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A Comparison of Three Sit-up Exercises for Improving Abdominal Strength and Endurance

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A COMPARISON OF
THREE SIT-UP EXERCISES FOR IMPROVING
ABDOMINAL STRENGTH AND ENDURANCE

by

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This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Dr. James E. Lidstone, Assoc. Prof., Thesis Advisor and HPER Research Coordinator — Date

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DEDICATION

The author wishes to dedicate this research paper to his parents, John and Betty Dunford, and his brothers and sister, whose love and support made it possible for me to attend undergraduate and graduate school. Also, the author wishes to dedicate this research paper to Annie Tonsfeldt, whose friendship was much needed and appreciated during the research and writing of this thesis.

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CHAPTER I

INTRODUCTION

The sit-up has been prescribed and used for years as a means for improving abdominal strength (Halpern & Bleck, 1979). By strengthening the abdominal muscles a person can benefit other parts of the body as well. Strong abdominal muscles protect the vital organs located in the abdominal region, assist in elimination and breathing, and improve posture (Mozee, 1984).

The muscles that comprise the abdominal region are the rectus abdominus and the external and internal obliques. These muscles do very little during trunk movements unless resistance is applied in either the sitting or standing positions (Partridge & Walters, 1959; Borkowicz, 1981).

The rectus abdominus is a long, slender muscle that extends vertically across the front of the abdominal wall. It originates on the crest of the pubis and inserts on the cartilages of the fifth, sixth, and seventh ribs (Hinson, 1981; Yessis, 1986).

The external oblique covers the front and side of the abdominal wall from the rectus abdominus to the latissimus dorsi. It originates on the lower eight ribs in alternation with the attachments of the serratus anterior and the latissimus. It inserts on the front half of the crest of the ilium, the upper edge of the fascia of the thigh, the crest of the pubis and the linea alba (Hinson, 1981; Yessis, 1986).

The internal oblique is located beneath the external oblique. It originates on the lumbar fascia, the anterior two-thirds of the crest of the ilium and the lateral half of the inguinal ligament. Insertion is on the cartilages of the eighth, ninth and tenth ribs and the linea alba (Hinson, 1981; Yessis, 1986).

The abdominal muscles are the least used muscles in the body (Mozee, 1984) and, like any other muscles, they can deteriorate from lack of use and fat will accumulate around the muscles. By isolating the abdominal muscles during exercise abdominal strength will improve at a faster rate. It is commonly believed that improving the strength of the abdominal muscles may also reduce lower back pain (Flint, 1958; Mozee, 1984; Vincent & Britten, 1980; Couch, 1980; Stamford, 1985; Halpern & Bleck, 1979). Flint (1958) showed that increasing abdominal power to a level concomittant with the back musculature brought relief from low back pain.

There are a variety of exercises that one can do to develop abdominal muscles. Many individuals do some form of sit-up exercise to increase abdominal strength and endurance. The sit-up should be performed with the knees bent in order to reduce pressure on the lower back muscles (Vincent & Britten, 1980; Couch, 1980; Stamford, 1985). Any type of sit-up that is done in the long-lying position is not really working the abdominals but instead is strengthening the hip flexors which, many agree, are strong enough already (Couch, 1980; Vincent & Britten; 1980).

Yessis (1986) claims that a sit-up which will bring greater muscle development to the entire abdominal wall is the bench sit-up. In this sit-up, the abdominal muscles are responsible for flexion of the lower spine and involves the movement of the upper body toward the lower body. To perform the bench sit-up, the person sits crosswise on a bench with the pelvic girdle well supported and the feet on the floor. With the feet supported and the arms across the chest, the individual slowly leans backward until the trunk is slightly below horizontal, creating a slight hyperextension of the spine. The trunk is then raised upward to the original position by executing spinal flexion. The head is kept tilted slightly upward during the entire exercise. This exercise is geared more towards advanced exercisers due to the great involvement of abdominal and hip flexor muscles (Yessis, 1986).

Additionally, there are numerous exercise devices that are marketed commercially which claim to do wonders for the abdominal region however the validity of these devices is questionable. Most, if not all, are marketed without substantial research to support their claims. It is in the best interest of the public to determine if these, as well as more conventional ways of doing abdominal exercises are effective in increasing abdominal strength and abdominal endurance.

Statement of the Problem

The purpose of this study was to compare three methods of improving abdominal strength and endurance. More specifically, the study sought to determine whether three distinctly different sit-up exercises, the Rowing Exerciser, the Sit-N-Trim exercise, and the "crunch" exercise, were similar or different in their ability to effect changes in muscular strength and/or muscular endurance.

Hypotheses

The fundamental question to be answered by this study is, is there a sit-up exercise that will improve strength and endurance more than any other? The specific hypotheses tested were as follows:

1. There will be no significant difference in strength gain between subjects in the Sit-N-Trim and crunch groups but there will be a significant difference between these two groups and the Rowing Exerciser group.

2. There will be no significant difference in endurance gain between subjects in the Sit-N-Trim and the crunch groups but there will be a difference between these two groups and the Rowing Exerciser group.

Definintion of Terms

Sit-N-Trim: The Sit-N-Trim is a metal device that attaches to a door knob. A piece of flexible rubber tubing is threaded through two eyelets at the top of the device. The subject sits in a chair in a comfortable position, slightly slouched, with feet extended in front of the body. The subject grabs each end of the rubber tubing and pulls the hands in tight to the chest. The subject then slowly curls down as far as possible against the resistance supplied by the rubber tubing and holds this position for a count of one. The subject then twists for one count to the left and one count to the right before returning to the middle for a count of one. The subject returns to the starting position and repeats the sequence.

Crunch Sit-up: To perform the "crunch" sit-up the subject lies down and places his/her feet over a bench or railing. This serves to stabilize the subject during peformance of the exercise. The subject moves close to the bench or railing so that the thighs are perpendicular to the floor. The subject begins flat on his/her back and crosses the arms across the chest. The subject then curls slowly up and holds this position for a count of one and then twists to the left for a count of one and to the right for a count of one and then back to the middle. They hold this position for a count of one and then return slowly to the floor. The entire sequence is repeated until the set is finished.

Rowing Exercise: The Rowing Exerciser is a coil spring with a handle at one end and two stirrups at the other. To perform the exercise the subject sits on the floor, places the feet in the stirrups and grasps hold of the handle with the knuckles of the hands pointing up. The subject lies back holding the handle until he/she is lying flat on his/her back. The subject then rises back up to a sitting position with the mild assistance of the coiled spring.

Abdominal Strength: Abdominal strength is the ability of the abdominal muscles to exert an external force and the amount of force the muscles can produce with a single maximal effort (Corbin & Lindsey, 1985). For the purpose of this study abdominal strength will be operationally defined as the peak torque that the muscles can generate during three contractions on the orthotron at a resistance of 60 degrees/second.

Abdominal Endurance: Abdominal endurance is the ability of the abdominal muscles to repeatedly exert themselves. (Corbin & Lindsey, 1985). For the purpose of this study abdominal endurance will be operationally defined as the number of repetitions the abdominal muscles can generate during the Modified Curl-up Test (Robertson & Magnusdottir, 1987).

Peak Torque: Peak torque is the maximum amount of force generated during one repetition or a set of repetitions. For

the purpose of this study it will be defined as the maximum amount of force generated in any of three successive repetitions. It is measured in lbs. ft. (pounds force feet).

Orthotron: The orthotron is a machine that provides constant resistance to a joint through the joint's full range of motion. It is an isolated joint, reciprocal, isokinetic system used for rehabilitation, exercise, and testing of the ankle, knee, hip, and shoulder (Lumex, Inc.). It can be modified to measure torque generated by the abdominal muscles.

Assumptions Underlying the Research

For the purpose of this study the following were assumed to be true and therefore were not subject to validation as part of the research.

1. It is assumed that abdominal strength and endurance will not increase without some sort of abdominal exercise being performed.

2. It is assumed that the subjects performed the exercises each time in the prescribed manner.

3. It is assumed that the subjects did not perform any abdominal exercises outside what was asked of them in the context of the experiment.

4. It is assumed that the Orthotron does accurately assess abdominal strength.

5. It is assumed that the Modified Curl-up Test is a valid and reliable means by which to assess abdominal endurance.

6. It is assumed that males and females have equal capacity to improve abdominal strength and endurance.

Limitations

No research project is without its flaws. While every effort was made to optimize the internal and external validity of this investigation certain factors may limit the generalizability and applicability of the findings.

1. The subjects were not selected through scientific sampling procedures. The subjects were volunteers affiliated in some way with the physical education program at South Dakota State University.

2. The study began with 45 subjects, 15 in each group. Because of the demands placed on students and faculty in the latter stages of the academic semester subject attrition was quite high.

3. No familiarization session was provided for the Orthotron or the Modified Curl-up Test. As such, fluctuation in subject scores may, in part, be due to learning.

4. The Orthotron accurately assesses the peak torque that the subject can generate through a range of motion, however, there was no way to completely eliminate the function of the hip flexor muscles and, thereby, isolate the effect of the abdominal muscles in contributing to peak torque.

Scope of the Study

The study was conducted during the spring semester of 1988 at South Dakota State University. Subjects were volunteers ranging in age from 18-40. A total of 34 people participated in this study.

Subjects were given two pretests, an Orthotron test to assess abdominal strength, and a curl-up test to assess abdominal endurance. Subjects were randomly assigned to one of three treatment groups and performed the prescribed exercise three times a week for seven weeks. At the end of the seven week period the subjects were given the posttests for abdominal strength and endurance. Data were gathered in the Brookings Sports Medicine Center facilities located in the Stanley J. Marshall HPER Center.

Significance of the Study

Physicians have continuously prescribed sit-up exercises to their patients for a variety of conditions. A goal for these prescriptions is to strengthen the abdominal muscles (Halpern & Bleck, 1979). A major medical problem with many people is low back pain. Researchers have found that the basic cause of lower back pain and discomfort is due to the lack of abdominal strength and poor postural problems (Kraus, 1970).

With the number of sit-up exercises and sit-up exercise devices available, it is important to determine if these exercises or devices are capable of improving abdominal muscle

strength and endurance. The purpose of this research is to assess whether or not these three methods of performing abdominal exercises do, in fact, elicit improvements in abdominal strength and endurance.

CHAPTER II

REVIEW OF RELATED LITERATURE

The literature pertaining to this study has been classified under three major categories: (a) electromyographic studies, (b) biomechanical analysis, and (c) measurement and evaluation of abdominal strength and endurance.

Electromyographic Studies

Partridge and Walters (1957) conducted a comprehensive study with electromyography, of abdominal action in various positions during exercise. The exercises used were the sit-up with feet held and not held, the "V" sit-up, the reverse curl, the trunk curl against a resistance and with no resistance, sit-up with a twist and a double leg lift. Two healthy, well-trained female subjects were used for this study. One subject was an adult and the other subject was a ten year old. Both had good abdominal musculature. In all, 3360 observations were made on the two subjects and, for comparative purposes, all measurements were done on the same day. Observations were made on the behavior of the upper and lower rectus abdominus, the interior, middle, and posterior fibers of the external oblique and the middle fibers of the internal oblique during the various abdominal exercises. Observations were also made on the hip flexors during some of the exercises to see how much they were involved in the performance of the task.

It was found that the hip flexors participated less when the angle at the knees was 65 degrees as opposed to 90 degrees. It was also found that hip flexors participated a great deal more when the feet were held by a strap or another person than when the feet were unanchored. The less the hip flexors are active, the more effort is needed from the abdominal muscles. It was found that the upper rectus abdominus participated to a greater extent during the sit-up with the feet held, the trunk curl with no resistance, the sit-up with a twist and the double leg lift. The lower rectus abdominus was more involved during the sit-up with the feet not held, the "V" sit-up, and the reverse curl. The "V" sit-up was found to be very effective for the external oblique muscle while the reverse curl and the sit-up with the feet unanchored proved to be good exercises for the internal oblique. Walters and Partridge (1957) concluded that the sit-up, with its modifications and variations in the trunk curl, and the "V" sit-up are the most effective exercises for all of the abdominal muscles.

Partridge and Walters (1959) utilized the same data from the 1957 study but this time focused on the external and internal obliques. The authors found that little activity was done by the external oblique and the rectus abdominus during trunk movements without resistance in the sitting or standing positions. Also, if the sit-up was done without a twist phase, the external

oblique and the rectus abdominus ceased contracting when the trunk reached an erect posture or 90 degrees (Partridge & Walters, 1959).

Flint (1965) looked at 10 variations of the sit-up using electromyography to determine which sit-up movement evoked the greatest muscle activity. Ten female students ranging in age from 18 to 25 were subjects in the study and each was considered to be in excellent physical condition with well-defined musculature. They were trained in the proper execution of the exercises: the sit-up with feet supported and unsupported; the curl-up with feet supported and unsupported, and feet supported and knees flexed 45 degrees; the sit-up with knees flexed 45 degrees and feet supported and unsupported; and the curl-up with a trunk twist, knees flexed 45 degrees and feet supported and unsupported. Each subject performed two repetitions of each exercise.

It was concluded that action potential was higher for the lower rectus abdominus when the feet were supported, that action potential was higher for the upper rectus abdominus during sit-ups when the feet were unsupported, and that the lower rectus abdominus remained in partial contraction while the trunk was flexed between 60 and 90 degrees in order to maintain trunk position. It was also found that the abdominal muscles were responsible for trunk flexion upward to 45 degrees and back down and that muscle activity decreases from 45 degrees to

perpendicular. The exercises involving flexed knees and with the back curled appeared to elicit the greatest response but no definite conclusion could be reached because of the lack of a clearly defined and consistent pattern of high potential readings. Trunk raising elicited a greater action potential than trunk lowering. The favored abdominal exercises were the trunk curl, knees flexed with body twist and feet supported or unsupported, the trunk curl with knees flexed and feet supported, and the sit-up with knees flexed and feet supported (Flint, 1965).

Godfrey, Kindig, and Windell (1977) conducted a study in which they looked at the duration of muscle activity for various sit-up exercises. Seventeen college women were studied performing eight sit-up variations in order to determine the best method for maximizing abdominal muscle activity and minimizing hip flexor activities. The sit-up exercises performed in this study were the hook-lying and long-lying sit-ups with feet supported and unsupported and slow and fast speeds of performance. Each subject performed five repetitions of each sit-up variation with a two minute rest between each one. It was found that the long-lying sit-up with feet supported was more demanding of the rectus abdominus than the hook-lying sit-up with feet supported. The hook-lying variations did not differ from one another. The hook-lying variations with feet unsupported were as desirable for total concentric duration of activity of

the rectus abdominus as the other variations with less duration of activity of the hip flexors (Godfrey, Kindig, & Windell, 1977).

Halpern and Bleck (1979) conducted a study in an attempt to apply scientific principles to common practice using five subjects. The subjects performed five repetitions of four different types of sit-up exercises recommended in orthopedic and physical therapy literature and one type in which the subject elevates the trunk only to a point where the scapula is lifted from the mat (shoulder lift). The four methods recommended by the literature were the long-lying sit-up, the crossed long-lying sit-up (in which the subject rises up and touches the right hand to the left foot, and vice versa), the hook-lying sit-up, and the hook-lying sit-up with a twist added. The results showed that the shoulder lift hook-lying sit-up produced the greatest duration of activity (90%) while the others were all less than 50%. The authors also found that this type of sit-up required the least amount of flexion of the lumbar spine and was less likely to result in an increased force across the lumbar disc (Halpern & Bleck, 1979).

Borkowicz (1981) looked at eight sit-up variations to determine which sit-up produced the most muscular activity. Subjects were male undergraduate physical education majors at the University of Wisconsin-Milwaukee. Subjects had to be capable of performing 50 sit-ups within one minute. The sit-up

exercises used were: (a) legs over a chair, (b) legs over chair with a sit-up bag, (c) legs straight, (d) legs straight with a sit-up bag, (e) knees bent, (f) knees bent with a sit-up bag, (g) a 30 degree incline board with legs straight, and (h) the incline board with straight legs and the sit-up bag. The feet were supported during each exercise. The subjects performed one repetition of each particular exercise followed by a three second rest period and then repeated the exercise a second time. Each sit-up exercise was performed at a rate of one complete sit-up per four seconds and there was at least a one minute rest period between the different exercises.

This study showed that the 30 degree incline board with legs straight and a sit-up bag produced the greatest amount of muscle activity. The authors concluded that the use of resistance plays a significant part in developing greater abdominal strength. The study also found that the most productive phase of each sit-up exercise occurred from the supine position to a 45 degree angle and back down to a lying position (Borkowicz, 1981).

Biomechanical Analysis

There are many different methods currently being used for doing sit-ups and it is critical to know which technique provides the most positive and beneficial results. Ricci, Marchetti, and Figura (1981) studied the interplay among some biomechanical aspects of four types of sit-ups; (a) the long-lying position,

(b) the hook-lying position, (c) both legs elevated (hips flexed at 150 degrees), and (d) the curl-up. Four male subjects volunteered for this study. The first three exercises were performed 10 times while the curl-up was performed 30 times. Each subject was secured immediately above the knee joint and at the ankle joint to a force monitoring, trunk displacement apparatus. The trunk was stabilized using a cloth head harness attached to the backrest. This way the head and trunk were properly aligned for the first three sit-up exercises.

The results showed that with trunk stabilization, the lumbar region was hollowed (lumbar curvature), the pelvis tilted forward, and the upper trunk was hyperextended before the performance of each type of sit-up. They also concluded that the rectus abdominus and the external oblique are involved initially in eccentric contraction in response to pelvic rotation, followed by concentric contraction and then isometric contraction. They discovered that, for the curl-up, the abdominal muscles were stressed the most from 170 degrees to 130 degrees and then the hip flexors took over. Lastly, they found that a variety of lower leg muscles are involved when performing sit-ups and concluded that lower limb muscle development could possibly result from doing sit-up exercises (Ricci, Marchetti, & Figura, 1981).

Kelly (1982) offered some thoughts about sit-ups that appear to be supported by the research. He stated that if a

person wanted to mildly work the anterior abdominal muscles, then simply lifting the head off the floor from a supine position would be sufficient. If more activity was desired, then a continual curl upward to a held position would suffice. He stated that there should be minimal low back curvature in all sit-up activities and this could be done by contracting the abdominal muscles in order to tilt the pelvis posteriorly. Kelly suggested that arm and hand placement be used to increase muscular exertion but a vigorous pulling on the back of the head or throwing the limbs forward should be avoided (Kelly, 1982).

Bullivant, Burchell, Chamberlain, Miller, and Wareham (1986) evaluated three sit-up techniques, the straight leg sit-up, the bent leg sit-up and the bench sit-up. Five subjects took part in this study which examined: (a) the forces applied by subject while performing the three different sit-up techniques, and (b) the muscular activity taking place in the abdominals during the sit-ups. Force was measured by means of an Electronic Force Dynamometer and muscle activity was monitored using electrodes attached to the subjects' abdominal area.

The results showed slight differences between the sit-up techniques. An expected result showed that the role of the hip flexors and hyperextension of the lumbar region became less significant as the angle between the trunk and thigh decreased. Muscle activity was difficult to compare due to varying degrees of body fat covering the abdominals and irregularities in

placement of the electrodes and sensitivity of reception (Bullivant, et al., 1986).

Measurement and Evaluation of Abdominal Strength and Endurance

There are many methods that have been used to assess abdominal strength and endurance. Walters and Harris, in 1953, devised an apparatus that would objectively measure the isolated strength and endurance of the abdominal muscles. A table was constructed with a large coil running horizontally beneath the table. Attached to the coil were a movable lever and a resistance rod. The movable lever surrounded the top end of the table and its purpose was to transfer the resistance from the coil to the chest of the subject by means of a bar that was placed across the subject's chest. Pressure would cause the lever to be raised. The resistance rod was used to tighten the coil so any desired resistance could be achieved. The subject would lie on the table in a hook-lying position with the knees bent at a right angle. The bar was then placed and fastened securely across the subject's chest two inches below shoulder level. The subject would curl the trunk up as far off the table as possible keeping the arms and hands at the side of the body and off the table. This position was held for 30 seconds against a resistance of 20 pounds.

Validity of this apparatus was determined by expert opinion and by a test conducted on a paraplegic who had no use of the hip flexor muscles. Reliability was determined for both muscular

strength and endurance using a test-retest procedure. Two to five days separated the tests and reliability was found to be .79 for abdominal muscle strength and .83 for abdominal muscular endurance (Walters & Harris, 1953).

Davies and Gould (1982) conducted a study that examined trunk testing using a prototype Cybex II Isokinetic Dynamometer Stabilization System. Findings were based on tests on 160 subjects (98 males and 62 females) for various isometric and isokinetic trunk measurements of strength and power. Subjects were placed on a stabilized dynamometer and testing frame and moved either superiorly or inferiorly so that the subject's clinical anatomical axis was aligned with the input axis shaft of the dynamometer. The axis used was the L5-S1 articulation. A bar was placed posteriorly at the level of the popliteal fossa with 15 degrees of knee flexion to avoid hamstring strain. Straps were used at the feet, distal quadriceps and pelvic area for stabilization but to permit movement through the intended range of motion. A roller bar was placed on the trunk posteriorly and distal to the spine of the scapula. A second bar was placed on the anterior trunk just below the suprasternal notch. The hands were placed across the chest and grasped the anterior trunk bar. Trunk flexion was tested first followed by trunk extension. Subjects performed three repetitions.

Results showed an increase in force production at the 45 degree position in both trunk flexion and extension. Trunk

flexion showed an increase by 16.4% for males and 25.1% for females while trunk extension showed an increase of 15% for males and 10.1% for females. This was most likely due to the biomechanical leverage and musculotendinous length tension ratio of the spine and hip at the 45 degree angle. Information from this study is useful in providing clinical guidelines for testing and rehabilitation (Davies & Gould, 1982).

Baldauf, Swenson, Medeiros, and Radtka (1984) did an assessment of trunk flexor muscle strength on healthy girls between the ages of three and seven. Seventy-five girls who had no history of hip or trunk surgery and who had the ability to perform neck flexion in the supine position through the full range of motion served as subjects. The girls were placed into five groups according to chronological age. A thigh stabilization board was constructed to support each subject's hips in 90 degrees of flexion during the testing. The lower legs rested over the top of the board with approximately 120 degrees of knee flexion. The subjects were placed in the supine position in a modified sit-up position with hips flexed 90 degrees and knees flexed at 120 degrees in order to maximize abdominal muscle activity and minimize hip flexor activity. There were six test grades assigned, Normal, Good, Fair, Poor, Trace, and Zero. The criteria for achieving a grade consisted of the subject rising up until a marked vertebra came completely off the mat and was visible to an examiner sitting two feet away. For a

Normal grade, the hands were clasped behind the subject's neck and the arms were adducted over the ears. For the Good grade, the arms were folded over the chest and for the Fair grade, the arms were extended with about 90 degrees of shoulder flexion. A Poor grade was assigned if the subject could not achieve a Fair grade but was able to flex the cervical spine and partially lift the scapulae off the mat. A Trace grade was assigned if the Poor grade was not attained but the subject was able to contract the abdominal muscles during coughing, exhaling, or attempting to flex the trunk. A Zero grade was given if no abdominal muscle activity could be palpated. A maximum of three trials for each muscle grade was allowed and each subject was allowed one practice for each movement.

The researchers found that the average muscle grade for three to four year olds was Fair, for five to six year olds it was Good and for seven year olds it was Normal. They discovered that with these subjects, muscle strength increased proportionately with age by about one-third of a muscle grade per year (Baldauf, et al., 1984).

Peterson, Amundsen, and Schendel (1987) compared the effectiveness of two pelvic stabilization systems on pelvic movement during maximal isometric trunk extension and flexion muscle contractions. The researchers developed a pelvic fixation system that consisted of fixation of the anterior superior iliac spines and sacrum and compared it to a pelvic

strap stabilization system consisting of straps across the anterior superior iliac spines and a posterior pad. Ten subjects, with no previous history of back surgery, spinal deformity, hip problems or back pain at the time of testing, were studied. Subjects were tested in a natural sitting position that emphasized weight bearing over the ischial tuberosities in a position of neutral anterior-posterior pelvic tilt. The attachment to the load cell and chest harness was visually adjusted to 90 degrees on each subject. Subjects performed three maximal isometric trunk extension and flexion muscle strength tests in four situations. The four situations were the use of the prototypal pelvic fixation system in a fully supported sitting position without stabilization of the lower extremities, the use of the pelvic strap stabilization system in a fully supported sitting position without stabilization of the lower extremities, and the use of each of the above systems with stabilization of the lower extremities. Markings were made on the subjects' bodies in order to document the change in position of the pelvis.

Results showed that the pelvis moved more with the pelvic strap stabilization system than with the prototypal pelvic fixation system during isometric extension and contraction and that the pelvis tilted posteriorly during extension testing. During isometric flexion testing pelvic movement was not affected by the type of pelvic or lower extremity stabilization

system and the pelvis tilted anteriorly during flexion testing. The authors supported the need for stabilization of the pelvis during testing of individual muscle groups to prevent movement (Peterson, Amundsen, & Schendel, 1987).

Noble (1975) conducted a study that evaluated a new method for administering a trunk curl test of abdominal muscular endurance. The test used a cardboard cutout that could be held at the level of the navel of the subject and situated perpendicular to the floor. For performance of the curl-up the subject's fingers were interlaced behind the head, with the knees bent, and feet unsupported. The elbows had to touch the cardboard in order to count as a score. Subjects were 48 males and 48 females, ranging in age from 18-60. Four trials were given to determine test-retest reliability for both untimed and timed trials. Reliability coefficients of .91 were found for both timed and untimed trials for females and reliability coefficients of .80 and .84 were found for timed and untimed trials, respectively, for males (Noble, 1975).

Robertson and Magnusdottir (1987) evaluated criteria associated with abdominal fitness testing. They evaluated a new modified curl-up test (CUT) against a standardized modified sit-up test (SUT). The curl-up test demands the most from the abdominal muscles with minimal demand on the hip flexors while the sit-up test demands the most from the hip flexor muscles with less demand on the abdominal muscles. Subjects consisted of

volunteer students in a kinesiology class. To perform the CUT, the subject was in the hook-lying position with arms by the side, forearms pronated, elbows locked, fingers straight and no foot restraint. The subject curled the head and upper back forward keeping the arms straight until they touched a special frame positioned 7.62 cm away from the longest fingertip. They then uncurled until the upper back touched the mat. The score for each subject was the number of curl-ups performed in one minute. To do the SUT, the subject was in the hook-lying position with the feet held and arms across the chest. The score was the number of times the subject could touch the forearms to the thighs in one minute.

The results showed almost 60% unexplained variance between the two techniques and the authors speculated that the unexplained variance may be due to the differences in abdominal and hip flexor muscle activity within each test and the difference in angular displacement of the trunk required for both tests (Robertson & Magnusdottir, 1987).

Summary

The sit-up is the most common exercise performed to strengthen the abdominal muscles and for increasing abdominal endurance. There is, however, a variety of sit-up exercises at one's disposal and most people would not have sufficient knowledge to be able to make a reasoned choice. The

electromyography studies appear to favor a trunk curl and a "V" sit-up as the most effective exercises (Partridge & Walters, 1957; Flint, 1965). Some of the studies also indicated that the use of resistance during sit-up performance may enhance muscular development (Borkowicz, 1981).

The proper method for performing a sit-up appears to be with the knees bent and feet unsupported to lessen the degree of work done by the hip flexors (Godfrey, Kindig, & Windell, 1977). The crunch exercise and the Sit-N-Trim place the subject in such a position that the angle between the trunk and the thighs is minimal. These positions lessen the degree of work done by the hip flexors (Bullivant, et. al., 1986) and thereby place more emphasis on the abdominal muscles. The feet are not supported in the Sit-N-Trim or crunch exercises. The heels of the feet are hooked over the bench or railing. In this position the work is being done by the hamstrings and not the hip flexors.

The new method for assessing abdominal endurance (CUT) seems to be appropriate (Robertson & Magnusdottir, 1987). The sit-up test employed in the various AAHPERD test batteries to assess abdominal muscle endurance has been used for years. The test, however, seems to be measuring hip flexor strength and endurance as well as some abdominal strength and endurance. The feet are anchored and the subject performs a sit-up by touching the elbows to the thighs. According to Partridge and Walter (1957), the hip flexors participate to a greater extent

when the feet are supported in some way. Flint (1965), and Borkowicz (1981), mention that the abdominal muscles are responsible for trunk flexion upward to 45 degrees and back down. The curl-up test (CUT), seems a logical method for testing abdominal muscle endurance, although work remains to be done in determining its validity. The feet are unsupported, the knees are bent, and the subject rises up to a position where the scapulae rise off the mat. This is consistent with the findings of Halpern and Bleck (1979) who discovered that the greatest duration of abdominal muscle activity (90%) occurred with a similar exercise.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to compare three methods of improving abdominal strength and endurance. More specifically, the study sought to determine whether three distinctly different sit-up exercises, the Rowing Exerciser, the Sit-N-Trim exercise, and the crunch exercise, were similar or different in their ability to effect changes in muscular strength and/or muscular endurance. For ease of presentation, this chapter is sub-divided into (a) subjects, (b) equipment, (c) pilot study, (d) pre-experiment procedures, (e) pretest procedures, (f) familiarization, (g) treatment period, (h) posttest procedures, and (i) analysis of data.

Subjects

Thirty-four subjects volunteered to take part in this study. Subjects were males and females between the ages of 18 and 40 who had some affiliation with South Dakota State University during the spring of 1988. The subjects consisted of a mix of students, faculty, staff, and spouses. Subjects were asked to refrain from doing abdominal exercises beyond what was asked of them during the seven weeks of the study. The subjects were randomly assigned to one of three abdominal exercise groups.

Equipment

The following equipment/apparatus were utilized during this study.

Sit-N-Trim: The Sit-N-Trim is a piece of exercise equipment manufactured by Applied Engineering of West Fargo, North Dakota. The inventor is Dr. Martin Johnson of Mayville State University. It is expected to be marketed in late fall. It is a metal device that attaches to a door knob. Two holes are located at the top of the device and a piece of rubber tubing is threaded through these holes. The tubing provides resistance as the subject performs the exercise.

Rowing Exerciser: The Rowing Exerciser is a device made in Taiwan and is widely available in department stores in the United States. It is a device that has two stirrups attached to one end of a coil spring and a handle attached to the other end. The subject sits on the floor, places her/his feet in the stirrups, grabs hold of the handle and leans back until the back touches the floor. The subject then performs full sit-up exercises with slight assistance from the action of the coil spring.

Orthotron: The Orthotron II (Lumex, Inc., Bay Shore, NY) is an isokinetic device and the machine was used for pre- and posttest procedures. Data were collected with the assistance of an IBM personal computer using the ISOSCAN II Software program. The Orthotron II was modified to interface with a microcomputer

through an interface box which transfers the electrical signal from the pressure transducer and the position signal from the potentiometer on the accuator of the Orthotron II to the microcomputer.

Other equipment involved in the study consisted of a four foot level used to determine a subject's anatomical zero position and a wristwatch with a stopwatch function for timing the Modified Curl-up Test.

Pilot Study

A pilot study was performed prior to the pretest. The purpose of the pilot study was to test procedures and equipment in order to find out if the Orthotron could be adapted to measure abdominal strength. Eight subjects volunteered to take part. Subjects sat on the edge of the Orthotron machine with one leg straddling the outside and the other leg on the inside edge. The subject was situated so that the back of the knees rested against the cushion. The top of the pelvic girdle was located on each subject and the center of the accuator was aligned at a spot about one inch from the top of the pelvic girdle. This is roughly where the fifth vertebra of the lumbar spine is located. The accuator arm was placed so that the pad was on the subject's chest and was secured with a velcro strap so the pad would not slide up and down on the chest during performance of the exercise. A strap was also placed across the thighs for stabilization. The accuator arm was placed at

vertical for anatomical zero but it was later decided that a level be used along the subject's back to determine anatomical zero. Data were collected to familiarize the investigator with the operation of the ISOSCAN II Software.

Pre-experimental Procedures

Prior to the pretest data collection, the researcher contacted prospective subjects and provided them with a brief description of the experiment. If the subjects expressed interest, they were invited to a general meeting. At this meeting, the administrator informed the subjects of the purpose of the experiment and that they would be pretested on the Orthotron for abdominal strength and on the modified curl-up test for abdominal muscular endurance. They were informed that they would be randomly placed in one of the three treatment groups and they would be required to come in three times a week for seven weeks, or a total of 21 treatment sessions. Subjects were told they could miss up two treatment sessions without being excluded from the study.

The three treatment groups were the Sit-N-Trim sit-up exercise, the crunch sit-up exercise, and the Rowing Exerciser. For the first two weeks of the study, subjects were told they would have to do one set of between 10 to 15 repetitions of the exercise they were assigned for each treatment session. For the next two weeks work increased to two sets of 10 to 15 repetitions. For the final three weeks of the study subjects

performed three sets of between 10 and 15 repetitions. Subjects were told that, at the end of the seven weeks, they would be posttested for abdominal strength in the same manner as the pretest. As an incentive they were informed that they would each receive a free Sit-N-Trim for participating in the study. Also, the decision was made to award a fifty dollar prize via a random drawing from those individuals who attended every treatment session.

At the conclusion of this briefing, a consent form was distributed (see Appendix A), read aloud, and anyone wishing to volunteer for the study was asked to sign and date the form. Following this, times were arranged to pretest the individuals on abdominal strength and endurance. Pretesting was carried out before the actual treatment sessions began.

Pretest Procedures

Abdominal Strength: Subjects were asked to come to the Brookings Sports Medicine Center facilities at the Stanley J. Marshall HPER Center on the campus of South Dakota State University for the pretest to assess beginning abdominal strength. Subjects were told to sit at one end of the Orthotron, with the right leg straddling the edge of the Orthotron on the inside and the left leg on the outside of the Orthotron. The axis of rotation was determined for each subject by locating the top of the pelvic girdle and setting the center of the axis of the accuator an inch below this point and along the midline of

the body. The lever arm pad was placed against the subject's chest and secured in such a manner to prevent the pad from sliding up and down on the chest. The lever arm was strapped around the subject's chest using a velcro strap. Another strap stabilized the thighs.

Once the subject was properly positioned on the Orthotron, relevant data was entered into the computer using the ISOSCAN II software program. Information gathered included:

1. Date of test
2. Name
3. Height
4. Weight
5. Sex
6. Age
7. Lever arm position
8. Accuator height
9. Approximate middle of the range of motion
10. Anatomical zero (determined by placing a 4 foot level against the subject's back while in an upright position)
11. Starting point for recording the data (expressed in degrees)
12. Ending point for recording the data (expressed in degrees)

After everything was entered into the computer, the subject was instructed to hold the lever arm against his/her chest, and to let the feet hang free so that they did not rest on or against anything. They were instructed to bend forward as far as they could and when the tester gave the command "begin" the subject lay back until the back touched the Orthotron bench. Once that position was reached the subject came up as hard and as fast as she/he could until they reached the starting

position. Three successive trials were given. Because only abdominal strength was being measured the subjects were encouraged not to overexert themselves as they returned to the lying position.

Abdominal Endurance: The subjects were instructed to return the following Monday for the endurance pretest. The curl-up test (Robertson & Magnusdottir, 1987), was used to gather data on beginning abdominal endurance. It was the opinion of the investigator that this test, more than any other available, isolates the abdominal muscles and nullifies any assistance from the hip flexor muscles. Subjects were placed in a hook-lying position on a mat with their longest fingertip 7.62 cm away from two blocks. The blocks were secured to prevent them from moving. The subject's feet were placed flat on the mat with heels toward the buttocks and were not supported in any way. The subjects were told to curl-up, keeping their arms stiff and hands on the mat, until the fingertips touched the blocks. They were then to curl back down until the upper back touched the floor. They were instructed to do as many curl-ups as they could in 60 seconds. Abdominal endurance consisted of the number of times they touched the blocks in 60 seconds. A trial was not counted if the middle finger of both hands did not contact the blocks.

Familiarization

Following the pretest data collection, familiarization sessions were held for each subject on his or her particular treatment group exercise. When subjects arrived on the indoor running track in the southeast corner of the HPER Center they were informed to which treatment group they had been assigned. Each subject was briefed on the proper way to perform their particular exercise and were observed performing several trials.

Sit-N-Trim Exercise

Subjects in the Sit-N-Trim group were instructed to sit in the chair below the Sit-N-Trim with the hips slightly forward and away from the chair back. The legs were extended with the heels resting on the floor. Subjects grasped the rubber tubing in both hands, holding the hands to the chest with elbows at the sides. They then curled the head down so that the chin came in contact with the chest. The subjects were told to inhale at this position and to curl the trunk forward as far as they could, holding this position for one count, then twisting to both sides, holding each of these positions for one count. After returning to the middle position they slowly returned to the upright position. As soon as they reached the starting position, they were to immediately begin the next repetition.

Crunch Exercise

Subjects in the crunch exercise group, lay on their backs and hooked their heels over a railing which is positioned approximately .50 meters above the floor. Their thighs were to be as close to perpendicular to the floor as possible. The arms were folded across the chest. The subjects curled up to approximately one-half to three-quarters of the way to vertical and held this position for one count, twisted to the sides holding each position for one count, and then returned to the middle position. They then returned to the starting position and as soon as their upper backs touched the mat, they began the next repetition.

Rowing Exercise

For the rowing exercise group, subjects were shown how to use the Rowing Exercise. Subjects sat on the mats, placed their feet in the stirrups, and grabbed hold of the handle with their palms facing down. Subjects then leaned back until they were lying flat on the floor. They then performed a full sit-up to an upright position. When they reached the vertical position they lay back down and repeated the procedure. The Rowing Exerciser offers a mild spring-aided assist at the beginning of the range of motion.

Treatment Sessions

Subjects were informed what was expected of them during the treatment sessions. For the first two weeks all groups performed one set of 10 to 15 repetitions. For the next two weeks they escalated to two sets of 10 to 15 repetitions and for the last three weeks they performed three sets of 10 to 15 repetitions. A minimum of 10 repetitions was set in the event that some unconditioned subjects could not perform the required 15. However, only 4 of 45 subjects could not do the 15 repetitions at the beginning and 31 of 34 subjects were performing the maximum number of repetitions during the seventh week. Subjects were encouraged to exercise during designated hours when the investigator was on hand to ensure that the exercises were being performed properly. If there was a conflict with those hours, an alternate time was selected. Subjects were told that, if the tester was not present at the time of their arrival, they could perform the exercise unsupervised and record it on the data collection sheet (Appendix B).

Posttest Procedure

Every effort was made to keep the posttest procedures identical to the pretest data collection. Subjects came to the Sports Medicine Center facilities on one day and were posttested on the Orthotron for abdominal strength using precisely the same settings recorded for the pretest. The posttest for abdominal

endurance was done the following afternoon. Every effort was made to ensure that the posttest was conducted in exactly the same fashion as the pretest.

Analysis of Data

Data gathered on the variables pretest and posttest abdominal strength and pre- and posttest abdominal muscular endurance were recorded and were analyzed using the PROC Univariate program of the Statistical Analysis System (SAS) installed on the South Dakota State University mainframe computer. In order to nullify differences which may have existed among the three groups of subjects prior to the experiment with respect to abdominal strength and endurance the subjects' pretest values were subtracted from their posttest values to create new variables which reflected the amount of change which had occurred due to the treatment. Analysis of variance procedures were performed on abdominal strength or peak torque change and abdominal endurance change to determine if the three exercises were similar or different in their ability to induce change. The .05 level of significance was employed for all comparisons. In the event that a significant F ratio was observed the Duncan/Waller multiple comparison procedure was utilized for pairwise comparisons.

CHAPTER IV

RESULTS AND DISCUSSION

The purpose of this study was to compare three methods of improving abdominal strength and endurance. More specifically, the study sought to determine whether three distinctly different sit-up exercises, were similar or different in their ability to effect changes in muscular strength and/or muscular endurance.

Subjects

The subjects were 34 males and females ranging in age from 18 to 40 years who were affiliated in some way with the physical education program at South Dakota State University. Heights of the subjects ranged from 1.59 meters to 1.95 meters and the weights of the subjects ranged from 47.73 kg. to 106.82 kg. A description of the 34 subjects, broken down by groups, is found in Table 1 below.

Table 1

Description of Subjects

Group	N	Age	Ht(cm)	Wt(kg)
Rowing Exerciser	10	26.5	176	68.23
Sit-N-Trim	11	25.4	174	64.42
Crunch	13	22.0	181	77.45
Total	34	24.41	177	70.52

Results

Pretest and posttest data were obtained for the variables abdominal muscular endurance and abdominal strength as measured by peak torque. To nullify possible differences which existed between the groups at the beginning of the experiment the subjects' pretest scores were subtracted from their posttest measures to create a change variable. Analysis of variance procedures were then carried out to determine if gains were comparable for the three treatment groups. Pretest, posttest, and change values for abdominal endurance are presented in Table 2. Findings indicate that subjects increased the most in the crunch sit-up group with an average change of 7.31. This is contrasted with the Sit-N-Trim group and Rowing Exerciser group with mean change values of 5.45 and 4.56 respectively.

Table 2

Descriptive Statistics for Abdominal Endurance

		Pretest		Posttest		Change
Group	N	M	SD	M	SD	M
Rowing Exercise	9	49.00	14.04	53.56	14.29	4.56
Sit-N-Trim	11	58.73	20.07	64.18	18.95	5.45
Crunch	13	59.92	17.92	67.23	15.27	7.31

The crunch group had a range of scores from 25 to 84 for the pretest and from 41 to 93 for the posttest. The Sit-N-Trim group had a pretest range from 24 to 90 and a posttest range from 32 to 96. The Rowing Exercise group had a range of scores from 35 to 77 for the pretest and from 38 to 78 for the posttest. The high standard deviation values are reflective of these widely varied scores. Given the relatively small number of subjects and the large amount of within-group variability it is not surprising that the ANOVA procedure would turn out to be non-significant.

A between-subjects one-way Analysis of Variance procedure was carried out to determine if the abdominal endurance gains were significantly different among the three treatment groups. Findings are summarized in Table 3.

Table 3

ANOVA Summary for Abdominal Endurance Change

Source	SS	df	MS	F	p
Between Groups	44.16	2	22.08	.10	.9046
Error	6583.72	30	219.46		
Total	6627.89	32			

The observed F ratio was not statistically significant (F=0.10, df=2,30, p=.9046), indicating that the three exercise groups

did not differ in their ability to induce gains in abdominal muscular endurance.

Abdominal strength was measured using the Orthotron. The peak torque in lbs. ft generated by the subject in three trials was the index of abdominal muscular strength used. Findings for abdominal strength are reported in Table 4.

Table 4

Descriptive Statistics for Abdominal Strength (lbs. ft.)

		Pretest		Posttest		Change
Group	N	M	SD	M	SD	M
Rowing Exerciser	10	90.00	27.91	98.9	25.31	8.90
Sit-N-Trim	11	86.94	29.62	93.75	23.17	6.81
Crunch	12	106.00	45.61	111.32	36.19	5.32

The data show that subjects in the Rowing Exerciser group had a mean peak torque increase of 8.90 as compared to subjects in the Sit-N-Trim group and crunch sit-up group with mean torque changes of 6.81 and 5.32 respectively.

Once again, however, the standard deviation values are quite high indicating a significant amount of within group variability. Peak torque values varied from 53.1 to 142.2 in the pretest and from 57.8 to 135.9 for the posttest for the Rowing Exerciser group. Variations from 48.4 to 143.8 for the pretest and 60.9

to 132.8 for the posttest were observed in the Sit-N-Trim group. Crunch subjects varied from 39.1 to 185.9 on the pretest and from 57.8 to 173.4 for the posttest.

A between-subjects one-way Analysis of Variance procedure was carried out to determine if the treatment groups differed with respect to the degree of abdominal strength change. Findings are summarized in Table 5.

Table 5

ANOVA Summary for Abdominal Strength Change (lbs. ft.)

Source	SS	df	MS	F	p
Between Groups	69.84	2	34.92	.18	.8342
Error	5744.79	30	191.49		
Total	5814.62	32			

The observed F ratio was not statistically significant (F=.18, df=2,30, p=.8342), indicating that the three exercise groups did not differ in their ability to induce gains in abdominal muscular strength.

Discussion

The analyses indicated that the three treatment groups were not significantly different with respect to their ability to effect change in abdominal muscle endurance. The crunch sit-up

group showed the greatest improvement with an average change of 7.31 while the Sit-N-Trim group increased an average of 5.45. These two groups are, perhaps, higher than the Rowing Exerciser group since the crunch and Sit-N-Trim may isolate the abdominal muscles to a greater extent than the Rowing Exerciser. The sit-up performed using the Rowing Exerciser is very similar to a conventional long-lying sit-up with straight legs and Bullivant, et al. (1986) have shown this type of movement to be heavily dependent upon the hip flexor muscles. Robertson and Magnusdottir (1987) found that the curl-up test demanded the most from the abdominal muscles with minimal demand placed on the hip flexors. The crunch sit-up and the Sit-N-Trim both involve a curling action which might indicate more demand from the abdominal muscles and less from the hip flexors. However, the reader is reminded that the group differences were not significant. It may be the case that these differences would be magnified if more repetitions were required and/or the study was of a longer duration but this is pure speculation and would need to be borne out through further research.

The change in peak torque was also not significantly different among the three groups. Even though it is not significant a surprising observation is that the Rowing Exerciser group exhibited the greatest mean change of 8.90 lbs. ft. as compared to 6.81 for the Sit-N-Trim and 5.32 for the crunch group. In the study by Partridge and Walters (1957) it was

concluded that the hip flexors participated to a greater degree when the feet were stabilized. In order to measure abdominal strength on the Orthotron in the present study, the thighs were held in place by a strap, although the feet were left unsupported. This might indicate that the hip flexors were providing some assistance in generating peak torque. Bullivant, et al. (1986) found that the hip flexors became less significant as the angle between the trunk and thigh decreased. The Rowing Exerciser puts the subject in a long-lying position where the angle between the trunk and the thighs is at its maximum. The crunch and Sit-N-Trim exercises decrease the angle between the trunk and the thighs, thus allowing for greater demand by the abdominal muscles. While the crunch and the Sit-N-Trim exercises worked mostly on the abdominal muscles, perhaps the Rowing Exerciser was stressing the hip flexors. Once again, however, the reader is cautioned against inferring too much from this since, statistically, there was no difference between the three methods.

Examining the two exercises that are believed to work mostly the abdominal muscles, the crunch and the Sit-N-Trim, the findings are somewhat in agreement with the study done by Borkowicz (1981). He concluded that the use of resistance plays a significant role in developing greater abdominal strength. Even though the mean change in peak torque for the two exercise groups was very close, 6.81 lbs. ft. for the

Sit-N-Trim and 5.32 lbs. ft. for the crunch group, it may be that the resistance provided by the rubber tubing of the Sit-N-Trim would enhance abdominal strength gain were the study prolonged.

In order for strength and endurance to increase, muscles must be overloaded through increased resistance and/or increased repetitions. Even though the study lasted a duration of seven weeks and the subjects exercised three times per week, the number of repetitions was relatively low and only minimal resistance was applied to the muscles for one of the groups. For those subjects who performed the maximum number of repetitions it resulted in 675 total "sit-ups" or an average of 32.14 per treatment session. Extrapolated over the total 147 days of the study this computes to be 4.59 repetitions per day. It is quite possible that, for healthy adults, with normal abdominal muscles this amount of exercise was simply not enough to induce change. This is compounded by the fact that there was a surprisingly high amount of variability in both abdominal muscular strength and endurance among comparatively few subjects. Even though some between-group variability was evident the tremendous amount of within-group variation clouded the analysis and contributed to the non-significance.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to compare three methods of improving abdominal strength and endurance. More specifically, the study sought to determine whether three distinctly different sit-up exercises, the Rowing Exerciser, the Sit-N-Trim exercise, and the crunch exercise, were similar or different in their ability to effect changes in muscular strength and/or muscular endurance.

Subjects took part in pretests for abdominal strength and endurance to find their beginning levels. Subjects were randomly assigned to one of three treatment groups. Subjects participated in three treatment sessions per week for a duration of seven weeks. Posttests were then performed on the subjects to determine any abdominal muscle strength and endurance gains that may have occurred.

Abdominal muscular endurance change and abdominal strength change, as measured by peak torque, were analyzed using Univariate ANOVA procedures to determine if a significant difference existed among the three treatment groups. No statistical difference was found between the three groups on either of the dependent variables.

Conclusions

Within the limitations of this study, the following conclusions have been made based on the obtained data. The reader, however, should be cautioned against drawing any conclusions about groups not represented in this study.

1. Hypothesis number one was not supported in its entirety. It was hypothesized that the crunch exercise and the Sit-N-Trim exercise would be equivalent in their ability to induce abdominal strength gains and, indeed, this was the case. However, it was also hypothesized that the above two exercises would be better than the Rowing Exercise. This was not supported by the findings.

2. Hypothesis number two was also not supported in its entirety. Once again there was no significant difference among the three treatment groups in terms of abdominal muscular endurance change when it was originally hypothesized that the crunch exercise and the Sit-N-Trim exercise would be more effective than the Rowing Exerciser.

Recommendations for Further Study

The present study sought to provide information with respect to increasing abdominal strength and endurance using a particular sit-up exercise. While the data did not show any significant difference, there are many more areas that could be examined.

The present study used both males and females as subjects. Given acknowledged differences between males and females in terms of muscular strength and endurance this, no doubt, contributed to the large amount of within-group variability. Similar studies should be conducted using only males or females as subjects.

It is also recommended that future studies employ a control group. In this way conclusions could be made regarding the significance of the pretest to posttest gains. In the present study all groups increased to a certain extent. Without a control group we are unable to determine if the change was due to the treatment or whether it was due to learning/motivation concerning the testing apparatus and procedures.

The present study examined only abdominal strength, as measured by peak torque, and abdominal endurance. Future studies could investigate the angle at which peak torque occurs. Perhaps it is the case that peak torque angle changes due to exercise with a particular apparatus.

This study employed a predetermined number of repetitions and sets. Future studies should consider increasing the number of repetitions and/or sets. Perhaps a minimal criterion should be set for inclusion in the study as did Borkowicz (1981). For the present study the number of repetitions was set at a low level to accomodate the poor fitness level of some of the subjects.

The present study used subjects ranging in age from 18-39. Similar studies should be conducted examining populations of different ages but perhaps keeping the age groupings more homogeneous.

This study employed healthy subjects in the investigation. Similar studies could be conducted using subjects experiencing low back pain or postural defects to determine if particular exercises are effective in alleviating these problems.

Finally, the present study used subjects who ranged in fitness level from sedentary to very active. Similar studies could be conducted using subjects with more homogeneous levels of conditioning.

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APPENDIX A

INFORMED CONSENT FORM

I, _____, agree to participate in the research study being conducted by Brent Dunford, graduate student in the HPER Department. The study is directed at comparing three different sit-up exercises and which one improves abdominal strength the most. The three sit-up exercises are the Sit-N-Trim exercise, the abdominal crunch sit-up exercise, and another sit-up exercise device on the market today. I have been selected for this project because I am between the ages of 18 and 40 and I am not actively involved in a weight-lifting program nor doing any exercises that are geared toward increasing abdominal strength. The study will run for 9 weeks, one week for a pretest, 7 weeks for data collection, and one week for a posttest.

I understand that I will be randomly placed in one of the three sit-up exercise groups and I must attend every session, sessions being on every Monday, Wednesday, and Friday for the seven week period.

I understand I am under no obligation to do this study and I may withdraw at any time.

I understand that the information gathered will be made available to a limitted number of people and will remain strictly confidential.

I hereby volunteer my services for the study as described by Brent Dunford and understand that I may withdraw at any time and all information will be kept confidential.

_____
(subject's signature)

_____
(today's date)

APPENDIX B
DATA COLLECTION SHEET

________________________ Workout Sheet

NAME	WEEK 1			WEEK 2		
	Day 1	2	3	Day 1	2	3

APPENDIX C

INSTRUCTIONS TO THE CRUNCH SIT-UP GROUP

1. Lie on the floor or on a mat in the supine position. Hook the legs over a railing and get the thighs as close to perpendicular to the floor as possible. Cross the arms over the chest (see Figure 1).

2. Curl up slowly to about half-way and hold this position for one count (Figure 2).

3. Twist to the left and hold for one count and then twist to the right and hold for one count (Figure 3).

4. Move to the middle position, hold for one count, and slowly lay back down.

5. As soon as the upper back touches the mat, begin the next repetition.

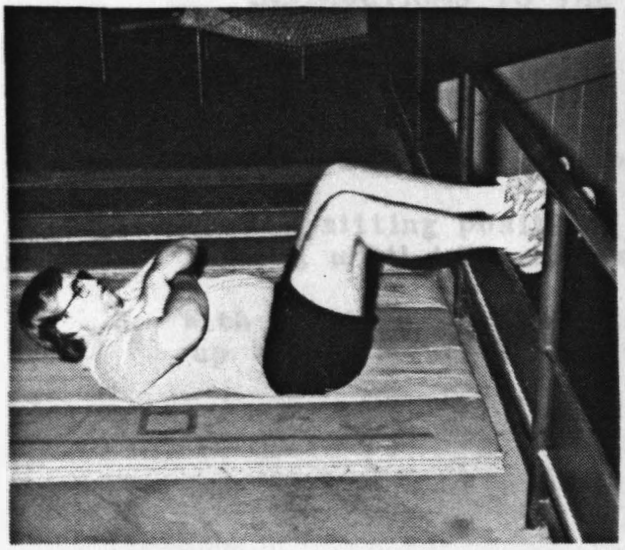


Figure 1: Start position

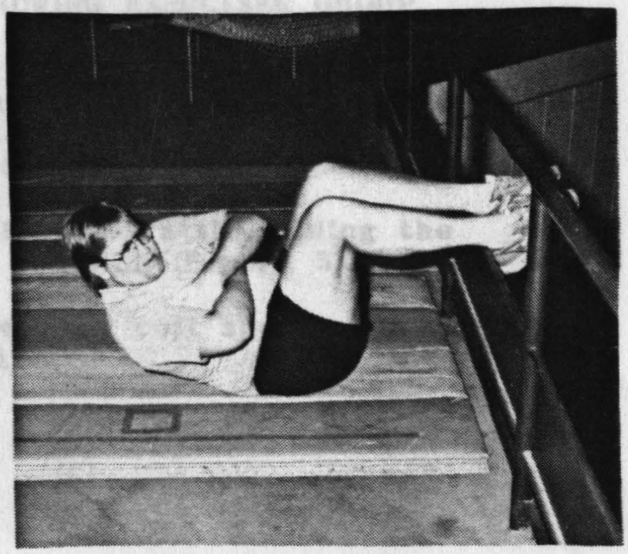


Figure 2: Curl-up half-way

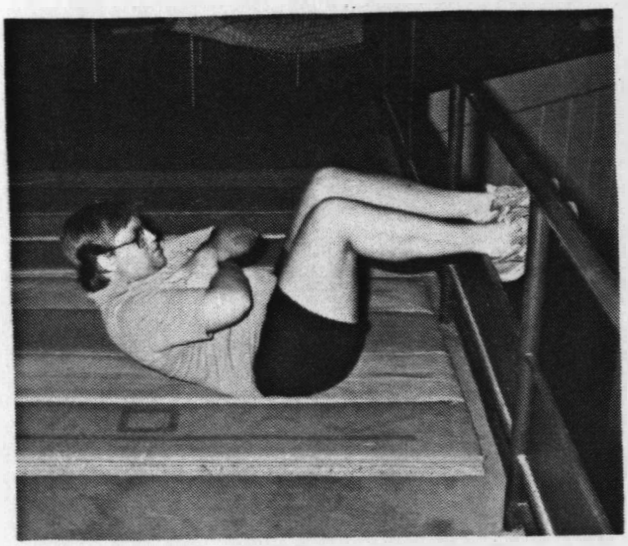


Figure 3: Twisting motion

APPENDIX D

INSTRUCTIONS TO THE ROWING EXERCISER GROUP

1. Sit on the floor or mat and place the feet in the stirrups. Grab hold of the handle with both hands and knuckles pointing up (Figure 4).

2. From a sitting position, lie back, still holding the handle, until in a supine position (Figure 5).

3. With a mild assistance from the coil spring, rise back up to the starting position.

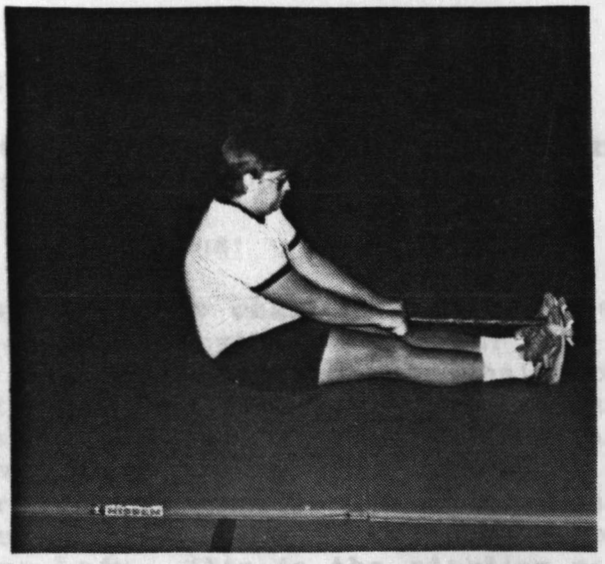


Figure 4: Start position

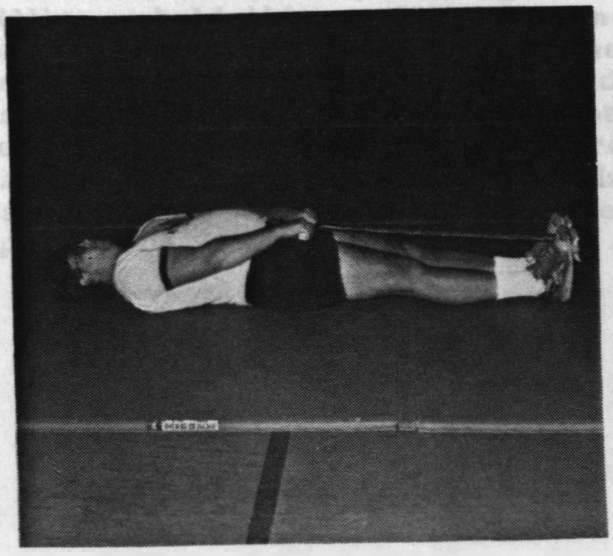


Figure 5: Supine position

APPENDIX E

INSTRUCTIONS FOR THE SIT-N-TRIM GROUP

I. Installation:

1. Attach the Sit-N-Trim to any door knob as illustrated in Figure 6.

II. Exercise Instructions:

1. Place a sturdy chair in front of the Sit-N-Trim and sit in a normal position with your hips slightly forward (3-4 inches) away from the chairback; legs should be extended comfortably with heels resting on the floor. Grasp the tubing firmly with both hands; hold your hands rigid against your shoulders; CURL your head forward and down so that your chin is in contact with your chest - your elbows should be along the sides of your body. This is the starting position (Figure 7).

2. While in the starting position inhale and curl the upper trunk slowly forward and down until your elbows come in contact with your thighs directly below your beltline - hold this position for one count (Figure 8) and then rotate to the left and then right, touching the opposite elbow to the thigh and holding each position for one count (Figure 9) before returning to the middle for one count. Slowly return to the upright positon and immediately upon reaching the starting position again take a breath and begin the next repetition.

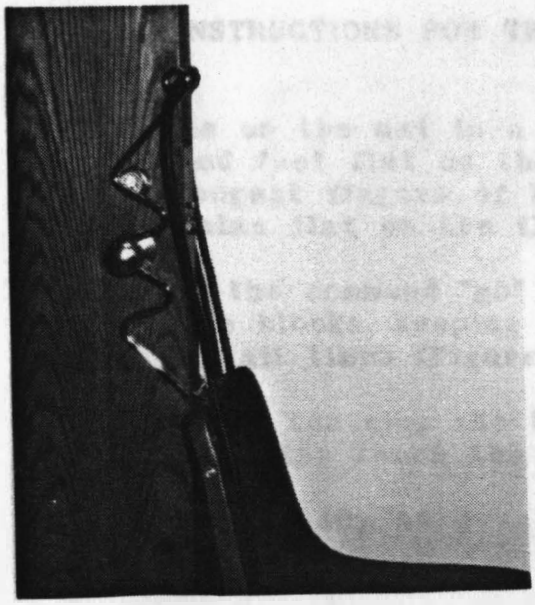


Figure 6: Installation

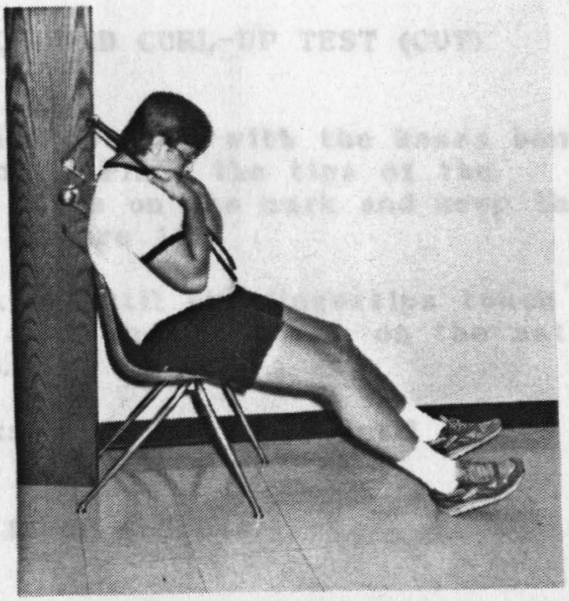


Figure 7: Starting position

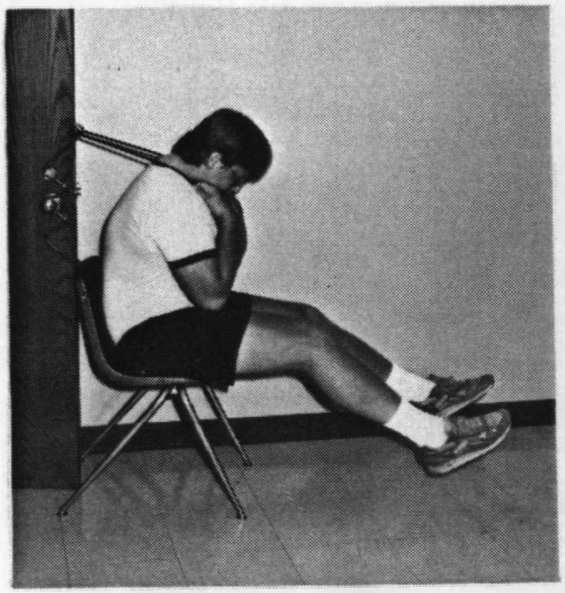


Figure 8: Curl to midway

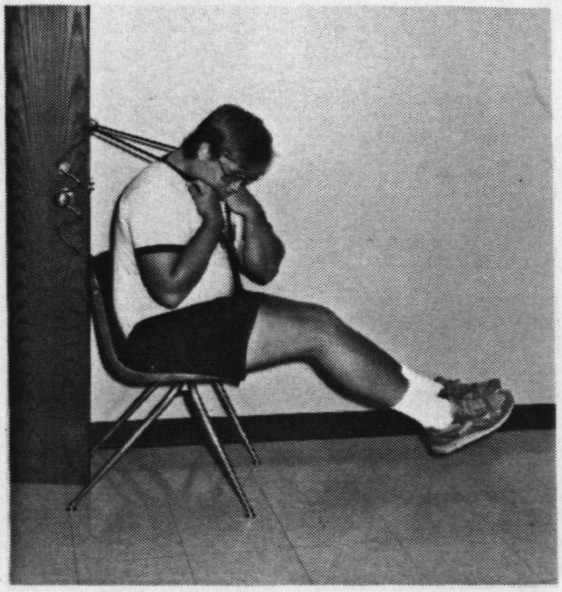


Figure 9: Twisting motion

APPENDIX F

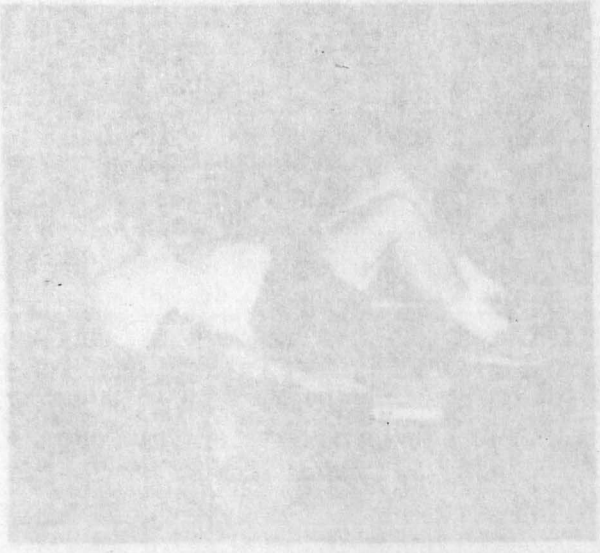
INSTRUCTIONS FOR THE MODIFIED CURL-UP TEST (CUT)

1. Lie on the mat in a supine position with the knees bent and feet flat on the floor. Place the tips of the longest fingers of both hands on the mark and keep the palms flat on the floor (Figure 10).

2. On the command "go" curl-up until the fingertips touch the blocks, keeping the arms and the hands on the mat at all times (Figure 11).

3. After touching the blocks, curl back down until the scapulae touch the mat.

4. Do as many as possible in 60 seconds.



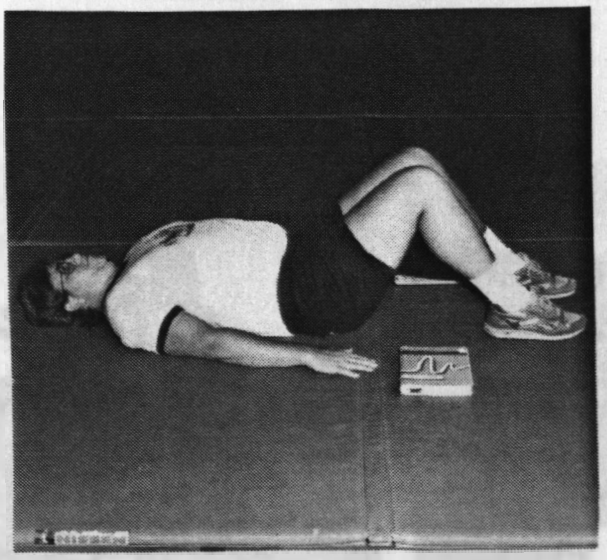


Figure 10: Start position

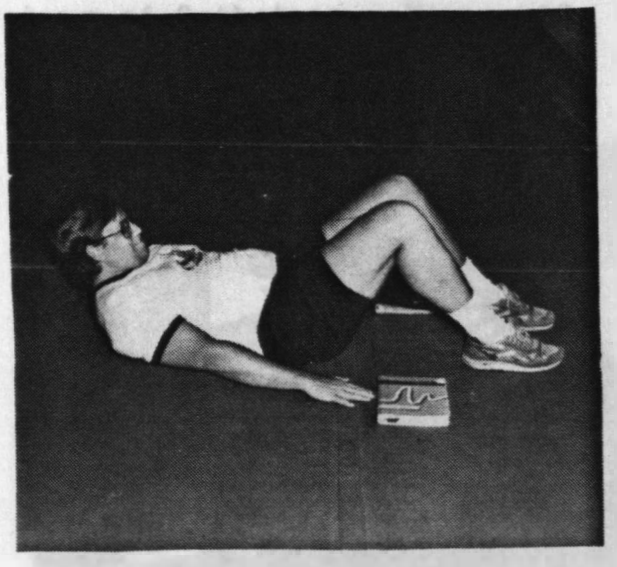


Figure 11: Curl-up to blocks

APPENDIX G

DIAGRAM FOR ORTHOTRON TEST

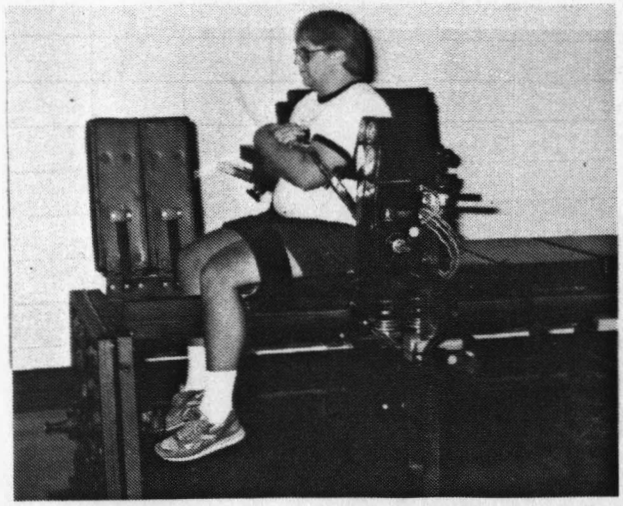


Figure 12: Set-up of Orthotron

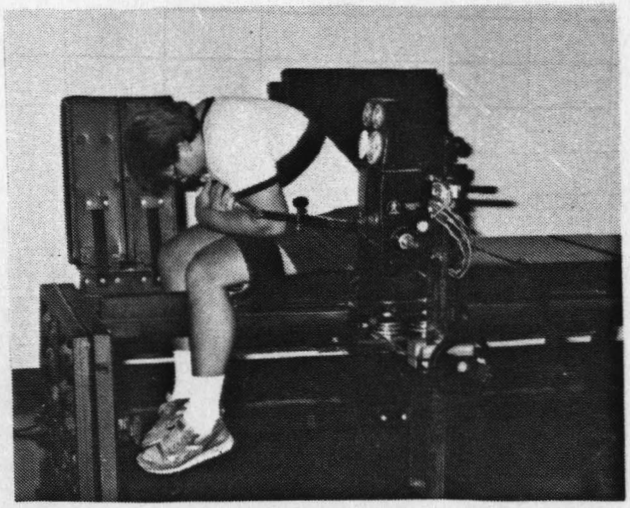


Figure 13: Start position

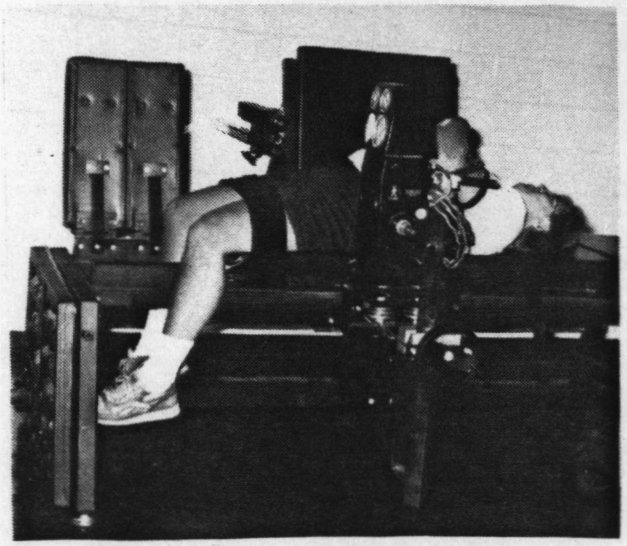


Figure 14: Supine position