth Hirschland revealed substantial weaknesses among American youth. One of the major problems found was the lack of adequate flexibility, and because of this investigation, an organization by the name of President's Council on Youth Fitness, supported by the federal government, started to pay more attention and provide more research on this topic.

Since the 1950's there has been a considerable amount of money appropriated, an emphasis by the government, and tremendous effort devoted by trainers, coaches, physical educators, and doctors in the field to improve the flexibility of students and athletes and provide programs which could improve and meet the high standards for good health and physical fitness. Because of the steps taken by the government toward better physical fitness for youth in general, there has been a great deal of work by investigators in the field. There have been many studies on flexibility,

and improved methods and techniques have been developed through research.

Importance of Flexibility

Flexibility is one of the unique qualities that an athlete should possess because there is a direct correlation between range of motion and the frequency of injuries, and most important, the severity of an injury to an individual. This is a well supported fact by many trainers, coaches, and medical doctors, especially those who deal with athletes more often. Muscle injuries are the most common among athletes, and muscle pull, a very common term which means "over-stretching" of muscle tissue, in many cases results in severe muscle injury. Corbin and Noble (1980) state "...a shortened muscle is much more likely to exceed its normal range of extensibility than one which has been stretched by gradual training" (p. 58).

There are numerous documents which support flexibility as a preventive element during physical activity. deVries (1974) found gradual stretching of both the agonist and antagonist seems to result in a lessened degree of soreness. This also means that the flexible individual not only receives fewer injuries and has less discomfort, but also that the flexible individual's injuries are less severe than are the injuries of those who are not flexible. Beaulieu (1981) strongly advocates the importance of adequate

flexibility and stretching for decreasing the number of musculotendinous injuries, reducing muscle soreness, and improving performance. There are other problems such as orthopedic conditions causing low back pain which may be due to insufficient flexibility.

One concept which should be mentioned is the negative effect of flexibility. This condition seems to be totally in opposition to what we have known about flexibility. Flexibility is an important preventive factor, but in the opposite extreme can be a very dangerous factor if an individual possesses too much flexibility. Marshall, Jahanson, and Wickiewicz (1980) state that joint looseness is deemed to be a trait and is not sex related even though females are more flexible than males. Marshall (1980) also believes there is an inverse relation between age and joint-looseness which means with increase of age joints tend to become stiffer. Marshall further finds a sprinter with joint-looseness performs poorer. This particular problem causes a joint to be unstable, as in a "loose knee" in some individuals. Corbin (1978) states "...a high degree of flexibility sometimes is referred to erroneously as "double jointedness" (p. 39). This problem can be caused by doing improper exercises such as the duck walk and deep squats. Corbin and Dowell (1978) contend that improper exercise that over develops one muscle group while neglecting the opposite

group results in an imbalance that results in restricting flexibility.

There is no exact information to support how much lengthening or stretching of muscles around each joint is required. This is something that should be studied on different individuals on specific joints over a period of time under skillful supervision. Allsen and Harrison (1977) state that flexibility is specific to a certain movement and certain joints of the body. Holt (1976) suggests athletes perform stretching exercises in order to accomplish one or more of the following objectives:

1. To reduce injuries due to tearing muscle tissue,
2. To increase the amplitude of movements inherent in the activity,
3. To promote muscle relaxation, and
4. To increase metabolism in muscles, joints, and associated connective tissues (warm-up).

Body Type and Flexibility

The question of whether or not there is any relationship between anthropometric measurements of an individual and the range of movement is in need of investigation. Measurement of body segments in different body types and looking at the range of movement has received much attention from investigators and there are numbers of studies in which answers are given to some of the questions existing in this

area. Allsen and Harrison (1977) found in their study that there is a negative correlation between body fat and degree of flexibility, and they further stated that an increase of body fat does contribute to a decrease in flexibility. Their idea was based on the premise that the larger the person, the less active he/she becomes. Tyrance (1958), in his study on three different body types--endomorphic (fat), mesomorphic (muscular), and ectomorphic (thin)--found that as the mesomorphic component (muscle) increased, neck and hip flexibility increased. He further indicated that the range of flexibility was significant enough to indicate that the difference is not due to change but rather to the significant relationship between the two factors.

The relationship of flexibility measurements to measurements of body segments is an important factor which should be considered when evaluating range of motion. Wear (1963) found a significant relationship and concluded the following.

1. The sit-and-reach flexibility is not significantly related to leg length, but is related to excess of trunk and arm length.
2. The prone back extension and supine back extension are not related to trunk length as measured.

In another related study, Matthews and Shaw (1959) concluded there is no significant relationship between several anthropometric measures such as standing reach,

height, weight, and lower limb length of right leg and two hip flexibility tests--the sit and reach test, and the floor touch test. They also found low correlation between body length and flexibility score.

Brower and Galles (1958) conducted a study on the relationship between various body measurements and toe-touch flexibility using three anthropometric measures, trunk, arm and leg length. They concluded no significant relationship existed. Harvey and Scott (1967) completed their study in a similar area and found that no significant relationship exists between a bend and reach flexibility test and trunk plus arm length over leg length. Evidence shows that a prediction of flexibility based on physical dimensions would not be justifiable even in those few flexibility tests in which body segments are important. Anthropometric measures are not important variables for predicting overall flexibility.

Flexibility and Performance

Performance is what every athlete is concerned with during competition simply because success in athletic competition depends largely on overall performance by the individual. By now there is awareness of what is required for an athlete to reach his/her highest level of performance, and every possible technique and device has been used to improve the level of skill. Corbin and Dowell (1978) emphasize the importance of flexibility; lack of flexibility

results in impaired and perhaps painful performance. Allsen and Harrison (1977), Beaulieu (1981) state that improper body movement is frequently the result of insufficient flexibility which can contribute to improper sitting, walking, running and other body movement. Cureton (1941) indicates in 1932 that Japanese and other Olympic swimmers were tested for joint flexibility, and the results revealed that the four Japanese record breakers had greater trunk flexion than members of the American Team.

The literature describing how one can perform his/her best is endless and the factors involved are numerous. Speed, strength, flexibility, height, and psychological readiness are several of the major ingredients involved in performance.

It is obvious no one can reach his/her potential level of excellence if any one of the above qualities is absent. It is the combination of all these single qualities which allows one individual to perform better than another. Athletes now jump higher, lift heavier weights, move faster, and throw farther than ever before. Among all of the qualities which an athlete should have, one is basic for every performer regardless of the nature of the sport or activity. That quality is flexibility. The importance of flexibility has to be understood correctly, because its contribution is not only for sports, but also is important everyday for activities in which people are involved.

Developing Flexibility

Because of the importance of flexibility there has been a great number of studies by people in the fields of physical education, sport physiology, kinesiology, and athletic training on how flexibility can be acquired. Information on duration, repetition and other factors of exercise which may enhance the range of motion have been proposed, and there have been many studies in recent years on new techniques and methods to achieve a greater range of motion in a shorter period of time and in a safer way.

The old method of stretching (dynamic or ballistic), which is defined as stretching with bouncing, now is replaced by a static stretching technique or slow stretching. Static stretching is believed to be more effective in obtaining a greater range of motion in a shorter period of time. Indeed, many common methods of stretching not only are not beneficial, but may be harmful because they shorten the muscles rather than lengthen them. Corbin, Dowell, Lindsey and Tolson (1978) state if static position is held for a long period, it will lead to shortened tissue and loss of mobility. The traditional method which is known as dynamic could also cause muscle injuries if used under wrong procedures. Allsen and Harrison (1977) found that fast, jerky, bouncing movements not only stretch the muscle but also cause the same muscle to contract simultaneously because of the

receptors located in the muscles. Payton (1977) found dynamic stretching to cause muscle soreness resulting from minute ruptures and tears in the tendons and in the muscle's connective tissue. He further indicated that these tears and ruptures can cause development of scar tissue which may contribute to gradual loss in the preexisting natural resilience and elasticity of the entire muscular structure.

The question of how muscles should be stretched, and for how long, still is not clear. It has been suggested by some that pain is the point at which stretching should be stopped. This is not a well supported statement, because in many cases pain is the result of injury and so the stretching should be stopped before the pain is perceived, but the idea is that muscles should be stretched beyond their normal length in order to receive the benefit of stretching. Beaulieu (1981) suggests that stretching should take place slowly and gently to the point at which tightness, not pain, is felt. Payton (1977), Beaulieu (1981), and Humphrey (1981) suggest the following guidelines for proper stretching:

1. Stretch after warm-up,
2. Stretch so that pull is felt,
3. Do not go beyond the point of mild discomfort,
4. Weight bearing muscles are the ones that most often require flexibility training.

The duration of stretching is another factor about which people have different ideas. Holt (1976) suggests a duration

of 5 to 10 seconds for getting maximum stretching. Corbin & Noble (1980) propose stretching should take at least six seconds in order to be effective. Beaulieu (1981) recommends longer periods, 30 to 60 seconds or maximum benefit will not be attained. Humphrey (1981) also advocates the idea of 30-60 seconds for each position to be held. The repetition of stretching is another factor which should receive attention. Several times daily is recommended by Corbin and Noble (1980).

One thing which needs to be recognized and understood is the difference between stretching for the purpose of warm-up and stretching for the purpose of flexibility. People sometimes do not seem to have a clear understanding for identifying these two uses of stretching. Warm-up is a rather fast type of stretching activity usually performed prior to competition to increase muscle temperature. This is considered to be an active warm-up and is believed to have a positive effect on performance. Another type of warm-up is a passive method which is to increase the body temperature with such techniques as hot baths, hot showers, and turkish baths. The effectiveness of either type of warm-up usually lasts only for twenty to thirty minutes. deVries (1974) believes the benefit of warm-up prior to performance is caused by physiological factors such as the following:

1. Increase of speed in muscle contraction and relaxation,
2. Greater efficiency because of lower viscous resistance in muscle,
3. The release of oxygen by hemoglobin due to higher temperature,
4. Increase of metabolic processes rate caused by increased temperature, and
5. Decreased resistance of the vascular bed because of temperature increase.

deVries (1974) further indicates the general heating of the body causes increased muscle temperature which improves performance. deVries (1980) found that dynamic flexibility is improved 20 percent by local warming of the joint and it is decreased by cooling. He further states experience indicates that static flexibility is probably similarly affected by temperature change. Sapega (1981) suggests that there should be a warm-up exercise such as mild running prior to stretching exercise to elevate muscle temperature. This increase of temperature within the tissue makes stretching both safer and more productive.

In contrast to the dynamic stretching method for warm-up purposes which is fast and short in duration, stretching for flexibility is slow and requires long periods of time because it is done by a passive method which is based on proprioceptive neuromuscular facilitation (PNF). Sapega

(1981) describes plastic stretching or permanent lengthening as contrasted to elastic stretching which is less favored. Sapega further recommends lower force, longer duration stretching at an elevated temperature to produce a permanent increase in range of motion. The PNF technique was originated by Kabat (1958). The PNF technique has the advantage of inducing relaxation of the muscles to be stretched through spinal reflexes. Windell and Decker (1962) indicate that PNF is based on maximal excitation or inhibition of anterior horn cells through a central mechanism. Cornelius (1981) further supports the PNF techniques to be more effective in increasing joint range of motion. Holt, Travis and Okita (1970) describe PNF stretching techniques as being based on the principles of successive induction, muscle relaxation, and reciprocal innervation. Briefly the PNF techniques involve a maximal contraction of the agonist (muscle to be stretched) followed immediately by a concentric contraction of the antagonist.

Reflexes play an important part in PNF during voluntary motion. Windell and Decker (1962) state "...they may be used to activate or inhibit a maximum number of anterior horn cells, or to initiate motion which may be brought under voluntary control" (p. 92). Moore and Hutton (1980) note PNF induces relaxation of the muscle to be stretched through spinal reflexes. Windell and Decker (1962) further believe

the neurophysiological mechanisms to increase excitation or inhibition are 1) reflexes, 2) irradiation which is spread from excitation in the central nervous system which causes contraction of all muscles used in a specific pattern, and 3) successive induction which means after a final common path has been used in one sense, the responses of a reflex in the opposite sense is augmented.

The PNF techniques as described by Corbin and Noble (1980) appear to be a complex procedure of stretching and requires assistance by persons who have experience in PNF techniques. Corbin and Noble (1980) further comment that early literature relating the use of PNF emphasized the need of working the muscle at diagonal patterns, while procedures suggested by others rarely indicate the use of the diagonal method. In terms of PNF effectiveness, Corbin and Noble support the idea that PNF is effective as static and active stretching procedures.

Although there is evidence to support both methods of stretching, i.e., dynamic and static which is based on PNF technique, the static stretching method might be preferred because there is less chance of injury and soreness and the antagonist muscles are fully relaxed.

deVries (1975) states that stretching by the static method prevents myotatic reflex which helps relax the muscle to be stretched, whereas stretching by bouncing (dynamic)

causes the stretch reflex which actually opposes the desired stretching and causes the inhibition of flexibility and also causes soreness and pain in the muscle. Beaulieu (1981) comments on the phenomenon of intense stretch reflex which happens during static stretching. Unlike the stretch reflex, inverse stretch reflex signals the muscle to relax and allows the muscle to stretch farther safely. deVries (1974) defines the static flexibility as range of motion of a particular joint and dynamic flexibility as the flexibility of motion.

New Techniques

In recent years, because of interest in and the necessity of flexibility among athletes and non-athletes, there has been a great number of studies undertaken to find the most effective techniques of improving flexibility. Holt (1976) presented a new technique, scientific stretching for sport (3S). Holt's 3S is a relatively new approach to improve flexibility of athletes and dancers. The 3S method by Holt is based on proprioceptive neuromuscular facilitation and requires an understanding of sequences and assistance by others in order to be effective. Markos (1979) conducted a study comparing two methods of exercise flexibility, contract-relax (c-R) and hold-relax (H-R). The C-R and H-R techniques were using an increasing range of motion on patients with neurological or orthopedic problems. Corneilus (1981)

presented two new methods of flexibility exercises (3-PIC) and (0-PIC). Both methods by Cornelius use the PNF technique, which provides relaxation for soft tissue. Holt, Travis, and Okita (1970) also developed a new method of flexibility exercise, isometric contraction of the agonist followed by concentric contraction of antagonist (IA-CA). Their new technique was superior when compared to two other conventional methods, fast stretch and slow stretch. The IA-CA method is based on the principle of PNF techniques.

Cold Application

For a long time cold and heat have been used as the two most important modalities in athletics and as medical treatment for injury and other purposes. Cold application is probably the most common treatment in the initial stage of injuries in athletics. The rationale behind the use of cold treatment and its effect is clearly documented. Licht (1972) reports beneficial results of local cold packs for treating problems such as muscle spasm, pain of myofascial origin, acute inflammation, traumatic lesions, thermal burns and many orthopedic conditions.

In contrast to cold, heat has been a very effective application treatment for the post initial state of an injury for speeding up the healing duration. The primary function of heat is to increase circulation toward an injured area

which aids the recovery of the injury. Heat is also a very effective device for reducing soreness and stiffness resulting from physical work.

In recent years, there has been tremendous progress in athletics to not only develop the most efficient athletes, but to be able to utilize them as much as possible during seasonal competition. One of the newest methods in recent years is the utilization of the flexibility exercise on injuries and during the rehabilitation period. The outcome has been satisfactory and is supported by investigators.

Utilizing cold application (ice pack) before and after physical activity has played a very effective role for better mobility, but the cold application and its effect on range of motion is yet to be documented. However, cold application does work as a pain reducing agent when applied. According to Olson (1972) the use of cold treatment will decrease pain and swelling after an injury. He further suggests the use of cold treatment for reduction of edema. Chambers (1969) notes the positive effects caused by cold treatment on problems such as elbow sprain, shoulder bursitis, cervical myositis, and rotator cuff tendinitis. Knight (1978) recommends cold treatment on most types of musculoskeletal injuries, sprains, strains, and contusions. Knight further believes in the immediate use of cold treatment during the initial stage for controlling the severity of an injury by

decreasing circulation and use of cold treatment during the rehabilitation phase which promotes healing by increasing circulation. This has to do with several physiological factors which enable an individual to perform a greater range of motion with less discomfort. There are also studies which demonstrate that cold application does improve performance if it is applied prior to competition. Robbins (1942) completed a study on the effects of heat and cold on adolscents participating in physical education classes. He found that cold baths contributed to a temperature drop, heart rate decrease, decrease in diastolic blood pressure, and a slight increase in strength and systolic pressure.

Another study by Happ, Tuttle and Wilson (1949) on physiologic effects of abdominal cold packs found results similar to Robbin's study on the physiologic effects of abdominal cold packs. The findings are as follows.

1. Recovery from fatigue of exercise was facilitated by the application of abdominal ice packs.
2. The application of an ice pack caused a decrease in basal metabolic rate.
3. The amount of oxygen required to perform a given amount of moderate work was decreased by use of the abdominal ice packs.
4. The resting pulse rate became significantly less as a result of the cold application.

Happ (1949) reports that cold application was used in Germany during World War II as a conditioning device in both industry and the air force. It is believed that this type of treatment was employed before work to prolong the onset of fatigue, and after work to hasten recovery from it. Further research is recommended on this issue, but it appears likely that cold treatments will enhance performance. Sills and O'Riley (1956) compared the effects of three variables, rest, exercise, and cold spray, upon performance in spot-running. On the basis of their findings physical performance as measured by spot-running is improved more by cold application than by either rest or exercise, and more by rest than by exercise. They further indicate that cold applications are more effective than either rest or exercise for the recovery from fatigue. Gross (1958) indicates that cold application decreased the fatigue rate. He states the belief that this is caused by the smaller amount of work performed by each contraction as compared with untreated muscle. Rosen (1952), in a similar study, looked at the effect of cold abdominal spray upon a repeat performance in the 440-yard run. Rosen's findings were positive in performance for four of the sixteen subjects following the use of the cold abdominal spray; the performance for the second time was better than the first time. An improvement of the second time did not occur when the cold spray was not used, according

to the author. Throughout the performance the mean of the subjects was always better (faster) following the application of a cold spray than the mean when no cold spray was applied.

Cold application as a device to control spasticity (muscle spasm) plays an important role. Bassett and Lake (1958) found cold application to be very effective in alleviating spasticity and enabling the patient to carry out exercise. They further recommended moist cold application as opposed to a dry ice bag. Their study was conducted with several individuals who had some type of difficulty because of lack of movement which usually resulted with joint discomfort. Because of the complex nature of spasticity on some patients they recommended patients be immersed in a tank instead of just localized cooling. Miglietta (1962) did a similar study and indicated a positive outcome of cold application on spasticity. The only difference in this study from Rosen and Bassett was the nature of the cold application. Mighietta used turkish towels packed in ice water.

Lind and Samueloff (1957) conducted a study on the effect of local cooling on successive sustained contractions and they confirmed that a single contraction held to fatigue was longer at a water-bath temperature of 18°C than at 34°C. They also indicated the endurance time was longer after

pre-cooling than after pre-warming. Clark, Hellan and Lind (1957) did somewhat the same study and their results were similar to those of Lind and Samueloff. The duration of the contractions increased with decreasing water-bath temperature down to 20°C. Further investigation by Clark and his colleagues resulted in the same outcome as for the other study by Lind and Samueloff, i.e. that contractions were longest after the arm had been immersed in water 18°C. The authors summarized these physiological advantages as being due to a decrease of metabolism and, because of these changes in the muscle, superficial muscle fibers do not contract as a result of interference in nervous or neuro-muscular transmissions due to cooling. Holt (1976) found good results when cold applications were followed by warm-up exercise prior to involvement in sports activities. Holt further recommended, for a rapid improvement in the range of motion for recovering from an injury, or for increasing amplitude of a needed movement, to wrap the limb body in a towel soaked in ice water, or put ice directly on the muscle group while performing exercise and follow with a conventional warm-up. Wilmore (1978) expresses this phenomena in more detail as follows:

> The cold application cools the body surface which enhances its ability to dissipate body heat. Cold causes a peripheral vasoconstriction and possibly a reflex vasodilation within the muscle which makes more blood available for the active tissue (p. 176).

The positive effects of cold have long been recognized for various purposes. Grant (1964) did a study of cryokinetics (massage with ice) on the treatment of painful conditions of the musculoskeletal system. The common painful conditions under this study were strains, myositis, fibrositis, arthritis, and bursitis. Grant found cold applications of one type or another effective treatment of such conditions and were recommended by some practitioners. This idea is supported by McComber and Herman (1971) who found cold packs relieve pain and edema. In their study, decreased spasticity was noted, nerve conduction time was increased, and the response to vibration was decreased because of hypothermia. Sapega (1981) also recommends the use of cold application over circumstances such as tearing connective tissue after surgery, when spasticity significantly interferes with the performance of range-of-motion, and when pain is present.

The clinical uses of cryotherapy (cold application) cause many physiological changes in the human body. Chambers (1969) found the following physiological effects of local cold application:

1. Drop of temperature rapidly for the first few minutes and thereafter spontaneous rewarming takes place,
2. A diminishing of the rate of transmission of impulses along a nerve and then at about 27°C or lower, nerve conduction will begin to fail, and

3. Reduction of spasticity because of myotatic reflex as a result of reduced nerve conduction.

Chambers further found in his investigation that positive results were obtained for relieving pain among his patients, and a large percentage showed a good increase in range of motion. Olson and Straxin (1972) also support and recommend cold as an effective agent in the reduction of pain and joint stiffness and in the improvement of joint motion. A study by Petajan and Watts (1962), looking at the effect of cooling on the triceps surae reflex, recorded skin, muscle, and oral temperature, and they indicated a reduction of spasticity. Murphy (1962) in his study reported several physiological effects of cold application such as changes in metabolism, heart rate, circulation, respiration, blood chemistry, internal organs (gastrointestinal system), skin, and muscle, He then indicated studies of the muscle when the body temperature is reduced to 20°C reveals elongation of the latent time, contraction time, and relaxation time. Murphy (1962) conducted a study on work capacity fatigue curves and gross body strength and indicated that short cold application will increase the work output on contractile force, but prolonged application of extreme cold will diminish muscular work. Knight and Aquina (1980) support the use of cold application for rehabilitation of musculoskeletal injuries, but they strongly supported cryokinetics (cold

with exercise) as more effective than just cold application. They advocated the blood flow was significantly greater than in both cold and heat pack. Knight (1978) reports five major effects caused by cryotherapy (cold application) as follows:

1. Decreased pain,
2. Decreased muscle spasm,
3. Decreased metabolism,
4. Decreased circulation (immediate care phase), and
5. Increased circulation (rehabilitation phase).

According to Knight, during immediate care phase cold controls swelling by decreasing circulation, but if applied during the rehabilitation phase it promotes healing by increasing circulation. This last phenomena by cold treatment makes it more useful and a safer application than heat treatment. Knight further reports that cold application breaks the pain-spasm-pain cycle, and the decreased muscle spasm prolongs relaxation of the muscle which allows easier range of motion, and thus earlier mobilization and use of the body part. Another positive effect of ice treatment is that it is used to partially anesthetize or numb the injured area so that active motion is possible. Cryostretching (using either passive or static stretch), and the contract-relax technique of proprioceptive neuromuscular facilitation (PNF) is an effective procedure for improving range of motion.

Cryokinetics and cryostretch are two relatively new techniques of cold treatment which have proved to be effective methods for improving range of motion. Holt (1976) and Knight (1978) both support the idea of applying cold to facilitate better range of motion, especially when active motion is not possible.

CHAPTER III

METHODS AND PROCEDURES

A detailed review of related literature indicates there is little that has been said on the topic of this study. In spite of the wealth of information available on cold treatment as an effective method of musculoskeletal injuries, it was not the main interest of this study to look only on the effect of cold therapy but to consider the effect of cold on flexibility.

The review of literature revealed that little research has been completed on the topic of utilizing cold prior to flexibility measurement. The methods and procedures for the completion of this study followed the basic steps commonly practiced in experimental study. The major steps which will be discussed in this chapter are (1) subjects, (2) instruments and materials, (3) test procedures, (4) research design and statistical analysis of the study. It is the primary purpose of this chapter to describe in detail the steps involved in preparing for and completing this study.

Subjects

A total of one hundred and twenty subjects were divided into eight groups of fifteen subjects per group by using

the random table, then each one of the eight techniques of stretching was randomly assigned to each of the groups. Each subject was scheduled to be present in the laboratory with adequate knowledge regarding the entire process of the study. The participation of each subject was voluntary and he could withdraw at any time. Each subject participated only once in one of the treatments which consisted of three trials with two minutes rest between each trial. The subjects for this study were students from the Physical Education Division at North Texas State University. The subjects were all males with no age limit. No subject was involved in a competitive athletic or other systematic training program which might have had an influence on the result. Also all subjects were free of physical limitation (physical defect) or injuries. All subjects possessed no more than eighteen percent body fat. This was to make sure that the effect of cold was not prevented by an excessive amount of body fat.

Instruments and Materials

1. Leighton Flexometer. There were several techniques available for obtaining data in this study including cinematography, electromyography, electrogoniometry, but because of the complexity of the hip joint and future difficulty which might have developed in collecting the data, the Leighton Flexometer was used to measure flexibility at the hip joint. This instrument contains a weighted 360 degree

dial and a weighted pointer, both moving freely and independently as affected by gravity. When the instrument is ready for use, the dial and the pointer point upward and coincide. Independent locking devices are provided for the pointer and the dial which stop all movement of either one at any given position. The Flexometer has a reliability coefficient of .978 for two trials for the thigh flexion test (Leighton, 1942).

2. A Skinfold Caliper (lange) was the instrument which was used to assess the body fat percentage. It has a constant force of 10/mm at the skinfold site (Lohman and Pollock, 1981).

3. The cold application in this study was in the form of ice cubes placed in an ordinary plastic bag. To prevent an error in terms of temperature, the same amount of ice was measured for every use.

4. A table was used to place the subject on during the flexibility testing.

Procedures

Because of the complexity of this study, particularly during the process of data collection, there were two people working in the laboratory. The procedure began with recording on a prepared form information on each subject including the date, name, age, sex, weight, height, and body fat percentage. The body fat percentage for each subject was determined by measuring three sites on the body

by the skinfold caliper, the chest, abdomen, and thigh. The chest, abdomen, and thigh sites have been recommended by Baun, Baun, and Raven (1981). Baun's (1981) nomogram method for measuring body fat not only is a valid method compared to quadratic equation, but is less time consuming and is more practical to use, because it is a simpler procedure for the purpose. Baun (1981) reports the value obtained from the quadratic equation on a 30 year old male was 10.91 percent, the nomogram by Baun produced body fat value of 11.0 percent.

After each subject was prepared for the flexibility test he was given one of four techniques of stretching under a cold or no-cold condition. The subjects under the cold condition received 10 minutes of cold application (ice bag). McMaster, Liddle, and Waugh (1978) state that among four cold modalities, chipped ice, frozen gel, chemical ice envelope, and refrigerant-inflated bladder used in their study, ice performed most efficiently, more economically and safer than the other three modalities. Immediately after the cold application the subject was tested under one of the four stretching techniques. Knight (1978) recommends that 10 minutes or more of cold application in the form of an ice bag is adequate for a cryostretching program.

During flexibility testing the subjects were in a supine position. The leg under study was the dominant leg which

was determined by asking each subject to kick a ball before the actual testing began. The leg not under study was secured by a strap to the table on which the subject was lying. This was to eliminate movements other than those required of the subject during the testing.

There were basically four techniques of stretching under two conditions as described in chapter one. The first technique (P) during which the subject flexed his dominant leg was at the hip joint while his knee was locked. The subject was assisted by the examiner and the test stopped at the point where the subject felt tension behind his knee. Data were collected with the use of a flexometer. The second technique was (PCP). Passive stretch was performed by the subject while being helped by the examiner to the point of tension behind the knee. At this point the subject was asked to flex his leg maximally without help (concentric contraction). Passive stretch again took place (flexion at the hip joint) by help of the examiner to the point of tension on the back of the subject's knee. Data were collected with the use of a flexometer.

The third technique (PI_eCP) started with passive stretch, described in techniques one and two to the point of tension followed with maximum voluntary isometric contraction (MVIC) of hip extensors for three seconds. During MVIC the subject was pushing his leg against the hand of the

examiner. The MVIC was followed with concentric contraction of the hip flexors, described in technique two, and ended with passive stretch by help of the examiner to the point of tension behind the subject's knee. Data were recorded. The fourth technique (PI_fCP) started with passive stretch described in the previous techniques to the point where tension was perceived followed with MVIC of flexors for three seconds. During MVIC in technique four, the subject was pulling his leg against the hand of the examiner. The MVIC was followed with concentric contraction of hip flexors as described in techniques two and three, and followed with passive stretch to the point of tension behind the knee. Data were recorded. The four techniques described previously were repeated under two conditions, cold and no-cold.

Research Design and Statistical Analysis

This study was a two by four design with four techniques of stretching under two conditions, cold and no-cold. The P, PCP, 3-PI_eCP, and 3-PI_fCP techniques of stretching defined in chapter one were used. The major dependent variable (flexibility) was analyzed with a two way analysis of variance. The post hoc test (Tukey's) was used to find the differences between the groups.

Techniques of Stretching

Conditions	P	PCP	3-PI_eCP	3-PI_fCP
Cold				
No-Cold				

Research Design

In addition, the relationship of body fat percentage, height and weight to flexibility at the hip joint were assessed by calculating the Pearson product-moment correlation coefficient.

CHAPTER IV

PRESENTATION OF RESULTS

This chapter presents the results of statistical analysis of the data. The following headings are the major components of this chapter; (1) Introduction; (2) Descriptive Data; (3) Intertrial Reliability Coefficient; (4) Correlation of Fat, Weight and Height to Flexibility at the Hip Joint; (5) Baseline Measures; (6) Results of Two-way Analysis of Variance (ANOVA) on Baseline Measures; (7) Difference on Three Trials Using Four Techniques of Stretching Under Cold, No-cold Conditions; (8) Results of Two-way Analysis of Variance from Three Trials; (9) Rank Order of Means Obtained From Each of the Four Techniques; and (10) Results From Post hoc Test to Observe the Difference Between the Techniques.

Introduction

The purpose of this study was to investigate, through flexibility measurement, the influence of cold application as opposed to normal temperature and the effect of four different techniques of stretching under the two above conditions. The following four techniques of stretching were used under cold and no-cold conditions: passive stretch (P),

passive stretch followed with concentric contraction of hip flexors followed with passive stretch (PCP), passive stretch followed with three seconds of isometric contraction of hip flexors followed with concentric contraction of hip flexors and ending with passive stretch (3-PI_fCP), and passive stretch followed with three seconds of isometric contraction of hip extensors followed with concentric contraction of hip flexors and ending with passive stretch (3-PI_eCP). A baseline measure was recorded for each subject with disregard to the treatment assigned for that subject to determine the difference between the baseline flexibility measure and flexibility after the treatment.

Descriptive Data

A sample of one hundred and twenty male volunteer students from physical activity classes in the Physical Education Division at North Texas State University with an average age of 21.51 years was used. Because of restrictions placed upon the percent of body fat and injury or other physical limitation, a number of subjects were rejected. The sample for this study was randomly assigned to one of the eight different treatments. The mean and standard deviation for each variable for the sample of N = 120 are presented in Table I.

TABLE I

SUMMARY TABLE OF COMPUTED MEANS, STANDARD DEVIATIONS AND STANDARD ERROR OF THE MEANS FOR FAT PERCENTAGE, AGE, WEIGHT, HEIGHT AND BASELINE MEASURES

N = 120

Variables	Mean	STD DEV	SEM
Fat	10.8975 Percent	3.8070	0.3475
Age	21.5167 Years	2.7069	0.2471
Weight	158.6583 Pounds	15.9023	1.4516
Height	69.5917 Inches	2.6459	0.2415
Baseline Measure	95.2417 Degrees	13.2240	1.2071

Intertrial Reliability Coefficient

For the purposes of consistency of the testing and the reliability of an instrument (flexometer) three measures were recorded for each of the subjects. A Pearson-product reliability coefficient was computed to determine whether or not there was consistency between the trials. As displayed in Table II a high reliability was found between the three trials for 120 subjects.

TABLE II

INTERTRIAL RELIABILITY COEFFICIENTS

N = 120

	T_1	T_2	T_3
T_1		0.9619 P 0.0001	0.9441 P 0.0001
T_2			0.9684 P 0.0001

Correlations of Fat, Weight, and Height to Flexibility

In addition to the major purposes of this study the relationship of body fat percentage, height, and weight to flexibility at the jip joint were assessed. The relationships were determined and the results indicate there is a low correlation existing between the three above variables and flexibility. As shown in Table III there is a low negative correlation between fat, height, and weight and flexibility. However, in all three cases the negative correlation coefficients are significant ($P < .05$).

TABLE III

SUMMARY TABLE OF PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS OF FAT, WEIGHT AND HEIGHT TO FLEXIBILITY

N = 120

Variable	Flexibility
Fat	r = -0.1846 *P = 0.022
Weight	r = -0.1546 *P = 0.046
Height	r = -0.1824 *P = 0.023

*P $<$ .05

Baseline Measures

The purpose of a baseline measure, which was a simple passive stretch (P) before any treatment for all of the subjects, was to see whether or not there were any significant differences among the groups.

The means, standard deviation, and standard error of the means were computed to see whether or not there were any differences on baseline measures under all eight treatment conditions. Descriptive information among the groups is shown in Table IV. It is proper to mention that the baseline

TABLE IV

TABLE OF DESCRIPTIVE STATISTIC OF BASELINE MEASURES
FOR ALL POSSIBLE TREATMENT CONDITIONS*

N = 120

	3-PI$_f$CP			PCP			3-PI$_e$CP			P			ROW		
	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM
Cold	97.93	10.14	2.62	93.53	13.43	3.47	96.13	11.90	3.07	90.53	14.41	3.72	94.53	12.57	1.62
No-cold	91.46	13.90	3.59	92.86	13.91	3.59	102.00	15.39	3.97	97.46	10.87	2.80	95.95	13.91	1.79
Col	94.70	12.40	2.26	93.20	13.44	2.45	99.06	13.84	2.53	94.00	13.03	2.38	95.24	13.22	1.20

*All data reported in degrees

measures recorded in this study were under only one condition (no-cold) and since the cold and no-cold conditions were one of the major parts of this investigation it would not be justifiable to make any assessment on baseline measures. Further, a two-way analysis of variance (ANOVA) with an equal number of observations per cell was used to observe whether or not differences found in Table IV are significant. As shown in Table V, no significant differences were found among the groups between the baseline measures.

Treatment Differences

The two major purposes of this study were to investigate whether or not there is any difference between the stretching techniques, P, PCP, 3-PI_fCP and 3-PI_eCP, and to determine the effect of cold application (ice) on each of the stretching techniques. Table VI includes descriptive information of means, standard deviations, and standard error of the means for the sample of N = 120.

Result of Two-way ANOVA on Treatment Differences

To analyze the information from Table VI a two-way ANOVA was utilized. The results are shown in Table VII and indicate that no significant differences exist between the two conditions of cold and no-cold. As shown in Table VII there were significant differences at the 0.05 level between the P and PCP, 3-PI_fCP, and 3-PI_eCP techniques.

TABLE V

SUMMARY TABLE FOR A TWO-WAY ANOVA FOR BASELINE DIFFERENCES FOR ALL POSSIBLE TREATMENT CONDITIONS DURING A FLEXIBILITY MANEUVER

N = 120

	Sum Squares	Degrees of Freedom	Mean Squares	F	P
Row	60.2083	1	60.2083	0.3502	0.5552
Column	619.0250	3	206.3417	1.2002	0.3131
Interaction	875.4250	3	291.8083	1.6973	0.1717
Within	19255.3333	112	171.9226		
Total	20809.9917	119			

TABLE VI

TABLE OF DESCRIPTIVE STATISTIC OF THREE TRIALS FOR ALL POSSIBLE TREATMENT CONDITIONS*

N = 120

	3-PI$_f$CP			PCP			3-PI$_e$CP			P			ROW		
	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM	$\bar{X}$	SD	SEM
Cold	112.10	8.84	2.28	110.62	10.76	2.78	113.24	9.91	2.56	98.24	12.78	3.30	108.55	12.04	1.55
No-cold	105.96	11.96	3.09	107.68	10.67	2.75	115.71	15.63	4.03	100.70	11.05	2.85	107.51	13.32	1.72
Col	109.03	10.79	1.97	109.15	10.63	1.94	114.47	12.92	2.36	99.47	11.80	2.15	108.03	12.05	1.15

*All data reported in degrees

TABLE II

SUMMARY TABLE FOR A TWO-WAY ANOVA FOR THREE TRIALS DIFFERENCES FOR ALL POSSIBLE TREATMENT CONDITIONS DURING A FLEXIBILITY MANEUVER

N = 120

	Sum Squares	Degrees of Freedom	Means Squares	F	P
Row	32.2403	1	32.2403	0.2389	0.6259
Column	3512.6243	3	1170.8748	8.6766	0.00001
Interaction	406.6010	3	135.5337	1.0044	0.3937
Within	15113.9562	112	134.9460		
Total	19065.4220	119			

Further, to observe the differences that exist between the four techniques of stretching and to be able to make a valid judgement on which of the techniques is superior, a rank order is displayed in Table VIII. As shown in Table VIII a mean for each technique under both conditions (cold, no-cold) is reported and indicates that the PCP, 3-PI_fCP and 3-PI_eCP techniques are superior over the P technique. Between the PCP, 3-PI_fCP and 3-PI_eCP, the latter is superior

to the two others and the PCP is better than the 3-PI_fCP technique. The factors causing the differences between the stretching techniques will be discussed in greater detail in the next chapter.

TABLE VIII

SUMMARY TABLE OF RANK ORDER FOR MEAN OF FOUR STRETCHING TECHNIQUES

N = 120

Rank #	Techniques	Means*	Number of Observations
1	3-PI_eCP	114.47666	30
2	PCP	109.14999	30
3	3-PI_fCP	109.02999	30
4	P	99.46999	30

*All data reported in degrees

Technique Differences

The result of the two-way ANOVA (Table VII) revealed significant differences between P, PCP, 3-PI_fCP and 3-PI_eCP stretching techniques. to find the differencts among the stretching techniques, a post hoc test (Turkey's) was used. The results of the post hoc test indicate that significant differences exist at the 0.05 level of significance between all three techniques, PCP, 3-PI_fCP and 3-PI_eCP, and the P

technique. The result of the post hoc test did not indicate any significant differences between PCP, 3-PI_fCP and 3-PI_eCP. To further simplify, based on the result of the post hoc test, it is correct to say that all three stretching techniques 3-PI_eCP and PCP had greater effect on flexibility at the hip joint than passive stretch (P), and each was an equally effective method of stretching.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE STUDY

Summary

This study was designed to investigate the effect of cold application and four stretching techniques, P, PCP, 3-PI_eCP and 3-PI_fCP on hip extensors and their influence on flexibility at the hip joint on college male students. There were two hypotheses under investigation: (1) there are differences between cold application and no-cold on flexibility at the hip joint and, (2) there are differences in flexibility as measured under four stretching techniques. A sample of one hundred and twenty male students was selected based on a voluntary participation. The sample was randomly divided into eight groups of fifteen subjects per each group. Each group was then randomly assigned to one of the eight treatment conditions. A single testing session was scheduled for each subject with a time period of twenty to thirty minutes. Weight, height, age and body fat percentage were recorded for each subject prior to the actual flexibility testing. The purpose of recording the above variables was to observe whether or not a relationship existed between the stated variables and the degree of flexibility at the hip joint.

The actual testing was started with a passive static stretch (P) as a baseline measure. Each subject then was measured three times under one of the eight treatment conditions with adequate information given to him verbally and visually prior to the actual testing. Information which consisted of name, age, weight, height, body fat percentage, baseline measure and the results of three trials was recorded on a single form prepared for each subject. This study did not include varsity athletes, individuals with an injury to their lower extremity, and individuals with more than 18 percent body fat.

Findings and Conclusions

The findings of this study did not support the hypothesis which stated that the application of cold would affect the flexibility of the hip joint. Cold application as recommended by several investigators including Knight (1978), Holt (1976), Murphy (1962), and Grant (1964) did not provide a significant positive result over the no-cold condition. This result may have been due to the minimum time period of the cold application which was ten minutes for this study. Several investigators have recommended cold application in the later stage of injury for the purpose of stretching and breaking scar tissue. Furthermore, cold application has been an effective modality for cases with pain, stiffness, spasms and other problems which affect range of motion. A possible

reason that cold application did not enhance the range of motion in this study is that none of the subjects was affected by factors such as pain, stiffness or spasms. It is yet unclear whether or not cold application promotes flexibility on an individual in a normal condition (free of injury). It is possible that the use of cold could be an inhibiting factor, causing stiffness, since cold does decrease peripheral blood circulation (vasoconstriction), (Wilmore 1978).

The effect of cold application to muscle tissue is still in the early stages of experimentation, and whether or not cold does allow for greater range of motion is yet to be determined. Much more study is needed to ascertain whether or not there is a positive effect from cold for flexibility purposes.

The results of the study of the four stretching techniques, P, PCP, 3-PI_eCP, 3-PI_fCP, supported the stated hypothesis that there would be differences in flexibility among the techniques. Three of the four techniques (PCP, PI_eCP and PI_fCP), which are based on the principle of proprioceptive neuromuscular facilitation (PNF), provided a greater range of motion than the passive static technique (P). (See Appendix F) The PNF techniques' positive effect over the passive stretch is due, perhaps, to the number of contractions involved in those techniques.

The neurophysiological processes of PNF ($3\text{-}PI_eCP$, $3\text{-}PI_fCP$ and PCP) techniques are influenced by two major sensory receptors, Golgi tendon organs and muscle spindles, which are located in the muscle structure. The findings indicate that PNF techniques allow greater range of motion than a passive static stretch (P) of the hip extensors. Greater range of motion was due partially to the three second maximum isometric contraction of hip extensor muscles ($3\text{-}I_e$) which was preceded by a passive static stretch of the same muscles. The use of ($3\text{-}I_e$) appeared to be a beneficial prestretching maneuver. Beaulieu (1981), Holt (1976) and Tanigawa (1972) advocate the use of a prestretched maximum isometric contraction (autogenic inhibition) which causes relaxation of the muscles to be stretched. They further explained that this phenomenon is influenced by way of receptors called Golgi tendon organs which are located between extrafusal muscle fibers and the tendon. During a maximum isometric contraction these tendon organs discharge tension in order to inhibit muscle contraction and cause relaxation of that muscle.

The use of a maximum three second isometric contraction of hip flexors ($3\text{-}I_f$) and concentric contraction of hip flexors (C) also played an important role in enhancing greater range of motion during a flexibility maneuver at the hip joint. Both ($3\text{-}I_f$) and (C) of the hip flexors provide

relaxation for the muscles to be stretched (hip extensors) by way of reciprocal inhibition. Windell and Decker (1962) found that the stretching techniques based on proprioceptive neuromuscular facilitation (PNF) cause inhibition of the anterior horn cells and this inhibition leads to reduction of sensory activity which results in relaxation of the muscles bundle and associated soft tissue. The three second isometric contraction time interval was used because of its practical application to a class setting. Furthermore, Cornelius (1980) found no significant difference between three and six second isometric contraction time intervals and concluded both were equally effective.

The static stretch, which is the older technique, still is preferred over techniques using a dynamic stretch by many practitioners who believe the latter to be incorrect stretching techniques for improving the range of motion. Beaulieu (1981) states if a muscle is held in a stretching position (static), the tension from stretch reflex contraction becomes strong enough to invoke the inverse stretch reflex which facilitates the muscle to relax and be stretched farther safely. The static technique is less complex than the PNF techniques which require a better understanding of muscular tissue and are more difficult to utilize. However, because of the benefits of the PNF techniques, it is worthwhile to study them in greater detail for future use.

While the Tukey test on technique differences was used to determine that the PNF techniques were superior to the passive technique, the 3-PI_eCP was superior to the PCP and 3-PI_fCP techniques in this study. This was due, perhaps, to the three seconds of isometric contraction of the hip extensors (3-I_e) which provided relaxation of the hip extensors resulting in a greater range of motion.

According to this study, there is a negative correlation between the flexibility mean of three trials and the three variables measured on each subject; percentage of body fat, height, and weight. The data revealed a high intertrial reliability which indicated accurate measurements and a reliable instrument. The finding from baseline measurements did not indicate a significant difference between cold and no-cold conditions.

Recommendations for Future Study

Because of the nature of this study, there was some difficulty during the testing in terms of controlling factors such as perceiving tension by the subjects, maximum effort during all phases of the flexibility maneuver particularly during the three seconds of isometric contraction, advantage and disadvantage of time of day when each subject participated in the study. Perhaps the most important factor affecting results was that some subjects had the benefit of activity in which they were involved prior to the testing

whereas some of the subjects did not. Even though the size of the sample did reduce the negative effect of the above factors considerably, nevertheless, it is assumed that there was negative or positive effect in some cases in the outcome of the study.

Careful study and planning should be given to eliminate the effect of those factors. The duration of cold application needs to be evaluated, because of the danger of over stretching which can be caused by the anesthetic property of cold if it is used for too long a period. The following topics are also recommended for further investigation:

1. Study of the Comparison of Cold and No-Cold on Passive Stretch;
2. Study of the Comparison of Cold and Heat on Passive Stretch;
3. Study of the Comparison of Cold Under Different Duration Periods During Flexibility Maneuver; and
4. The Effect of Cold Application on Hip Extensors and Hip Flexors During Flexibility Maneuver.

APPENDICES

APPENDIX A

THE INSTITUTIONAL REVIEW BOARD

FOR THE PROTECTION OF HUMAN SUBJECTS

NORTH TEXAS STATE UNIVERSITY

EXPEDITED REVIEW FORM

1. Activity Director Khosrow Ebrahim
2. Activity Title Study of the Effect of Cold Application and Flexibility Techniques on Hip Extensors and Their Influence on Flexibility in College Males
3. Department Physical Education and Dance
4. Phone 788-2651
5. Date Submitted 10/15/81

_____ The statement submitted for this activity conforms to the Department of Health and Human Services and the Food and Drug Administration Final Regulations for the protection of human subjects under the category of Expedited Review under 45 CFR 46.110 and is approved.

Rollie Schafer, Chairperson,
Institutional Review Board

Dec 30, 1981
Date

APPENDIX B

PROPOSAL FOR RESEARCH

COLLEGE OF EDUCATION

Researcher Khosrow Ebrahim

Proposed Title The Effect of Cold Application and Flexibility Techniques on Hip Extensors and Their Influence on Flexibility in College Males

We the Doctoral Advisory Committee, have read the proposal and have determined that

1. No risk factor of human subjects exists.
2. No deception of subjects exists.
3. Informed consent by adults (or by a parent of children) has been obtained.
4. Subjects have been given the right to refuse to participate if desired.

Therefore, we agree that the rights of involved human subjects are protected.

For the committee,

Bea Miller — Division Chairperson

Jack Watson — Major Professor

October 30, 1981 — Date

Note to Presider:

Please attach this completed form to the transmittal letter. When doubt exists, the proposal should be referred to the Institutional Review Board.

APPENDIX C

Dear Subject:

Thank you for considering my request for your participation in this study. This study is designed to measure flexibility at the hip joint. Since it is my responsibility to inform you about the nature and procedure of this study I would like to explain the following steps.

1. The test starts with collecting information such as name, weight, height, age and body fat percentage which will be measured. Following, each subject will be assigned randomly to one of the four stretching techniques. Each stretching technique will be performed under two conditions, cold and no-cold. The cold will be in the form of ice cubes placed in plastic bags. The duration of cold application is 10 minutes. Each subject will participate only once in one of the techniques.

2. There will be minimal risk involved in this study and during the entire testing you will be assisted by the examiner. The two major parts of this testing are cold application and maximum stretching which may cause discomfort.

3. This study will provide information which will help to understand the use of cold application and its benefits for the purpose of stretching.

4. Your participation in this study is voluntary and you may withdraw at any time. Your cooperation is important and is surely appreciated.

Sincerely,

Khosrow Ebrahim

APPENDIX D

FORM 2
USE OF HUMAN SUBJECTS
INFORMED CONSENT

NAME OF SUBJECT: _____

1. I hereby give consent to Khosrow Ebrahim to perform or supervise the following investigation procedure or treatment:

The Effect of Cold Application and Flexibility Techniques on Hip Extensors and Their Influence on Flexibility in College Males

2. I have (seen, heard) a clear explanation and understand the nature and purpose of the procedure or treatment; possible appropriate alternative procedures that would be advantageous to me (him, her); and the attendant discomforts or risks involved and the possibility of complications which might arise. I have (seen, heard) a clear explanation and understand the benefits to be expected. I understand that the procedure or treatment to be performed is investigational and that I may withdraw my consent for my (his, her) status. With my understanding of this, having received this information and satisfactory answers to the questions I have asked, I voluntarily consent to the procedure or treatment designated in Paragraph 1 above.

_____
Date

_____ OR _____
Witness Witness

_____ _____
Subject Person Responsible

_____
Relationship

Instructions to persons authorized to sign:
If the subject is not competent, the person responsible shall be the legal appointed guardian or legally authorized representative. If the subject is a minor under 18 years of age, the person responsible is the mother or father or legally appointed guardian. If the subject is unable to write his name, the following is legally acceptable: John H. (His X Mark) Doe and two (2) witnesses.

APPENDIX E

SUBJECT'S DATA

DATE _____

NAME _____ # _____ TREATMENT _____

AGE _____

SEX _____M_____

WEIGHT _____

HEIGHT _____

BODY FAT PERCENTAGE _____

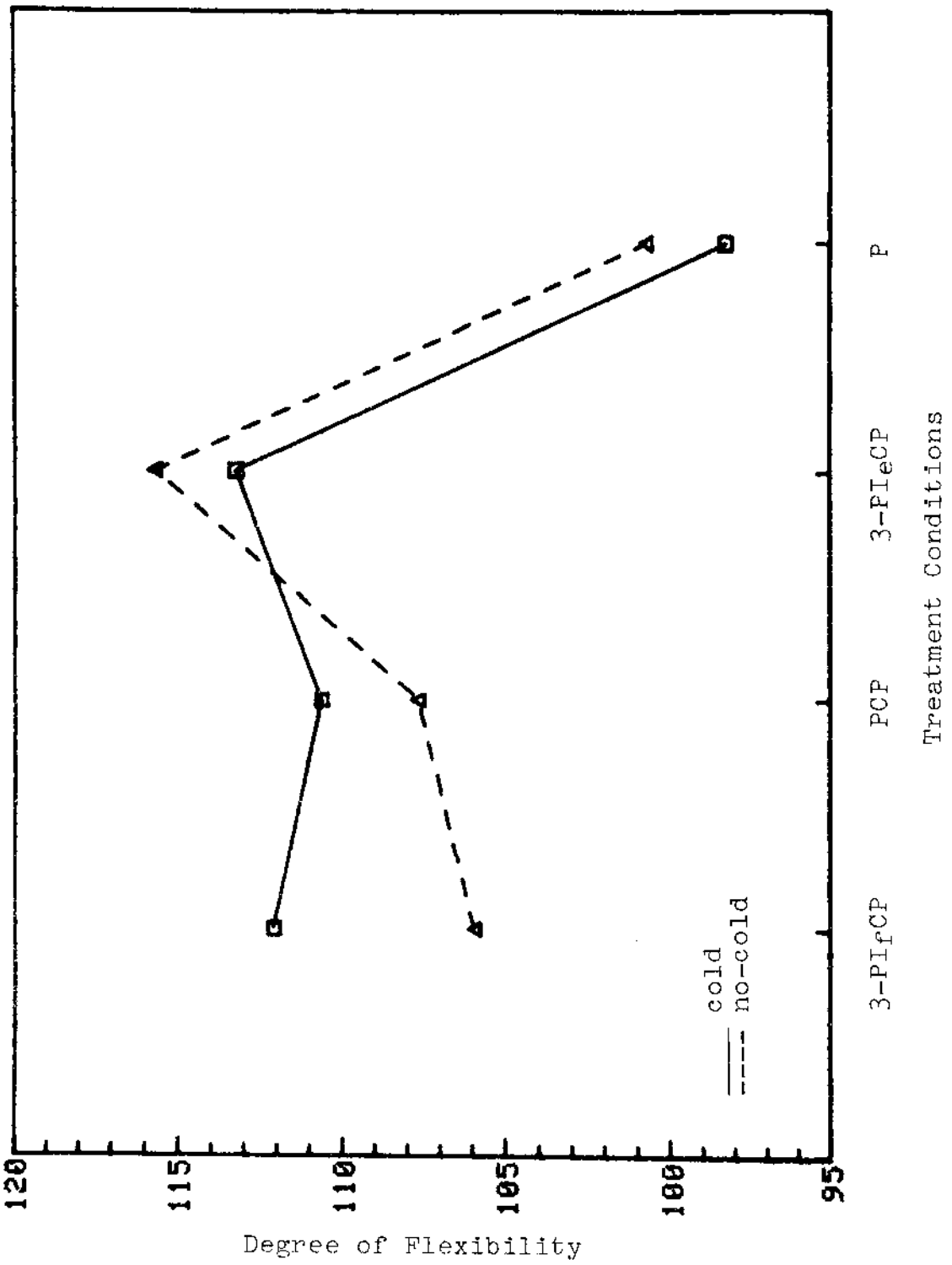
	Cold	No-Cold
P	_____	_____
PCP	_____	_____
3-PI_fCP	_____	_____
3-PI_eCP	_____	_____

BASELINE MEASURE _____

TRIAL I	TRIAL II	TRIAL III	MEAN
_____	_____	_____	_____

APPENDIX F

MEAN DISPLAY OF ALL POSSIBLE TREATMENT CONDITIONS



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