A COMPARISON OF THE EFFECTS OF
PRESCRIBED FITNESS EXERCISES AND BOWLING
ON SELECTED ELEMENTS OF PHYSICAL FITNESS
IN COLLEGE WOMEN

by

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INTRODUCTION

The present peace time interest in physical fitness was emphasized through the efforts of Dr. Hans Kraus and Ruth P. Hirschland. The results of studies by Kraus and his associates indicated the apparently appalling state of physical fitness of American school youth as compared to European children. This information was brought to the attention of President Eisenhower, who in June, 1956, called a conference on the "Fitness of American Youth." The President felt more should be done to help youth acquire fitness so that they could be better prepared to meet the demands of modern life. (56:8)

This was the beginning of nation-wide attention to fitness, which was uncommon during peace time. The American Association for Health, Physical Education, and Recreation has actively encouraged this national trend by establishment of its Youth Fitness Project and Operation Fitness-U.S.A., programs concerned with the total fitness of American youth.

The American Association for Health, Physical Education, and Recreation, in its book Fitness for Secondary School Youth (3), has defined total fitness as including physical, emotional, mental, and social fitness.

Emotional fitness includes feelings of security, self-sufficiency, freedom from dominance, ability to make decisions, ability to pursue a course of action, ability to face reality, and ability to adjust satisfactorily to situations. (3:16)

Mental fitness includes the ability to habitually meet the problems of life in such a way as to satisfy individual needs and at the same time contribute to the welfare of society. (3:17)

Social fitness includes the ability to adjust to various social situations in such a way as to be satisfying to oneself and to society. (3:18)

Physical fitness, with which this study is concerned, has been defined as including strength, flexibility, endurance, and health. (49:15) "The degree of physical fitness desired is determined by one's psychologic, physiologic, and morphologic characteristics and should be at least the minimum needed to adjust to the conditions of wholesome and complete living." (3:16)

Physical fitness includes among its many components the elements of strength and flexibility. Investigation has shown that American youth are weak in abdominal strength, shoulder-girdle strength, and hamstring flexibility. The Kraus-Weber tests of minimum physical fitness found that the greatest failure by American school children was in the flexibility test, which was in essence a test of hamstring flexibility. (15:7) It has been found that the greatest degree of failure on strength items in the Kraus-Weber test was on the abdominal strength test. (55:321) It has also been found that "the weakest parts of the body appear to be the shoulder-girdle and arms." (3:29) It was primarily for the above reasons that these three elements of physical fitness were selected for investigation in this study.

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The issue of physical fitness of American youth is causing physical educators to consider their programs in light of their contributions to fitness. No clear picture is apparent in the many studies that have been conducted to determine the relative influence of various physical education activities on the development of elements of fitness. One reason for this is that investigators have compared different groups of activities and have selected different elements of physical fitness to study.

The value of an activity to physical fitness depends upon the elements of physical fitness being studied. The contributions which any activity can make to the various fitness elements depend upon the nature of the activity, the physiological work load required, the amount of continuous movement involved, and the degree of skill that is necessary before continuous activity is possible.

All studies dealing with fitness type exercises have found considerable improvement in many elements of physical fitness. This would be expected, since the exercises can be geared to the fitness elements found to be at a low level, without being restricted by a framework of rules as is the case in a sport activity. (26:18) However, specific exercises produce effects which are specific to that exercise alone. (14:119) Fitness exercises seldom lead to development of the skills which will be used in recreational or leisure time activities.

Exercises of a specific nature have long been used, and with great value, in developing in athletes the elements of fitness needed for top performance in competitive athletics. These athletes are already in possession of physical skill and certainly a minimum of physical fitness. Specific exercises have also been found useful in developing elements of fitness in individuals who have only a minimum level of physical fitness. However, sport activities have also been found to contribute to an increase in physical fitness, depending upon the nature of the sport and the fitness elements measured. There is indication that by participating in sports, an individual can increase his level of physical fitness at the same time he is learning skills that may be performed during his leisure time. It is with this last thought in mind that the writer tried objectively to ascertain if such could be claimed.

CHAPTER II

STATEMENT OF THE PROBLEM

The purpose of the experiment was to compare the effects of bowling and prescribed fitness exercises on certain selected components of physical fitness in college women. Of the many components of physical fitness, the three selected for investigation in this study were shoulder-girdle strength, hamstring flexibility, and abdominal strength.

The study compared the effects of controlled bowling sessions and prescribed fitness exercises on the shoulder-girdle strength, hamstring flexibility, and abdominal strength of college women who made initial low scores on one or more of the three fitness items selected.

The study compared the effects of bowling and body mechanics classes on shoulder-girdle strength and hamstring flexibility of the college women enrolled in these classes.

A secondary purpose of the experiment was to determine relationships between initial and final test scores within the individual and to determine relationships amongst the three fitness elements measured.

CHAPTER III

REVIEW OF LITERATURE

The attention of President Eisenhower and of the nation was focused on the fitness of American youth when Kraus and Hirschland published their findings on the physical deficiencies of American children compared with European children. In June, 1956, The President called a conference to discuss the fitness of American youth because, ". . . he felt that more should be done to help youth become physically fit and better qualified to face the requirements of modern life." (56:8) By executive order, The President provided for a Council on Youth Fitness and a Citizen's Advisory Committee on the Fitness of American Youth. In September, 1956, Shane MacCarthy was appointed Executive Director of The President's Council on Youth Fitness. (36:17)

In September, 1956, The American Association for Health, Physical Education, and Recreation held a national conference on fitness. In January, 1959, this association presented its framework for action, Operation Fitness-U.S.A., a program which is concerned with the total fitness of American youth. (54:26)

Physical fitness has been included as one of the aspects of total fitness by both the President's Council on Youth Fitness and Operation Fitness-U.S.A. (54:25)

Karpovich (7:244) defined physical fitness as, ". . . a fitness to perform some specified task requiring muscular effort." McCloy (49:15) included strength, flexibility, endurance, and health as elements of physical fitness. He stated (49:15) that the amount of strength and endurance needed to achieve physical fitness should be ". . . more than completely adequate for that person's emergency need, for off-the-job work, and for recreation." Hunsicker (40:17), in describing the American Association for Health, Physical Education, and Recreation Youth Fitness Project described physical fitness as including ". . . those qualities which permit an individual to perform life activities involving speed, strength, agility, power, and endurance. . . ." Mayer (48:70) defined fitness as ". . . a combination of limberness, strength, and endurance . . . ."

Physical fitness consists of many specific elements. Larson and Yocom (11:159-61) listed as elements of physical fitness: resistance to disease, muscular strength, muscular endurance, cardiovascular-respiratory endurance, muscular power, flexibility, speed, agility, coordination, balance, and accuracy. Mohr (52:340) included endurance, strength, and agility as certain elements of physical fitness. Stafford and Kelly (20:8) listed the fundamental characteristics of physical fitness as balance, flexibility, agility, strength, power, and endurance.

The best way to acquire and maintain physical fitness has been the subject of extensive investigations. These studies present reason to believe that physical fitness and some of its elements, including strength and flexibility, can be improved by participating in physical education activities.

A review of research concerning the contributions of sports to physical fitness was presented by Broer (26). She stated that the value of an activity to physical fitness depended upon the elements of physical fitness being measured. "The contributions which any activity can make to these various elements [of physical fitness] will vary with the teacher, the skill level of the class, and the incentive of the students." (26:18)

Mohr (52), using six-hundred eight-six freshmen and sophomore college women, measured the effects of a physical education program consisting of swimming, recreational sports, dance, and team sports, on some of the aspects of physical fitness. She found that almost all groups showed significant improvement in abdominal strength as measured by sit-ups and arm strength as measured by pull on a spring scale, but no group made significant improvement in arm and shoulder-girdle strength as measured by knee push-ups. No specific activity was found to be superior for the development of physical fitness.

Wilbur (62) compared an apparatus program with a sports program, consisting of boxing, wrestling, track and field, soccer, and swimming, to see which program made the greater improvement in the Physical Fitness Index. He found that the sports program was significantly superior in developing total physical fitness, agility, body coordination, and arm and shoulder-girdle strength. The sports program and apparatus program were equally effective in the areas of arm and shoulder-girdle coordination, speed of legs, endurance, and leg strength.

Gobelman (67) determined the degree of improvement made in physical fitness by three-hundred eighty-seven male freshmen who participated in physical education for one term. He found that classes in swimming, wrestling, fundamentals, body building, and soccer made at least a fifteen per cent improvement as measured by the workmeter. Classes in touch football, tennis, and apparatus-tumbling failed to make at least a fifteen per cent improvement on the workmeter. No activity met the fifteen per cent improvement standard on the dynamometer. However, Gobelman felt, as did Broer, that the quality of instruction and class objectives had a greater effect on the degree of improvement than did the nature of the class activity. In spite of this feeling, he concluded that individuals who are below a normal level of physical fitness can be brought to normal by a program designed for this purpose.

Smalley and Smalley (60) recorded change in endurance and arm and shoulder-girdle strength of four-hundred and fifty college women enrolled in archery, badminton, basketball, dance fundamentals, fencing, field hockey, folk dancing, tennis, swimming, and volleyball for eight weeks. They found that individual and dual sports contributed to improvement in endurance more than did team sports. A significant increase in arm and shoulder-girdle strength was shown in all activities except fencing, swimming, folk dancing, and field hockey. The average mean of strength increase after participating in these activities was significant at the 1% level of confidence.

Bennett (25) studied the relative contributions of modern dance, folk dance, basketball, and swimming to agility, coordination, strength, flexibility, and speed in eighty-two college women. The hierarchy of the four activities in the development of the selected abilities was swimming, modern dance, basketball, and folk dancing. She found that both swimming and modern dance made significant contributions to abdominal and general strength.

Ball (65) investigated the contributions of modern dance, basketball, and skiing to the Strength Index and Physical Fitness Index of one-hundred and fifty college women. She found a significant increase in the Strength Index and Physical Fitness Index of the skiing and modern dance groups.

Landiss (44) studied the relative effects of boxing, conditioning, swimming, tennis, tumbling-gymnastics, volleyball, weight-training, and wrestling on the physical fitness and motor ability of one thousand college men. All of the sport groups studied,with the exception of swimming showed significant improvement in physical fitness as measured by a 300-yard shuttle run, pull-ups, and sit-ups. Swimming and boxing were the only groups that failed to make significant gains in the Larson Test of Motor Ability.

Porter (75) stated that the general motor ability of college women could be improved by physical education activities. Harris (70) stated that games and sports techniques having therapeutic basis might be used to supplement formalized physiotherapy treatment in the re-education of paralytic muscles.

Steinhaus, Hawkins, Giaugue, and Thomas in the booklet, <u>How to Keep Fit and Like It</u> (21:43), attempted to answer the question: Can fitness be achieved through all sports? They noted that:

> Only a few sports, such as strenuous swimming or handball, produce all-around development of strength and endurance.
> Most sports contribute to the development of endurance and leg strength, but afford little opportunity for the development of

abdominal, arm, and shoulder strength.
Many popular sports, such as archery, bowling, and golf, are of little value for endurance or strength.

Stehr (77), using thirty-six university women, measured the contributions of basketball and modern dance to arm and shoulder-girdle strength, leg strength, abdominal strength, agility, and endurance. The subjects were enrolled in physical education classes of basketball or modern dance which met twice a week for twelve weeks. She found that the combined scores of the two classes showed no significant improvement on any one item of the test battery. The results indicated that neither basketball nor modern dance contributed greatly to individual improvement in the elements measured. Stehr felt that any improvement that was made was due almost entirely to individual effort, rather than the result of the activity.

The majority of evidence indicates that elements of physical fitness can be improved by participating in physical education activities. However, opinions such as those expressed by Steinhaus, Hawkins, Giaugue, and Thomas (21:43) and findings of studies such as Stehr's (77) indicate that more research needs to be done into the problem of how to achieve physical fitness. (49:38)

One of the elements of physical fitness of concern in this study is strength. Hunsicker and Donnelly (41:408) in their article on the history of strength measuring instruments, pointed out that man has always been interested in muscle strength, but it was not until modern times that attempts were made to measure man's strength scientifically. Hunsicker and Greey (42) cited selected studies on strength testing and discussed the fact that we still do not know what actually takes place when strength increases.

Clarke (30) compared instruments for recording muscle strength and found the cable tensiometer was the best for precision, stableness, usefulness, and had an objective coefficient of .90 to .96. He described (31) the original research done on the cable tensiometer in establishing directions, descriptions, validity, and reliability of the various tests. Revision of some of Clarke's original tests for this instrument are described by Clarke, Bailey, and Shaw (32).

An instrument frequently used to measure arm and shoulder-girdle strength is the push-pull dynamometer. Lipovetz (12:283) describes this instrument as a precise measure of the condition of a person's motor apparatus.

Scott and French (18:169) used the dynamometer in testing sixty-two college women and found a reliability coefficient of .91. Wilson (63), in studying strength of fifty-two college women, found a reliability coefficient of .76 for the push and .89 for the pull.

In studies involving the dynamometer, Duvall, Houtz, and Hellebrandt (37) determined that a single effort muscle test on the hand dynamometer is as reliable, .97 to .99, as either the best of three or the best of ten trials.

Wilson (63), in her study of arm and shoulder-girdle strength of fifty-two college women in selected tests, found that when correlated with scores on the push-pull dynamometer, knee-push-ups had a coefficient of .265 and modified pull-ups a coefficient of .302. The sum of the push-pull correlated .492 with Roger's Short Strength Index. In comparison with Roger's Short Strength Index, Wilson found knee-push-ups had a coefficient of .717 and modified pull-ups a coefficient of .797. Wilson (72:261) concluded that strength could be measured by performance tests, consisting of push and pull ups, with a relatively high validity according to a criterion consisting of Roger's Short Strength Index. This perhaps was due to the fact that Roger's Short Strength Index includes push-ups and pull-ups as items in its test battery.

Mohr (52:347) stated that knee push-ups must be carefully watched for errors in order to insure their validity.

Anderson (24) found that pull-ups correlated .282 with pull and .212 with push on a dynamometer. She found that dips correlated .372 with pull and .286 with push.

Carpenter (28) found that the pull and push on the dynamometer are slightly superior in validity to chinning and dipping as an index of arm and shoulder-girdle strength. Chinning and dipping tests for girls have not shown significantly high correlation with actual strength to justify their use as valid tests of strength. (1:103)

Another strength measurement technique that is mentioned frequently in research is the Martin-Break technique (46). In this method, a subject resists a pull rather than exerts his strength in an active effort. The test measures the maximum resistance contracted muscles offer against stretching. Anderson (24) used this technique in measuring the strength of thigh flexors to determine the extent that individual athletic performance in girls was dependent upon strength. She found that strength is not the sole factor in girls' athletic ability, but that body build, relative fatness, and environmental elements also seemed to influence the girls' ability.

Wedemeyer (61) used this technique in his study on the values of sit-ups as measures of strength and endurance of abdominal muscles.

DeWitt (35) also used the Martin-Break technique, and found, as did Wedemeyer, a low correlation between ability to perform sit-ups and abdominal strength and endurance.

From the research it seems clear that the strength of the abdominal muscles are best measured with an instrument, such as the cable tensiometer or that used in the Martin-Break technique, rather than by an exercise type test such as sit-ups. Arm and shoulder-girdle strength are better measured by a push-pull dynamometer than by performances such as chin-ups and dips.

Research indicates a great deal of interest concerning various methods and systems of developing strength. Physiologists and physical educators agree, however, that in order to increase strength a muscle must contract against a weight or resistance. (13:485; 12:193; 10:17; 16:216) Investigation has been conducted concerning the length, amount, and type of contractions and the amount of weight or resistance necessary for the development of muscular strength.

One method of strength development that has been extensively investigated is DeLorme's system (4) of progressive resistance exercises. DeLorme advised ten repetitions daily using maximum strength in his system of strength development. D. H. Clarke and E. L. Herman (29) established a practical method for determining the maximum resistance load for ten repetitions for the quadriceps. They found that fifty per cent of the maximum strength, as measured by the cable tensiometer, is a satisfactory method for determining the maximum weight the muscle can correctly lift ten times.

Flint (38) used progressive resistance exercises, with ten repetitions of each exercise using maximum strength, in increasing back and abdominal muscle strength. She found the maximum strength development mean occurred in the twenty-fifth exercise period and in the twelfth week.

Capen (27) reviewed various recommended methods of weight training that had demonstrated scientific evidence of effectiveness in the development of strength. He found the methods reviewed were variations of a few basic programs that varied in amount of weight, length of contraction, and number of executions. Capen's purpose in his experiment was to determine which of four methods of weight training was superior in strength development. He compared the effects on strength improvement of various weights, number of executions, and number of exercise bouts per week on eight groups of male university freshmen. He found that ". . . weight training programs that utilized the heaviest weights that would permit a maximum number of five executions were superior to the other programs in this study for the development of muscular strength." (8:140)

Herrold (71) compared four methods of developing strength in the elbow flexors and knee extensors of eighty-eight male physical education majors. The men were assigned to four groups, where they exercised three days per week for six weeks. The methods compared were:

1. The maximum weight that could be lifted through a full range of motion fifteen times.
2. The maximum weight that could be lifted through a full range of motion ten times.
3. The maximum weight that could be lifted through a full range of motion five times.
4. Lifting to the point of fatigue, three-fourths of the maximum weight that could be lifted through a full range of motion one time.

Herrold concluded that significant difference in strength did not exist among the four groups. Strength increase occurred from both lifting heavy weights slowly and lifting lighter loads rapidly.

DeLorme's technique of progressive resistance exercise involves the use of isotonic contractions of a muscle to increase strength. Isotonic muscular contraction involves the shortening of a muscle which results in movement being produced. Another type of contraction used to increase strength is isometric contraction in which the muscle contracts, but its length remains the same and no movement is produced.

E. A. Muller (53) has postulated that there is no better way to increase muscular strength than one short, about half maximal, isometric contraction once a day. This method has been substantiated by current research.

Wolbers and Sills (64) found that a six second static contraction of a muscle once a day, five days a week, for eight weeks, produced significant gains in back lift, leg lift, and combined hand grip tests of high school boys.

Rarick and Larson (51) found that a single six second isometric contraction at two-thirds maximum tension proved as effective for strength development of the wrist as more frequently repeated exercise at eighty per cent of maximum tension. However, the more frequently repeated exercise at eighty per cent of maximum tension was found superior for strength retention.

Mathews and Kruse (47), in comparing the effects of isometric and isotonic exercises on elbow flexor muscles, found no common regression line, indicating that strength changes were peculiar to the individual, regardless of the exercise frequency; however, the isometric exercise caused a greater number of subjects to gain significantly in strength.

Salter (58) compared the effects of isotonic and isometric contraction on strength development of supination of the left hand. Isotonic contraction consisted of lifting seventy-five per cent of the maximum weight possible as far as possible for four seconds. Isometric contraction consisted of applying a gradually increasing force to the maximum possible over a four second period. Her subjects consisted of twenty men and women who executed thirty contractions at a rate of either two or fifteen per minute for four days per week for four weeks. She found that all training procedures resulted in an improvement in muscle strength, but no significant difference was found between the four different methods used. Salter also found that the amount of exercise provided by the test contraction alone is not enough to produce a significant increase in strength.

Darcus and Salter (34) studied the effects of repeated maximum isotonic and isometric contractions on strength of pronation and supination of the hand and flexion of the elbow. Daily training sessions consisted of thirty contractions at intervals of one minute. Both types of training resulted in an increase in strength, but the effects of "static" training were not felt until after twenty days. "Static" training resulted in an increase in all other positions tested besides the one trained. They felt that their method of training is original since the subject makes maximum exertions at intervals (one minute) designed to allow full recovery. Their static training involved isometric contractions only held momentarily, whereas other methods involved holding submaximal weights for a period of time. Darcus and Salter felt that it is difficult to make a maximal isometric contraction because the subject does not know when he has reached maximum. They concluded by agreeing with others that muscle strength may be increased by systematic voluntary exercise, but there is no agreement regarding the most effective way of doing this.

There are studies to indicate that strength may be increased not only by these specific methods of strength development, but also by participating in general physical education activities.

Exercises of the type used in general physical education classes involving body weight without special apparatus have also been used to increase strength.

Grande (68) used the dips described by the Woman's Army Corps (23) in significantly increasing the strength of the shoulder-girdle of college women.

Walters (79) found that prescribed strenuous exercise consisting of pull-ups, push-ups, and sit-ups, improved the physical efficiency of college women as measured by the grip dynamometer, bicycle ergometer, and treadmill walking.

Sills (59) found that conditioning exercises of pull-ups, sit-ups, push-ups, curls and pull-overs with weights, and running produced significant gains in the fitness of thirty-three college male freshmen as measured by the Iowa Physical Fitness Tests.

Wedemeyer (61) used sit-ups to strengthen the abdominal muscles of forty-seven high school boys. After two months he found no markedly significant relationship between the number of sit-ups a boy could do and his abdominal strength. He felt that after the abdominal and thigh flexor strength reached a certain level, further improvement in the number of sit-ups was not accompanied by a significant increase in strength.

Studies that have found an increase in strength after participation in various sports have been presented in the section on improving physical fitness through participation in physical education activities. Mohr (52), Wilber (62), Bennett (25), Ball (65), Landiss (44), and Smalley and Smalley (60) have found a significant increase in strength after participation in various sport activities. Stehr (77) in his study, however, found no significant improvement in strength.

Another aspect of physical fitness of concern in this study is that of flexibility. Instruments to measure flexibility are not as numerous, nor have they been investigated as extensively as have instruments of strength measurement. Cureton (33) describes the use of one of the older measures of flexibility, a slidingwood caliper, for his method of measuring hip flexibility. Kraus (10:37) stated that a goniometer or protractor was usually used to measure the range of a joint. The Leighton Flexometer, a gravity type goniometer, is the instrument most frequently used today in research studies involving measurement of flexibility. Leighton (45) found the flexometer was a simple yet valid and reliable instrument for measuring flexibility with a coefficient of .99.

Gurewitsch and O'Neill (39), using five simple tests in studying the flexibility of health children from four to eighteen years of age, found that training and attempts at limbering up will considerably change the results of the tests.

Cureton (33:381) defines flexibility as, "the capacity to bend, or to be flexed, or extended without breaking; to be pliant, not stiff, or brittle." Lipovetz in his book, Medical Physical Education (12:358), said, "Flexibility is a capacity to move the body easily to full range of joint motion; indicating body suppleness."

McCue (50), in her study of flexibility measurements of college women, found that individuals who had a past history of more activity tended to be more flexible.

Flexibility exercises in general are concerned with the extent to which the active muscles may be shortened and the antagonists elongated (33:381). There is little information in professional literature concerning methods of improving flexibility. Swedish medical gymnastics describe various exercises for increasing the range of movement in joints. However, the majority of information relative to flexibility is to be found in the field of physical therapy. However, in this area the exercises are mainly for individuals recovering from injury or disease and are not for the "normal" individual.

Kraus (10:26) stated that "Lack of physical elasticity (contracture) can be overcome only by stretching." Kounovsky (9:12) recommended for those who lack flexibility, "perform mostly stretching and relaxing exercises, avoid too many strength exercises and too much muscular tension." These are very general statements, but they do not define specific stretching and relaxing exercises that have proven successful in improving flexibility.

Dr. J. Arvedson, in Kleen's Massage and Medical Gymnastics (8:157-58), described active and passive movement as two types of exercise used in medical gymnastics to increase flexibility. Active movement occurs when the patient's muscles are innervated and brought into action either with or without resistance. Passive movement occurs when movement is performed in the patient's joints by some outside force.

Scott (17:345) discussed means of increasing flexibility and stated, "Flexibility can be developed by gradually increasing the amount of force used in elongating the muscle and at the same time gradually increasing the range. Antagonistic muscle action may be used, or it may be done passibly by the weight of body parts, or by external resistance."

Kleen (8:134) stated that passive movements are of greatest value in the treatment of joint affections, and can be used to stretch ligaments and contractions.

Cureton (33:381), however, stated:

> Flexibility exercises are not passive movements in the true sense because joint flexion movements are opposed by the resistance of opposing muscles, tendons, and ligaments, since the structures have elastic properties. Dynamic contraction of the active muscles is involved.

Tidy (22) tended to support Cureton when he listed his objections to the "pressure" method of correcting scoliosis. He says that it is impossible to correct scoliosis by pressure because there is resistance of actually shortened structures and because, "the patient involuntarily contracts the muscles which the operator is trying to stretch, in order to avoid the pain--or, at least, the discomfort--produced by the stretching." (22:323) He recommends an active movement where the antagonists relax as the muscles performing the action contract.

Riddle (76), in determining the best method for increasing flexibility of the trunk and hip joint, tested three methods of stretch. They were the held-stretch—from the Swedish system of gymnastics where the part is carried to the limit of range of movement and held for several seconds; the spring-stretch—from the Danish system of gymnastics; and a combination of the two. She found that all three methods increased flexibility, with the spring-stretch method being slightly, but not significantly, superior to the other methods tested.

Hupprich and Sigerseth (43) measured the flexibility in sixty-six different movements of three hundred girls, six to eighteen years of age. They found a reliability coefficient of .9 for every measurement taken.

They correlated each possible pairing of the variables studied using the Pearson product-moment method. The intercorrelations indicated that only nine of the sixty-six coefficients were higher than .3, which indicated that flexibility factors were specific to each joint movement measured.

Forbes (66), in studying the characteristics of flexibility in boys ten to eighteen years of age, found that, "flexibilities opposite to the more frequently utilized joints are the more supple."

Kingsley (72) measured flexibility changes that occurred in high school boys enrolled in tumbling class and found that the flexibility did improve in most areas of the body. Of the thirty areas measured, eighteen showed a significant increase in flexibility.

McCue (50) used as subjects those individuals whose flexibility score was in the lower quartile of the group measured. They performed "exercises of a type in common use" designed to increase hip flexion, hip rotation, ankle flexion and extension, trunk flexion, and total back and neck extension. After daily performance for three weeks a significant increase in flexibility was found in all areas measured.

Studies completed at the University of Oregon compared the flexibility of non-athletes and varsity competitors in football, shot putting, discus throwing, swimming, baseball, and basketball. Haliske (69) found that football players were significantly less flexible in thirteen of twenty-one areas when compared with non-football players. Lemire (73) found that shot putters and discus throwers were significantly less flexible than non-athletes, swimmers, and baseball players.

Syverson (78) found that baseball players were significantly more flexible than football players, basketball players, and non-athletes. Williams (80) found that basketball players are significantly more flexible than football players, and significantly less flexible than swimmers and baseball players. Pickens (74) found that swimmers, on the whole, were significantly more flexible than football players, baseball players, basketball players, and non-athletes.

Since it has been shown that sports, as well as exercise, contribute to the improvement of flexibility and strength, there appears to be the possibility of using sports and games to correct postural defects.

Lipovetz (12:356) did not think prescribed exercises of much value in correcting posture when he said,

> Everyone has in recent years heard a great deal about the meager results of our efforts to correct postural defects by prescribed exercises. Thus one hears stories of C grade postures becoming C- after four years of "correction," of the posture of school children growing progressively worse in the schools with up-to-date programs of physical education, etc. Here and there some are eventually successful, but on the whole, it seems to me, the note is pessimistic.

Metcalf (51:208) sent out questionnaires to twenty-nine colleges and universities concerning their corrective programs. He found a tendency among men's departments to feel that a well-rounded program of chiefly games "will produce amazingly fine results from the standpoint of improvement of posture or body mechanics, and general fitness." Metcalf then questioned whether we should use a program of all games, all exercise, or a combination of games and exercises in corrective programs.

According to Stafford (19:38), "On the basis of the possible corrective value of adapted sports, there is little evidence to support the 'correction phase' of this type of activity." Foote (5:84) believed that using modified games to supplement specific corrective exercises might be of use in contributing to the correction of some of the more common postural defects. She stressed that these games should not be used as a substitute for corrective work.

Physical fitness, which is of interest and concern to many physical educators today, is composed of several specific elements. Research indicates that sports and exercise, as taught in our general physical education programs, contribute to the improvement of these various elements of physical fitness. Strength, one element of physical fitness, can be increased by various methods, all of which involve muscular contraction against a resistance. Flexibility, another element of physical fitness, can be increased by stretching a muscle. Both sports and exercises have been found to contribute to the development of strength and the increase of flexibility. The research indicates that there is ample basis for a comparison of the relative effects of a sport and exercises on strength and flexibility of students.

CHAPTER IV

PROCEDURE

The purpose of this study was to compare the effects of bowling and prescribed fitness exercises on certain selected components of physical fitness in college women.

Selection of Subjects

The experimental subjects for this study were selected from among one hundred eleven women enrolled in three body mechanics and five beginning bowling classes at the Woman's College of the University of North Carolina for the spring semester, 1959. The three body mechanics classes were taught by three different instructors. The five bowling classes were also taught by three different instructors, the investigator teaching one class, and two other staff members each teaching two classes. A total of forty-two bowling and nineteen body mechanics students, all of whom scored in the lower fifty per cent of their class on one or both initial tests and were not participating in physical activity other than class work, were used as the experimental subjects for this study.

Twenty-nine control subjects were selected at random, using a table of random numbers (2:142), from among one hundred and twenty-eight upperclass women living in the North and South Spencer Residence Halls at the Woman's College of the University of North Carolina. The control subjects possessed no physical handicaps, were not taking physical education course work, and performed only mild physical activity during their daily routines.

Selection of Measuring Instruments

Abdominal Strength

An aircraft tensiometer, as recommended by Clarke (30), was used to measure the abdominal strength of the subjects. The tensiometer, Model T5-6007-117-00, used in this study was manufactured by the Pacific Scientific Company, Inc., Los Angeles, California. It was specially calibrated for an "up-pull" on a cable to a maximum of one hundred pounds. The instrument had a maximum tension pointer to facilitate reading the subject's score.

The subject assumed a supine lying position upon the testing table, hips in 180° extension and adduction, knees fully extended, arms folded on chest. A simple web belt with a sliding buckle was strapped around the subject's chest, close under the arm pits. The pulling assembly was attached to the back of the belt beneath the subject, through a slit in the table. To prevent the subject's hips from lifting, the investigator exerted pressure downward upon the anterior superior iliac spine of the subject. The subject was then instructed to sit-up, exerting as much pressure as possible against the belt.

The pulling assembly consisted of a double hasp, attached to both the belt and a two-inch aluminum clamp, of the type used by carpenters. This first clamp was hooked to a second three-inch clamp, which in turn was hooked to a third one-inch clamp. This third clamp was finally clamped to the end of a 1/16" cable. This cable was inserted in a standard frame of the type used to secure the cable and tensiometer when measuring grip strength. This frame was attached to the bottom brace of the table (which was directly under the slit in the table), by means of an iron bar and two four-inch aluminum clamps. The cable tensiometer was attached to the cable and held securely in the frame by means of a two-inch aluminum clamp.

The tension recorded by the instrument was converted into pounds by means of interpolation from an imperical table provided by the manufacturer. This table with its conversion scores may be found in the Appendix.

To measure the actual strength of the abdominal muscles the "gravity factor," or weight of the trunk, must be added to the tension measured by the tensiometer. (32:139) The actual strength of the abdominal muscles was not calculated by the investigator since the process was time consuming, and the results would not have been of practical value in this study which was concerned primarily with differences between initial and final testing.

Shoulder-Girdle Strength

A single push and pull on a grip dynamometer with a push-pull attachment, as described by Scott and French (18:168-169), was used to measure the shoulder-girdle strength of each subject.

When measuring pushing strength, the subject was instructed to grasp the handles of the push-pull attachment, with the palms of the hands facing each other, the forearms horizontal, and push on the handles as hard as possible, being sure to keep the instrument from touching the body. The instructions for measuring pulling strength were the same except the subject was instructed to pull on the handles as hard as possible.

The score for both the push and pull was recorded to the nearest pound after being corrected by reference to a correction table. A copy of this table may be found in the Appendix. The corrected push and pull scores were combined to find the subject's total shoulder-girdle strength.

Hamstring Flexibility

The Leighton Flexometer (45), a gravity type goniometer, was used to measure the flexibility of the hamstring muscles. The subject assumed a supine lying position upon the testing table, arms at sides, legs at 180° extension and adduction, knees fully extended, ankles in dorsal flexion. The instrument was strapped to the lateral side of the ankle just proximal to the lateral malleolus of the fibula and the dial set to 0°. The subject's hips were held down on the table by the administrator or an assistant, while the subject raised her right leg as far as possible, keeping her knees extended and her ankle dorsally flexed. This position was held for a few seconds while a reading was taken on the instrument. The same procedure was followed in determining the flexibility of the left hamstrings.

The subjects' scores on the right and left legs were combined to obtain her total hamstring flexibility score.

Procedure

Initial Tests - Experimental Subjects

During the week of February 2 - 6, 1959, the investigator met with each of the three body mechanics and five bowling classes on their second scheduled physical education class period. The purpose of the study was briefly explained previous to the initial testing which took place at this time. Each woman filled out a testing card, a copy of which may be found in the Appendix, and proceeded to the research laboratory where she was tested for shoulder-girdle strength and hamstring flexibility by six graduate assistants of the department of physical education. Each student's test results were recorded on her testing card. A total of seventy-seven bowling and thirty-four body mechanics students were tested at this time. The abdominal strength test was not administered to the eight classes due to its length and complexity.

Since the purpose of this experiment was to compare the effects of bowling and specific exercises, the testing cards were arranged into two groups according to the physical education class in which the student was enrolled. Those students who scored in the lower fifty per cent of their class on one or both of the initial tests and were not participating in physical activity other than class work, were contacted by the investigator and asked to participate in the study. Each girl who met the above qualifications was told her relative standing in relation to the others tested, and exactly what would be expected of her as an experimental subject. If the student was willing to participate in the study, a time was set for her to attend three experimental sessions each week, held on days she did not meet her physical education class. A total of forty-two bowling and nineteen body mechanics students indicated a willingness to participate in this study. Of those willing, thirty-two bowling and fifteen body mechanics students scored in the lower fifty per cent of the groups measured on shoulder-girdle strength; and thirty-two bowling and fourteen body mechanics students scored in the lower fifty per cent of the groups measured on hamstring flexibility.

Initial Tests - Control Subjects

The twenty-nine control subjects were tested on shoulder-girdle strength, hamstring flexibility, and abdominal strength during the week of February 1 - 7, 1959. The investigator was the sole test administrator for all control subjects.

The purpose of the study, qualifications for the control group, and the nature of the tests were explained to each of the control subjects prior to the initial testing. It was emphasized that the control subjects should continue with their normal daily routine and not engage in any but mild physical activity until they had been tested again in one month.

Intervening Exercise Sessions

The experimental sessions covered a total period of four weeks. During this time, the subjects participated in regular class activity two days each week and a controlled experimental session three days each week. No attempt was made by the investigator to regulate the number of class meetings a subject attended nor the amount or type of activity performed during class time. The twelve experimental sessions were conducted so that all subjects would have some common experience regardless of their regular class activity. Prior to the first experimental session, the abdominal strength of each subject was measured by the cable tensiometer.

Bowling Group

The four lane bowling alley, included among the Woman's College physical education department's facilities, and regulation ten pins and balls were used throughout the experiment. The subjects were required to set pins for one another since pin boys or automatic pin setters were not available. The device used to set pins consisted of a pedal, which when depressed raised a two-inch metal rod in the center of each of the ten pin spots. The subject then had to place each pin on a metal rod, one by one. This pedal was depressed, and held down by the subject's foot, each time the bowling pins were set up. The subject setting pins also had to lift the bowling ball from the pit to the return track, a distance of about four and a half feet.

Since the subjects would be performing the activities connected with setting pins, as well as bowling, each subject was given a card on which she recorded the number of balls bowled, the number of balls returned from the pit, and the number of pins set each day during both her class period and the experimental sessions. A copy of this card may be found in the Appendix.

During the first and second weeks of the experiment, subjects were required to bowl fifteen balls each experimental session. There was not a specified number of balls to be returned nor pins to be set; only the number of balls bowled was constant. During the first week the subjects bowled at only three pins--the one, three, and five. Beginning in the second week, the subjects bowled at all ten pins and their bowling score was kept. During the third and fourth weeks the subjects were required to bowl twenty balls each experimental session. The subjects usually bowled half of the required number of balls at one time, before setting pins.

Throughout the experiment the subjects were told to perform the skills as they were being taught in their respective classes, using either the one, three, or four step approach. Assistance and coaching on the approach and release was given by the investigator, who was present at all experimental sessions.

Two of the classes from which subjects were selected started the first week of class instruction with duck-pin bowling. During the second week, however, the instructor was kind enough to change the instruction to ten pin bowling.

The bowling scores made by the subjects during the experimental sessions were submitted to the respective instructors to do with as they wished.

<u>Body Mechanics Group</u>

Experimental sessions for the body mechanics group were held on Monday-Wednesday-Friday and Tuesday-Wednesday-Thursday evenings in the game room of two of the residence halls at the Woman's College. During the first experimental session each week the subjects were given a list of exercises with instructions, and their performance was carefully supervised by the investigator. During the experimental sessions the subjects performed the specific exercises for the area in which they were in the lower fifty per cent on the initial test; however, all subjects performed the abdominal exercises.

Each week the instructors of the three body mechanics classes were given a copy of the prescribed exercise routine. The instructors allowed the subjects to perform the experimental exercises during class time. Many times the entire body mechanics class participated in the experimental exercises, along with the experimental subjects, under the supervision of the class instructor.

The majority of exercises used were selected from body mechanics and physical therapy books. The reference and complete description of each exercise may be found in the Appendix. The following exercises were performed by the experimental subjects:

Abdominal Strengthening:

First Week
Flexion and Extension - 5 times, 3 seconds
Single Knee Kiss - 5 times
Roll Down - 5 times

Second Week
Double Flexion and Extension - 5 times,5 seconds
Leg Circles - 5 times
Sit-Ups - 5 times

Third Week
Leg Hold - 3 times, 10 seconds
Trunk Swing - 3 times
Sit-Ups - 10 times

Fourth Week
Leg Hold - 5 times, 10 seconds
Trunk Swing - 5 times
Sit-Ups - 15 times

Shoulder-Girdle Strengthening:

First Week
Wing Spread Against Resistance - 5 times, 3 seconds
Partner Dip - 5 times
All Fours Dip - 5 times

Second Week
Wing Spread Against Resistance - 5 times, 5 seconds
Elbow Push-Ups - 5 times, 5 seconds
Let Down - 5 times

Third Week
Knee Push-Ups - 5 times
Let Down - 5 times
Vertical Pull-Ups - 3 times

Fourth Week
Knee Push-Ups - 10 times
Let Down - 10 times
Vertical Pull-Ups - 5 times

Hamstring Stretching:

First Week
Toe Touch - 3 times, 3 seconds
Stand and Touch Toes - 3 times, 3 seconds
Leg Extension - 3 times

Second Week
Toe Touch - 3 times, 5 seconds
Assisted Stretch - 3 times, 3 seconds
Chair Stretch - 3 times, 3 seconds

Third Week
Toe Touch - 5 times, 5 seconds
Assisted Stretch - 5 times, 5 seconds
Straight Leg Raising - 5 times

Fourth Week
Toe Touch - 5 times, 10 seconds
Assisted Stretch - 5 times, 8 seconds
Hamstring Stretch - 5 times, 5 seconds

If the subjects were unable to attend a class or experimental session, they were requested to perform the exercises on their own, without supervision, so that each subject performed the exercises a total of five days each week. Due to college activities held in the evenings, subjects were unable to attend all the experimental sessions. The number of times a subject attended experimental sessions ranged from one to nine, with a mean of six sessions.

Final Tests - Experimental Subjects

The second and final testing took place during the week after the experimental sessions were completed.

The five bowling and three body mechanics classes were again tested during their class period on shoulder-girdle strength and hamstring flexibility. The experimental subjects were also tested on abdominal strength at this time. The same graduate assistants administered both the initial and final tests in all classes except one, where the shoulder-girdle strength test was administered by a different assistant. The investigator administered all abdominal and flexibility tests on both the initial and final tests.

A total of seventy-five women in bowling and thirty-three in body mechanics classes were administered the final test. Two bowling and one body mechanics student, who were tested initially, had dropped the course or were unavailable at the time of the final test. All the experimental subjects, forty-two bowling and nineteen body mechanics students, completed the final test.

<u>Final Tests - Control Subjects</u>

During the final week of the experiment, the control subjects were again contacted and an appointment made on the following week for their final test. Twenty-six of the twenty-nine original control subjects completed the final tests, three subjects being unavailable for testing. The investigator again was the sole test administrator.

CHAPTER V

PRESENTATION OF DATA

The purpose of the experiment was to compare the effects of bowling and prescribed fitness exercises on the shoulder-girdle strength, hamstring flexibility, and abdominal strength of selected college women enrolled in five bowling and three body mechanics classes. The effects were determined in terms of scores made on a dynamometer, a flexometer, and a cable tensiometer. The initial measurements were taken prior to the intervening exercise sessions. The final measurements were taken after the subjects had participated in the intervening exercise sessions.

After the initial test, the scores of the five bowling classes were combined, and further consideration was given to the scores of the total bowling group rather than to the scores of individual classes. The same procedure was followed for the three body mechanics classes, which were combined to form the total body mechanics group.

Those students who were willing to participate in this study as subjects and scored in the lower fifty per cent of the total bowling or total body mechanics group on the shoulder-girdle strength test or the hamstring flexibility test, comprised the experimental sub-groups in this study.

The total groups for both bowling and body mechanics were divided into five sub-groups to facilitate the comparison of data.

1. Bowling S-G and Body Mechanics S-G: this sub-group

was composed of experimental subjects scoring in the lower fifty per cent on the initial shoulder-girdle strength test.

2. Bowling H-S and Body Mechanics H-S: this sub-group was composed of experimental subjects scoring in the lower fifty per cent on the initial hamstring flexibility test.
3. Bowling ABD and Body Mechanics ABD: the abdominal strength sub-group, composed of all experimental subjects.
4. Non-Experimental Bowling and Non-Experimental Body Mechanics: this sub-group was composed of all students in the classes concerned who were not experimental subjects.
5. Total Bowling and Total Body Mechanics: this sub-group was composed of all students in the five bowling or three body mechanics classes who were tested.

The reason for dividing the total groups into five sub-groups was to facilitate the comparison of the effects of sports and exercise on the three fitness elements of concern in this study. The Bowling or Body Mechanics S-G and H-S sub-groups dealt with only those students scoring in the lower fifty per cent on the initial test, and, therefore, those who had the greatest room for improvement. The Non-Experimental Bowling or Body Mechanics sub-groups dealt with those students who either scored in the upper fifty per cent on the initial tests, or else were in the lower fifty per cent, but could not participate in the study as experimental subjects. This sub-group, therefore, was composed of all students who participated in class work, but did not participate in the intervening exercise sessions. The Total Bowling or Body Mechanics sub-groups dealt with both subjects who participated in the intervening exercise sessions, and those students who participated only in class work. The Control Group dealt with students who did not participate in any strenuous physical activity and were not enrolled in the bowling or body mechanics classes.

Statistical Analysis

Differences Between Means

Since the experiment was designed to compare differences that might exist between participation in bowling and body mechanics type activities, Fisher's "t" formulae (6:220) were used to compute the significance of difference between means and between the means of difference scores.

It was decided that the five per cent level of confidence or below would be acceptable for statistical significance.

Shoulder-Girdle Strength

The test for significance of difference between uncorrelated means was applied to each sub-group's initial and final mean score on the shoulder-girdle strength test.

In this respect, a difference in the Bowling S-G sub-group was found to be statistically significant at the one per cent level of confidence, with the final mean score being the larger.

All means and standard deviations for the initial and final shoulder-girdle strength tests may be found in Table I. The "t" values computed for the significance of difference between the initial and final mean scores may be found in Table II, page 42.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the initial shoulder-girdle strength test.

In this respect, a difference between the Total Bowling and the Bowling S-G sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Total Bowling sub-group being the larger.

Similarly in this respect, a difference between the Total Body Mechanics and the Bowling S-G sub-groups was found to be statistically significant at the one per cent level of confidence. A difference between the Total Body Mechanics and the Body Mechanics S-G sub-groups was found to be statistically significant at the two per cent level of confidence. In both instances the mean of the Total Body Mechanics sub-group was found to be the larger.

A difference between the Non-Experimental Bowling and the Bowling S-G sub-groups was found to be statistically significant at the one per cent level of confidence. A difference between the Non-Experimental Bowling and the Body Mechanics S-G sub-groups was found to be statistically significant at the five per cent level of confidence. In all instances the mean of the Non-Experimental Bowling sub-groups was found to be the larger.

TABLE I

MEANS AND STANDARD DEVIATIONS FOR
INITIAL AND FINAL SHOULDER-GIRDLE STRENGTH TESTS

	Initial Test			Final Test		
Sub-Groups	N	M	σ	N	M	σ
Bowling S-G	32	80.1874	11.0352	32	87.9061	11.4849
Body Mechanics S-G	15	82.3666	9.3086	15	90.4000	12.3063
Control Group	29	87.2415	22.6233	26	90.4615	18.6450
Total Bowling	77	90.0520	18.0035	75	94.8665	16.7965
Total Body Mechanics	34	94.6470	17.3725	33	99.1210	15.7170
Non-Experimental Bowling	35	96.0000	20.7300	33	98.3635	19.5895
Non-Experimental Body Mechanics	15	100.0000	14.6970	14	102.3572	12.4088

TABLE II

SIGNIFICANCE OF DIFFERENCE BETWEEN INITIAL AND
FINAL SHOULDER-GIRDLE STRENGTH TESTS

Sub-Groups	"t"
Bowling S-G	2.6983*
Body Mechanics S-G	1.9482
Control Group	.5618
Total Bowling	1.6931
Total Body Mechanics	1.0879
Non-Experimental Bowling	.4753
Non-Experimental Body Mechanics	.4487

*Indicates statistical significance at the 1 per cent level of confidence.

A difference between the Non-Experimental Body Mechanics sub-group and the Bowling S-G and Body Mechanics S-G sub-groups was found to be statistically significant at the one per cent level of confidence. A difference between the Non-Experimental Body Mechanics and the Total Bowling sub-groups was found to be statistically significant at the five per cent level of confidence. In all instances the mean of the Non-Experimental Body Mechanics sub-group was found to be the larger.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the initial shoulder-girdle strength test may be found in Table III.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the final shoulder-girdle strength test.

In this respect, a difference between the Total Bowling and the Bowling S-G sub-groups was found to be statistically significant at the five per cent level of confidence, with the mean of the Total Bowling sub-group being the larger.

Similarly in this respect, a difference between the Total Body Mechanics and Bowling S-G sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Total Body Mechanics sub-group being the larger.

A difference between the Non-Experimental Bowling and the Bowling S-G sub-groups was found to be statistically significant at the two per cent level of confidence, with the mean of the Non-Experimental Bowling sub-group being the larger.

TABLE III

SIGNIFICANCE OF DIFFERENCE AMONGST SUB-GROUPS ON
INITIAL SHOULDER-GIRDLE STRENGTH TEST

Sub-Groups	Bowling S-G	Body Mechanics S-G	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics S-G	.6481					
Control Group	1.5442	.7820				
Total Bowling	2.8573*	1.5938	.6592			
Total Body Mechanics	3.9459*	2.5258*'	1.4441	1.2415		
Non-Experimental Bowling	3.7883*	2.3948**	1.5882	1.5293	.2891	
Non-Experimental Body Mechanics	5.0281*	3.7929*	1.9338	1.9908**	1.0188	.6643

*Indicates statistical significance at the 1 per cent level of confidence.
*'Indicates statistical significance at the 2 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

A difference between the Non-Experimental Body Mechanics and the Bowling S-G sub-groups was found to be statistically significant at the one per cent level of confidence. A difference between the Non-Experimental Body Mechanics and the Body Mechanics S-G sub-groups was found to be statistically significant at the two per cent level of confidence. A difference between the Non-Experimental Body Mechanics sub-group and the Control Group was found to be statistically significant at the five per cent level of confidence. In all instances the mean of the Non-Experimental Body Mechanics sub-group was found to be the larger.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the final shoulder-girdle strength test may be found in Table IV.

Since the experiment was concerned with the relationship between individual differences of the subjects, a difference score was computed by subtracting an individual's score recorded on the initial test from her score recorded on the final test. This resulted in secondary measurements labeled the difference scores and these scores were used further to clarify statistical relationships which might exist amongst the experimental groups.

The test for significance of difference between correlated pairs of means was applied, with regard to direction of change, to the means of the difference scores between the initial and final shoulder-girdle strength test for each sub-group.

In this respect, the mean difference of the Bowling S-G, Body Mechanics S-G, and Total Bowling sub-groups was found to be statistically

TABLE IV

SIGNIFICANCE OF DIFFERENCE AMONGST SUB-GROUPS ON
FINAL SHOULDER-GIRDLE STRENGTH TEST

Sub-Groups	Bowling S-G	Body Mechanics S-G	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics S-G	.6635					
Control Group	.4012	.0111				
Total Bowling	2.1199**	.9678	1.1082			
Total Body Mechanics	3.2243*	1.8602	1.9011	1.2253		
Non-Experimental Bowling	2.5737*'	1.4190	1.5439	.9376	-.1706	
Non-Experimental Body Mechanics	3.7458*	2.5127*'	2.0907**	1.5713	.6705	.6901

*Indicates statistical significance at the 1 per cent level of confidence.
*'Indicates statistical significance at the 2 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

significant at the one per cent level of confidence.

Similarly in this respect, the mean difference of the Total Body Mechanics sub-group was found to be statistically significant at the five per cent level of confidence.

All means and standard deviations of mean difference scores between the initial and final shoulder-girdle strength test may be found in Table V.

All "t" values computed for the significance of difference between means of difference, with regard to direction of change, may be found in Table VI, page 49.

The test for significance of difference between uncorrelated means was applied amongst the mean difference scores of the various sub-groups on the shoulder-girdle strength test.

In this respect, a difference between the Bowling S-G sub-group and the Control Group was found to be statistically significant at the five per cent level of confidence, with the mean difference of the Bowling S-G sub-group being the larger.

All "t" values computed for the significance of difference amongst the means of difference scores for the various sub-groups may be found in Table VII, page 50.

Hamstring Flexibility

The test for significance of difference between uncorrelated means was applied to each sub-group's initial and final mean score on the hamstring flexibility test.

In this respect, a difference in all sub-groups, except the Control Group and the Non-Experimental Bowling sub-group, was found to be statis-

TABLE V

MEAN AND STANDARD DEVIATION OF DIFFERENCE SCORES
BETWEEN INITIAL AND FINAL SHOULDER-GIRDLE STRENGTH TESTS

Sub-Groups	N	M	σ
Bowling S-G	32	7.9687	9.5246
Body Mechanics S-G	15	8.1333	9.9188
Control Group	26	2.0000	11.5826
Total Bowling	75	4.7733	11.6342
Total Body Mechanics	33	4.7272	11.0790
Non-Experimental Bowling	33	2.1515	13.4977
Non-Experimental Body Mechanics	14	2.5714	10.5269

TABLE VI

SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF DIFFERENCE SCORES ON SHOULDER-GIRDLE STRENGTH TEST

Sub-Groups	"t"
Bowling S-G	4.6584*
Body Mechanics S-G	3.0681*
Control Group	.8633
Total Bowling	3.5295*
Total Body Mechanics	2.4136**
Non-Experimental Bowling	.9017
Non-Experimental Body Mechanics	.8807

*Indicates statistical significance at the 1 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

TABLE VII

SIGNIFICANCE OF DIFFERENCE AMONGST MEANS OF DIFFERENCE
SCORES ON SHOULDER-GIRDLE STRENGTH TEST

Sub-Groups	Bowling S-G	Body Mechanics S-G	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics S-G	.0533					
Control Group	- 2.1163**	- 1.6770				
Total Bowling	- 1.3570	- 1.0335	1.0381			
Total Body Mechanics	- 1.2431	- .9978	.9041	- .0191		
Non-Experimental Bowling	- 1.9703	- 1.5053	.0447	- 1.0168	- .8344	
Non-Experimental Body Mechanics	- 1.6738	- 1.4135	.1497	- .6519	- .6059	.1016

**Indicates statistical significance at the 5 per cent level of confidence.

tically significant at the one per cent level of confidence. There was no statistically significant difference found between the initial and final means of the Control Group and the Non-Experimental Bowling sub-group. In all instances the final mean score was found to be the larger.

All means and standard deviations for the initial and final hamstring flexibility tests may be found in Table VIII.

All "t" values computed for the significance of difference between the initial and final mean scores on the hamstring flexibility test may be found in Table IX, page 53.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the initial hamstring flexibility test.

In this respect, a difference between the Control Group and the Bowling H-S sub-group was found to be statistically significant at the one per cent level of confidence. A difference between the Control Group and the Body Mechanics H-S sub-group was found to be statistically significant at the two per cent level of confidence. In both instances, the mean of the Control Group was found to be the larger.

Similarly in this respect, a difference between the Total Bowling sub-group and the Bowling H-S and Body Mechanics H-S sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Total Bowling sub-group being the larger.

A difference between the Total Body Mechanics and Bowling H-S and Body Mechanics H-S sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Total Body Mechanics sub-group being the larger.

TABLE VIII

MEANS AND STANDARD DEVIATIONS FOR
INITIAL AND FINAL HAMSTRING FLEXIBILITY TESTS

	Initial Test			Final Test		
Sub-Groups	N	M	σ	N	M	σ
Bowling H-S	32	158.5000	9.8076	32	174.9690	14.8880
Body Mechanics H-S	14	154.2142	9.9960	14	192.0000	16.0365
Control Group	29	168.7240	18.6290	26	176.6155	15.8065
Total Bowling	77	171.2723	20.3833	75	183.1331	20.1047
Total Body Mechanics	34	172.1470	21.0210	33	200.9089	21.7483
Non-Experimental Bowling	35	176.4285	20.6250	33	185.4242	21.8617
Non-Experimental Body Mechanics	15	178.3335	15.8585	14	201.2855	22.5880

TABLE IX

SIGNIFICANCE OF DIFFERENCE BETWEEN INITIAL AND FINAL HAMSTRING FLEXIBILITY TESTS

Sub-Groups	"t"
Bowling H-S	5.1433*
Body Mechanics H-S	7.2086*
Control Group	1.6535
Total Bowling	3.5885*
Total Body Mechanics	5.4225*
Non-Experimental Bowling	1.7197
Non-Experimental Body Mechanics	3.0717*

*Indicates statistical significance at the 1 per cent level of confidence.

A difference between the Non-Experimental Bowling sub-group and the Bowling H-S and Body Mechanics H-S sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Non-Experimental Bowling Sub-group being the larger.

A difference between the Non-Experimental Body Mechanics and the Bowling H-S and Body Mechanics H-S sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean of the Non-Experimental Body Mechanics sub-group being the larger.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the initial hamstring flexibility test may be found in Table X.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the final hamstring flexibility test.

In this respect, a difference between the Body Mechanics H-S sub-group and the Control Group and Bowling H-S sub-group was found to be statistically significant at the one per cent level of confidence, with the mean of the Body Mechanics H-S sub-group being the larger.

A difference between the Total Bowling and the Bowling H-S sub-groups was found to be statistically significant at the five per cent level of confidence, with the mean of the Total Bowling sub-group being the larger.

A difference between the Total Body Mechanics sub-group and the Bowling H-S, Control, Total Bowling, and Non-Experimental Bowling sub-groups was found to be statistically significant at the one per cent

TABLE X

SIGNIFICANCE OF DIFFERENCE AMONGST SUB-GROUPS ON
INITIAL HAMSTRING FLEXIBILITY TEST

Sub-Groups	Bowling H-S	Body Mechanics H-S	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics H-S	- 1.3264					
Control Group	2.6725*	2.6667*'				
Total Bowling	3.3557*	3.0314*	.5814			
Total Body Mechanics	3.2935*	2.9893*	.6677	.2045		
Non-Experimental Bowling	4.4097*	3.7736*	1.5289	1.2245	.8414	
Non-Experimental Body Mechanics	5.1375*	4.6897*	1.6651	1.2547	.9979	.3131

*Indicates statistical significance at the 1 per cent level of confidence.
*'Indicates statistical significance at the 2 per cent level of confidence.

level of confidence, with the mean of the Total Body Mechanics sub-group being the larger.

A difference between the Non-Experimental Bowling and the Bowling H-S sub-groups was found to be statistically significant at the five per cent level of confidence, with the mean of the Non-Experimental Bowling sub-group being the larger.

A difference between the Non-Experimental Body Mechanics sub-group and the Bowling H-S, Control, and Total Bowling sub-groups was found to be statistically significant at the one per cent level of confidence. A difference between the Non-Experimental Body Mechanics and the Non-Experimental Bowling sub-groups was found to be statistically significant at the five per cent level of confidence. In all instances, the mean of the Non-Experimental Body Mechanics sub-group was found to be the larger.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the final hamstring flexibility test may be found in Table XI.

Difference scores between the initial and final hamstring flexibility tests were obtained and the test for significance of difference between correlated pairs of means was applied, with regard to direction of change, to the means of difference scores for each sub-group.

In this respect, the mean differences of all sub-groups were found to be statistically significant at the one per cent level of confidence with the exception of the Control Group, whose mean difference was found to be statistically significant at the two per cent level of confidence.

All means and standard deviations of mean difference scores between

TABLE XI

SIGNIFICANCE OF DIFFERENCE AMONGST SUB-GROUPS ON FINAL HAMSTRING FLEXIBILITY TEST

Sub-Groups	Bowling H-S	Body Mechanics H-S	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics H-S	3.4106*					
Control Group	.4004	- 2.8470*				
Total Bowling	2.0481**	- 1.5422	1.4851			
Total Body Mechanics	5.5058*	1.3521	4.7032*	4.0900*		
Non-Experimental Bowling	2.2112**	- .9938	1.6991	.5262	- 2.8407*	
Non-Experimental Body Mechanics	4.5654*	1.2084	3.9280*	3.0042*	.0525	2.2041**

*Indicates statistical significance at the 1 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

the initial and final hamstring flexibility tests may be found in Table XII.

All "t" values computed for the significance of difference between means of difference, with regard to direction of change, may be found in Table XIII, page 60.

The test for significance of difference between uncorrelated means was applied amongst the mean difference scores of the various sub-groups on the hamstring flexibility tests.

In this respect, a difference between the Body Mechanics H-S sub-group and all other sub-groups, with the exception of Total Body Mechanics, was found to be statistically significant at the one per cent level of confidence. In all instances the mean difference of the Body Mechanics H-S sub-group was found to be the larger.

Similarly in this respect, a difference between the Bowling H-S sub-group and the Control Group was found to be statistically significant at the one per cent level of confidence. A difference between the Bowling H-S and the Non-Experimental Bowling sub-groups was found to be statistically significant at the five per cent level of confidence. In both instances, the mean difference of the Bowling H-S sub-group was found to be the larger.

A difference between the Total Bowling sub-group and the Control Group was found to be statistically significant at the two per cent level of confidence, with the mean difference of the Total Bowling sub-group being the larger.

A difference between the Total Body Mechanics sub-group and the

TABLE XII

MEAN AND STANDARD DEVIATION OF DIFFERENCE SCORES
BETWEEN INITIAL AND FINAL HAMSTRING FLEXIBILITY TESTS

Sub-Groups	N	M	σ
Bowling H-S	32	16.3750	10.2675
Body Mechanics H-S	14	37.2142	12.7515
Control Group	26	6.7307	11.3665
Total Bowling	75	12.8933	10.9819
Total Body Mechanics	33	28.1818	14.9777
Non-Experimental Bowling	33	10.8485	11.2845
Non-Experimental Body Mechanics	14	21.8571	13.8969

TABLE XIII

SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF DIFFERENCE SCORES ON HAMSTRING FLEXIBILITY TESTS

Sub-Groups	"t"
Bowling H-S	8.8796*
Body Mechanics H-S	10.5225*
Control Group	2.9607*'
Total Bowling	10.0997*
Total Body Mechanics	10.6438*
Non-Experimental Bowling	5.4381*
Non-Experimental Body Mechanics	5.6708*

*Indicates statistical significance at the 1 per cent level of confidence.
*'Indicates statistical significance at the 2 per cent level of confidence.

Bowling H-S, Control, Total Bowling, and Non-Experimental Bowling sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean difference of the Total Body Mechanics sub-group being the larger.

A difference between the Non-Experimental Body Mechanics sub-group and the Control, Total Bowling, and Non-Experimental Bowling sub-groups was found to be statistically significant at the one per cent level of confidence, with the mean difference of the Non-Experimental Body Mechanics sub-group being the larger.

All "t" values computed for the significance of difference amongst the means of difference scores for the various sub-groups on the hamstring flexibility tests may be found in Table XIV.

Abdominal Strength

The test for significance of difference between uncorrelated means was applied to each sub-group's initial and final mean score on the abdominal strength test.

In this respect, a difference in the Bowling ABD sub-group was found to be statistically significant at the one per cent level of confidence, with the final mean score being the larger.

Similarly in this respect, a difference in the Body Mechanics ABD sub-group was found to be statistically significant at the five per cent level of confidence, with the final mean score being the larger.

All means and standard deviations for the initial and final abdominal strength tests may be found in Table XV, page 63.

All "t" values computed for the significance of difference between the initial and final mean scores may be found in Table XVI, page 64.

TABLE XIV

SIGNIFICANCE OF DIFFERENCE AMONGST MEANS OF DIFFERENCE
SCORES ON HAMSTRING FLEXIBILITY TESTS

Sub-Groups	Bowling H-S	Body Mechanics H-S	Control Group	Total Bowling	Total Body Mechanics	Non-Experimental Bowling
Body Mechanics H-S	5.7385*					
Control Group	- 3.3316*	- 7.5507*				
Total Bowling	- 1.5160	- 7.3212*	2.4190*'			
Total Body Mechanics	3.6372*	- 1.9312	5.9517*	5.8779*		
Non-Experimental Bowling	- 2.0305**	- 6.8903*	1.3631	- .8760	- 5.2289*	
Non-Experimental Body Mechanics	1.4556	- 2.9353*	3.6124*	2.6488*	- 1.3234	2.7865*

*Indicates statistical significance at the 1 per cent level of confidence.
*'Indicates statistical significance at the 2 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

TABLE XV

MEANS AND STANDARD DEVIATIONS FOR
INITIAL AND FINAL ABDOMINAL STRENGTH TESTS

	Initial Test			Final Test		
Sub-Groups	N	M	σ	N	M	σ
Bowling ABD	42	28.1428	12.3684	42	40.3330	13.2585
Body Mechanics ABD	19	27.8419	11.1177	19	38.8425	14.7980
Control Group	29	28.4137	13.2966	26	31.4614	12.8280

TABLE XVI

SIGNIFICANCE OF DIFFERENCE BETWEEN INITIAL AND FINAL ABDOMINAL STRENGTH TESTS

Sub-Groups	"t"
Bowling ABD	4.3058*
Body Mechanics ABD	2.5211**
Control Group	.8473

*Indicates statistical significance at the 1 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the initial abdominal strength test.

In this respect, there was no statistically significant difference found amongst the sub-groups.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the initial abdominal strength test may be found in Table XVII.

The test for significance of difference between uncorrelated means was applied amongst the mean scores of the various sub-groups on the final abdominal strength test.

In this respect, a difference between the Bowling ABD sub-group and the Control Group was found to be significant at the one per cent level of confidence, with the mean of the Bowling ABD sub-group being the larger.

All "t" values computed for the significance of difference amongst the mean scores of the various sub-groups on the final abdominal strength test may be found in Table XVII.

Difference scores between the initial and final abdominal strength tests were obtained and the test for significance of difference between correlated pairs of means was applied, with regard to direction of change, to the means of difference scores for each sub-group.

In this respect, the mean differences of the Bowling ABD and the Body Mechanics ABD sub-groups were found to be statistically significant at the one per cent level of confidence.

TABLE XVII

SIGNIFICANCE OF DIFFERENCE AMONGST SUB-GROUPS ON INITIAL AND FINAL ABDOMINAL STRENGTH TESTS

Sub-Groups	Bowling ABD	Body Mechanics ABD
Body Mechanics ABD Initial Test	- .0892	
Body Mechanics ABD Final Test	- .3855	
Control Group Initial Test	.0867	.1520
Control Group Final Test	- 2.6739*	- 1.7535

*Indicates statistical significance at the 1 per cent level of confidence.

All means and standard deviations of mean difference scores between the initial and final abdominal strength tests may be found in Table XVIII.

All "t" values computed for the significance of difference between means of difference, with regard to direction of change, may be found in Table XIX, page 69.

The test for significance of difference between uncorrelated means was applied amongst the mean difference scores of the various subgroups on the abdominal strength tests.

In this respect, a difference between the Bowling ABD sub-group and the Control Group was found to be statistically significant at the one per cent level of confidence, with the mean difference of the Bowling ABD sub-group being the larger.

Similarly in this respect, a difference between the Body Mechanics ABD sub-group and the Control Group was found to be statistically significant at the one per cent level of confidence, with the mean difference of the Body Mechanics ABD sub-group being the larger.

All "t" values computed for the significance of difference amongst the means of difference scores for the various sub-groups on the abdominal strength tests may be found in Table XX, page 70.

Correlations

The Pearson Product-Moment Coefficient of Correlation was the statistical procedure used in computing degrees of relationship between the initial and final test scores of the various sub-groups on the shoulder-girdle strength test, hamstring flexibility test, and the abdominal strength test.

TABLE XVIII

MEAN AND STANDARD DEVIATION OF DIFFERENCE SCORES BETWEEN INITIAL AND FINAL ABDOMINAL STRENGTH TESTS

Sub-Groups	N	M	σ
Bowling ABD	42	12.4850	11.6452
Body Mechanics ABD	19	11.9736	11.3627
Control Group	26	2.1557	10.4705

TABLE XIX

SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF DIFFERENCE SCORES ON ABDOMINAL STRENGTH TESTS

Sub-Groups	"t"
Bowling ABD	6.8647*
Body Mechanics ABD	4.4707*
Control Group	1.0294

*Indicates statistical significance at the 1 per cent level of confidence.

TABLE XX

SIGNIFICANCE OF DIFFERENCE AMONGST MEANS OF DIFFERENCE SCORES ON ABDOMINAL STRENGTH TESTS

Sub-Groups	Bowling ABD	Body Mechanics ABD
Body Mechanics ABD	- .1574	
Control Group	- 3.6368*	- 2.9289*

*Indicates statistical significance at the 1 per cent level of confidence.

In this respect, a positive relationship, statistically significant at the one per cent level of confidence, was found between all initial and final tests with the exception of the Body Mechanics sub-group. A positive relationship, statistically significant at the five per cent level of confidence, was found between the initial and final shoulder-girdle strength and hamstring flexibility tests for the Body Mechanics sub-groups.

All coefficients of correlation between the initial and final tests may be found in Table XXI.

The Pearson Product-Moment Coefficient of Correlation was the statistical procedure used in computing the degrees of relationship amongst the various tests.

In this respect, a positive relationship between the initial shoulder-girdle strength and abdominal strength tests for the Experimental Bowling sub-groups was found to be statistically significant at the five per cent level of confidence.

Similarly in this respect, a positive relationship between the initial shoulder-girdle strength and hamstring flexibility tests for all the students tested was found to be statistically significant at the five per cent level of confidence.

A positive relationship between the final shoulder-girdle strength and abdominal strength tests for the Experimental Body Mechanics sub-groups was found to be statistically significant at the five per cent level of confidence.

All coefficients of correlation amongst the various tests may be found in Table XXII, page 73.

TABLE XXI

CORRELATIONS AMONGST INITIAL AND FINAL TESTS

Sub-Groups	Shoulder-Girdle Strength	Hamstring Flexibility	Abdominal Strength
Control Group	.8132*	.7397*	.6782*
Experimental Bowling Groups	.6389*	.7175*	.5982*
Experimental Body Mechanics Groups	.6069**	.5926**	.6496*
All Subjects Tested	.7803*	.7571*	

*Indicates statistical significance at the 1 per cent level of confidence.
**Indicates statistical significance at the 5 per cent level of confidence.

TABLE XXII

CORRELATIONS AMONGST VARIOUS TESTS

Sub-Groups	Shoulder-Girdle Strength & Hamstring Flexibility	Shoulder-Girdle Strength & Abdominal Strength	Hamstring Flexibility & Abdominal Strength
Control Group			
Initial Test	.2232	.1903	- .0062
Final Test	.1872	.3600	.0736
Experimental Bowling			
Initial Test	.0195	.3069**	.1324
Final Test	- .2814	.2711	.0124
Experimental Body Mechanics			
Initial Test	- .3294	.1827	.2135
Final Test	- .0208	.5018**	- .0289
All Students Tested			
Initial Test	.2104**		
Final Test	.0965		

**Indicates statistical significance at the 5 per cent level of confidence.

CHAPTER VI

ANALYSIS OF DATA

The effects of bowling and prescribed fitness exercises on the shoulder-girdle strength, hamstring flexibility, and abdominal strength of college women were determined by drawing comparisons and computing relationships amongst the measurements recorded from subjects before and after intervening exercise sessions.

Measurements were treated statistically to determine the significance of difference between initial and final test scores for each sub-group. All initial and final mean scores and mean difference scores, the latter considered with regard to direction of change, were compared. The difference scores represented the directional change in measurements between the initial and final test scores for each individual in the sub-group.

Measurements were also treated statistically to determine relationships between initial and final test scores and to determine relationships amongst the three items measured.

Bowling S-G Sub-Group

The Bowling S-G sub-group began the experiment with shoulder-girdle strength that was not significantly different from the shoulder-girdle strength of the Body Mechanics S-G and Control Groups. This same relationship of no statistically significant difference between the shoulder-girdle strength of the three sub-groups was also found to be true on the final shoulder-girdle strength test.

Since all the students who participated in these three sub-groups had approximately an equal amount of strength both at the beginning of the experiment and at the end, it would seem to indicate that the experimental bowling sessions were not sufficiently strenuous in themselves to raise the shoulder-girdle strength of weaker students above the level of students who did not participate in physical education activities.

The Total and Non-Experimental Bowling and Body Mechanics sub-groups were found to be significantly stronger than the Bowling S-G sub-group both at the beginning and at the end of the experiment. This difference was to be expected at the beginning, since the Bowling S-G sub-group was composed of students who scored in the lower fifty per cent on the initial test, and the Total and Non-Experimental sub-groups included all students who scored in the upper fifty per cent. However, the fact that the Total and Non-Experimental Bowling and Body Mechanics sub-groups remained significantly stronger on the final test would indicate that the additional experimental bowling sessions were not strenuous enough to increase sufficiently the strength of the weaker students so that there would no longer be a statistically significant difference between their strength and the strength of the stronger girls. The Bowling S-G sub-group, however, was able to decrease the mean difference between their strength and the strength of the Total and Non-Experimental Bowling sub-groups.

Even though there was no statistically significant difference found between the shoulder-girdle strength of the Bowling S-G sub-group and the Body Mechanics and Control Group, the Bowling S-G sub-group did show a statistically significant increase in strength after participating in the four weeks of experimental bowling sessions. Bowling S-G was the only sub-group to show this significant increase, which indicates that the experimental bowling sessions were strenuous enough to bring about a statistically significant increase in the shoulder-girdle strength of the weaker students, even though that increase was not proportionally greater than the other groups.

The majority of Bowling S-G subjects had not bowled with a ten pin bowling ball before the experiment began. The ball was quite heavy for these weaker students, especially when held by three fingers and directed down the alley. The writer attributes the increase in shoulder-girdle strength of the Bowling S-G sub-group to the exercise involved in lifting the ball from the pit to the return rack, lifting the ball from the rack in preparation to the approach, and the actual technique of bowling itself.

The average shoulder-girdle strength increase of the Bowling S-G sub-group was also found to be statistically significant. The Bowling S-G sub-group's average strength increase was significantly greater than the average increase in shoulder-girdle strength made by the Control Group. Therefore, the experimental bowling sessions were of sufficient intensity to produce an average increase in strength significantly greater than that made by a group that did no physical activity. Since no other sub-group had an average increase in strength significantly greater than the Control Group, it seems to indicate that bowling is better than the prescribed exercises for increasing the shoulder-girdle strength of weaker students.

Body Mechanics S-G Sub-Group

Since there was no statistically significant difference found between the shoulder-girdle strength of the Body Mechanics S-G, Bowling S-G, and Control Groups at the beginning nor at the end of the experiment, there is indication that the prescribed shoulder-girdle exercises were not sufficiently strenuous to raise significantly the strength of the weaker students above the strength of students who did not participate in physical activities.

A critical examination of the shoulder-girdle exercises utilized in the experiment may help to explain why the weaker students did not significantly increase in strength. The writer purposefully avoided using exercises involving weights and mechanical devices, even though research has shown them to be effective in increasing strength, because these techniques are not commonly used in a general body mechanics class. The writer feels that the exercises prescribed for the first two weeks, with the exception of the let downs, were not difficult enough to increase gradually the strength of the subjects before they performed the more strenuous exercises prescribed during the last two weeks. The majority of subjects did not have sufficient strength to perform adequately the let downs, push-ups, and pull-ups prescribed. These exercises would have been difficult for even the stronger girls to perform, let alone the weaker subjects. The writer feels that if the exercises given the first two weeks had been more taxing, the subjects would have been better able to perform correctly the more strenuous exercises.

A second possible reason advanced for the lack of significant strength increase is that some of the subjects experienced muscle soreness after performing the exercises, and this uncomfortable sensation may have prevented them from trying as hard during the next exercise session.

As was the case in the Bowling S-G sub-group, the Body Mechanics S-G sub-group was significantly weaker than the Total Body Mechanics and the Non-Experimental Bowling and Body Mechanics sub-groups due to the fact that the Body Mechanics S-G subjects were in the lower fifty per cent on the initial test. The fact that there was no statistically significant difference found on the initial test between the strength of the Body Mechanics S-G and Total Bowling sub-groups was due to the fact that the Body Mechanics sub-groups, on the whole, began the experiment with more strength than their corresponding Bowling sub-groups, although this difference was not statistically significant.

After the Body Mechanics S-G sub-group had performed the prescribed shoulder-girdle exercises for four weeks, the only group that was significantly stronger than they was the Non-Experimental Body Mechanics sub-group. This indicates that the shoulder-girdle exercises were adequate for raising the strength of the weaker students to a level equal to all the other sub-groups with the exception of the Non-Experimental Body Mechanics sub-group; however, the increase in shoulder-girdle strength made by the Body Mechanics S-G sub-group between its initial and final test was not found to be statistically significant. Thus it appears that although the shoulder-girdle exercises were adequate for increasing shoulder-girdle strength, they were not strenuous enough to create a statistically significant increase in strength.

The average increase of the subjects comprising the Body Mechanics S-G sub-group was found to be statistically significant, but it was not greater than the average increase made by any of the other sub-groups. Thus it may be said that the shoulder-girdle exercises were adequate for producing a significant average strength increase, but not strenuous enough to produce an increase significantly greater than that made by bowling, or that made by not participating in physical activity.

Control Group S-G

The Control Group started the experiment with a shoulder-girdle strength that was equal with the shoulder-girdle strength of all the other sub-groups. At the end of the experiment the Control Group was also not significantly stronger than any of the other sub-groups. The fact that there was no statistically significant difference between the initial and final test scores of the Control Group, and no statistically significant average increase in shoulder-girdle strength, leads to the belief, as might be suspected, that shoulder-girdle strength will not be increased when subjects do not engage in physical activity.

Bowling H-S Sub-Group

The Bowling H-S sub-group began the experiment with hamstring flexibility that was not significantly different from the hamstring flexibility of the Body Mechanics H-S sub-group. On the final test, Bowling H-S was significantly less flexible than the Body Mechanics H-S sub-group, indicating that the flexibility exercises performed by the Body Mechanics H-S sub-group were more successful in raising the flexibility of the hamstrings than was bowling.

The nature of the bowling activity itself tended to limit the amount of increase in flexibility that might be expected from participating in the sport. Setting pins, returning balls from the pit, and the approach and release of the ball required a certain degree of flexibility beyond which further flexibility was not required by the activity. The flexibility exercises, on the other hand, were designed to stretch continually the hamstrings beyond the flexibility level that had previously been attained.

On the initial test, the Bowling S-G sub-group was significantly less flexible than the Control Group, due again to the fact that Bowling H-S was composed of students scoring in the lower fifty per cent on the initial test. On the final test, there was no statistically significant difference between the hamstring flexibility of these two groups, indicating that the bowling sessions were adequate for increasing the flexibility of less flexible students so that it would be on a par with the flexibility of girls who did no physical activity.

The Total and Non-Experimental Bowling and Body Mechanics sub-groups were found to be significantly more flexible than the Bowling H-S sub-group, both at the beginning and at the end of the experiment. This difference was to be expected at the beginning since Bowling H-S was composed of students who scored in the lower fifty per cent on the initial test. However, since the Total and Non-Experimental Bowling and Body Mechanics sub-groups remained significantly more flexible on the final test, it would indicate that the experimental bowling sessions did not stretch the hamstrings enough to increase sufficiently the flexibility of the less flexible students so that there would no longer be a statistically significant difference between their flexibility and that of the more flexible girls.

Bowling H-S showed a statistically significant increase in flexibility between the initial and final tests. This would indicate that the bowling sessions were capable of bringing about a significant flexibility increase in the less flexible girls. The average increase in flexibility made by the Bowling H-S sub-group was statistically significant, as was the average increase for all the sub-groups. This average flexibility increase made by the Bowling H-S sub-group was significantly greater than the average increase made by the Control and Non-Experimental Bowling sub-group. This would indicate that the exercise provided by the experimental bowling sessions was sufficient to account for a significantly larger average increase in flexibility than does not participating in physical activity, as in the case of the Control Group, or bowling only twice a week in class, as did the Non-Experimental Bowling sub-group.

Even though the experimental bowling sessions were able to increase significantly the flexibility of the Bowling H-S sub-group, the Body Mechanics sub-groups increased considerably more than did the Bowling sub-groups.

<u>Body Mechanics H-S Sub-Group</u>

The Body Mechanics H-S sub-group was significantly more flexible than the Bowling H-S and Control Groups at the end of the experiment. Considering that at the beginning of the experiment there was no statistically significant difference between Body Mechanics H-S and Bowling H-S, and the Control Group was significantly more flexible, the Body Mechanics H-S group evidenced a significant increase in hamstring flexibility. This flexibility increase was perhaps due to the flexibility exercises which the subjects performed five days a week for four weeks.

These exercises were designed to continually stretch the hamstrings beyond the flexibility range presently attained by each student. No student expressed having felt pain after performing the hamstring exercises. Discomfort was felt during the exercise, but not after the stretching had ceased; therefore, subjects were willing to endure more stretching, knowing that there would be no discomfort afterwards.

Another reason that may be advanced for the success of these exercises is that the students could easily see their improvement. The fact that while performing the assisted stretch exercise, a subject could at first almost touch her head to her knee, then she could touch her knee, and then even touch her head to the floor acted as a strong self-motivation factor.

The significantly greater flexibility of the Total and Non-Experimental Bowling and Body Mechanics sub-groups at the beginning of the experiment was to be expected, since they were composed of all students scoring in the upper fifty per cent on the initial test, and the Body Mechanics H-S sub-group was composed of students scoring in the lower fifty per cent. At the end of the experiment there was no statistically significant difference between the Body Mechanics H-S and the Total and Non-Experimental Bowling and Body Mechanics sub-groups. This indicates that the flexibility exercises were adequate in increasing the flexibility of the less flexible subjects to a par with those who were significantly more flexible at the start.

The average increase in flexibility made by the subjects in the Body Mechanics H-S sub-group was statistically significant. This average increase in flexibility was significantly greater than the average increase of all the other sub-groups except that of the Total Body Mechanics. The fact that the Body Mechanics H-S sub-group comprised about half of the Total Body Mechanics sub-group may account for the lack of significant difference between the average increase of their flexibility.

The fact that Body Mechanics H-S had an average increase in flexibility that was significantly greater than that made by the Control or any Bowling sub-group seems to indicate that the flexibility exercises were significantly more successful than bowling in increasing the hamstring flexibility of the less flexible subjects.

Control Group H-S

On the initial hamstring flexibility test the Control Group, which was composed mainly of girls who had not had physical education for at least one semester, was found to be significantly more flexible than either the Bowling H-S or Body Mechanics H-S sub-groups. The Bowling H-S and Body Mechanics H-S sub-groups were composed mainly of girls who had been enrolled in physical education classes the previous semester. The superior flexibility of the Control Group, therefore, seems to indicate that perhaps by not engaging in physical activity, flexibility will remain at a higher level. However, since there was no statistically significant difference between the flexibility of the Non-Experimental sub-groups, composed as were the H-S sub-groups mainly of students who were enrolled in physical education classes the previous semester, the statistically significant flexibility of the Control Group compared to the H-S sub-groups is due to the H-S sub-groups being composed of students scoring in the lower fifty per cent on the initial hamstring flexibility test.

At the end of the experiment the three body mechanics sub-groups were significantly more flexible than the Control Group. Thus the flexibility exercises performed by the Body Mechanics H-S sub-group, and the nature of the work in the body mechanics classes was better for increasing hamstring flexibility than was inactivity.

The Control Group did not make a statistically significant increase in flexibility between its initial and final tests; however, the average increase in flexibility for the Control subjects was found to be statistically significant. This seems to contradict the indications that inactivity will not increase flexibility; however, upon observation of the individual difference scores of the Control subjects, it was noted that four individuals increased their final hamstring flexibility twenty degrees or more over their initial scores. The rather large increase in flexibility of these four subjects may account for the significant average improvement of the Control Group as a whole. This statistically significant average increase in flexibility made by the Control Group was not greater than the average increase of any other sub-group, and was found to be significantly less than the average increase of five of the other sub-groups. Therefore, it seems safe to say that inactivity will not increase hamstring flexibility as well as will engaging in physical activity.

Bowling ABD Sub-Group

There was no statistically significant difference found between the abdominal strength of the Bowling ABD, Body Mechanics ABD, and Control Group at the beginning of the experiment, but at the end the Bowling ABD sub-group was the only sub-group to be found significantly stronger than the Control Group. Thus, the experimental bowling sessions may be assumed to have been strenuous enough to produce an abdominal strength level significantly greater than that of girls who did no physical activity.

In bowling, some abdominal activity may be involved in the approach and in the release of the ball. Just how much abdominal activity is involved in these skills depends upon the individual subject and exactly how she manages her body during the approach and release. Some abdominal strength may have also been received from the actions involved in setting pins, and returning balls from the pit.

There was a statistically significant increase in abdominal strength between the initial and final tests of the Bowling ABD sub-group, indicating that the bowling sessions were strenuous enough to significantly improve the abdominal strength of the bowlers.

The Bowling ABD sub-group made a statistically significant average increase in abdominal strength which was significantly greater than the average increase of the Control Group. This then would indicate that the experimental bowling sessions produced an average increase in abdominal strength that was significantly greater than the average increase of a group who did no physical activity.

Body Mechanics ABD Sub-Group

The Bowling ABD, Body Mechanics ABD, and Control Group began the experiment with nearly equal abdominal strength. At the end of the experiment the Body Mechanics ABD sub-group was not significantly stronger than either of the other sub-groups. Even though the Body Mechanics ABD sub-group made a statistically significant increase in abdominal strength between the initial and final tests, the fact that this sub-group was not significantly stronger than either of the others at the end of the experiment indicates that the abdominal exercises were sufficient to increase significantly the abdominal strength of students, but not strenuous enough to raise significantly their level of strength above that of students who performed no physical activity.

The writer doubts that the majority of subjects would have been able to perform abdominal exercises that were more strenuous than those prescribed. As in the case of the shoulder-girdle exercises, some students experienced soreness which may have prevented them from performing each exercise to their fullest capacity. On the fourth week the subjects were just beginning to experience greater ease in performing the exercises, and the writer feels that four weeks was not a long enough time in which to increase significantly abdominal strength above that of the other groups.

The Body Mechanics ABD sub-group made a statistically significant average increase in abdominal strength which was significantly greater than the average increase of the Control Group. Thus, the abdominal exercises were sufficiently strenuous to produce an average increase in abdominal strength that was significantly greater than the average increase of a group who did no physical activity.

Control Group ABD

In considering abdominal strength, the indication was found that by engaging in bowling or body mechanics, abdominal strength will be significantly increased, and inactivity will not significantly increase abdominal strength.

Total Bowling and Body Mechanics Sub-Groups

It must be remembered in comparing the Total Bowling and Body Mechanics sub-groups that they are composed of both the students scoring in the lower fifty per cent, thus those participating in the experimental exercise sessions, as well as those students in the classes who did not participate in these experimental sessions.

On the shoulder-girdle strength test, there was no statistically significant difference between the Total Bowling and Total Body Mechanics sub-groups on either the initial or final test. Neither of the Total sub-groups made a statistically significant increase in shoulder-girdle strength between their initial and final tests. Both of the Total sub-groups did, however, indicate a statistically significant average strength increase. This significant average increase may be attributed to the fact that the Bowling and Body Mechanics S-G sub-groups, each of which made a significant gain in average strength increase, comprised approximately one-half of the Total sub-groups. The other one-half was composed of the Non-Experimental sub-groups which showed no significant average increase in strength.

On the hamstring flexibility tests, both the Total Bowling and Total Body Mechanics sub-groups showed a statistically significant improvement between their initial and final tests, due again perhaps to the H-S sub-groups being included in the Total sub-groups. On the initial test there was no statistically significant difference found between the flexibility of the Total Bowling and Total Body Mechanics sub-groups, but on the final test the Total Body Mechanics sub-group was significantly more flexible. This superiority of body mechanics for increasing hamstring flexibility was further emphasized when the average increase in flexibility of the Total Body Mechanics sub-group was found to be significantly greater than that made by the Total Bowling sub-group.

Non-Experimental Bowling and Non-Experimental Body Mechanics Sub-Groups

The Non-Experimental Bowling and Body Mechanics sub-groups were composed of all students who participated in their physical education class activity, but did not participate in the intervening exercise sessions. Therefore, if these two groups are compared, we are in essence comparing the activity content of the bowling and body mechanics classes and its effect on the three elements of fitness of concern in this study.

On the shoulder-girdle strength test there was no statistically significant difference found between the Non-Experimental Bowling and Body Mechanics sub-groups. It was also found that neither sub-group made a statistically significant increase in shoulder-girdle strength, which indicates that the physical education activities of the bowling and body mechanics classes are not sufficient to increase significantly the shoulder-girdle strength of the stronger students enrolled.

There was no statistically significant difference in the hamstring flexibility of the Non-Experimental Bowling and Body Mechanics sub-groups on the initial test, but on the final test all of the body mechanics sub-groups were found to be significantly more flexible than the Non-Experimental Bowling sub-group.

Both the Non-Experimental Bowling and Body Mechanics sub-groups showed a statistically significant average improvement in hamstring flexibility, but the average improvement of the Non-Experimental Body Mechanics sub-group was significantly greater.

This superiority of the Non-Experimental Body Mechanics sub-group in increasing hamstring flexibility indicates that body mechanics as an activity is more successful in increasing hamstring flexibility than is bowling. One reason that may be advanced for this superiority of body mechanics is that often the entire body mechanics class performed the flexibility exercises prescribed for the Body Mechanics H-S sub-group. This may be the reason also for the significant increase in the flexibility of the Non-Experimental Body Mechanics sub-group, but these exercises were of a type normally performed in a body mechanics class.

Correlations

A statistically significant positive correlation was found between the initial and final tests of each of the sub-groups. This would indicate that even though the sub-groups as a whole may have shown a significant improvement between their initial and final test scores, those subjects who made the lower scores on the initial test tended also to make the lower scores on the final test. This relationship also holds true for subjects making the higher scores on the initial test in that they also tend to score higher on the final test.

It is interesting to note that in all but three instances there was no statistically significant relationship between shoulder-girdle strength, hamstring flexibility, and abdominal strength, and in no instance was there a significant relationship between hamstring flexibility and abdominal strength.

A further consideration, however, of the significant positive relationship between the initial shoulder-girdle strength and hamstring flexibility of all the students tested indicates that those students weak in shoulder-girlde strength were also the least flexible, the same being true of the stronger girls tending to be more flexible. In the final tests, however, this relationship was no longer significant, indicating that a girl who was weak in shoulder-girdle strength was not necessarily less flexible. This lack of significant shoulder-girdle strength-hamstring flexibility relationship in the final test may be attributed to the significantly large increase in flexibility made by the Body Mechanics sub-groups as a whole.

In considering the statistically significant positive relationship between the final shoulder-girdle strength and abdominal strength of the Experimental Body Mechanics sub-groups, it is interesting to note that there was no significant relationship between the initial tests. Perhaps this may be explained by the fact that only those students in the lower fifty per cent on the initial shoulder-girdle strength test performed the exercises designed to increase shoulder-girdle strength, whereas all the Experimental Body Mechanics subjects performed the abdominal strength exercises. Thus, those subjects weak in shoulder-girdle strength initially, the Body Mechanics S-G sub-group, made a significant strength increase, as measured by their mean difference scores, which may account for this significant relationship between shoulder-girdle strength and abdominal strength on the final tests.

CHAPTER VII

SUMMARY AND CONCLUSIONS

The experiment was conducted primarily for the purpose of comparing the effects of bowling and prescribed fitness exercises on the shoulder-girdle strength, hamstring flexibility, and abdominal strength of selected college women enrolled in five bowling and three body mechanics classes at the Woman's College of the University of North Carolina.

Forty-two bowling and nineteen body mechanics students, all of whom scored in the lower fifty per cent on one or both initial tests, were used as the experimental subjects in this study.

Twenty-nine control subjects were selected from upper-class women who possessed no physical handicaps, were not taking physical education course work, and performed only mild physical activities during their daily routines.

The three fitness items were measured with a push-pull dynamometer to measure shoulder-girdle strength; a Leighton Flexometer to measure hamstring flexibility; and a cable tensiometer to measure abdominal strength.

Initial measurements were taken prior to a four-week intervening exercise session in which the experimental subjects participated in regular class activities two days each week, and a controlled exercise session three days each week. During the exercise sessions, the subjects in the experimental bowling sub-groups each bowled fifteen to twenty balls three days each week, and the subjects in the experimental body mechanics sub-groups performed prescribed fitness exercises five days a week.

At the end of four weeks the tests for shoulder-girdle strength, hamstring flexibility, and abdominal strength were again administered to the Control Group and to the bowling and body mechanics classes tested initially.

Measurements were treated statistically to determine the significance of difference between initial and final test scores for each sub-group. All initial and final mean scores and mean difference scores were compared.

Measurements were also treated statistically to determine relationships between initial and final test scores and to determine relationships amongst the three items measured.

Findings

Shoulder-Girdle Strength

1. It was found that the experimental bowling sessions brought about a significant increase in the shoulder-girdle strength of the weaker students.

2. The prescribed shoulder-girdle exercises were found to increase the shoulder-girdle strength of the weaker students, but this increase was not found to be significant.

3. The experimental bowling sessions were found to be more successful for increasing the shoulder-girdle strength of the weaker students than were the shoulder-girdle exercises prescribed in this study.

4. It was found that neither the experimental bowling sessions nor the prescribed shoulder-girdle exercises were able to increase the shoulder-girdle strength of the weaker students above that of the Control Group.

5. Both the experimental bowling sessions and the prescribed

shoulder-girdle exercises were found to decrease the mean difference between the shoulder-girdle strength of the weaker and stronger subjects.

6. The activities of both the general bowling classes and the general body mechanics classes were not found to increase significantly the shoulder-girdle strength of the stronger students enrolled.

Hamstring Flexibility

1. It was found that both the experimental bowling sessions and the prescribed hamstring exercises brought about a significant increase in the hamstring flexibility of the less flexible students.

2. The experimental bowling sessions were found to increase the flexibility of the less flexible students so that it would be on a par with the flexibility of the Control Group.

3. The prescribed hamstring exercises were found to increase the hamstring flexibility of the less flexible students so that they were significantly more flexible than the Control Group.

4. The experimental bowling sessions were not found to increase the flexibility of the less flexible students so that there would no longer be a significant difference between their flexibility and that of the more flexible students.

5. The prescribed hamstring exercises were found to have increased the flexibility of the less flexible students to a level equal with those students who were significantly more flexible at the beginning of the experiment.

6. The experimental bowling sessions were found to bring about a significant average increase in the flexibility of the less flexible students.

7. The prescribed hamstring exercises were found to produce a greater average increase in flexibility than any of the other sub-groups.

8. Both the experimental bowling sessions and the prescribed hamstring exercises were found to develop a significantly larger average increase in flexibility than did either not participating in physical activity, or participating twice a week in general class work.

9. It was found that the experimental bowling sessions were not as successful as the prescribed exercises in increasing flexibility significantly.

10. Body mechanics as an activity was found to be more successful in increasing hamstring flexibility than was bowling.

Abdominal Strength

1. Both the experimental bowling sessions and the prescribed abdominal exercises were found to increase significantly the abdominal strength of the subjects.

2. The experimental bowling sessions were found to produce a level of abdominal strength that was significantly greater than that of the Control Group.

3. The prescribed abdominal exercises were not found to raise the strength of the experimental subjects above that of the Control Group.

4. Both the experimental bowling sessions and the prescribed abdominal exercises were found to produce a significant average increase in the abdominal strength of the subjects.

5. Both the experimental bowling sessions and the prescribed abdominal exercises were found to produce an average increase in abdominal strength that was significantly greater than the average strength increase

of the Control Group.

Correlations

1. It was found that individuals who scored high on the initial test also tended to score high on the final test, and students who scored low on the initial test also tended to score low on the final test.

2. It was found that there was no relationship between abdominal strength and hamstring flexibility.

3. No significant correlation was found between shoulder-girdle strength and hamstring flexibility or shoulder-girdle strength and abdominal strength.

In general, the experimental bowling sessions were found to be the better method of developing shoulder-girdle strength and abdominal strength in the weaker students. Prescribed hamstring exercises in body mechanics classes were found to be the better method for developing hamstring flexibility.

Conclusions

The contributions which any sport activity can make to the improvement of fitness depend upon the elements of fitness being considered, the nature of the activity, the physiological work load required, the amount of movement involved, and the degree of skill necessary for continuous activity. As has been previously stated, specific exercises produce effects which are specific to that exercise alone (14:119), but they seldom develop skills which will be used in leisure time activities. By participating in sports, however, an individual may increase his level of physical fitness, and at the same time learn skills that may be performed during his leisure.

The results of the present experiment have found that both bowling and prescribed exercises are successful methods of developing shoulder-girdle strength, hamstring flexibility, and abdominal strength in women students who are below the average level of ability in these three elements of fitness. In view of related literature and the findings of this experiment it may be suggested that since bowling provided an improvement in three elements of fitness, the same may be true of other sports activities.

It is with this last thought in mind that the writer wishes to recommend that further research be conducted as to the specific contributions that each sport might make to the various elements of fitness. It is also recommended that the contributions made by sports activities be compared with the contributions made by specific exercises.

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APPENDIX

TABLE XXIII

CORRECTED SCORES FOR CABLE TENSIOMETER

Instrument Reading	Correction	Corrected Reading	Instrument Reading	Correction	Corrected Reading
0	0	0	17.5	.625	26.88
.5	1.250	1.25	18.0	.625	27.50
1.0	1.250	2.50	18.5	.625	28.13
1.5	1.250	3.75	19.0	.625	28.75
2.0	1.250	5.00	19.5	.625	29.38
2.5	.625	5.63	20.0	.625	30.00
3.0	.625	6.25	20.5	.833	30.83
3.5	.625	6.88	21.0	.833	31.67
4.0	.625	7.50	21.5	.834	32.50
4.5	.625	8.13	22.0	.833	33.33
5.0	.625	8.75	22.5	.833	34.17
5.5	.625	9.38	23.0	.834	35.00
6.0	.625	10.00	23.5	.625	35.63
6.5	1.250	11.25	24.0	.625	36.25
7.0	1.250	12.50	24.5	.625	36.88
7.5	1.250	13.75	25.0	.625	37.50
8.0	1.250	15.00	25.5	.625	38.13
8.5	.625	15.63	26.0	.625	38.75
9.0	.625	16.25	26.5	.625	39.38
9.5	.625	16.88	27.0	.625	40.00
10.0	.625	17.50	27.5	.833	40.83
10.5	.625	18.13	28.0	.833	41.67
11.0	.625	18.75	28.5	.834	42.50
11.5	.625	19.38	29.0	.833	43.33
12.0	.625	20.00	29.5	.833	44.17
12.5	.625	20.63	30.0	.834	45.00
13.0	.625	21.25	30.5	.833	45.83
13.5	.625	21.88	31.0	.833	46.67
14.0	.625	22.50	31.5	.834	47.50
14.5	.625	23.13	32.0	.833	48.33
15.0	.625	23.75	32.5	.833	49.17
15.5	.625	24.38	33.0	.834	50.00
16.0	.625	25.00	33.5	1.250	51.25
16.5	.625	25.63	34.0	1.250	52.50
17.0	.625	26.25	34.5	1.250	53.75

TABLE XXIII (Continued)

Instrument Reading	Correction	Corrected Reading	Instrument Reading	Correction	Corrected Reading
35.0	1.250	55.00	42.5	1.250	66.25
35.5	.833	55.83	43.0	1.250	67.50
36.0	.833	56.67	43.5	1.250	68.75
36.5	.834	57.50	44.0	1.250	70.00
37.0	.833	58.33	44.5	1.250	71.25
37.5	.833	59.17	45.0	1.250	72.50
38.0	.834	60.00	45.5	1.250	73.75
38.5	.625	60.63	46.0	1.250	75.00
39.0	.625	61.25	46.5	.833	75.83
39.5	.625	61.88	47.0	.833	76.67
40.0	.625	62.50	47.5	.834	77.50
40.5	.625	63.13	48.0	.833	78.33
41.0	.625	63.75	48.5	.833	79.17
41.5	.625	64.38	49.0	.834	80.00
42.0	.625	65.00			

TABLE XXIV

CORRECTED SCORES FOR DYNAMOMETER

Instrument Reading	Corrected Reading	Instrument Reading	Corrected Reading	Instrument Reading	Corrected Reading
0	0	31	26	62	61
1	0	32	27	63	62
2	0	33	28	64	63
3	0	34	29	65	64
4	0	35	30	66	65
5	0	36	31	67	66
6	0	37	33	68	67
7	0	38	34	69	68
8	0	39	35	70	69
9	1	40	36	71	71
10	2	41	37	72	72
11	3	42	38	73	73
12	4	43	39	74	74
13	6	44	40	75	75
14	7	45	42	76	76
15	8	46	43	77	77
16	9	47	44	78	78
17	10	48	45	79	79
18	11	49	46	80	81
19	12	50	47	81	82
20	13	51	49	82	83
21	14	52	50	83	84
22	16	53	51	84	85
23	17	54	52	85	86
24	18	55	53	86	87
25	19	56	54	87	88
26	20	57	55	88	89
27	21	58	56	89	91
28	22	59	57	90	92
29	24	60	58	91	93
30	25	61	59	92	94

TESTING CARD

Name ____________________

S1 S2 S3 E1 E2 E3 C

Age ____ Year in School __________

Physical Education Class:
Bowling ___ Body Mechanics ___ Other ___

Campus Mailing Address: __________

Instructor __________ Hour _____

Campus Residence __________

What sports do you participate in outside of your physical education class? __________
____

Are you now participating in R.A.? ___
If "yes," in what activities? ______
____

TESTING DATA

	First Test			Second Test			Difference
	Score		Date	Score		Date	
	R	L		R	L		
Hip Flexibility							
	Push	Pull		Push	Pull		
Shoulder-Girdle Strength							
Abdominal Strength							

SAMPLE CARD USED BY THE EXPERIMENTAL BOWLING SUB-GROUPS
TO RECORD THE NUMBER OF BALLS BOWLED, THE NUMBER OF BALLS RETURNED,
AND THE NUMBER OF PINS SET EACH DAY

NAME				WEEK		
	Monday	Tuesday	Wednesday	Thursday	Friday	Total
Balls Bowled						
Balls Returned						
Pins Set						

Prescribed Exercises for the

Experimental Body Mechanics Sub-Groups

Hamstring Flexibility

First Week:

Toe Touch (10:113) - Sit on floor, feet against wall, knees straight. Touch toes with hands and hold position for three seconds. Repeat three times.

Stand and Touch Toes (10:113) - Stand with straight knees, bend forward, touch toes with fingertips and hold position for three seconds. Repeat three times.

Leg Extension (10:110) - Sit on chair. Grasp edge of chair with both hands. Extend right leg to 180°. Lower to starting position. Repeat with left leg. Repeat three times with each leg.

Second Week:

Toe Touch (10:113) - Sit on floor, feet against wall, knees straight. Touch toes with hands and hold position for five seconds. Repeat three times.

Assisted Stretch (20:168) - Sit on floor, legs straight. Try to place forehead on knees while partner applies steady pressure on back of shoulder blades. Hold position at the maximum tolerable for three seconds. Repeat three times.

Chair Stretch (16:226) - Stand with right foot raised on a chair, knees straight, hands on hips. Bend forward from waist and try to place head on right knee. Hold position for three seconds. Repeat with left foot on chair. Repeat three times with each leg.

Third Week:

Toe Touch (10:113) - Sit on floor, feet against wall, knees straight. Touch toes with hands and hold position for five seconds. Repeat five times.

Assisted Stretch (20:168) - Sit on floor, legs straight. Try to place forehead on knees while partner applies steady pressure on back of shoulder blades. Hold position at the maximum tolerable for five seconds. Repeat five times.

Straight Leg Raising (10:110) - Lie on back, hands at side of body. Keeping legs straight, raise right leg as high as possible without bending knee. Ankle in plantar flexion. Repeat five times with each leg.

Fourth Week:

Toe Touch (10:113) - Sit on floor, feet against wall, knees straight. Touch toes with hands and hold position for ten seconds. Repeat five times.

Assisted Stretch (20:168) - Sit on floor, legs straight. Try to place forehead on knees while partner applies steady pressure on back of shoulder blades. Hold position at the maximum tolerable for eight seconds. Repeat five times.

Hamstring Stretch (10:113) - Lie on back. Grasp right foot with right hand and stretch knee to full extension. Repeat with left foot and hand. Hold knee in extended position for five seconds. Repeat five times with each leg.

Abdominal Strength

First Week:

Flexion and Extension (10:124) - Lie on back. Flex right leg and left arm so that knee and elbow touch. Stretch right leg and left arm to full extension and hold ten inches off floor for three seconds. Repeat with left leg and right arm. Flex both legs and arms so that right knee hits right elbow and left knee hits left elbow. Stretch both arms and legs and hold ten inches off floor for three seconds. Repeat series five times.

Single Knee Kiss (10:125-126) - Lie on back, keeping head and shoulders flat on floor throughout exercise. Flex right knee and bring thigh as close to chest as possible. Stretch right leg to full extension and lower slowly. Repeat with left leg. Repeat five times with each leg.

Roll Down - Sit with hips and knees in extreme flexion, feet flat on floor and close to buttocks. Partner holds feet. Hands placed behind head, slowly roll down until back and shoulders are flat on floor. Assume sitting position again anyway possible. Repeat five times.

Second Week:

Double Flexion-Extension (10:124) - Lie on back. Flex both knees and elbows so that elbows and knees touch. Stretch both legs and arms to full extension and hold ten inches off floor for five seconds. Repeat five times.

Leg Circles (10:126) - Lie on back, hands locked behind head. Raise one leg with knee straight to 45º, make a circle with leg, slowly lower leg to floor. Repeat with other leg. Raise both legs to 45º and describe circles with each leg going in opposite direction. Slowly lower legs to floor. Repeat series five times.

Sit-Ups (20:179) - Lie on back with hands locked behind head, heels near buttocks. Partner holds feet. Slowly sit up and touch elbows to knees. Slowly return to floor. Repeat five times.

Third Week:

Leg Hold (10:126) - Lie on back, hands locked behind head. Partner holds pelvis down on floor. Raise both legs with straight knees to 45º and hold for ten seconds. Relax slowly. Repeat three times.

Trunk Swing (10:127) - Lie on back, hands behind head. Partner holds thighs down on floor. Raise trunk six inches from floor and slowly swing to the left, then to the right, and then lower trunk to floor. Relax. Repeat three times.

Sit-Ups (20:179) - Lie on back with hands locked behind head, heels near buttocks. Partner holds feet. Slowly sit up and touch elbows to knees. Slowly return to floor. Repeat ten times.

Fourth Week:

Leg Hold (10:126) - Lie on back, hands locked behind head. Partner holds pelvis down on floor. Raise both legs with straight knees to 45º and hold for ten seconds. Relax slowly. Repeat five times.

Trunk Swing (10:127) - Lie on back, hands behind head. Partner holds thighs down on floor. Raise trunk six inches from floor and slowly swing to the left, then to the right, and then lower trunk to floor. Relax. Repeat five times.

Sit-Ups (20:179) - Lie on back with hands locked behind head, heels near buttocks. Partner holds feet. Slowly sit up and touch elbows to knees. Slowly return to floor. Repeat fifteen times.

Shoulder-Girdle Strength

First Week:

Wing Spread Against Resistance (10:127) - Sit on floor, hands locked behind head. Press arms backwards against resistance offered by partner. Hold for three seconds. Repeat five times.

Partner Dip (23:42) - One partner acts as support. Girl exercising stands with feet together, body straight. Place heels of hands against partner's, arms extended at shoulder height. Keep body in straight line from head to heels while lowering. Return to starting position. Repeat five times.

All Fours Dip (23:43) - On hands and knees with hips directly above knees and shoulders above hands. Slowly bend elbows to permit chin to touch floor. Keep back flat. Slowly straighten elbows and return to starting position. Repeat five times.

Second Week:

Wing Spread Against Resistance (10:127) - Sit on floor, hands locked behind head. Press arms backwards against resistance offered by partner. Hold for five seconds. Repeat five times.

Elbow Push-Ups (20:172) - Lie on back, knees bent, feet flat on floor. Place hands under small of back palms down, elbows flat on floor. Push against floor with elbows to raise trunk and head from floor. Hold position for five seconds. Repeat five times.

Let Down (23:44) - Assume prone fall position, weight on hands and toes. Lower body slowly to floor by bending elbows. Assume starting position again by shifting weight back to knees, straightening knees, and assume prone fall position again. Keep body in a straight line while lowering. Repeat five times.

Third Week:

Knee Push-Ups (23:44) - Lie face down on floor with knees bent and feet up towards ceiling. Hands placed outside shoulders. Straighten elbows and push body up to a supported position resting on hands and knees. Slowly bend elbows and return to start. Repeat five times.

Let Down (23:44) - Assume prone fall position, weight on hands and toes. Lower body slowly to ground by bending elbows. Repeat five times.

Vertical Pull-Ups (20:173) - Jump to hanging, palms away from body. Pull chin up to bar, and slowly lower it again. If cannot raise chin to bar, do the following: Step on chair to reach bent arm hanging position. In this position pull chin over bar. If still cannot raise chin, hold bent arm hanging position as long as possible, and give way as slowly as possible. Repeat three times.

Fourth Week:

Knee Push-Ups (23:44) - Lie face down on floor with knees bent and feet up toward ceiling. Hands placed out at side of shoulders. Straighten elbows and push body up to a supported position resting on hands and knees. Slowly bend elbows and return to starting position. Repeat ten times.

Let Down (23:44) - Assume prone fall position, weight on hands and toes. Lower body slowly to ground by bending elbows. Repeat ten times.

Vertical Pull-Ups (20:173) - Jump to hanging, palms away from body. Pull chin up to bar, and slowly lower it again. If cannot raise chin to bar, do the following: Step on a chair to reach a bent arm hanging position. In this position pull chin over bar. If still cannot raise chin, hold bent arm hanging position for at least ten seconds. Repeat five times.

TABLE XXV

RAW DATA FOR EXPERIMENTAL BOWLING SUB-GROUPS

	Name	Age	Year	Shoulder-Girdle Strength Initial		Shoulder-Girdle Strength Final	Hamstring Flexibility Initial		Hamstring Flexibility Final	Abdominal Strength Initial	Abdominal Strength Final
1.	J.B.	19	Soph	81	*	92	178		195	25.63	34.17
2.	E.H.	18	Fr	92	*	97	204		210	18.13	50.00
3.	L.H.	19	Soph	97	*	92	194		194	52.50	43.33
4.	E.J.	19	Soph	94	*	83	220		217	33.33	55.83
5.	J.K.	19	Fr	85	*	106	195		200	22.50	42.50
6.	S.M.	18	Fr	87	*	83	212		214	48.33	40.00
7.	N.M.	18	Fr	89	*	93	178		182	26.25	37.50
8.	J.M.	19	Fr	79	*	71	180		193	10.00	40.00
9.	K.S.	19	Fr	71	*	89	180		194	32.50	36.25
10.	J.W.	18	Fr	91	*	104	189		216	36.25	55.00
11.	M.A.	18	Fr	68	*	78	161	*	188	27.50	41.67
12.	F.B.	19	Fr	85	*	109	165	*	166	28.75	50.00
13.	J.C.	19	Fr	83	*	101	150	*	163	43.33	56.67
14.	S.C.	18	Fr	69	*	67	175	*	204	35.00	35.00
15.	S.H.	18	Fr	74	*	83	173	*	198	19.38	33.33
16.	E.H.	19	Fr	94	*	97	160	*	160	33.33	32.50
17.	R.M.J.	18	Fr	76	*	90	168	*	186	35.00	38.75
18.	B.J.L.	19	Fr	70	*	87	147	*	161	31.67	30.00
19.	J.M.	19	Soph	83	*	79	157	*	165	28.75	31.67
20.	M.A.M.	19	Fr	84	*	94	155	*	180	25.00	33.33
21.	S.S.	17	Fr	68	*	80	155	*	170	35.00	46.67
22.	L.R.	19	Fr	95	*	92	175	*	193	50.00	79.17
23.	A.R.	18	Fr	97	*	94	150	*	140	33.33	61.25
24.	K.S.	18	Fr	74	*	76	168	*	189	2.50	10.00
25.	J.S.	18	Fr	76	*	78	149	*	180	22.50	21.25
26.	K.S.	19	Soph	58	*	74	145	*	157	10.00	48.33
27.	K.T.	19	Fr	73	*	84	162	*	182	45.00	42.50
28.	M.T.	19	Fr	88	*	113	165	*	197	21.88	52.50
29.	M.W.	18	Fr	61	*	68	160	*	190	17.50	18.75
30.	S.W.	18	Fr	67	*	85	164	*	190	18.13	47.50
31.	E.W.	18	Fr	94	*	101	170	*	178	17.50	31.67
32.	L.W.	18	Fr	65	*	83	160	*	162	12.50	23.75
33.	S.B.	18	Fr	103		110	135	*	159	40.83	41.67
34.	P.C.	18	Fr	99		101	145	*	176	10.00	41.67

*Scored in lower fifty per cent on initial test. Comprised Bowling S-G and Bowling H-S sub-groups.

TABLE XXV (Continued)

	Name	Age	Year	Shoulder-Girdle Strength Initial	Shoulder-Girdle Strength Final	Hamstring Flexibility Initial		Hamstring Flexibility Final	Abdominal Strength Initial	Abdominal Strength Final
35.	M.D.	20	Soph	101	110	170	*	189	18.75	33.33
36.	R.G.	18	Fr	105	90	156	*	174	25.00	37.50
37.	C.G.	19	Fr	101	104	157	*	172	21.25	31.67
38.	M.H.	19	Soph	99	102	173	*	185	29.38	37.50
39.	A.Mc.	19	Fr	110	126	150	*	152	49.17	52.50
40.	M.N.	18	Fr	99	94	155	*	168	56.67	75.00
41.	M.S.	19	Fr	105	105	150	*	158	23.75	35.63
42.	R.W.	18	Fr	101	114	146	*	163	22.50	33.33

*Scored in lower fifty per cent on initial test. Comprised Bowling S-G and Bowling H-S sub-groups.

TABLE XXVI

RAW DATA FOR EXPERIMENTAL BODY MECHANICS SUB-GROUPS

	Name	Age	Year	Shoulder-Girdle Strength Initial		Shoulder-Girdle Strength Final	Hamstring Flexibility Initial		Hamstring Flexibility Final	Abdominal Strength Initial	Abdominal Strength Final
1.	H.J.B.	19	Fr	87	*	92	190		205	48.33	43.33
2.	S.G.	18	Fr	86	*	92	217		240	29.38	19.38
3.	C.H.	17	Fr	65	*	76	212		248	23.13	48.33
4.	J.M.W.	18	Fr	81	*	88	199		207	28.75	31.67
5.	S.W.	18	Fr	91	*	113	193		214	52.50	71.25
6.	M.A.C.	18	Soph	92	*	87	146	*	183	17.50	35.63
7.	S.C.	20	Jr	86	*	95	153	*	185	36.25	55.00
8.	J.E.	20	Sr	92	*	117	148	*	170	33.33	40.00
9.	M.G.F.	18	Fr	79	*	88	166	*	198	31.67	33.33
10.	M.G.	19	Fr	67	*	67	153	*	185	16.88	34.17
11.	L.H.	18	Fr	71	*	95	157	*	198	15.00	27.50
12.	D.J.	18	Fr	97	*	92	169	*	212	10.00	26.25
13.	H.S.	17	Fr	79	*	79	170	*	205	10.00	18.75
14.	L.S.	18	Fr	79	*	97	150	*	187	26.25	59.17
15.	J.S.	18	Fr	87	*	83	135	*	154	27.50	21.25
16.	M.L.E.	18	Fr	126		117	145	*	200	32.50	53.75
17.	B.A.G.	18	Fr	99		102	167	*	186	17.50	40.00
18.	T.H.	19	Fr	130		115	151	*	213	23.75	28.13
19.	S.S.	19	Fr	124		143	150	*	205	34.17	55.00

*Scored in lower 50 per cent on initial test. Comprised the Body Mechanics S-G and Body Mechanics H-S sub-groups.

TABLE XXVII

RAW DATA FOR CONTROL GROUP

	Name	Age	Year	Shoulder-Girdle Strength Initial	Shoulder-Girdle Strength Final	Hamstring Flexibility Initial	Hamstring Flexibility Final	Abdominal Strength Initial	Abdominal Strength Final
1.	C.B.	20	Jr	103	100	170	180	37.50	31.67
2.	A.B.	20	Jr	73	83	153	174	10.00	8.75
3.	S.A.B.	21	Sr	92	76	178	177	38.75	38.75
4.	S.B.	19	Soph	115	105	201	208	25.00	21.25
5.	M.B.	20	Jr	62	59	165	172	22.50	18.13
6.	F.C.	21	Jr	71	76	160	185	40.00	40.00
7.	O.F.C.	20	Jr	118	125	167	170	45.00	38.75
8.	P.C.	24	Jr	86	81	145	158	10.00	13.75
9.	M.B.D.	21	Jr	106	93	176	178	26.25	27.50
10.	B.F.	21	Sr	79	81	205	195	19.38	23.75
11.	M.H.	20	Jr	81	110	185	195	31.67	53.75
12.	G.H.	22	Jr	113	102	158	163	8.75	20.63
13.	N.J.	21	Jr	91	106	158	150	33.33	22.50
14.	N.L.J.	19	Jr	141	133	189	192	41.67	55.00
15.	C.L.	21	Sr	73	70	186	183	22.50	46.67
16.	M.A.Mc.	20	Jr	66	74	185	183	10.00	10.00
17.	P.N.	20	Jr	44	56	165	160	27.50	35.00
18.	C.R.	20	Jr	112	100	175	181	44.17	34.17
19.	S.R.	21	Sr	96	97	160	179	52.50	35.00
20.	A.S.	21	Sr	98	89	175	187	22.50	27.50
21.	N.S.	21	Sr	61	79	165	170	24.38	36.25
22.	K.S.	21	Sr	81	97	150	135	48.33	49.17
23.	F.T.	20	Jr	74	81	143	150	28.75	30.00
24.	S.T.	19	Jr	73	78	167	190	22.50	19.38
25.	L.W.	20	Jr	88	111	157	194	20.00	43.33
26.	N.J.W.	20	Jr	76	83	170	174	60.00	48.33
27.	J.A.	20	Sr	119		160		8.75	
28.	A.D.	21	Sr	55		112		10.00	
29.	R.T.	22	Sr	78		185		43.33	

TABLE XXVIII

RAW DATA FOR NON-EXPERIMENTAL BOWLING SUB-GROUPS

	Name	Age	Year	Shoulder-Girdle Strength		Hamstring Flexibility	
				Initial	Final	Initial	Final
1.	K.A.	18	Fr	83	80	162	170
2.	S.B.	18	Soph	81	90	128	138
3.	N.L.B.	20	Soph	128	134	179	180
4.	M.J.B.	18	Fr	70	61	170	167
5.	B.B.	19	Soph	119	96	178	177
6.	W.B.	26	Fr	65	72	170	187
7.	J.B.	19	Soph	105	110	175	198
8.	E.S.B.	18	Fr	68	111	155	165
9.	D.C.	18	Fr	123	117	181	193
10.	J.C.	18	Fr	101	96	184	209
11.	R.C.C.	19	Fr	139	123	191	180
12.	J.F.	18	Fr	90	79	150	167
13.	A.G.	18	Fr	72	83	167	170
14.	G.H.	19	Fr	123	108	206	223
15.	A.H.	18	Fr	67	70	194	174
16.	J.J.	19	Soph	121	107	191	190
17.	B.K.	19	Soph	99	127	137	151
18.	A.M.	18	Fr	83	78	161	179
19.	L.Mc.	18	Fr	108	103	203	215
20.	B.P.	19	Fr	87	106	182	194
21.	E.P.	18	Fr	92	101	162	176
22.	C.R.	19	Fr	110	103	186	188
23.	S.S.	18	Fr	99	102	217	235
24.	J.S.	20	Soph	61	72	135	174
25.	S.Sp.	18	Fr	90	104	185	210
26.	B.S.	18	Fr	90	99	170	180
27.	J.T.	18	Fr	141	150	201	209
28.	L.T.	18	Fr	101	90	162	168
29.	K.K.W.	18	Fr	97	105	177	205
30.	M.V.W.	18	Fr	99	90	217	232
31.	L.W.	19	Fr	94	112	167	177
32.	M.K.W.	18	Fr	88	83	171	189
33.	P.W.	19	Fr	69	74	172	174
34.	B.P.	19	Fr	114		204	
35.	K.S.	18	Fr	78		170	

TABLE XXIX

RAW DATA FOR NON-EXPERIMENTAL BODY MECHANICS SUB-GROUPS

Name	Age	Year	Shoulder-Girdle Strength Initial	Shoulder-Girdle Strength Final	Hamstring Flexibility Initial	Hamstring Flexibility Final
1. R.B.	18	Soph	106	101	205	228
2. C.C.	18	Fr	112	104	190	208
3. N.D.	19	Soph	108		150	
4. P.H.	18	Fr	79	83	189	252
5. S.H.	18	Fr	97	94	155	168
6. A.J.	18	Soph	112	122	177	179
7. M.A.K.	19	Fr	126	117	157	173
8. M.K.	18	Fr	94	113	194	227
9. C.K.	20	Jr	94	99	185	200
10. K.K.	19	Fr	96	92	189	214
11. S.M.	18	Fr	86	85	163	182
12. P.S.	19	Soph	103	115	190	202
13. B.L.W.	18	Fr	121	118	193	204
14. S.W.	18	Fr	74	101	162	192
15. J.W.	20	Soph	98	90	170	196

Typed by

ELIZABETH BOOKER