



Utilizing Evidence Based Abdominal Exercise Programs for Improving Core Strength and Endurance: A Critical Review Comparing the Analysis of the Effects of Two Abdominal Exercise Programs

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Utilizing Evidence Based Abdominal Exercise Programs for Improving Core Strength and Endurance: A Critical Review Comparing the Analysis of the Effects of Two Abdominal Exercise Programs

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Foreword and Review by

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“Dedicated to all of my students who have attended and conquered my Ab and Core classes at Central Missouri State University, Butler County Community College, University of Houston, University of Kansas, Butler College MConnell Air Force Base, Lone Star College, The YMCA, The YWCA, Senior University and Arizona State University”.

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Foreword By Dr. Daniela L. Benavidez, ABD

With the explosion of the fitness movement over the last few decades, the importance of variation has continually resurfaced as a significant component of the effectiveness of workout programs. It has been well-established that differentiating exercises can help avoid hitting plateaus, serving to continue benefiting from a workout regimen. In the area of abdominal strength and endurance, the immensurable amount of existing exercises can be an enticing way to remain interested and challenged in a regular exercise plan. The difficult part is choosing which exercises to include in workouts.

Dr. Garcia's study investigated the use of two different types of abdominal exercises for the improvement of muscular strength and endurance. Compared, are the effects provided by a full-range (bent-knee) sit-ups program, to the benefits of training with a combination of full-range sit-ups and curl-ups. Developing and increasing abdominal muscular strength and endurance is a common goal among individuals seeking to improve health and appearance, and among athletes wishing to improve speed and core strength.

When it comes to improving abdominal strength and endurance, Utilizing Evidence Based Abdominal Exercise Programs for Improving Core Strength and Endurance: A Critical Review Comparing the Analysis of the Effects of Two Abdominal Exercise Programs is an excellent resource for physical educators and coaches alike, because curl-ups have become a common staple in America's physical education and athletic programs. Other core exercises such as crunches, v-sits, baskethang, leg raise, bicycles, side bends, bar twists, back extensions, knee raises, roman chair twists, roman chair sit-ups, vertical sit-ups and incline sit-ups are also recommended for improving overall core strength and endurance (Garcia, 1992). This study provides the reader with the evidence necessary to determine whether the addition of curl-ups may be an appropriate exercise for a particular group of students or athletes.

Review By Dr. Daniela L. Benavidez, ABD

More than twenty years after having been conducted, Dr. Garcia's research on effective abdominal exercises is still as relevant as ever. In this review and reprint edition, Utilizing Evidence Based Abdominal Exercise Programs for Improving Core Strength and Endurance: A Critical Review Comparing the Analysis of the Effects of Two Abdominal Exercise Programs, brings with it a refreshing perspective to the current design of physical education and athletic workout programs in America.

While not all abdominal exercises are created equal, it is no surprise that neither the benefits of such exercises. Dr. Garcia's study compared the abdominal strength and endurance improvements of two groups of weight-training students. One group performed traditional full-range (bent-knee) sit-ups, while the other group performed both curl-ups and full-range sit-ups. The study sought to determine whether including curl-ups in an abdominal exercise plan was as effective, less effective, or more effective, when compared to performing full-range sit-ups alone. It is of import to notate that the bent-knee sit-up test was used in this study. This assessment is common in fitness competitions and endorsed by several health organizations including the American College of Sports Medicine and the National Strength and Conditioning Association (Garcia, 1992).

In the day of modifications, differentiated instruction, and universal access physical education, perhaps the most relevant inquiry is: will an exercise help improve health and physical performance? Dr. Garcia's study answers just that. In the quest for continued improvement and excellence in the area of abdominal strength and endurance, this study reveals that the bent-knee full range sit-up exercise is preeminent for improving the performance of sit-up assessments and sit-up competitions in already-fit individuals.

A Comparative Analysis of the Effects of Two Abdominal Exercise Programs on Abdominal Strength and Endurance

A Thesis Presented to the Faculty of the Department of Physical Education Central Missouri State University

In Partial Fulfillment of the Requirements for the Degree Master of Science by **Robelyn A. Garcia**

Thesis Chair: Professor Mary E. Lyon

Abstract

The purpose of this study was to investigate the effects of two different abdominal training programs on abdominal strength and endurance, as measured by the bent-knee sit-up test.

Twenty females and twenty-two males from two weight training classes were used for this study. Abdominal training programs were randomly assigned to these two classes. Group I participated in a bent-knee sit-up exercise program and Group II participated in a combination curl-up and bent-knee sit-up exercise program. Both groups trained two times a week, for two minutes a workout session, for seventeen sessions. Group I executed bent-knee sit-ups for the seventeen workout sessions. Group II executed curl-ups for the first nine sessions of the training program, then progressed to bent-knee sit-ups for the last eight sessions of the program.

It was found that the bent-knee sit-up exercise program was effective and the curl-up/bent-knee sit-up exercise program had no significant effect on abdominal strength and endurance.

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2. Dr. Jane Marken
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4. Dr. James Conn
5. Lew Curry
6. The Kansas University Service Center Staff.
7. The students who participated in this study.
8. My best friend, Kay Kay Hart.

Thank You

Introduction

The conditioning of the abdominal muscles has long been a serious concern of physical educators, athletic trainers, coaches, physicians, physical therapists, and others involved with improving physical fitness. Activities recommended for improving the strength and endurance of these muscles are numerous and varied. Many differences of opinion exist concerning which exercise, or combination of exercises, contribute most toward the development of the abdominals [1]. The majority of research reported supports the sit-up or one of its variations as being the most effective for abdominal fitness [2].

Flint & Guggell [3] revealed in their study that exercises other than sit-ups will develop the abdominal musculature. These exercises included the crunch, curl-up, and back extension. Other conflicting evidence has been reported relative to the value of these and other abdominal exercises. Williams [4] agrees that a number of other exercises develop abdominal strength, but he warns exercisers to avoid abdominal exercises which cause an increased lumbar curve. Although these exercises help to strengthen the abdominal muscles they also can place a tremendous stress on the low back area [5]. concluded that the exercises involving the oblique muscles (trunk twists and side bends) also contribute significantly to abdominal strength and endurance.

Well developed abdominals have long been recognized as important considerations in decreasing low back weakness and low back pain. Strong abdominal muscles also help prevent postural problems and add to the physical fitness of the individual. Abdominal muscles play a major role in preventing an excessive forward tilt of the pelvis, and strong abdominal muscles support the trunk in postures that otherwise could cause back problems. When a person is leaning forward, strong abdominal muscle contractions can decrease the stress placed on the spine. It is a basic assumption that the need for abdominal strength and endurance will continue. This research project was designed to help resolve the current debate concerning methods of improving abdominal strength and endurance.

Statement of the Problem

This study was conducted to investigate the relative effects of two different abdominal training programs on abdominal strength and endurance as measured by the bent-knee sit-up test. Two physical education classes were used for the investigation. These classes trained two days a week, for eight and a half weeks. Each class met for fifty minutes; however the abdominal training programs only took two minutes per class period. The two training programs were the bent-knee sit-up program and the curl-up/bent-knee sit-up program.

Purpose of the Study

Physical educators, athletic trainers, coaches, physicians, and physical therapists have long been concerned with the development of abdominal musculature. These professionals involved with improving physical fitness need a standard training program that has been shown effective in this area.

The results of this study will help to fill the existing gap in information concerning the improvement of abdominal strength and endurance.

Need for the Study

Differences of opinion are apparent concerning the value and effectiveness of various abdominal training programs. There have been several studies relative to the effects of the sit-up and sit-up variations on the abdominal musculature. However, these studies have not compared the effectiveness of a progression of sit-up variations on the development of abdominal musculature.

Delimitations

The delimitations of this study were:

1. Subjects were college men and women attending The University of Kansas.
2. Subjects were students who elected to take a weight training class.
3. The independent variables were two different abdominal training programs: 1) bent-knee sit-up program and 2) curl-up/bent-knee sit-up program.
4. The dependent variables were abdominal strength and endurance as measured by the bent-knee sit-up test.
5. Classes trained two days a week for eight and a half weeks. The bent-knee sit-up group met Tuesday and Thursday from 11:30 A.M. to 12:20 P.M., and the curl-up/bent-knee sit-up group met Monday and Wednesday from 1:30 P.M. to 2:20 P.M.
6. The training programs consisted of doing as many prescribed exercises as individually possible in the allotted two minute workout session.
7. The pre-test means for this study ranged in the good and excellent levels of abdominal strength and endurance.

Limitations

The limitations of this study were:

1. Intact groups were used.

2. Testing and training were done at different times of the day. The bent-knee sit-up group met from 11:30 A.M. to 12:20 P.M. and the curl-up/bent-knee sit-up group met from 1:30 P.M. to 2:20 P.M.
3. Although subjects were told not to perform any variations of abdominal exercises except when instructed to do so by the researcher, it cannot be assumed that the instructions were followed. This was controlled as closely as possible by a questionnaire at each session.
4. Students had participated in a weight training program for three weeks prior to the start of the study and continued on that program throughout the study.
5. The pre-test mean for Group I's abdominal strength and endurance was in the excellent category for men and the pre-test mean for Group II's abdominal strength and endurance was in the excellent category for men.
6. Due to lack of available subjects, statistical comparisons could not be done by gender.

Statement of the Hypotheses

The hypotheses tested were:

- a. A bent-knee sit-up exercise program is effective in increasing abdominal strength and endurance.
- b. A combination curl-up and bent-knee sit-up exercise program is effective in increasing abdominal strength and endurance.
- c. There is no significant difference between the effects of training the abdominals for strength and endurance

using a bent-knee sit-up exercise program and using a combination curl-up and bent-knee sit-up exercise program.

Definition of Terms

The following terms are defined as they are used in this study:

- a. Abdominal strength and endurance is the ability to perform bent-knee sit-ups as quantified by determining the number completed in one minute.
- b. Training program bent-knee sit-up - In a supine position, lying flat on the floor with the knees bent at a 45 degree angle, the upper torso is raised by contracting the abdominal musculature. In the up position, with the arms crossed on the chest the elbows must touch the thighs and in the down position the shoulders must touch the floor. The feet were not stabilized during the training sessions.
- c. Testing bent-knee sit-up - In a supine position, the knees were bent at a right angle. The hands were placed at the side of the head with the fingers over the ears. The elbows had to be pointed toward the knees. In the up position the elbows had to touch the knees and in the down position shoulders had to touch the floor. The feet were stabilized for testing by holding the ankles.
- d. Curl-up - While lying on the back cross the arms over the chest and place the hands on opposite shoulders. The knees should be bent at a 45 degree angle with the feet not stabilized. Curl-up to the point when both shoulder blades leave the floor and then return to the starting position.

Review of Literature

Little doubt remains today as to the importance of abdominal strength and endurance in competitive sports and in the demands of everyday physical activities. The conditioning of the abdominal muscles has long been a concern of many professionals. Striving to fulfill this need, several research projects have been done to investigate the effects and benefits of the sit-up and its variations on the abdominal musculature. These studies are discussed in part one and part two of the review of literature. Part three consists of studies utilizing similar testing procedures.

Benefits of Abdominal Fitness

Well, developed abdominals are recognized as an important part of physical fitness. The development of abdominal strength and endurance is considered a vital component of most physical fitness programs. Those involved in these fitness programs and others participating in an abdominal workout series will reap many benefits.

Strong abdominal muscles help prevent excessive anterior pelvic tilt, detrimental postural conditions, and lower back pain. Well, developed abdominals also play an important role in protecting the lumbar spine, reinforcing the trunk and reducing the load placed on the musculoskeletal system of the back in forward bending and lifting positions [6].

Maintaining adequate strength and endurance in the abdominal muscles can help alleviate or even avoid low back problems and pain. The abdominal muscles counteract the erector spinae muscles, which parallel the spine and which must contract with sufficient force to hold the trunk upright. If the abdominal muscles are weak, the continual contraction of the erector spinae muscles may result in an extreme pelvic tilt or swayback, which often leads to episodes of low back pain. A program designed to strengthen the abdominal muscles and improve their endurance can reduce pelvic tilt and also the accompaniment of low back pain.

Well, conditioned abdominals are especially important for athletes involved in contact sports as strong abdominals offer protection to internal organs, act as muscle stabilizers in many exercises, and help alleviate back problems [7].

Decreasing the likelihood of having low back pain symptomatology is a significant factor involving the implementation of abdominal exercise programs into secondary school physical education curriculums. The results of Harman's [8] investigation showed that improving abdominal strength will not only reduce low back pain but also reduce disc damage and improve physical activity safety. In Ricci's [5] article, "Biomechanics of Sit-up Exercises", it was revealed that both the abdominal and lower back muscle groups benefited from the sit-up. Abdominal

exercises involve a variety of muscles of the thigh, calf group, hamstring group, and foot dorsiflexors, which would indicate potential benefit to total body development.

Abdominal Exercises

The abdominal muscles include the rectus abdominis, the external oblique, the internal oblique, and the transverse abdominis. These muscles are involved in trunk flexion, lateral trunk flexion, trunk rotation and compression of the abdominal cavity anatomically; the abdominals extend from the xiphoid process and the cartilage of the fifth and seventh ribs to the lower border of the pelvic girdle at the pubic crest and symphysis pubis. Any time this distance is shortened against a resistance, the abdominal muscles are utilized. Because the ribs are attached to the spine, this causes spinal flexion. Exercises that cause spinal flexion help to strengthen the abdominals.

Differences of opinion exist as to desirable practices for effective development of abdominal strength and endurance, and conflicting evidence has been reported relative to the value of various abdominal exercises and the best method to employ them. Individuals with lower levels of abdominal strength may need to progress gradually from the less strenuous to the more strenuous abdominal exercises. Williams [4] suggests beginning with the curl-up and progressing to the bent-knee sit-up. Research has shown that the curl-up exercise is very effective for increasing abdominal strength and endurance, and is less likely to create increased pressure in the lumbar area.

Franks [9] states that the best type of exercise for the abdominal region is a slow curl-up, with knees bent and feet flat but not held. Humphrey [10], the exercise advisor for *The Physician and Sportsmedicine*, also recommends the trunk curl exercise for increasing abdominal strength and endurance. Humphrey continues to warn exercisers of doing double straight leg raises and straight leg trunk curls, because of the increased risk of low back injury.

Not all professionals agree with the above statements concerning abdominal exercises. Clarke [11] has suggested from his research that the baskethang, v-sit, curl-up, and the leg raise are effective tools for increasing abdominal fitness.

Fairbanks [12] recommends the torso abdominal pull-down and torso abdominal crunch as excellent exercises for reducing the unsightly and voluminous protrusion of the abdominal wall (pot belly: usually a combination of weak abdominal muscles and excessive fat deposits).

Thomas [13] conducted an investigation studying resistance exercise program effects on abdominal function and physique. The purpose of this study was to compare

the effects of different abdominal function and physique. Forty-five men and women (aged 18-26) were randomly assigned to three training groups using: (1) abdominal curl; (2) seated incline machine; or (3) bent-knee incline sit-up. Strength training occurred three times per week for ten weeks. All groups improved in abdominal muscular strength and endurance, as measured by the timed sit-up. The bent-knee incline sit-up group and the abdominal curl-up group improved in muscular strength and endurance. These results suggest that abdominal curls, seated incline machines, or the traditional bent-knee incline sit-up are effective in altering abdominal muscular function, but it is apparent that more investigations need to be done to determine which exercise program will increase abdominal strength and endurance most effectively.

Exercises such as crunches, bicycles, incline sit-ups, sidebends, bar twists, back extensions, roman chair sit-ups, vertical sit-ups, knee-raises, and the body curls have also been suggested as exercises to increase abdominal strength and endurance [14]. Bending the knees on any variation of the sit-up is very important, because this technique places less strain on the back [2]. The two most common exercises used and recommended were the curl-up and the bent-knee sit-up.

Eckerson [7] states that the bent-knee sit-up develops general abdominal strength and endurance and that the National Strength and Conditioning Association uses this exercise to evaluate abdominal endurance in highly skilled athletes. Athletes are not the only population which can benefit from doing bent-knee sit-up exercises. An investigation conducted by Smidt [15] studied the effects of trunk resistive exercise on muscle strength in postmenopausal women. This study showed that postmenopausal women can benefit from abdominal exercises. Fifty-five women with an average age of 56 years participated in this study to determine the effects of a home based, exercise program on trunk and abdominal muscular strength. These women were divided into three groups and each group did three sets of ten repetitions three times a week using one of three different exercises. The three exercises utilized were the bent-knee sit-up, prone trunk extension, and double-leg flexion exercises. The training programs lasted twelve months. Large, significant strength gains (25%-30%) were made by each exercise group. This study demonstrates that older women can increase trunk and abdominal strength using controlled resistant exercise over a long period of time. This exercise approach might be considered for use in treatment of low back dysfunction.

Debate has continued over the years as to which activity, or activities, contributes most toward the development of abdominal muscular strength and in turn treatment and prevention of low back pain. Many investigators have tested this using the electromyograph. Gutin [16] studied the upper and lower rectus abdominis electromyographically through a series of ten strenuous abdominal exercises and a trunk flexion isometric strength test. Results of this study listed

the five most strenuous exercises in order of intensity from high to low as follows: baskethang, three variations of the hook sit-up, curl-up, and the inclined and conventional bent-knee sit-up. The v-sit was the least strenuous exercise.

The purpose of Sevier's [17] dissertation was to determine the relationship, if any, between three abdominal muscles (rectus abdominis, external oblique, and internal oblique) while running and performing sit-ups as measured electromyographically. The results of the study showed that the internal oblique and rectus abdominis muscles are more active during the performance of sit-ups than while running.

Utilizing the electromyograph and a center of gravity test, Bennett [18] investigated the transverse plane center of gravity and muscular activity of the hook-lying and feet-stabilized bent-knee sit-up. The results supported the belief that the rectus abdominis, internal oblique, and external oblique muscles are active whether or not the feet are stabilized. The investigator also found that greater intensity in all three muscles occurred in the first half of the up phase and second half of the down phase.

Vincent's [19] study results supported some of Bennett's conclusions. The research revealed that during the bent-knee sit-up the abdominal muscles account for only the first twenty to thirty degrees of trunk flexion. The remaining movement through the full ninety degrees is accomplished by hip flexors. Vincent highly recommended the curl-up for abdominal strength and endurance training.

Similar Testing Procedures

For the testing procedures of this study, it was necessary to review recent literature on practical tests of abdominal muscular strength and endurance. Muscular strength and endurance are related. An increase in one component usually results in some degree of improvement in the other [6]. Therefore the bent-knee sit-up test was chosen to measure the combination of abdominal strength and endurance. This procedure is used by Fitness Canada and is included in the Canadian Standardized Test of Fitness Operations Manual [20]. Canada Fitness uses norms from this test to categorize and rate Canadians for fitness. These norms were established in 1981 by a survey conducted on women and men 15 - 69 years of age. The research was done by Canada Fitness Lifestyles Research Institute located in Ontario.

The American College of Sports Medicine [21] also uses this bent-knee sit-up test for their exercise testing and prescription and in the Practical Examination for Health/Fitness Instructor Certification. This bent-knee sit-up test is recommended by The American College of Sports Medicine, an organization that is committed to the diagnosis, treatment, and prevention of sports-related injuries and the advancement of the science of exercise.

Validity of the bent-knee sit-up test used in this study as a measure of abdominal strength and endurance is based on logical validity [22]. The validity of the sit-ups test has

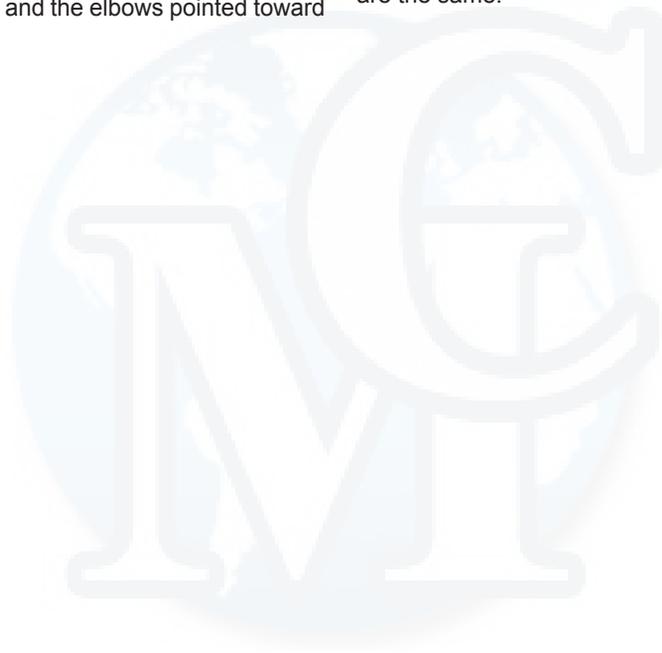
not been clearly established. Electromyographic studies of sit-ups have shown that the abdominal muscles are active during the execution of a sit-up. However, other muscles are active as well, in particular the hip flexors. No evidence exists to justify a specified number of sit-ups as representative of desirable amount of abdominal strength. Thus, the Modified Sit-Ups Test is validated on the basis of logical validity [22].

Electromyographic studies have shown that the abdominal muscles are active during a bent-knee sit-up [16,17]. Test reliability estimates have ranged from .68 to .94 for various forms of sit-up tests currently used for measuring abdominal strength and endurance [22]. For comparative purposes Erbaugh [23] found test-retest reliability of .93 for the AAHPERD modified sit-up test. The AAHPERD modified sit-up test is similar to the bent-knee sit-up test utilized in this study except the arms are crossed over the chest in the AAHPERD test, whereas the arms are in front of the body with the hands over the ears and the elbows pointed toward

the knees in the bent-knee sit-up test.

Several research projects indicate that the abdominals are very active during a sit-up and therefore the sit-up test is a good measure of abdominal strength and endurance [3,5,16,24].

Joan Eckerson States that the National Strength and Conditioning Association recommend the bent-knee sit-up for testing and evaluating abdominal endurance in athletes. One recommendation in the National Strength and Conditioning Association's guidelines for the bent-knee sit-up test is different from the guidelines for the bent-knee sit-up test used in this study. The difference is the grip of the hands. The bent-knee sit-up test used for this study has the subjects place their hands at the side of their head over their ears, whereas the National Strength and Conditioning Association recommends that the fingers be intertwined and hands placed on the posterior neck. All other guidelines are the same.



Procedures

This chapter includes a description of the experimental methods used in this study. The descriptions include: A. Selection of subjects, B. Subject orientation, C. Selection of test, D. Test administration, E. Training period, F. Training programs, and G. Statistical procedure.

A. Selection of subjects

College men (N=22) and women (N=20) from two weight training classes at The University of Kansas participated in this study. The students elected to enroll in these classes to fulfill a requirement in physical education. Twenty-one of the thirty members of the 11:30 A.M. Tuesday-Thursday class agreed to participate in the study. In the 1:30 P.M. Monday-Wednesday class twenty-one of the thirty-one students agreed to participate. These two classes were chosen because the researcher had the opportunity to direct the training programs. The age range was from 20 to 25 years old. Those excluded from the study were:

- i. Students who could not perform at least one bent-knee sit-up,
- ii. Students who performed abdominal exercises outside of class time during the training, and
- iii. Students who did not make up missed workout sessions.

B. Subject orientation

On the first meeting day of both classes used for the investigation, the study was introduced and described. The study was introduced and explained to the students by the investigator as follows:

The purpose of this study is to investigate the effects of two different abdominal training programs on abdominal strength and endurance, as measured by the bent-knee sit-up test. Each class will be participating in different abdominal training programs. After pre-testing today all participants will take part in a two minute workout session, during each class period for the next seventeen class periods. Each subject will then be post-tested to determine the increase, if any, in abdominal strength and endurance.

Following the introduction and description of the study, those who wished to participate in the investigation signed their names on the signup sheet and read and signed the experiment consent forms ([Appendices A & B](#)).

C. Selection of test

Muscular strength and endurance are related. An increase in one component usually results in some degree of improvement in the other [25]. Therefore the bent-knee sit-up test, which tests both muscular strength and

endurance, was chosen for measuring the combination of abdominal strength and endurance. This procedure is used in the Canadian Standardized Tests of Fitness and is also included as an assessment of musculoskeletal fitness in Nieman's Fitness and Sports Medicine: An Introduction [26]. Research indicates that the abdominals are very active during a sit-up and therefore the sit-up test is a good measure of abdominal strength and endurance [3,5,16,24].

The description of the bent-knee sit-up test is as follows: Subject lies in a supine position, In every other reference to the angle of the knees, they are said to be at a 45 degree angle. A right angle would indicate a 90 degree angle, and feet shoulder-width apart. The hands are placed at the side of the head with the fingers over the ears. The elbows are pointed towards the knees. The hands and elbows must be maintained in these positions for the entire duration of the test. Also, the ankles of the participant must be held throughout the test by the appraiser to ensure that the heels are in constant contact with the mat.

The participant is required to sit up, touch the knees with the elbows and return to the starting position (shoulders touch the floor). The participant performs as many sit-ups as possible within one minute. A rocking or bouncing movement is not permitted. The buttocks must remain in contact with the mat at all times [27].

Each subject was tested individually. The subject's feet were stabilized by another student and were kept between 30.48 cm and 45.72 cm away from the buttocks. This was controlled by lines on the floor. This procedure was added to have more control over the position and angle of the knees. The investigator counted and recorded the number of correctly performed sit-ups.

D. Test administration

The pre-test and post-test were administered in the exact same manner. The same procedures were used and executed in identical order for both tests. The introduction and the pre-test were given during the first class period. The post-test was given on the nineteenth day of class.

Pre-testing and post-testing utilized the bent-knee sit-up test for measurement of abdominal strength and endurance. All subjects were tested in The University of Kansas weight room, Robinson 103. Subjects warmed up before the test with a two minute brisk walk followed by light stretching of the anterior and posterior hip area. The testing procedure was demonstrated by the researcher and the assistant.

The correct form for a bent-knee sit-up was demonstrated by the investigator and described as follows:

From a hook lying position, with feet held at the ankles, heels touching the feet line and buttocks centered on the

middle line, raise your upper body (torso) by contracting the abdominal musculature. In the up position your elbows must touch your thighs, and in the down position your shoulder blades must touch the floor. Your knees will be kept at a 45 degree angle.

Place the hands at the side of the head with the fingers over the ears. Keep your elbows pointed toward the knees through the entire test. The heels must be kept on the feet line and buttocks must be kept between the buttocks lines on the floor. If your buttocks slip during the test, you will be asked to correct this, in the up phase of the sit-up, by moving your buttocks to the middle line.

If your feet slip during the test, the correction will be made in the down position by the person holding the feet. Go as quickly as you can. Your score will be the number you can do in one minute. If your elbows do not touch the thighs or if your shoulder blades do not touch the floor, that sit-up will not count. The investigator will remind you if you are performing the sit-ups incorrectly. If you become tired, you may rest, and then resume the sit-ups.

After the demonstration the test was administered. Subjects were tested individually by the researcher. Another student

stabilized the feet of each subject by grasping the top of the arch. The subject laid in a supine position, knees flexed at a 45 degree angle, feet flat on the floor with the heels touching the lines and hands placed at the ears. The distance between the feet and buttocks was checked by the researcher using previously marked lines on the floor. The subject, upon a given signal from the investigator, performed as many bent-knee sit-ups as possible in sixty seconds. The subject was instructed to stop when sixty seconds had expired. The investigator used a stopwatch to time the test. Correctly performed sit-ups were counted and recorded by the investigator. The investigator also told subjects when to make feet and buttocks adjustments. Feet adjustments were made when the heels moved so there was no contact with the feet line. The buttocks were adjusted when the seat touched the outside line.

The lines which were used for making feet and buttocks adjustments were placed on the floor prior to testing. These distances (45.72 cm and 30.48 cm) are used by AAHPERD [28-30] for the modified sit-up test to ensure the positioning of buttocks and angle of the knees. The lines were measured and marked by the investigator as illustrated below (Figure 1).

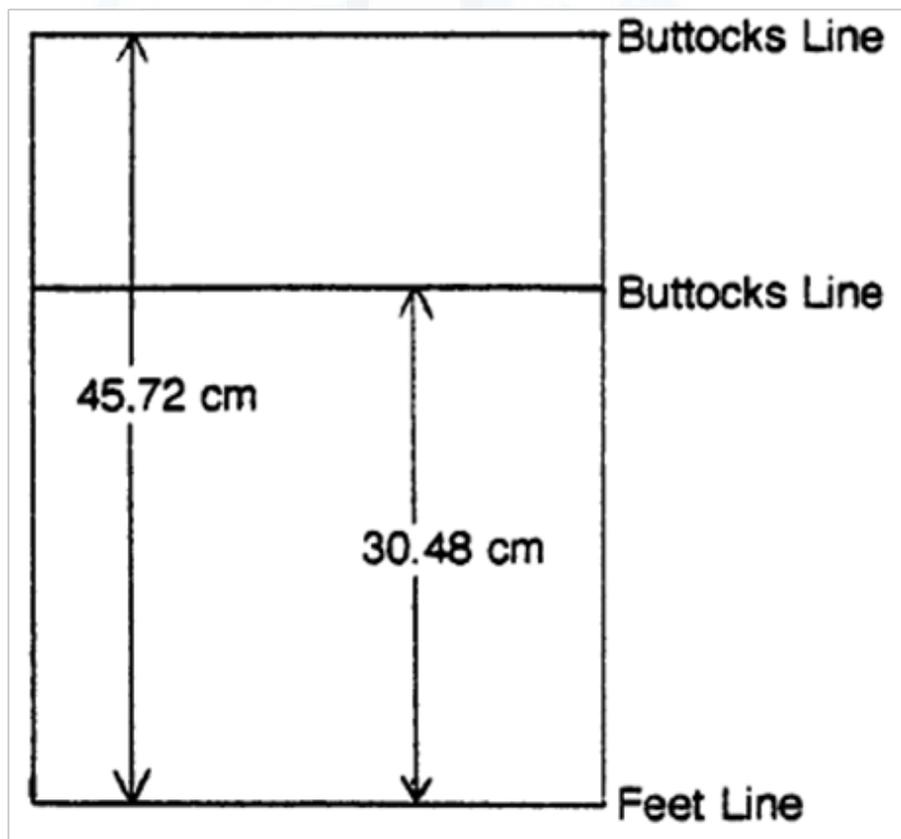


Figure 1: Diagram of Floor Markings for Modified Sit-up Test.

Students who were absent during the pre-test class period were tested during the next class period, prior to beginning their experimental abdominal exercise programs. The make-up tests were given at the beginning of the period before students started their regular weight training program [31-40].

E. Training Period

Each class met twice a week for one semester. The bent-knee group met on Tuesday and Thursday from 11:30 A.M. to 12:20 P.M. and the curl-up/bent knee group met on Monday and Wednesday from 1:30 P.M. to 2:20 P.M. Eight and a half weeks were allotted for the training programs. Subjects participated in their prescribed training program for seventeen days. If subjects missed a class period, they scheduled a make-up time with the researcher within seven days. The make-up time could not be on the same day that they participated in a normal workout. If students failed to make-up a workout within seven days, they were excluded from the study.

F. Abdominal Training Programs

In this study two classes were used to investigate two different abdominal training programs. Training programs were assigned randomly to classes. One class completed the bent-knee sit-up exercise program (Group I) and one class completed the curl-up/bent-knee sit-up exercise program (Group II).

The subjects who used the bent-knee sit-up program completed as many bent-knee sit-ups as individually possible within two minutes. The description of the bent-knee sit-up used for the experimental training program is as follows:

In a supine position, lying flat on the floor with the knees bent at a 45 degree angle, the upper torso is raised by contracting the abdominal musculature. In the up position, with the arms crossed on the chest, elbows must touch the thighs and in the down position the shoulder blades must touch the floor. Feet are not stabilized for this exercise. This abdominal workout was utilized twice a week for seventeen training sessions, the entire training period (Appendix C).

The subjects who used the curl-up/bent-knee sit-up program completed as many curl-ups as individually possible in two minutes. The description of the curl-up used for the experimental training program is as follows: Lying on your back, cross your arms over your chest and place your hands on opposite shoulders. Knees should be bent at a 45 degree angle, and your feet should not be held down. Curl up to the point when both shoulder blades leave the floor and then return to starting position [40-50].

This portion of this abdominal workout was utilized twice a week for nine training sessions. For the remaining eight

sessions Group I completed the same training program as Group II (bent-knee sit-ups for two minutes). The investigator timed and observed all workouts (See Appendix C).

Sheets for recording the number of repetitions completed each period and for recording outside abdominal exercises performed between periods were provided for each subject (See Appendix D). The subjects were instructed to perform as many repetitions as they could possibly do within the two minute workout segment. The subjects were also instructed to try to increase the number of repetitions completed from their last workout by two, or as many as possible, utilizing the overload principle. The sheets were used for recording and motivational purposes. The sheets also served as a control for the study by having subjects report any abdominal exercises completed outside of the training program. Journals were also kept by students to record their regular weight-training program and any other outside physical activity [51-60].

G. Regular weight training program

The regular weight-training program utilized for this class allowed students to select desired exercises. The instructor provided workout sheets which listed exercises for working different body parts. The student selected three exercises from each body part group. Three body parts were worked each day. Day 1 (Monday or Tuesday) was used to work the chest, back, and biceps. Day 2 (Wednesday or Thursday) was used to work the triceps, shoulders, and legs. A total of nine exercises were to be completed each class period by the students, using their choice of equipment (free weights or Universal). Students were also allowed to pick the number of repetitions they wanted to complete depending on their fitness goals. The instructor of the class recommended low weight and high repetitions for toning and shaping the muscles and he recommended high weight and low repetitions for building muscle mass and strength. For workout sheet see Appendix E.

Class Journal

As mentioned previously, a journal was kept by each student for this class. The journal contained all exercises completed inside and outside of class. Resting heart rates and comments were also required for each day of activity. The journal entries started on February 17th and continued until April 30th. The journals covered the same eleven weeks as the investigation [61-70].

Statistical Procedure

Analysis of Covariance was applied to the experimental data in order to determine if there was a significant difference between the groups. This statistical analysis was chosen because the researcher was unable to physically equate the groups. The .05 level of significance was used in this study

Analysis of Data

The purpose of this study was to investigate the effects of two different abdominal training programs on abdominal strength and endurance. The data were analyzed using Analysis of Covariance (ANCOVA) and t-tests. The ANCOVA statistical analysis was chosen because the researcher could not equate the experimental groups.

Findings

The results presented below are from the Analysis of Covariance conducted on the data obtained (Table 1).

Table 1: Analysis of Covariance Summary.

Source	Adj. SS	DF	MS	F
Between	202.10	1	202.10	10.62*
Within	742.44	39	19.04	

*Significant at .0027

An F ratio of 10.62 was obtained using ANCOVA in the comparison of the post-test scores of the two groups. This F was significant at the .05 level.

Changes occurring between group means

The mean scores were calculated for both groups and both tests (Table 2). The pre-test mean of Group I was 44.48 and the pre-test mean of Group II was 47.57. The post-test means were 50.81 for Group I and 49.10 for Group II. The difference between post-means was 1.71 sit-ups. However, when the final means were adjusted in ANCOVA, the difference was 4.44. For pre-test and post-test scores for each subject, by group, see [Appendix F & G](#).

Table 2: Pre-test and Post-test Means, by Gender and by Group.

	Pre-test M	Post-test M	Adjusted M	
Female	Group I	37.64	44.09	
	Group II	48.67	49.22	
Male	Group I	52.00	58.20	
	Group II	46.75	49.00	
Combined	Group I	44.48	50.81	52.10
	Group II	47.57	49.10	47.73

Table 2 shows pre-test and post-test means for women and men in Group I and Group II. The pre-test mean for females in Group I was 37.64 and the post-test mean for females in Group I was 44.09. The pre-test mean for females in Group II was 48.67 and the post-test mean for females in Group II was 49.22. The pre-test mean for males in Group I was 52.00 and the post-test mean for males in Group I was 58.20. The pre-test mean for males in Group II was 46.75 and the post-test mean for males in Group II was 49.00.

The pre-test standard deviation for Group I was 11.915 and the post-test standard deviation for Group I was 11.831. The pre-test standard deviation for Group II was 8.795 and the post-test standard deviation for Group II was 8.179 (Table 3 & 4) [71-80].

Table 3: Standard Deviations, by Groups.

	Pre-Test SD	Post-Test SD
Group I	11.915	11.831
Group II	8.795	8.179

Table 4: t-tests: Pre-test and Post-test, by Groups.

	df	n	t
Group I	20	6.33	7.34*
Group II	20	1.52	1.41

* Significant at .0001

The t-test results for Group I shows that Group I's training program was effective. The t-test results for Group II did not show the same results that were revealed for Group I. The difference between pre-test and post-test scores for Group II was 1.52 sit-ups, and this difference was not significant at the .05 level.

Results

Three hypotheses were tested at the .05 level of significance.

1. A bent-knee sit-up exercise program is effective in increasing abdominal strength and endurance. This hypothesis was accepted at the .05 level of significance.
2. A combination curl-up and bent-knee sit-up exercise program is effective in increasing abdominal strength and endurance [31]. This hypothesis was rejected at the .05 level of significance.

3. There is no significant difference between the effects of training the abdominals for strength and endurance using a bent-knee sit-up exercise program and using a combination curl-up and bent-knee sit-up exercise program. This hypothesis was rejected at the .05 level of significance.

Discussion

The mean abdominal strength and endurance levels for subjects in both groups were higher than expected. The combined male and female test means of Group I and Group II were in the excellent category for men. The pre-test mean for Group I males was 52 sit-ups, this score was also in the excellent category. The pre-test mean for Group I females was 37.64 sit-ups and in the excellent category for women. The post-test means for Group I were in the excellent category for both women (44.09) and men (58.20). Pre-test means of Group II fell into the excellent category for women (48.67) and in the excellent category for men (46.75). Post-test means for Group II were also in the excellent category for women (49.22) and men (49.00). For rating scales and norms see [Appendix H](#).

This high level of abdominal fitness might have been due to the type of individual that elects a weight training course. Students at The University of Kansas are required to take two hours of physical education, but these hours could be in a variety of areas. Those who chose weight training probably had an interest in maintaining a high fitness level [81-83].

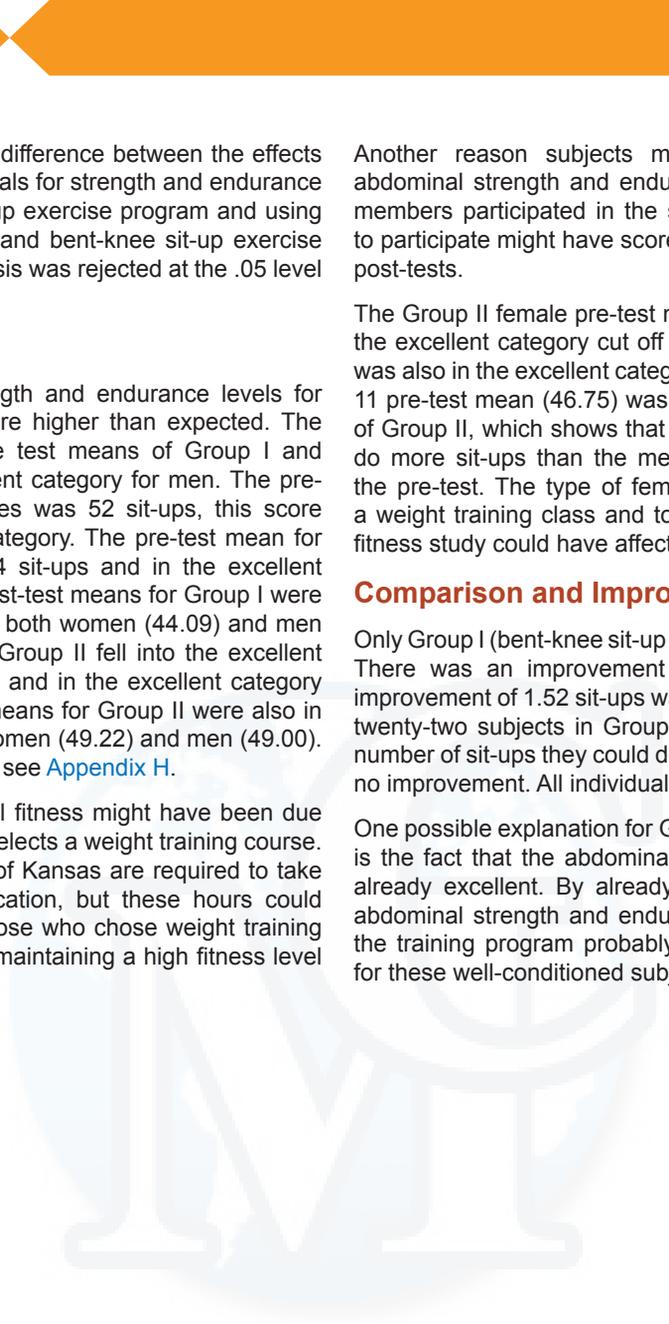
Another reason subjects might have had such good abdominal strength and endurance was that not all class members participated in the study. Those who chose not to participate might have scored lower on the pre-tests and post-tests.

The Group II female pre-test mean (48.67) was well above the excellent category cut off for women at 36. This mean was also in the excellent category for men. The male Group II pre-test mean (46.75) was lower than the female mean of Group II, which shows that the women in Group II could do more sit-ups than the men in Group II at the time of the pre-test. The type of female which elects to enroll in a weight training class and to participate in an abdominal fitness study could have affected these unusual results.

Comparison and Improvement

Only Group I (bent-knee sit-up group) improved significantly. There was an improvement of 6.33 sit-ups. Group II's improvement of 1.52 sit-ups was not significant. Eight of the twenty-two subjects in Group II actually decreased in the number of sit-ups they could do and two individuals showed no improvement. All individuals in Group I improved.

One possible explanation for Group II's lack of improvement is the fact that the abdominal fitness of the subjects was already excellent. By already having above the average abdominal strength and endurance, the curl-up portion of the training program probably was not strenuous enough for these well-conditioned subjects.



Summary, Conclusions, and Recommendations

Summary

The conditioning of the abdominal muscles has long been a serious concern of physical educators, athletic trainers, coaches, physicians, physical therapists, and others involved with improving physical fitness. Activities recommended for improving the strength and endurance of these muscles are numerous and varied. However, the majority of research reported supports the sit-up or one of its variations. The purpose of this study was to investigate the effects of two different abdominal training programs on abdominal strength and endurance, as measured by the bent-knee sit-up test.

Twenty females and twenty-two males participated in this study. These subjects were in two weight training classes at The University of Kansas, during the 1992 Spring semester. Abdominal training programs were randomly assigned to these two classes. Group I participated in a bent-knee sit-up exercise program and Group II participated in a combination curl-up and bent-knee sit-up exercise program. Both groups trained two times a week, two minutes a workout, for seventeen sessions. Group I executed as many bent-knee sit-ups as individually possible in all two minute workout sessions.

Group II did curl-ups for the first nine sessions of the training program, then progressed to the bent-knee sit-up for the last eight sessions.

The bent-knee sit-up test was used for both the pre-test and post-test of this study. The investigator chose the .05 level of significance and Analysis of Covariance for data analysis. The investigator also used t-tests to test for improvement of each of the two groups.

The Analysis of Covariance test revealed that the bent-knee sit-up exercise training program was superior to the curl-up/bent-knee sit-up exercise program. The t-tests indicated

that the bent-knee sit-up exercise program was effective and the curl-up/bent-knee sit-up exercise program had no significant effect on abdominal strength and endurance.

Conclusions

Within the limitations and delimitations of this study the following conclusions have been drawn on the basis of the data collected:

- a. A bent-knee sit-up exercise program will significantly increase abdominal strength and endurance.
- b. A combination curl-up and bent-knee sit-up exercise program will not significantly increase abdominal strength and endurance.
- c. Training the abdominals for strength and endurance using a bent-knee sit-up exercise program is more effective than using a combination curl-up and bent-knee sit-up exercise program.

Recommendations for Further Study

Based on the findings of this investigation the following recommendations for further study on developing abdominal strength and endurance are made:

- a. This study should be repeated using subjects with poor to average abdominal fitness.
- b. This study should be repeated utilizing training programs with different frequencies, intensities, and durations.
- c. This study should be repeated with the subjects separated by gender.
- d. This study should be repeated using a larger number of subjects.
- e. A control group could be added to determine if the age group used for the study would lose abdominal strength and endurance if they were not participating in the exercise programs.

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