DUNN, BETTY LOU. The Effects of Isometric Conditioning on Accuracy in Archery. (1973) Directed by: Dr. Gail M. Hennis. Pp. 79

The purpose of this study was to determine the effects of isometric exercises on shooting accuracy and whether an increase in arm and shoulder girdle strength would result from a short term program of isometric exercises.

The twenty-four subjects who participated in this study were women students enrolled at The University of North Carolina at Greensboro during the second semester of the 1969-70 academic year. All of the subjects had had previous experience in archery. The subjects were measured initially as to shoulder abduction strength, forearm and shoulder flexion strength, horizontal shoulder and forearm flexion strength, bow arm and shoulder extension strength, archery scores, and the number of hits scored for a Junior Columbia Round. The subjects were then grouped by a rough ranking according to the four strength measures and assigned to experimental and control groups. The two groups were equated initially in terms of strength. The cable tensiometer was used as the measuring instrument for all strength tests.

The experimental group was then given a program of isometric exercises designed to increase arm and shoulder girdle strength. The program consisted of four six-second bouts of isometric contractions with four repetitions of each exercise daily for a period of fifteen days. The groups were then retested on strength measures and shooting ability.

The raw data were subjected to the Tsar Program of Computer Analysis. The analysis of variance technique was used to determine if the groups were equated initially in terms of strength and in terms of shooting ability. Since the two groups were not equated initially in terms of shooting ability, the analysis of covariance technique was used for comparison of the final test of shooting ability. Analysis of variance was used to compare the groups on all measures of strength. Both the experimental and the control groups had a statistically significant improvement for all measures of strength from the initial to the final tests, and both groups showed an increase in shooting accuracy from the initial to the final test. Although both groups had an improvement in shooting scores and an increase in strength, there were no statistically significant differences between the groups for the final tests of accuracy and strength.

As a result of the findings of this study, it was concluded that a short term program of isometric conditioning exercises such as that used in the study was not effective in producing more significant strength gains or a more significant increase in shooting accuracy among college women experiencing the program than those who did not.

THE EFFECTS OF ISOMETRIC CONDITIONING
ON ACCURACY IN ARCHERY

by

Betty Lou Dunn

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APPROVAL PAGE

This thesis has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

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CHAPTER I

INTRODUCTION

History tells us that the bow was the weapon of war and the tool of existence for the man of yesteryear. Archers of that period were no doubt strong, burly men as indeed they had to be to handle the long unyielding straight limbed bow. Today archery is seldom thought of as a sport requiring great physical strength of its participants, although the physiological effects of exercise may be found in archery as in other more physically demanding sports.

> Drawing the bow and holding the anchor position helps to build strength and endurance in shoulder and upper back muscles. Contraction of the abdominals adds strength necessary for maintenance of erect posture. Expansion or stretching of the chest muscles helps to offset fatigue that builds up. . . . (1:5)

Though the exercise derived from participation in archery is limited, it may well serve to counteract the effects of a sedentary way of life. (1)

Archery is a sport which appeals to all ages and to both sexes and can be enjoyed by those physically handicapped as well as the healthy. Even a beginner can easily learn to shoot fairly well with one or two lessons and may find it a good sport to do alone or with friends.

In many sports, physical prowess is often essential for efficiency and effectiveness in performance. Lack of sufficient strength necessary to execute a particular movement may be a deterrant to learning and performance. The archer must have sufficient arm and shoulder strength to provide the muscle power to enable him to draw the bow with ease and comfort and to avoid introducing errors into his performance. If sufficient strength is not present, it is possible learning may be delayed or inhibited.

It has seemed to the writer that there is a relationship between an archer's strength and the type of errors involved in his shooting. Archery requires the ability to sustain movement for varying lengths of time. To sustain such movement, it is essential that the archer have adequate strength in the muscles involved. He must have the necessary muscle power to draw the bow with ease as well as the endurance to hold the full draw position while aiming. The beginner may find that he is unsuccessful in archery if he does not have sufficient strength to handle the bow weight or the shooting distance he has selected. Weaker archers frequently allow the string hand to creep forward to relax the strain of pulling to and maintaining the full draw position while aiming, or they may underdraw thereby losing the benefit of the full draw. Other errors which seem to be common among archers are: failing to hold the anchor position long enough for aiming accurately; collapsing the bow arm on or before releasing the arrow; leaning toward or away from the target; pushing the bow arm forward on release of the arrow; and straightening the bow arm. This latter fault results in the bowstring hitting the elbow when the arrow is released. Although these errors are incurred by many archers, it seems that they are more frequent among archers lacking in arm and shoulder girdle strength and thus seemingly related to the strength of the archer.

The writer has contended for some time that a program of conditioning for archers which would add to their strength should aid in eliminating many of the so-called "common errors" in their shooting. If, as authorities agree (1, 2), the ability to inhibit extraneous movement is essential to archery, the development of sufficient strength in the arm and shoulder girdle to inhibit such movement should be an asset to an archer's performance. It was to test this contention that this study was undertaken.

STATEMENT OF THE PROBLEM

It was the purpose of this study to determine the effects of an isometric conditioning program on shooting accuracy in archery among college women. The investigation was conducted with the following twofold purposes:

1. to determine if accuracy of shooting would improve following an isometric training period,
2. to determine if arm and shoulder girdle strength would increase significantly as a result of a short term program of isometric exercises.

Scores for a Junior Columbia Round, as well as the number of hits recorded, were used to determine improvement in shooting accuracy. The results of strength measures from initial and final testing sessions were also compared for subjects in experimental and control groups; between testing sessions the subjects in the control group were involved in their normal daily activities while the subjects in the experimental group participated in addition in an isometric exercise program.

LIMITATIONS OF THE STUDY

Of the sixty-five students who had been previously enrolled in beginning archery classes at the college, only thirty were able and willing to participate in the study. This limited the number of subjects available. An additional limitation on the number of subjects participating in the study was the occurrence of campus unrest due to the Cambodian Crisis which occurred during the final week of the test period, causing the loss of several subjects.

Further limitations of the study were caused by the lack of an indoor archery range which would have permitted the study to be conducted over a longer period of time and would have made it possible for the subjects to have been tested on more than two occasions.

CHAPTER II

REVIEW OF LITERATURE

The initial phase of this review of literature deals with strength development which answers the question of what is strength and how it may be developed and with the findings of previous research relative to isometrics as a means of strength development. The writer then reviews the various methods of strength testing and the research findings of others to determine the various methods best suited for the purposes of this study. The final area of the review of literature deals with a brief history and development of archery and some analysis of the muscles involved in shooting.

Strength Development

Cureton described strength "as the capacity of the body to exert force on some external resistance whereby the body pushes, pulls, kicks, lifts, or carries some object." (6: 23)

Rasch and Burke (16:436) have stated that "muscular strength is perhaps the most important of all factors in athletic performance." They further state: "If an individual desires to increase his muscular strength, hypertrophy, and endurance, he must be willing regularly to subject his body to the stress of the repeated all-out effort." Steinhaus concurredly stated: "The full attainment of skill often awaits the strengthening of certain key muscles which in specific coordination should alone carry the load." (18:23)

Steinhaus (18), and other researchers (7, 11, 13, 16), have agreed that in order to increase strength one must place the muscle under demands of greater work than previously demanded by that muscle. This means that one must overload. Overload may be accomplished by speeding up movements or by using the body weight as resistance. The overload principle, as defined by Steinhaus, is the intensity of work required of a muscle over and beyond that to which it is currently accustomed. (18:85) He divided overload into two categories: one which he called formal and the other functional. Formal overloading is the use of weight training and heavy calisthenics to strengthen muscles while functional overloading is the use of an activity which overloads the movements used in sports.

According to Hettinger, ". . . an increase in muscle tension above that previously demanded of a muscle is the stimulus for an increase in muscle strength." (11:23) Broer supported this view when she stated that:

> . . . strength of a muscle group can be increased by use, but to increase strength a muscle must be overloaded, either by the intensity of contraction or its duration (or both) must be greater than normal for the muscle. . . . the student may understand the mechanics of the skill but if he lacks the strength to carry them out no amount of discussion of his incorrect movement will be of help to him. Exercises to condition the weak muscles are essential. (2:51)

deVries (7:310) cited a study by Muller and Rohmert that showed that strength gain was not constant; gain was rapid in muscles with a low minimum strength and slower in muscles trained nearly to potential strength. Lucien Brouha, writing on the effects of training, has stated:

> Strength of the muscles can be developed only by exercising them against a gradually increasing resistance such as pulling or pushing springs, lifting weights and/or moving the body at increasing speed. The gain in strength is more striking than the hypertrophy of the muscle; it is possible to increase the power of muscles three times or more without a proportional increase in volume. The final result of training on the muscles varies with the kind of exercise performed, the degree of repetition, speed, duration, and intensity of contractions. Individual factors are also involved, and two subjects following the same training program may not necessarily develop their muscles in a similar manner. (12:403-404)

It is an established physiological fact that strength may be gained through exercise, although there still remains much debate as to the methods to be employed.

Berger stated:

> The scientific principle of increasing the load or resistance against which the muscles worked as strength increased has been called progressive resistance exercises and has been employed extensively in modern times by individuals interested in competitive weight lifting and general strength development for improving athletic performance. Still more recently, the principle has gained wide use in rehabilitating individuals physically weakened by disease or injury. (21:168)

A further study of strength development by Berger (20), comparing static and dynamic strength increases after twelve weeks of training, found that strength increased significantly more when training statically to improve static strength and dynamically to improve dynamic strength. Chui (25) also studied the effects of dynamic weight-training exercises. He used seventy-two male subjects who were divided into three exercise groups. One used isometric contractions, a second group used rapid dynamic contractions, while a third group used slow dynamic contractions. Cable tensiometer tests were used as the measuring instrument. Strength gains were measured on eight different measures of the training program. The results showed that there were no greater gains in strength in relation to a specific method.

Hislop (31) conducted an extensive study of muscular strength changes during isometric exercises and stated: "One of the few established facts, corroborated again in this study, is that the performance of muscles can be improved by systematic exercises." (31:34) She tested ninety-one male subjects in 115 experiments and found improvements in maximal strength of the forearm flexors after a six-week training period using varying frequencies, durations, and intensities of isometric exercises. Hislop concluded that:

> . . . the numerous training programs that have been described and the myriad of instruments devised to measure strength attest to the fact that no agreement has been reached regarding the optimal method(s) of achieving strength gains. (31:34)

Isometrics

Since 1953 when Hettinger and Mueller reported their research on isometric exercises there has been, and still continues to be, a wide controversy (20, 21, 23) as to the value of isometric exercises. This controversy has been largely due to the misuse of isometrics and false claims by exercise "faddists" and those in the commercial world who have led people to believe that isometrics were the answer to fitness and/or strength development without effort.

Isometric contractions are muscular contractions against a resistance without movement.

As cited by Hildreth (43), Hettinger and Mueller in their original research with isometrics found:

1. One six-second practice period once a day results in as great a strength increase as longer periods and more frequent periods of exercise.

2. Muscular strength increases more rapidly with increasing intensity up to two-thirds maximum strength but the increase beyond this point is of no benefit in terms of strength development.

3. Muscular strength increases an average of five per cent per week at one-half maximum strength level. (43:9)

Since the original work by Hettinger and Mueller, much research has been conducted to test their observations. Many researchers (27, 29, 31, 32, 37, 38) have confirmed their findings as to the amount of muscular strength increase obtained and the amount of intensity required. Research in this area has agreed that isometrics do increase strength rapidly as indicated by the work of Hettinger and Mueller. On the other hand, there does not seem to be complete agreement as to the number of repetitions or the length of time required for isometric exercises to increase strength.

Rarick (38) tested and retested three groups of college men on the cable tensiometer once each week during a four-week training period. One experimental group did isometric wrist exercises for six seconds each day while another group exercised more frequently each day. His work supported Hettinger and Mueller's hypothesis that brief periods of exercise at two-thirds strength load was as effective as more frequent bouts at maximum strength.

Gardner (29), as a result of testing sixty subjects, found that strength increase was specific according to the position at which a limb was exercised. The subjects tested were trained for six weeks using specific degrees of knee extensions and all were tested for maximum isometric strength at all angles including those at which they had trained.

Dennison and his associates compared a 15-minute isometric exercise group with a 45-minute weight-training group in chin-ups, dips, and arm strength index. The subjects in the isometric exercise group improved significantly at the .05 level of confidence on chin-ups and dips. Both groups increased in strength but the differences in exercise time was a significant implication favoring isometrics. (27)

Additional support to the value of isometrics was given by Mathews and Kruse (36) who used two groups to compare strength increases as a result of isotonic and isometric exercises. The data obtained showed greater strength increase in the isometric exercise group with the greater gains by the group with higher frequencies per week.

Howell, Kimoto, and Morford (32) studied muscular endurance with three groups that exercised twice each week for eight weeks. One group lifted weights, one did isometric exercises, and the third, the control group, was asked to pursue normal activities for the course of the experiment. On a bicycle ergometer test, both the weight-lifting and isometric exercise groups showed increases in muscular endurance which were significant at the .01 level of confidence. The investigator concluded that muscular endurance can be developed by isometric exercises.

Armstrong determined the strengthening effects of one daily six to ten second static contraction performed five times per week for four weeks using forearm flexion at specific angles. Training angles were 90 degrees, 115 degrees, and 140 degrees. He found that those training at 90 degrees and 115 degrees both showed significant gains in terms of cable tension performance. He concluded that strength gains are significant to specific angles for which trained. (40)

Start and Graham (39), having studied isometric endurance of an isolated muscle group, stated that "muscular endurance is related to the capacity of a muscle to maintain or repeatedly develop a certain degree of tension. . . ." (39:193)

In his study, Burnham (41) compared the development of muscular strength by isotonic and isometric exercises and found that there was no real difference between methods except that less time and equipment was necessary for the group using isometrics. He stated:

> . . . performance of any individual, regardless of inherited qualities will be improved by the development of an optimum level of strength through training. The successful performance of most kinds of muscular activity requires an appropriate amount of strength. (41:1)

Since the principal muscles involved in shooting archery would be exposed to strain while shooting, it would appear to be important that those muscles be strong enough to also possess endurance without undue fatigue.

Berger (22) has studied isometric training and sports extensively and makes these statements regarding sports training:

> In sports such as golf, tennis, baseball, and handball, the level of strength needed for potentially best performance is probably less than the level required for sports involving the movement of greater loads; however, one thing is certain, if the athlete does not possess sufficient strength in his sport he will have limited ability to the extent that he is deficient. Strength improvement can result in an increase in power, speed, coordination, balance, and muscular endurance. . . . training isometrically has certain advantages over isotonic training or weightlifting. Little or no equipment is needed and the same muscle can be exercised in a small fraction of the time required for weight training. Since little fatigue is developed during isometric training, workout session may be conducted during the sport season without deleterious effects to the participants. (22:126)

Research reviewed indicates that isometric exercises can result in significant strength gains. The advantage of these exercises are that they do not require performance over long periods of time nor is an excessive amount of equipment involved. Evidence might lead one to conclude that an archer who wished to develop strength without having to devote valuable practice sessions to long and extensive conditioning programs could utilize an isometric training program. The literature pertaining to archers' participation in conditioning programs is limited.

Strength Tests

Measurement in physical education varies from subjective observation to objective appraisal using well validated tests and instruments. There still remain controversy and questions as to the best methods of measurement for the field.

Since strength is necessary for performance in many areas of physical education, the measurement of strength is important to the physical educator. In 1873 Sargent introduced the "inter-collegiate strength test" which included back and leg strength measured with a dynamometer; right and left grip, measured with a manuometer; lung capacity, recorded on a wet spirometer; and arm strength, measured by the number of pull-ups and dips the subject could perform. (5)

The year 1896 marked the next development in the area of strength testing. Kellog developed the Universal Dynamometer, a device which could be used to test twenty-five muscle groups. In 1925 Rogers introduced his "strength index" which included a combination of back and leg lifts, right and left grips, lung capacity, chinning and dipping.

Interest in strength testing per se appeared to wane until 1945 when Clarke and Peterson developed the cable tension tests for testing the strength of individual muscle groups. The tensiometer, an instrument designed to measure the tension of aircraft control cable, was adapted for use in muscle testing to record pounds of force exerted as a result of muscular action. The purpose of adapting the instrument was to test the strength of muscle groups involved in orthopedic disabilities. The researchers developed thirty-eight tension tests which involved most of the muscle groups of the body. Clarke has continued to up-date the original tests through extensive study of strength measures, body positions and application of strength, strength relationships, strength decrement fatigue patterns, and effect of gravity on scores. (3) Clarke (4) reported objectivity coefficients for the cable tension strength tests ranging from .74 to .99. Thirty-three of the correlation coefficients were between .90 and .99.

In 1954 Clarke (26) compared the cable tensiometer, Wakim-Porter strain gauge spring scale, and the Newman Myometer as instruments for measuring strength. His results indicated that the tensiometer was the best measure of strength and was more reliable than any of the other instruments tested.

Gardner (29) used the tensiometer to determine the effect of cross transfer through the use of isometric exercises. Rarick and Larson (38) used the tensiometer to test effectiveness of single daily six-second exercise bouts using two-thirds maximum tension with an exercise program of more frequent exercise bouts at 80 percent maximum tension.

Hunsicker (33:418) evaluated studies dealing with strength tests and stated: "It can be safely assumed that the instruments available for testing human strength are sufficiently valid and reliable for meeting the needs of the profession."

Archery

The use of the bow and arrow has evolved through the centuries from its use as a weapon for hunting and warring to its use today for sport and recreation - from the crude bow of prehistoric man to the beautiful precision instrument of modern man.

In prehistoric times the bow and arrow was used for warfare and killing game. Ancient carvings of the Egyptians and Assyrians have recorded pictorial accounts of the use of the bow and arrow. Legends have centered around the use of the bow and arrow in medieval Europe in tales of Robin Hood and the battles of Crecy, Agincourt, and others. (19)

Archery was used for warfare in Europe until 1664 and after that time was used primarily for recreation and amusement; it was not until 1870 in London, when the Toxophilite Society was established, that it began to flourish as a sport. (19)

In the United States, the American Indian used the bow and arrow for hunting and warring. The prowess of the Indian with bow and arrow is controversial as some sources believe the Indians' skill with archery was due largely to his skill as a stalker rather than his ability to shoot. (30)

The first American Archery club was founded in 1828 as the United Bowmen of Philadelphia and is still an active body today. After the Civil War, archery became popular as a result of the exploits of Maurice and Will Thompson in the Florida Everglades. In 1878, Maurice Thompson published the Witchery of Archery. In 1879 he organized and served as the first president of the National Archery Association. Public interest in archery was increased by the discovery of an Indian named Ishi in 1911 in California. Ishi was the last of the Yanas Indians and he and Saxton Pope worked together to compile and perserve complete and authoritative materials on archery traditions and techniques of the American Indians. (30)

Today the bow and arrow is still employed in warfare by the United States Special Forces and the crossbow is used in Vietnam as a silent kill weapon. Power companies use the bow and arrow to string lines in remote areas of the country and biologists have used bow and arrow to drug wild animals for capture. By far the greatest use of the bow and arrow today, however, is for sport in target and field shooting. (30)

The techniques of archery may not vary greatly from those used by our forefathers, but they have been refined and today's archer is by far a better shooter with greater accuracy and consistency. The success of the modern day archer is due largely to refinements in the craftsmanship of his equipment. Today's archer has the benefits accorded by stronger more durable bows which have greater elasticity and more consistency of performance than the bow of yesteryear.

In shooting, the stance is important because it places the body in a balanced position for applying sideward force and steadies the bow arm during the draw and release. Two stances may be used: open or square. The square or traditional stance is one in which the archer's feet are evenly spaced and parallel to the target face; whereas, in the open stance the archer's feet are turned slightly toward the target and away from the midline of the body. The open stance is often preferrable for beginners because the slight body rotation which occurs tends to draw the bowstring away from the bow arm at a wider angle and removes the fear of bow string slap.

Two basic grips are recommended for handling the bow. Either the high or extended wrist position or the low or palming grip may be used. In the technique of shooting target archery, the main differences appear in the position for the anchor. The most important factor is that the anchor be consistent with each shot regardless of whether it is a low anchor with the string hand under the jaw bone or a high anchor with the index finger at the mouth or eye. Aiming may be accomplished by the use of bowsights in freestyle shooting, by the use of a point of aim, or by instinct as in barebow shooting. The choice is usually made according to the individual archer's preference. The release of the arrow should be smooth and relaxed. (1, 9, 15)

> Archery is a sport which calls for precision of movement. It is largely dependent upon the kinesthetic perception of position and ability to always produce exactly the desired position. It demands static rather than dynamic precision such as found in throwing. Archery belongs to the same class of skills as throwing, but involves the projection of the arrow by mechanical rather than muscular force. However, the muscular force of the performer operates the bow. (17:252)

Hart (42) conducted a study of the factors which contribute to success in archery. She studied six factors, one of which was the relationship between strength and archery success. She found ". . . a definite relationship between the subject's ability to shoot and their test scores on strength and hand-eye dominance. . . ," (42:56) with a coefficient of correlation between strength and archery success which was significant at the .05 level of confidence. She stated: "It is possible that the ability to pull a stronger bow should have some influence on archery scores since more exact aim can be taken when the required point of aim is on or below the target." (42:56) The ability to inhibit movement while aiming is essential to archery, thus requiring that the archer have the needed strength. Bots (24), writing an article for the June 1968 - June 1970 DGWS Archery-Riding Guide, suggested a program of isometric exercises to be given three to four weeks prior to the archery unit and to be used daily after the shooting period. These exercises were designed to develop the strength and endurance of the upper arm, shoulder, and upper back muscles.

A brief discussion of the muscles involved in the act of shooting is pertinent to this study. As the archer draws, the tricep holds the bow arm extended while the arms are held at shoulder level by the action of the deltoid and supraspinatus muscles. The posterior deltoid, the teres minor, and the latissimus dorsi muscles allow horizontal extension of the arms as the bow is drawn and the anchor position is assumed. As the bow is drawn, the scapulae are adducted by the rhomboids and the trapezius muscles. The muscles of the bow arm are held in static contraction while extended. The elbow flexors, biceps, and pronator teres muscles control the action of the drawing arm. The scapulae are adducted throughout shooting. As the archer aims, his head is rotated by the sternocleidomastoid and the upper trapezius muscles aided by the splenus and erector spinae. The arrow is released by the relaxation of the flexor profundus digitorum and the contraction of the extensor communis digitorum. (17:254)

CHAPTER III

PROCEDURES

The purpose of this study was to determine the effects of an isometric conditioning program on shooting accuracy in archery. The investigator assumed that: (1) if an archer could increase his strength, his shooting accuracy might be improved significantly, and (2) an increase in arm and shoulder girdle strength would result from a short term program of isometric exercises.

To test these assumptions, the following null hypotheses were formulated: (1) There are no significant differences between the initial and final measures of arm and shoulder girdle strength, shooting accuracy, or total archery scores for either the experimental or control groups of subjects. (2) There are no significant differences between subjects comprising the experimental isometric exercise group and the control group with respect to arm and shoulder girdle strength, shooting accuracy, and total archery score prior to or following the experimental phase of the study.

The .05 level of confidence was the criterion accepted for significance.

SELECTION OF TESTS

The cable tensiometer was selected as the instrument for measuring arm and shoulder girdle strength because of its previously demonstrated reliability and validity in strength testing. (3, 14, 27) Clarke (4) obtained objectivity coefficients of .90 and above using the tensiometer in testing strength with thirty-eight muscle groups.

The tensiometer used in this study was an aircraft cable tensiometer manufactured by the Pacific Scientific Company, Los Angeles, California. (See Figure 1, page 62, in the Appendix) This instrument is calibrated to test a capacity of from five to one hundred pounds. Scores are read as indicated by a maximum pointer and converted to tension pounds by using a conversion table. A copy of the calibration chart used in converting scores may be found on page 69 of the Appendix.

The strength tests used in this study were Clarke's (4) shoulder abduction test and three additional measures of arm and shoulder girdle strength involving forearm and shoulder flexion strength, horizontal shoulder and forearm flexion strength, and bow arm and shoulder extension strength. The latter tests were devised by the investigator following Clarke's (4) suggestion that tests may be devised for movements other than those specifically covered by his testing techniques. These tests are specific to the movements involved in archery and to the angles of motion involved in the draw and hold position for aiming. Dr. Francis Pleasants of the School of Health, Physical Education, and Recreation of The University of North Carolina at Greensboro was consulted prior to and during a pilot study of the tests. He was of the opinion that on the basis of the mechanics involved these tests would accurately measure strength as related to shooting in archery. The tests were given to five graduate students in order to test for objectivity and reliability. The latter resulted in a correlation coefficient of .84.

Archery scores were obtained for a Junior Columbia Round, which consisted of shooting twenty-four arrows at 40, 30, and 20 yards respectively. The number of hits scored by each individual was also recorded as a test of accuracy in shooting.

SELECTION OF SUBJECTS

In choosing subjects for the study, the investigator desired subjects with some archery experience who would have some consistency in shooting ability and accuracy. It was also felt by the investigator that she should not teach the subjects as she might tend to influence their choice of bow weights or point out errors which she felt were related to strength factors thereby affecting later test results.

Sixty-five women students who had been enrolled in beginning archery classes during the fall semester of 1969 at The University of North Carolina at Greensboro were contacted as possible subjects for this study. Those contacted were given a brief explanation of the purpose and length of the study and asked to participate only if their schedule would permit. Of the thirty subjects who volunteered, twenty-six were undergradute students and four were graduate students in physical education. Eleven of the undergraduates were sophomore physical education majors.

TESTING PROCEDURES

Strength Testing

Subjects were assigned to an initial testing time between 8 a.m. and 6 p.m. on May 11 or 12, 1970. All subjects were tested first for strength using the cable tensiometer. The four strength tests were administered as follows:

Shoulder abduction strength test. The subject was placed in a supine lying position with hips and knees flexed; free hand on chest and feet resting on the table. A folded towel was placed under the subject's hips and shoulders to allow free passage of the pulling assembly. The upper arm on the side tested was adducted and extended at the shoulder to 180 degrees with the elbow in 90 degrees flexion and the forearm in a mid-prone-supine position. A strap was placed around the distal end of the humerus with the pulling assembly placed under the subject's back and attached to the opposite wall by means of a welded link chain attached to a one-sixteenth inch flexible cable with interlocking clasps. When the taut cable was passed through the two sectors and the riser of the tensiometer, the trigger was closed and the tensiometer held steady by the investigator. The subject was instructed to pull as forcefully as possible to abduct the arm. The subject's shoulder was stabilized by an assistant. The investigator recorded the tension pounds exerted by the subject. (See Figure 2, page 63, in the Appendix)

Forearm and shoulder flexion test. The subject stood with the feet in a stride position (twelve inches apart) as if standing on a shooting line for archery. The side of the subject's body was towards the wall. The bow arm was against the wall and fully extended with the palm of the hand resting on a 2 x 2 inch board. The pulling assembly consisted of an adjustable welded link chain with interlocking clasps attached to a one-sixteenth flexible cable with interlocking clasps connected to a three inch "D" ring which the subject held by the fingers of the string hand. The assembly was adjusted to permit the subject to assume only a half draw. The elbow of the pulling arm was at 90 degrees to the body and the hand of the pulling arm was opposite and just beyond the elbow of the extended bow arm. The assembly was attached to the wall by means of a hook placed at the proper height for each subject. The subject's feet were stabilized by the investigator and an assistant stabilized the subject's hips. The subject was instructed to apply as much pressure as possible without any body rotation or lean. The subject was instructed to pull the arm backward as if drawing an arrow but not to exert pressure by pushing with the opposite arm, although it could be used for stability. The cable was placed between the two sectors and riser and the trigger closed. The investigator held the tensiometer as pressure was applied, and recorded the tension pounds as indicated by the maximum pointer of the tensiometer. (See Figure 3, page 64, in the Appendix)

Horizontal shoulder and forearm flexion strength test. The subject assumed a standing position with feet twelve inches apart and parallel to the wall. The arm opposite the testing arm was extended 165 degrees with the palm of the hand resting against a 2 x 2 inch board and the body turned sideward. The subject's feet were stabilized by the investigator while an assistant stabilized the subject's hips. The subject was instructed to draw the cable just as if it were the string of a bow and to assume the anchor position she would use if actually shooting. The cable was then attached to a hook on the wall at the proper height and tautness. The pulling assembly was an adjustable welded link chain with interlocking clasps attached to a one-sixteenth inch flexible cable with a three inch "D" ring which the subject held with the fingers of the string hand. The subject was instructed to exert as much pressure as possible on the cable while keeping the elbow of the string hand at shoulder level. The investigator read and recorded the tension pounds as indicated by the maximum pointer of the tensiometer. (See Figure 4, page 65, in the Appendix)

Bow arm and shoulder extension strength test. The subject was seated in a chair braced against the wall with blocks. (See Figure 5, page 66, in the Appendix) She was instructed to sit with feet together flat on the floor, with the bow arm away from the wall. An assistant stabilized the subject's shoulders while the investigator stabilized the knees. The subject was then instructed to extend the bow arm as if holding the bow with the elbow at 165 degrees. An adjustable strap was placed around the subject's thumb and hand. The strap was connected to a one-sixteenth inch flexible cable which in turn was connected with interlocking clasps to a welded link chain hooked on the wall according to the height of the subject. After the chain was adjusted to the proper tautness, the subject was instructed to push the strap and attempt to apply pressure to the cable just as if holding a bow in the hand. The investigator placed the cable between the two sectors and the riser and instructed the subject to exert as much force as possible. The tension pounds were then read as indicated by the maximum pointer and recorded on the subject's score card.

Archery Testing

Following the completion of the strength testing, each subject was asked to shoot a Junior Columbia Round consisting of twenty-four arrows at distances of 40, 30, and 20 yards respectively. Subjects were asked to wear glasses for the shooting test if they normally wore them for seeing at a distance.

The subjects were allowed to select their own bows according to the bow weight last used or one that could be comfortably drawn to a full draw position when using the correct arrow length. The subjects were permitted to use any method of aiming including the use of bow sights. All subjects were asked to refrain from additional shooting for the duration of the study. The subjects were then told that they would be notified as to which group they would be in and all would be notified as to the next testing date and time. The total testing time required for each subject was approximately one hour and ten minutes.

Make Up of Groups

Subjects were divided into two equal groups (fifteen subjects in each) after a rough ranking according to strength. The

Fisher "t" test for significance of difference between means was used to determine if the two groups were actually equated on the basis of initial tensiometer tests. There were no significant differences between groups on any of the strength tests. The control group was designated as Group I and the experimental group as Group II.

The subjects assigned to the experimental group were notified that they were to report to Rosenthal Gymnasium at 5 p.m. on May 14. These subjects were also given instructions for and explanations of the isometric exercises and asked to report daily for fifteen days to Rosenthal weight-training room to perform the exercises. All subjects were free to exercise at the same time except one who could only come at 9 a.m. All exercises were performed under the supervision of the investigator.

During the experimental period, six of the subjects had to be dropped from the study; this involved three subjects in each of the two groups. One of the subjects was dropped due to ill health and the other five were dropped when it was learned that they would not be able to complete the time period necessary for the exercise program or be present for final testing due to their electing to take grades in classes rather than final exams because of their involvement in the protest of the Cambodian Crisis.

Analysis of variance was computed on strength data for the new groups, and it was found that the groups were still equated according to strength.

EXERCISE PROGRAM

When determining the exercise program to be used, the investigator attempted to include exercises for the muscle groups specifically involved in the act of shooting, exercises which could be performed in a short period of time, and exercises which required little or no equipment.

Research reviewed had revealed that exercises are more advantageous for strength development when they are in accordance with the specific angles of involvement relative to the activity for which strength is being developed, and that exercise periods and programs may vary in frequency, duration, and repetitions performed according to the demands of the study or activity.

Berger (23) conducted a study of the optimum number of repetitions required for strength development and found that training with less than two repetitions and more than ten repetitions would not improve strength as rapidly as training with four, six, and eight repetitions three times a week for twelve weeks. With regard to these findings, the investigator elected to use less repetitions performed daily to determine if strength would occur from a short term program of isometric exercises.

Exercises

Each subject was given a short length of rope which was attached to the wall and adjusted to her arm length and height. This rope was used to simulate the full draw position in archery. The draw position was used because it was felt that some of the difficulties incurred in shooting are derived from the inability to obtain and maintain a full draw when shooting and because the investigator believed that an archer would be more likely to benefit from an exercise which would strengthen the drawing arm throughout the aiming and release phases of shooting. The bow arm must also be strong enough to sustain movement and to hold the bow both during and after the draw and release. It must also be strong enough to withstand the tendency to buckle under pressure of the draw or the tendency to hunch the shoulder when drawing. The strength of the draw is obtained from the shoulders. Therefore, the isometric handclasp exercise was used to strengthen both shoulders and, at the same time, develop the muscles involved in holding the draw position during shooting. An isometric contraction with both scapulae fully adducted and the elbows held high was performed to aid in strengthening the shoulder girdle and permit the archer to overcome the effects of shoulder fatigue while shooting.

A detailed description of each exercise may be found in the Appendix, page 68.

Schedule

Subjects reported to Rosenthal Gymnasium at 5 p.m. on May 14. At this time, the investigator demonstrated the exercises and answered any further questions that the subjects had relating to the study. The exercise program was then begun with all subjects performing the exercises together. Subjects were given verbal motivation and cautioned to maintain the proper position and angle of arms, shoulders, and elbows at all times during the exercise period.

Four six-second bouts of isometric exercises were performed with four repetitions of each exercise. Each exercise bout was followed by a five-second rest period. The investigator supervised and timed all exercise periods. The exercise program was continued daily for fifteen days.

FINAL TESTING

All subjects in the control group were notified by mail one week in advance of the testing date to report for final testing. They were reminded of their appointments by telephone the day before testing. All subjects were again tested for strength and then the subjects shot a Junior Columbia Round. The testing times varied from 8 a.m. to 7 p.m., and all subjects were tested within two days. The procedures used were identical to those followed in the initial testing sessions.

TREATMENT OF DATA

The raw data were subjected to the Tsar Program of computer analysis. The analysis of variance technique was used to determine if the groups were equated initially with respect to strength factors. An analysis of variance was also used to determine if there were any statistically significant changes in either arm and shoulder girdle strength or in shooting accuracy within each group. The analysis of variance was employed to determine significance of difference between means of the two groups on the initial and final tests of accuracy of scoring (number of hits scored) and total archery scores, as well as the final strength tests. Because a significant difference was found to exist between the two groups on the scores made on the initial Junior Columbia Round, the analysis of covariance technique was used to compare the two groups on the basis of total archery scores.

CHAPTER IV

ANALYSIS AND INTERPRETATION OF DATA

This study, conducted at The University of North Carolina at Greensboro during the spring semester of the 1969-70 academic year, was designed (1) to determine the effects of a program of isometric exercises on shooting accuracy in archery, and (2) to determine if an increase in arm and shoulder girdle strength would result from a short term program of specific isometric exercises.

PRESENTATION OF FINDINGS

The thirty subjects who volunteered to participate in this study had all had at least one semester of archery instruction. They were initially tested for shoulder abduction strength, forearm and shoulder flexion strength, horizontal shoulder and forearm flexion strength, bow arm and shoulder extension strength, and the score and the number of hits made on a Junior Columbia Round. The subjects were then divided into two groups by a rough ranking according to strength. The groups were designated as Group I (control) and Group II (experimental). The raw data were treated by the analysis of variance and covariance techniques.

As is evidenced by the data presented in Table I and II on page 32 and Table III and IV on page 33, there were no initial

TABLE I

ANALYSIS OF VARIANCE FOR THE INITIAL SHOULDER ABDUCTION TEST BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	48.1667	1	48.1667	
Within groups	2475.9783	22	112.5445	.4279
Total	2524.1450	23		

TABLE II

ANALYSIS OF VARIANCE FOR THE INITIAL TEST OF FULL DRAW POSITION STRENGTH BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	48.1667	1	48.1667	
Within groups	2414.8617	22	109.7659	.4388
Total	2463.0284	23		

TABLE III

ANALYSIS OF VARIANCE FOR THE INITIAL STRENGTH TEST OF THE HALF DRAW POSITION BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	96.8017	1	96.8017	
Within groups	3816.9767	22	173.4989	.5579
Total	3913.7784	23		

TABLE IV

ANALYSIS OF VARIANCE FOR THE INITIAL TESTS OF BOW ARM STRENGTH BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	45.1004	1	45.1004	
Within groups	366.1292	22	16.6422	2.7099
Total	411.2296	23		

differences between the experimental and control groups with respect to the four strength measures: shoulder abduction, full draw position, half draw position, and bow arm strength. On the basis of these data, it could be assumed that the two groups were equated with respect to the strength measures considered in this study as being important to shooting in archery.

Prior to and immediately following a three-week period during which the subjects in the experimental group participated in an isometric exercise program, in addition to their normal daily activities, all subjects shot a Junior Columbia Round. In the interim between the pre- and post test rounds none of the subjects used a bow. Analysis of variance was used to determine if a significant difference existed between the two groups on initial scores for the Junior Columbia Round. The obtained F did indicate a difference between groups significant at the .05 level of confidence. Archers in the control group had significantly better scores than those in the experimental group. The data for the analysis are presented in Table V, page 35.

Since the two groups were not equated initially in terms of shooting ability as measured by performance on a Junior Columbia Round, the analysis of covariance technique was used to make comparisons between groups on the basis of post test scores. It was found that there was no statistically significant differences between groups on their post test archery scores when adjustments were made for differences in initial test scores. These data are presented in Table VI, page 36. The hypothesis that there would

TABLE V

ANALYSIS OF VARIANCE OF INITIAL SCORES FOR THE JUNIOR COLUMBIA ROUND BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	30602.0417	1	30602.0417	6.4689*
Within groups	104074.5833	22	4730.6629	
Total	134676.6250	23		

*Significant at .05 per cent level of confidence.

TABLE VI

ANALYSIS OF COVARIANCE FOR THE DIFFERENCES BETWEEN MEANS FOR THE INITIAL SHOOTING SCORES BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	df	SSx	EXY	SSy	SS Error of Estimate	df	Adjusted Mean Square	F
Between groups	1	30602.042	25138.65	20650.67	293.7	1	293.7	
Within groups	22	104074.583	97103.60	169925.17	79325.4	21	3777.4	.0775
Total	23	134676.625	122242.25	190575.83	79619.1	22		

be no significant differences between subjects comprising the experimental (isometric) group and the control group with respect to total archery score following the experimental phase of the study was found tenable.

The number of hits scored for the Junior Columbia Round was used as an additional measure of shooting ability. Table VII, page 38, shows the results of the analysis of variance for the number of hits scored on the initial shooting test. Again the differences were found to be statistically significant at the .05 level of confidence.

The two groups were not equated initially with respect to the number of hits scored for the Junior Columbia Round; therefore, in order to compare the two groups on the final test the analysis of covariance statistic was used. Covariance revealed that when adjustments were made for initial differences between groups, the groups were not statistically different in number of hits scored on the final test. The covariance data are shown in Table VIII, page 39.

A comparison was also made between difference scores obtained from initial and final testings for the two groups on the Junior Columbia Round. Table IX, page 40, shows the results of the analysis of variance for these differences. As is indicated, these difference scores were not statistically different for the two groups. The difference scores between number of hits on the initial and final shooting tests for the two groups were also compared using analysis of variance. Table X, page 40, shows that no statistically

TABLE VII

ANALYSIS OF VARIANCE FOR NUMBER OF HITS SCORED ON INITIAL SHOOTING TEST BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	590.0417	1	590.0417	
Within groups	2219.5833	22	100.8902	5.8484*
Total	2809.6250	23		

*Significant at .05 per cent level of confidence.

TABLE VIII

ANALYSIS OF COVARIANCE FOR THE DIFFERENCES BETWEEN MEANS OF THE INITIAL NUMBER OF HITS SCORED BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	df	SSx	EXY	SSy	SS Error of Estimate	df	Adjusted Mean Square	F
Between groups	1	590.04	536.50	486.00	1.74	1	1.74	
Within groups	22	2219.58	2211.75	3411.83	1207.88	21	57.52	.0302
Total	23	2809.63	2748.25	3897.83	1209.62	22		

TABLE IX

ANALYSIS OF VARIANCE FOR THE DIFFERENCES BETWEEN INITIAL AND FINAL SHOOTING SCORES BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	1080.0417	1	1080.0417	
Within groups	21397.5833	22	972.6174	1.1105
Total	22477.6250	23		

TABLE X

ANALYSIS OF VARIANCE FOR DIFFERENCES BETWEEN HITS SCORED ON INITIAL AND FINAL TESTS FOR EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	16.6667	1	16.6667	
Within groups	463.1667	22	21.0530	.7917
Total	479.8334	23		

significant difference had occurred between groups between testing periods.

Since one of the purposes of this study was to determine if an increase in arm and shoulder girdle strength would accrue as a result of the isometric exercise program, comparisons were also made between final strength measures for the two groups. The analysis of variance technique was again used to test for these differences. There were no statistically significant differences between groups on the final test of shoulder abduction strength as is shown by the data in Table XI, page 42. Table XII, page 42, shows the results of comparisons between groups on the full draw position. Again there was no statistically significant difference. The results of the final test for strength for the half draw position, shown in Table XIII, page 43, also indicated no significant difference between groups.

The groups were also retested for bow arm strength after the training period. As is evidenced by the data in Table XIV, page 43, the results of the post test indicated no statistically significant difference for this test.

The differences between the initial and final tests of shoulder abduction were computed for each subject and the data for the two groups were then compared. The differences between the groups were not statistically significant as is shown by data in Table XV, page 44. The initial and final tests of full draw position strength were also compared. Table XVI, page 44, shows the results which indicated no statistically significant difference between the groups.

TABLE XI

ANALYSIS OF VARIANCE OF FINAL SHOULDER ABDUCTION STRENGTH MEASUREMENT BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	36.7538	1	36.7538	
Within groups	2145.3858	22	97.5175	.3769
Total	2182.1396	23		

TABLE XII

ANALYSIS OF VARIANCE OF FINAL TEST OF FULL DRAW POSITION BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	24.8067	1	24.8067	
Within groups	1288.0517	22	58.5478	.4237
Total	1312.8584	23		

TABLE XIII

ANALYSIS OF VARIANCE OF THE FINAL STRENGTH TEST SCORES FOR THE HALF DRAW POSITION BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	19.8017	1	19.8017	
Within groups	2520.8117	22	114.5823	.1728
Total	2540.6134	23		

TABLE XIV

ANALYSIS OF VARIANCE OF THE FINAL TEST OF BOW ARM STRENGTH BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	20.5350	1	20.5350	
Within groups	859.5850	22	39.0720	.5256
Total	880.1200	23		

TABLE XV

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN INITIAL AND FINAL SHOULDER ABDUCTION STRENGTH TESTS BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	.02667	1	.02667	
Within groups	984.3583	22	44.7436	.0006
Total	984.3850	23		

TABLE XVI

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN INITIAL AND FINAL TESTS OF STRENGTH IN THE FULL DRAW POSITION BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	22.0417	1	22.0417	
Within groups	507.0633	22	23.0483	.9563
Total	529.1050	23		

The analysis of variance was again used to compare the differences between initial and final strength tests of the half draw position and for bow arm strength between the two groups. The results shown in Table XVII, page 46, and Table XVIII, page 46, indicated that there were no statistically significant differences.

The evidence indicated that there was a statistically significant increase in all the measures of strength for each group. Table XIX, page 47, shows the results of this statistical analysis. Both groups improved significantly in terms of shooting ability from the initial to the final test as is shown by Table XX, page 48.

INTERPRETATIONS OF FINDINGS

Using the analysis of variance technique, the two groups were compared for difference in an initial test of accuracy using the total score for the Junior Columbia Round and the total number of hits scored for the round. The analysis of variance showed that the two groups were equated initially in terms of shooting scores. It is possible that the subjects comprising the control group have had greater archery experience than those of the experimental group, thus accounting for the differences in scores. Three subjects in the control group were graduate students in physical education, whereas only one subject in the experimental group was a graduate student in physical education. Since scores were recorded for only one round of shooting, it is possible also that this was not sufficient shooting to provide a reliable indicator of consistency and accuracy of shooting ability.

TABLE XVII

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN INITIAL AND FINAL STRENGTH TESTS OF THE HALF DRAW POSITION BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	14.2604	1	14.2604	
Within groups	531.4992	22	24.1591	.5903
Total	545.7596	23		

TABLE XVIII

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN INITIAL AND FINAL TESTS OF BOW ARM STRENGTH BETWEEN EXPERIMENTAL AND CONTROL GROUPS

Source of Variation	Sum of Squares	df	Mean Square	F
Between groups	12.4704	1	12.4704	
Within groups	317.6558	22	14.4389	.8637
Total	330.1263	23		

TABLE XIX

SIGNIFICANCE OF DIFFERENCES OF CHANGES BETWEEN INITIAL AND FINAL STRENGTH MEASURES WITHIN EXPERIMENTAL AND CONTROL GROUPS

Strength Measure	Group	Mean**	Standard Deviation	Standard Error of Mean	"t"
Shoulder abduction	1	6.3583	5.6954	1.7172	3.7027*
	2	6.2917	7.5531	2.2773	2.7628*
Full draw	1	7.4833	6.0287	1.8177	4.1169*
	2	5.5667	3.1227	.9385	5.9315*
Half draw	1	6.8833	4.8581	1.4647	4.6995*
	2	8.4250	4.9716	1.4990	5.6204*
Bow arm	1	3.8667	3.1149	.9392	4.1170*
	2	5.3083	4.3790	1.3203	3.3167*

*Significant at the .05 per cent level of confidence.
**Measured in pounds.

TABLE XX

SIGNIFICANCE OF DIFFERENCES OF CHANGES BETWEEN INITIAL AND FINAL TESTS OF SHOOTING ABILITY FOR EXPERIMENTAL AND CONTROL GROUPS

Shooting Test	Group	Mean**	Standard Deviation	Standard Error of Mean	"t"
Junior Columbia	1	51.3333	28.3672	8.5528	6.0019*
round	2	37.9167	33.7974	10.1901	3.7209*
Number of hits	1	6.4167	4.2950	1.295	4.9550*
scored	2	4.7500	4.8641	1.4665	3.2390*

*Significant at the .05 per cent level of confidence.
**Measured in pounds.

In order to compare the two groups for the final test of shooting ability, it was necessary to apply the analysis of covariance technique to adjust for initial differences between the two groups. On the basis of these adjusted means, it was found that there were no significant differences. It should be noted that the final testing took place during the final examination period, thus subjecting the results to the possibility of effects from the physical and mental fatigue and stress incurred by the subjects during an examination period. An additional factor which may have had some bearing on the outcomes of this study was the state of turmoil throughout the campus created by the Cambodian Crisis which occurred during this time. Five of the original subjects were dropped from the study when it was learned that they had chosen not to remain in school during final examination period. Another subject was also dropped due to ill health. Of the subjects dropped, there were three in each of the two groups.

The subjects were tested on four measures of arm and shoulder strength. The results of the initial tests of strength indicated that the two groups were equated with respect to the strength measured. The members of the experimental group were then subjected to a period of isometric exercises daily for three weeks. Both groups were again tested on the four measures of strength. The analysis of variance revealed no significant differences between groups either in the final test or from the initial to the final test.

Although there were no statistically significant differences between the groups, both groups evidenced statistically significant strength gains from the initial to the final tests. This was true for all measures of strength as well as shooting scores. It is possible that the subjects were better motivated in the final testing period or that after having had the initial tests, the subjects were more familiar with the testing procedures and thus able to perform more effectively.

One subject in the experimental group was unable to train with the entire group, therefore, she took her exercises under the supervision of the investigator at another time. This subject was the weakest member of the experimental group on the initial tests of strength and showed greater gains than any other subject. It is important to note that she had the greatest potential for strength gains. It is possible that this subject showed greater gains from the conditioning program due to the fact that she felt compelled to give greater all out effort than the subjects training as a group, or that the investigator was able to give greater motivation to one subject as opposed to a group.

In order for a muscle to increase in strength, it must be overloaded. The fact that both groups showed appreciable gains would seem to indicate that the exercises performed were not necessarily the reason for the experimental group's improvement in strength gains. The apparent failure of the exercise program to produce greater significant results within the experimental group could have been due to the number of repetitions performed, to the length of the exercise program, or to the frequency of performance. One difficulty frequently incurred with using isometric exercise is that of determining two-thirds maximum contraction, and it is possible that this level of contraction was not reached by each subject when performing the exercises.

CHAPTER V

SUMMARY AND CONCLUSIONS

The investigator attempted to answer the following questions in conducting this study: (1) Will a short term program of isometric exercises result in increased shooting accuracy? (2) Will a short term program of isometric exercises result in a significant strength increase?

It was the purpose of this study to determine if there were a significant difference between subjects in an experimental group and a control group with respect to arm and shoulder girdle strength, shooting accuracy, and total archery score prior to or following the experimental phase of the study.

The twenty-four subjects who participated in this study were women students enrolled at The University of North Carolina at Greensboro during the second semester of the 1969-70 academic year. All of the subjects had had previous experience in archery.

The subjects were divided into two groups and assigned to either the experimental or control condition. Subjects were equated in terms of strength at the beginning of the study. Both groups were given cable tensiometer strength tests and asked to shoot a Junior Columbia Round in archery. The experimental group was then given a program of isometric exercises designed to increase arm and shoulder girdle strength. The program consisted of four six-second bouts of isometric contractions with four repetitions of each exercise daily for a period of fifteen days.

The groups were retested on strength measures and shooting ability. The raw data were treated statistically to determine the significance of differences between initial and final tests of strength, total archery scores, and number of hits scored.

The following results were obtained:

1. None of the differences between groups for any measures of strength in the initial tests were statistically significant.
2. Archery scores of Group I (control group) were statistically higher than those of Group II at the .05 per cent level of confidence on the initial shooting test.
3. There was a significant difference between the groups with respect to the number of hits scored during the initial shooting test.
4. Neither the archery scores nor number of hits scored were statistically different between groups at the final testing.
5. There were no significant differences between the two groups for measures of strength on the final tests.
6. Both groups improved significantly in strength from the initial period to the final testing period.
7. There was a significant change in archery scores for both groups between initial and final testing sessions.

As a result of the findings of this study, the following conclusion was drawn: a short term program of isometric exercises such as used in this study was not effective in producing more significant strength gains or a more significant increase in shooting accuracy among college women archers experiencing the program than those who did not.

As a result of the findings and procedures of this study, the following suggestions are made should the study be repeated:

1. The subjects should have a pre-test trial of each of the tests involved in the study to familiarize them with the procedures involved in the tests.
2. The number of subjects should be increased.
3. The duration of the experimental exercise program should be continued for five weeks or longer.
4. The number of rounds of shooting should be increased and perhaps the shooting distance increased to fifty or sixty yards.
5. To avoid influencing the results by factors of mental and physical fatigue and stress, the study should be undertaken at such time as to allow at least seven weeks for participation and completion of the study, and the proximity to a final examination period should be avoided.

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APPENDIXES

APPENDIX A

Illustrations of Tests

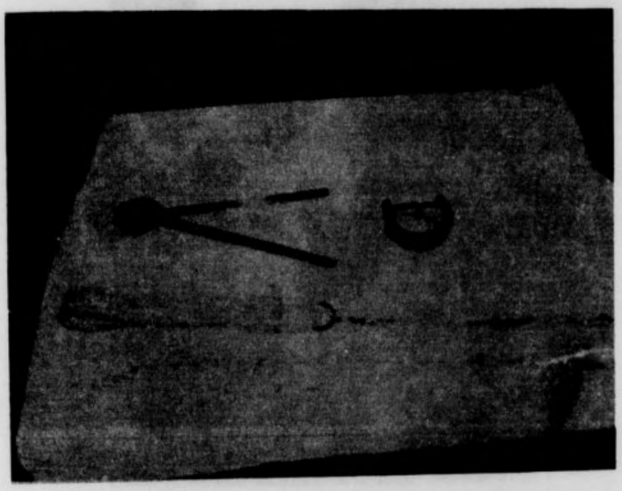

FIGURE 1

TESTING APPARATUS

FIGURE 2

SHOULDER ABDUCTION STRENGTH TEST

FIGURE 3

FOREARM AND SHOULDER FLEXION TEST

FIGURE 4
HORIZONTAL SHOULDER AND FOREARM FLEXION TEST

FIGURE 5

BOW ARM AND SHOULDER EXTENSION TEST

APPENDIX B

Description of Exercises

Calibration Chart for Cable Tensiometer

DESCRIPTION OF EXERCISES

1. The subject should stand with (her) weight evenly distributed on both feet. The arms are held at shoulder level with the hands clasped (by finger tips) in front of the body. The elbows are kept parallel to the floor. As the muscles are contracted, the hands are pulled in opposition to each other. The grip is not released. The contraction is held for six seconds. Repeat the exercise four times with a five-second rest period between each bout.

2. Assume the same position as in the previous exercise except the grip is released and the shoulder blades are pulled close together. The elbows are held high and the palms are turned downward with the fingers of the hands extended forward. As the muscles of the shoulders are contracted, the shoulder blades are pulled together with the arms held horizontal. The contraction is held for six seconds and the exercise is repeated four times.

3. A rope is attached to the wall and adjusted in length and height to the individual. The subject should stand with the feet apart as if shooting a bow, with the palm of the bow hand placed against the wall. The rope is pulled (as if shooting a bow) to a full draw position. To measure the full draw position, pull the rope until the hand of the pulling arm is in the anchor position for shooting. The elbows are held parallel to the floor. Do not push against the wall with the other arm. The contraction is held for six seconds and the exercise is repeated four times.

4. The rope is attached to the wall as in previous exercise. The subject should assume a proper shooting position and hold the rope in the bow hand with the string arm next to the wall. The rope is pushed as if holding a fully drawn bow. Hold the contraction for six seconds and repeat the exercise four times.

CALIBRATION CHART FOR CABLE TENSIOMETER

Instrument Reading	Tension Pounds	Instrument Reading	Tension Pounds
2	5	32	48
3	6	33	50
4	7	34	52
5	8	35	55
6	10	36	57
7	12	37	58
8	15	38	60
9	16	39	61
10	17	40	62
11	18	41	64
12	20	42	65
13	21	43	67
14	22	44	70
15	23	45	72
16	25	46	75
17	26	47	77
18	27	48	78
19	28	49	80
20	30	50	82
21	32	51	83
22	33	52	85
23	35	53	88
24	36	54	90
25	37	55	92
26	39	56	93
27	40	57	95
28	41	58	97
29	43	59	100
30	45		
31	47		

APPENDIX C

Sample of Archery Score Sheet

Sample of Subject's Score Card for All Tests

SAMPLE OF ARCHERY SCORE SHEET

Name ____________________

Round Junior Columbia

Date Initial Test

At 40 Yds.						Hits	Score
7	7	5	3	0	0	4	22
9	5	3	3	3	1	6	24
9	7	7	5	5	0	5	33
7	5	5	3	3	0	5	23
						20	102

SAMPLE OF SUBJECT'S SCORE CARD FOR ALL TESTS

Name ______________________ Telephone Number ____________

Address ____

Test	Initial Test		Final Test	
Strength Tests	Instrument Reading	Tension Pounds	Instrument Reading	Tension Pounds
Shoulder Abduction				
Half Draw				
Full Draw				
Bow Arm				
Archery Tests	Initial Test		Final Test	
Archery Scores				
Number of Hits Scored				

APPENDIX D

Raw Data

RAW DATA

RESULTS OF ARCHERY TESTS - SHOOTING SCORES

	Initial Test	Final Test	Differences
Group I			
1.	353	394	41
2.	268	339	71
3.	291	236	-55
4.	246	260	14
5.	210	257	47
6.	381	439	58
7.	377	407	30
8.	273	214	-59
9.	292	168	-124
10.	150	131	-19
11.	198	152	-46
12	172	120	-52
Group II			
1.	179	185	6
2.	111	117	6
3.	178	269	91
4.	187	168	-19
5.	293	286	-7
6.	230	152	-78
7.	249	257	8
8.	166	222	56
9.	117	207	90
10.	295	244	-51
11.	171	141	-30
12.	178	165	-13

RAW DATA

RESULTS OF ARCHERY TESTS - NUMBER OF HITS SCORED

	Initial Test	Final Test	Differences
Group I			
1.	63	68	5
2.	58	67	9
3.	57	48	-9
4.	54	50	-4
5.	47	59	12
6.	67	69	2
7.	67	69	2
8.	53	48	-5
9.	54	38	-16
10.	40	37	-3
11.	42	38	-4
12.	38	32	-6
Group II			
1.	38	41	2
2.	31	29	-2
3.	36	36	0
4.	41	42	1
5.	55	56	1
6.	52	37	-15
7.	53	60	7
8.	44	48	4
9.	27	37	10
10.	61	60	-1
11.	43	32	-11
12.	40	37	-3

RAW DATA

RESULTS OF STRENGTH TESTS - SHOULDER ABDUCTION

	Initial Test		Final Test		
	Reading-Tension Lbs.		Reading-Tension Lbs.		
Shoulder Abduction	Lbs.	Conversion Lbs.	Lbs.	Conversion Lbs.	Differences
Group I					
1.	17	26.2	26	38.6	12.4
2.	3	6.2	12	20.0	13.8
3.	26	38.6	20	30.0	8.6
4.	31	46.6	33	50.0	3.4
5.	15	23.6	22	33.3	9.7
6.	31	46.6	39	61.2	14.6
7.	23	35.0	23	35.0	0
8.	28	41.6	27	40.0	-1.6
9.	18	27.5	19	28.6	1.1
10.	22	33.3	22	33.3	0
11.	13	21.2	12	20.0	-1.1
12.	25	37.5	18	27.5	-10
Group II					
1.	3	6.2	21	31.6	25.4
2.	17	26.2	17	26.2	0
3.	20	30.0	21	31.6	1.6
4.	24	36.2	21	31.6	-4.6
5.	22	33.3	18	27.5	-5.8
6.	25	37.5	26	38.6	1.1
7.	15	23.6	16	25.0	1.4
8.	25	37.5	22	33.3	-4.2
9.	12	20.0	22	33.3	13.3
10.	26	38.6	34	52.5	13.9
11.	22	33.3	21	31.6	-1.7
12.	18	27.5	16	25.0	-2.5

RAW DATA

RESULTS OF STRENGTH TESTS - FULL DRAW

Full Draw	Initial Test Reading - Tension Lbs.	Initial Test Conversion Lbs.	Final Test Reading - Tension Lbs.	Final Test Conversion Lbs.	Differences
Group I					
1.	24	36.2	34	52.5	16.3
2.	24	36.2	30	45.0	8.8
3.	28	41.6	31	46.6	6.6
4.	46	75.0	37	58.2	-16.8
5.	31	46.6	38	60.0	13.4
6.	32	48.2	27	40.0	-8.2
7.	33	50.0	34	52.5	2.5
8.	38	60.0	32	48.2	-11.8
9.	28	41.6	28	41.6	0
10.	28	41.6	29	43.3	1.7
11.	23	35.0	24	36.2	1.2
12.	40	62.5	38	60.0	-2.5
Group II					
1.	22	33.3	30	45.0	11.7
2.	34	52.5	31	46.6	-5.9
3.	28	41.6	29	43.3	1.7
4.	35	55.0	33	50.0	-5.0
5.	34	52.5	33	50.0	-2.5
6.	28	41.6	33	50.0	8.4
7.	21	31.2	24	36.2	5.0
8.	31	46.6	30	45.0	-1.6
9.	24	36.2	22	33.3	-2.9
10.	34	52.5	31	46.6	-5.9
11.	34	52.5	39	61.2	8.7
12.	30	45.0	34	52.5	7.5

RAW DATA

RESULTS OF STRENGTH TESTS - HALF DRAW

Half Draw	Initial Test Reading - Tension Lbs.	Initial Test Conversion Lbs.	Final Test Reading - Tension Lbs.	Final Test Conversion Lbs.	Differences
Group I					
1.	21	31.2	31	46.6	15.4
2.	24	36.2	23	35.0	-1.2
3.	22	33.3	20	30.0	-8.6
4.	46	75.0	48	77.0	2.0
5.	32	48.2	32	48.2	0.0
6.	38	60.0	34	52.5	-7.5
7.	38	60.0	32	48.2	-11.8
8.	34	52.5	41	63.6	11.1
9.	26	38.6	33	50.0	11.4
10.	33	50.0	35	55.0	5.0
11.	21	31.2	24	36.2	5.0
12.	38	60.0	41	63.6	3.6
Group II					
1.	22	33.3	23	35.0	1.7
2.	30	45.0	35	55.0	10.0
3.	28	41.6	31	46.6	5.0
4.	30	45.0	34	52.5	7.5
5.	34	52.5	31	46.6	-5.9
6.	30	45.0	33	50.0	5.0
7.	22	33.3	26	38.6	5.3
8.	25	37.5	32	48.2	10.7
9.	20	30.0	30	45.0	15.0
10.	47	76.6	38	60.0	-16.6
11.	31	46.6	33	50.0	3.4
12.	28	41.6	36	56.6	15.0

RAW DATA

RESULTS OF STRENGTH TESTS - BOW ARM

Bow Arm	Initial Test Reading - Tension Lbs.	Initial Test Conversion Lbs.	Final Test Reading - Tension Lbs.	Final Test Conversion Lbs.	Differences
Group I					
1.	19	28.6	14	22.5	-6.1
2.	12	20.0	14	22.5	2.5
3.	16	25.0	21	31.6	6.6
4.	16	25.0	18	27.5	2.5
5.	17	26.2	20	30.0	3.8
6.	19	28.6	27	40.0	-2.4
7.	16	25.0	16	25.0	0.0
8.	14	22.5	21	31.6	9.1
9.	16	25.0	19	28.6	3.6
10.	15	23.6	14	22.5	-1.1
11.	12	20.0	12	20.0	0.0
12.	21	31.2	14	22.5	-8.7
Group II					
1.	17	26.2	14	22.5	-3.7
2.	22	33.3	26	38.6	5.3
3.	17	26.2	16	26.2	0.0
4.	21	31.6	14	22.5	-9.1
5.	19	28.6	19	28.6	0.0
6.	18	27.5	17	26.2	-1.3
7.	12	20.0	10	17.5	-2.5
8.	13	21.2	23	35.0	13.8
9.	14	22.5	22	33.3	10.8
10.	22	33.3	19	28.6	-4.7
11.	21	31.6	18	27.5	-4.1
12.	21	31.6	27	40.0	8.4