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Changes in the Physical Fitness of Adult Men as a Result of a Self-administered Battery of isometric Contraction, Isotonic Contraction and Breath-holding Exercises

Jerry D. Hess

CHANGES IN THE PHYSICAL FITNESS OF ADULT MEN AS A RESULT OF A SELF-ADMINISTERED BATTERY OF ISOMETRIC CONTRACTION, ISOTONIC CONTRACTION AND BREATH-HOLDING EXERCISES

BY

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This thesis is approved as a creditable, independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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Thesis Adviser

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Head of the Major Department

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JDH

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CHAPTER I

INTRODUCTION

The physical fitness of Americans and American youth has been of concern to our nation for over two decades and especially since World War II. The Kraus-Weber tests of minimum muscular fitness brought forth even more concern over the physical fitness of our nation, since these tests showed that we are not keeping pace with other nations in physical fitness. The findings of the Kraus-Weber tests were later supported by a series of physical fitness tests sponsored by the American Association for Health, Physical Education, and Recreation. Tests of physical fitness at American colleges and universities also showed a steady decline in fitness.[1,2] This growing decline is a matter of urgent concern to conscientious Americans. Much of the research in the area of physical fitness has been done with youth, but very little has been done with adults. There is concern that adults are lacking in physical fitness in the same way as our youth. Our adults of today were the "soft Americans" of 10-20 years ago. What can be done about today's "soft Americans"? Not all of them will become physically fit before reaching adulthood.

The physical vigor of our citizens is one of America's most precious resources. If it is wasted or neglected, much of the ability to meet the great and vital challenges which confront our people will be destroyed, and thus, as a nation, our full potential will not be realized. The lack of physical fitness as a nation is, in a very real sense, a menace to our nation's security. Only if every American is

willing to assume responsibility for his own fitness and the fitness of his children may the physical soundness of our nation be fully restored.[3]

The President of the United States, John F. Kennedy, has stated:

> We do not live in a regimented society. We are not forced to live our lives in the interest of the State.
>
> We are, all of us, as free to direct the direction of the activities of our bodies as we are to pursue the objects of our thoughts.
>
> But if we are to retain this freedom for ourselves and for generations to come, then we must be willing to work for physical toughness upon which the courage and intelligence and skill of man so largely depend.[4]

Need for the Study

The same civilizations that gave us much of our philosophy, drama, government, and art also gave us a belief in the importance of physical soundness which has become a part of Western tradition. John Locke in Some Thoughts Concerning Education states:

> A sound mind in a sound body is a short but full description of a happy state in this world. He that has these two has little else to wish for; and he that wants either of them will be but little better for anything else.[5]

These fundamental beliefs cannot be forgotten. Physical fitness has value for all -- individually and as a nation.

Since the alarm over the fitness of our youth is not new, it would seem that many of these unfit youth have become unfit adults. If physical fitness has value for youth, it must also have some value for adults. The adults of today need a brief and simple program by which they may develop and maintain fitness. The author has attempted to develop such a program and to prove or disprove its value through the use of isometric contraction, isotonic contraction, and breath-holding exercises.

Statement of the Problem

This study was undertaken to determine whether or not a battery of isometric contraction, isotonic contraction, and breath-holding exercises could be devised that would be effective in developing physical fitness in adult men. Such an exercise program could be effective only if the subjects were willing to perform the exercises on their own time and of their own free choice. The exercise battery was designed to be self-administered and to fit into the busy schedules of most adult men. The problem was subdivided into: (1) devising a battery that would develop and maintain physical fitness, (2) devising a battery in which adults were willing to participate and thus make it truly effective.

Delimitations

1. This study was limited to 26 adult male volunteers from the Brookings, South Dakota, community. Most of the participants were members of the Brookings Junior Chamber of Commerce.

2. The training consisted of one workout each day, six days each week, for a period of ten weeks on a selected battery of isometric contraction, isotonic contraction, and breath-holding exercises.

3. No attempt was made to control the outside activities or diet of the subjects. It should also be noted that the program took place during six weeks of Lent.

4. There was no control over how accurately or conscientiously the subjects followed the instructions for the battery of exercises. No efforts were made to encourage the subjects or to give them any incentive other than what would normally occur from personal desire.

5. No control group was used in this study. Since it was felt that the growth and strength patterns of adults are fairly well-established, it was not deemed necessary to use a control group.

6. The majority of the subjects were unacquainted with the testing instruments and methods.

Definition of Terms

1. Physical fitness -- One phase of total fitness. In addition to freedom from germinal or chronic disease, possessing good teeth, good hearing, good eyesight, and normal mentality, physical fitness means ability to handle the body well and the capacity to work hard over a long period of time without diminished efficiency.[6] Motor fitness more aptly fits the area commonly called physical fitness.[7]

> The person with adequate physical fitness should be able to carry out his daily tasks without undue fatigue and should still have ample reserve of energy to enjoy leisure time and to meet unforeseen emergencies.[8]

2. Isometric contraction -- A contraction of a muscle in which there is no change in the length of the muscle. No movement takes place and no work is done.[9] All the energy is used in tension and none in movement.[10] It is a static contraction.

3. Isotonic contraction -- A contraction in which the muscle shortens against a load. This results in movement and performance of work.[11]

4. Breath-holding -- As used in this study meant to inhale as deeply as possible and to hold it. The lungs remained in an expanded state with no further inhalation taking place.

5. Strength -- Emphasizes the capacity of the body or the extremities to exert force. Strength in its ultimate analysis is a complex human quality involving will power, the number of muscle fibers that can be brought into the act, and the nutritive state of the muscle fiber involved.[12] It is an important quality in physical fitness.[13]

6. Endurance -- Emphasizes the capacity for continuous exertion with partial recovery during exercise.[14] It is dependent to a large degree upon strength.[15]

7. Muscle tonus -- All mucles possess the property of tonicity. It is an involuntary state of tension that exists within a muscle. The ability of a muscle to stay in tonus continuously, with very little display of metabolic activity, is thought to be due to the fact that muscle fibers, arranged in groups, work in relays. In this way only a part of the muscle fibers are active at any one time. Tonus is most pronounced in the postural muscles. If tonus is reduced, posture suffers.[16] It is a state of low grade muscle contraction caused by the discharge of nerve impulses along its nerve fibers.[17]

8. Vital capacity -- The amount of air that may be forceably expired from the lungs.

There was no attempt made in this study to determine the significance of the individual items of the exercise battery on adult physical fitness. Over-all gain or loss of physical fitness was sought as a result of the administration of the total battery.

CHAPTER II

REVIEW OF LITERATURE

Literature regarding general physical fitness is very abundant; however, there appears to be a lack of specific literature dealing with adult physical fitness. By far the majority of the literature available expressed favorable views toward exercise and physical fitness. This is no doubt due to our present concern over the fitness of the people of our nation.

The Role of Exercise and Fitness in Health

McCloy in discussing old age and exercise stated that old age is partly a matter of the inherited quality of the tissues and glands of the body. For this reason some people "wear out" or "age" sooner than others. However, this is only one cause of premature old age. To a larger degree than most people realize, premature old age is a function of three things: (1) a lack of strength, (2) a growing inflexibility, and (3) an attitude of mind. As a man grows older he loses his strength, hence, he soon lacks endurance, his antagonistic muscle groups shorten, hence, he loses flexibility and becomes "stiff." As a result he considers himself an old man. This is not a natural phenomenon. As man ages he becomes slightly slower, but his strength remains until the waning years of life, provided that a proper routine of activity is maintained. Exercise may not be able to prolong the years of life, as that is probably largely a matter of heredity, but it can prolong the youthful, active years of life.

He further stated that in the study of isolated cells, it has been indicated that cells which maintain a monotonous environment become old, stay old, and wear out. If kept in this environment too long, they tend to function explosively instead of adaptively when stimulated. On the other hand, where environment is constantly changing and the cell is subjected to higher and lower temperatures and intermittent spurts of activity, these cells develop at their best. Exercise would seem to be one of the best means for the rejuvenation of tissue for its changes affect cell oxidation and produce radical temperature changes within the cell.[18] After a sedentary man passes 30, he begins to take a physical nose dive. Thousands of microscopic blood vessels that normally carry oxygen and nutrients to the muscles, lungs, heart, and other organs slowly fall into disuse. The key to turning back the clock of physical aging is to force open and use these blood vessels. The method: regular exercise to raise the metabolism, strengthen the heart, keep plenty of blood flowing, and to create a demand by the muscles for more oxygen and nutrients.[19]

Barker related that undoubtedly a career of activity, rather than of idleness, will work in favor of length of life. No definite age can be predicted as the time for retirement or for marked reduction of activities. Each person should carry on full activity as long as he can do so without over-fatigue or other injury to his constitution.[20]

Research at the University of Illinois, the University of Michigan, Michigan State, the University of Southern California, and at the University of Oregon point sharply to the fact that hard exercise is needed in the middle-age span of life. The lack of it causes the decline in physical fitness. In these studies on adults, improvements have been

made in cardio-vascular condition, strength, metabolism, and nutritional status through progressive training programs to the level of hard endurance. The improved endurance as well as the better scores on various tests of motor ability show that the decline in the fitness of the human body can be appreciably checked.[21]

The human body, according to Dr. C. H. Cureton, is the only mechanism that functions better -- and more healthily -- the more it is used. He is convinced that although a man may grow older in years, the major physical ailments of aging -- chronic fatigue, headaches, shortness of breath, digestive upset, overweight, certain forms of heart and circulatory disorders -- can be completely avoided or postponed for as many as 15 years by a daily program of body conditioning and active recreation.[22]

Numerous medical doctors have expressed their views on the role of exercise and fitness. Kraus called a lack of sufficient exercise a serious deficiency comparable with vitamin deficiency. The prevention of this deficiency is an urgent need. Lower back pain often results if the deficiency remains uncorrected.[23] According to Jokl, those who maintain activity have better performance records, fewer cases of degenerative diseases and probably a longer life expentancy than the general population. There is little doubt that the inclusion of proper physical activity in the way of life can significantly delay the aging process. Sprague expressed the view that the best insurance against coronary disease is exercise and plenty of it. A combination of diet and exercise may reverse the present trend of coronary disease.[24] A man who has repeatedly spoken of the role of exercise and fitness, and the man who treated former President Dwight D. Eisenhower, Dr. Paul White, stated

that all healthy persons should exercise regularly regardless of their age. Exercise is just as essential for the best health as rest and sleep, food, one's job, and peace of mind. He termed exercise "Man's Best Medicine."[25] In another source he stated that those in the middle-aged bracket should have physical fitness uppermost in their minds.[26] Federkiewicz expressed his views by stating that the average person either exercised too little or followed the wrong exercise methods. This is the major reason why the average man becomes sick. Exercise is one good health tonic which cannot be replaced by any doctor's prescription, especially if the exercises are performed in the open air. In discussing his viewpoint, Klumpp calls fatigue the greatest obstacle to a happy useful life for those in old age. The best antidote when one feels tired is physical activity. Over and over it has been demonstrated that physical activity at the end of a trying day will bring refreshment and renewed energy that nothing else can equal.[27]

These views and remarks tend to show that medicine stands for a broad concept of fitness. Medicine does not discourage activity, sports, competition, or even a reasonable risk of injury for the sake of physical fitness.[28]

There are values of exercise and physical fitness that are more specific. Various sources state that it promotes better digestion and circulation, better use of the lungs, better elimination functions, better control over the nervous system, better relaxation, and tends to speed glandular functions.

Experiments at the Wistar Institute showed that rats in activity cages for a period corresponding to 14 years in human beings increased

over confined rats 6.8% in body weight, 20% in weight of the heart, kidneys, and liver, 4% in brain weight, 34% in ovaries, and 12% in testes. In the lack of precise data for man we may assume that similar effects would result in man.[29]

Kraus and his associates reported that the "study, treatment, and prevention of physical inactivity as an important etiological factor of many disabling diseases is imperative for our national welfare." They also stated that coronary heart disease is twice as frequent in the sedentary as in the active. Other health problems, more frequent in the sedentary, include diabetes, duodenal ulcer, emotional difficulties, lack of adaptability to stress, susceptibility to neuromuscular tension, high pulse rate, lack of strength and flexibility, and premature aging.[30] In his studies of the health habits of adults who had suffered heart attacks, Luongo found evidence to show that sedentary living and poor health habits were the real culprits and not hard work, over-exercise or occupational stress. He concluded that proper diet and exercise should be carried on through middle age and into old age.[31]

Value of Strength, Endurance, and Tonus

McCloy wrote that it is known that a muscle that is too weak for its task works at a lower efficiency than does one that is adequately developed for its task. For this reason an individual who is underdeveloped will work inefficiently, so far as his muscles are concerned, and will suffer greater fatigue both locally and generally than one who is developed.[32]

In a study on the significance of strength, Rogers found that

strength is an indication of physical condition and organic efficiency. According to his study the positive and very high relation of muscular strength to good health, physical fitness, or capacity for activity can hardly be questioned. With no strength there can be no physical activity. When muscular strength is low all other life functions are handicapped. Practically every change in the condition of the vital organs carries a corresponding change in the condition or functioning of voluntary muscles.[33]

Hoffman and associates believe that muscular strength increases coordination and control, speed, endurance, and power, and is an important component of agility.[34] Strength is generally accepted as a prerequisite to superior athletic performance and to youthful posture and poise.[35]

A number of researchers have supported the contention that physical fitness is related to mental achievements. Rogers and Jarman with studies 37 years apart found that men and boys who scored high on strength tests had significantly higher grade point averages in their classwork.[36] At Syracuse University, Page found that 83% of those dismissed from Syracuse University because of low grades had Physical Fitness Indices below 100; however, it may be noted that these students were well above average in scholastic aptitude.[37] McCollum and Coefield at the University of Oregon found that the 78 male freshmen with the lowest Physical Fitness Indices during a term were definitely low in scholastic accomplishment. Again in this study it was found that the low fitness students were above average in scholastic aptitude.[38] This would seem to indicate that strength or physical fitness is of important value in mental alertness

and achievement. Thus it may be said that a fit individual is more prone to be physically and mentally alert and to suffer less from efficiency-destroying fatigue than if unfit.[39]

Research has also shown that physically unfit people, especially boys and girls, experience difficulty in day by day personal adjustments with others and in developing good social habits and attitudes. In a study by Popp, the 20 highest scores and the 20 lowest scores on the Physical Fitness Index from a group of approximately 100 boys were arranged in an alphabetical list. Five judges were asked to pick 10 boys with the qualities they would most want their sons to have and the 10 with qualities they would least want their sons to have. Of boys picked as "desirable" 69% had high Physical Fitness Indices. In the group picked as "undesirable" only 25% had high Physical Fitness Indices.[40] At the United States Military Academy, a study by Appleton showed that 12.9% of the cadets in the lower 7% on the West Point motor fitness test needed psychiatric help. This percent exceeded the number given psychiatric help in the upper 93% on the test.[41]

The ability to persist at a task is recognized as an important quality and whether the task is physical or mental, endurance will be a factor. The development of endurance demands exercise. It is a very elementary truth which is borne out by observation that people with muscular, nervous, and circulatory endurance and fitness can work hard and long without complaint or feeling overworked.[42]

Exercise develops tonus which steps up the ability of a muscle to do work. It also increases the muscles' ability to absorb the shock which all parts of the body are subjected to, such as falling down, and

automobile accidents. The ability of muscles to support and protect the viscera of the body is enhanced by tonus, as is posture. Circulation and digestion become more efficient as a result of improved tonus. Muscles with sufficient tonus are stronger, more powerful, have a quicker more effective reaction to stimulation, and are better coordinated. Effective muscular contraction requires muscle tonus, hence, a lack of tonus in the heart muscles becomes a serious situation.[43]

Development of Strength, Endurance, and Tonus

Little doubt exists today that exercise of the right type and amount will develop strength, endurance, circulatory-respiratory endurance, and general muscular tonus. In fact, it is generally accepted that exercise is the only means of acquiring the ability to engage in physically demanding tasks. Herkimer in his study on the effects of physical exercise on adult men found that through the use of general individualized physical activity, physical condition can be improved. He found a great improvement in heart and cardio-vascular condition and important gains in strength as a result of exercise. Gains were also found in the Larson C-VJ-D test.[44] Another investigator, Hopkins, also found exercise to be useful in developing cardio-vascular condition and strength, and in improving scores on the Larson C-VJ-D test. In his study of adults a program of volleyball and calisthenics was used as the form of exercise.[45] Brodt's study of weight lifting and physical fitness of adults showed significant gains in strength could be made by means of heavy exercise.[46] Through a program of conditioning exercises over a period of six months, Wells found that cardio-vascular condition

could be improved. Improvement in speed, agility, and the Larson C-VJ-D test was also found but no significant changes in strength were shown.[47]

According to available literature there are two methods of developing strength, these being isometric muscle contraction and isotonic muscle contraction. Both of these methods have been used successfully by investigators, and in both types of exercise the overload principle applies. This principle states that a muscle must be "overloaded" in order to be strengthened. If it is adequately overloaded it will grow in size and strength.[48] The amount of tension a muscle must exert to overcome a resistance is the key to muscular development.[49]

Isotonic contraction is our oldest method of muscle development. It has been used as a means of muscular development for centuries. Two pictures dated at about 2500 B.C. on an Egyptian tomb depict strength-developing exercises.[50] This method puts more emphasis on the overload aspect and somewhat less on the tension aspect. Much scientific study and research has been done on the development of muscle by this method and an abundance of literature is available.

Isometric contraction has been more recently developed and only in the last half of the 20th century has research definitely established its effectiveness. The first studies concerning isometric contraction were done at Springfield College by Elbel, Grunberg, Labree, and Hughes in 1928. Their findings indicated that static contraction exercises could improve strength and posture.[51] It was not until 1953 that any further investigations were reported regarding isometric contraction. The first of many recent studies was by Hettinger and Muller, two German physiologists, who reported that six second static contractions at about

two-thirds maximum strength once a day would develop strength at its highest possible rate.[52] Not all of the research since has supported the findings of the above-mentioned study in their entirety. This method puts more emphasis on the development tension than on the overload principle; however, it may be said that development of tension and overload are very similar.

Available literature revealed conflicting opinions and findings as to which method is more effective in developing strength. The majority of the studies reveal very little significant difference between the two methods. Since this study is not an attempt to prove the value of one method over the other, no further discussion is necessary.

Kozik in his book says that Zatopek, the marathon runner, used daily breath-holding practice in his training routine. The main reason expressed for this was to "train his will" but no study was made as such.[53]

Sward found that daily breath-holding practice over a training period of three months would increase all-out exertion and running endurance. This increase was due in part to an increase in will power, but the results indicated that improvement in the ability to withstand carbon dioxide accumulation was a more significant factor.[54] Other literature on breath-holding discuss it as being useful in the measurement of endurance and physical fitness or that it will improve as a result of practice. No other literature was found using breath-holding as a means of developing endurance.

The phenomenon of rapid recovery from fatigue or the postponement of fatigue is very complex. It is known that the development of

endurance, especially muscular endurance, greatly parallels the development of strength. This is due largely to the number of tiny functioning capillaries (arterioles) in the working muscles, which includes the heart and vascular muscles. Long ago it was demonstrated that the sedentary person has many nonfunctioning capillaries but when such a person engages in an activity program, these nonfunctioning capillaries gradually begin to function. The development of endurance also requires increased efficiency of the lungs. Through training, a 20% increase in the surface area of the lungs is possible due to the development of "partitions" in the lungs. This increases the amount of oxygen that may be absorbed from the air, and the amount of carbon dioxide that may be expelled.[55] Changes in the chemical make-up of the blood, mainly an increase in hemoglobin, also takes place which permits the blood to carry a larger volume of gas.

Muscle tonus, like endurance, is closely related to strength. The only known means by which proper muscle tonus can be maintained is through exercise. In a study at Springfield College by Hughes, it was found that static contractions would improve posture because of improved tonus of the posture muscles. Although tonus may be produced electrically, an optimum amount of exercise is a very necessary agent in stepping up muscle tonus. In so doing, one must be careful to exercise all muscles equally so as to produce tonic balance.[56]

CHAPTER III

PROCEDURE

Source of Data

This study dealt with the changes in Physical Fitness as a result of a selected battery of isometric contraction, isotonic contraction, and breath-holding exercises after a ten-week training period.

The subjects participating in the study were volunteers; the majority were members of the Brookings Junior Chamber of Commerce. Other subjects participating were volunteers from the faculty at South Dakota State College. A total of 26 subjects took part in the initial test. Occupations and professions of the subjects included teachers, sales clerks, bank employees, engineers, salesmen, and businessmen of the community.

At the time of the final test only 16 subjects returned to be tested. The results of two subjects were not included because of their failure to perform what the author judged to be a sufficient number of exercise bouts. All of the subjects were contacted to return for the final test. Reasons for not returning for the final test included: illness at the time of the final test (1), lack of time in which to take the test (2), injury during the period of training, but not as a result of the exercises (2), temporary incapacitation--bursitus and illness (2), failure to do the exercises (3). This made a total of 10 not retested.

Testing Procedure

The subjects were recruited at a meeting of the Junior Chamber of Commerce, Brookings, South Dakota, at which time the author spoke briefly on the need for and the value of physical fitness; he also described and demonstrated the exercises. The names of those who were interested were taken and times arranged as to when to report for the initial test. Other subjects were recruited on the campus by personal contact.

All testing was completed over a period of two consecutive afternoons and evenings. The test battery took approximately 45 minutes to complete. An attempt was made to give the test battery to the subjects in groups of three or four. The subjects were asked to do the best they reasonably could on the test items, and no attempt was made to motivate the subjects while taking the test.

The items in the test battery and their order are as follows: age to the nearest full year, normal sitting pulse for one minute, waist measurement to the nearest one-fourth inch, push-up test, grip test -- right and left, vital capacity, leg lift test, back lift test, weight to nearest one-fourth pound, height to the nearest one-half inch, pull-up test, and the Harvard Step Test. The test battery was administered by the author and a group of assistants, all of whom were physical education graduate students and trained in the administration of these items. The procedures and directions for administering each of the above items may be found in Appendix A.

Training

Each subject was given a copy of the battery of exercises, including a calendar diary on which to record each time that the battery of exercises was completed and verbal instructions on its use. The following is the complete contents of the booklet:

EXERCISE BRIEFS (Complete exercises inside) (Cover)

1. Breath holding
2. Neck exercises: A, B, C, D
3. Chest exercise
4. Upper back exercise
5. Shoulder exercises: A, B (right and left)
6. Upper arm exercises: A, B, C, D
7. Fore-arm exercises: A, B
8. Lower back exercise
9. Abdomen exercises: A, B
10. Upper leg exercises: A, B, C
11. Lower leg exercises: A, B
12. Buttock exercise
13. Breath holding

A Battery of Static, Isometric, and Isotonic Contractions and Breath Holding Exercises to Improve Physical Fitness (Page 1)

1. Sitting or standing position: Take a deep breath...hold it as long as possible.

2. Neck group
   Sitting or standing position:
   A. Interlock hands behind head. Pull head back. Prevent this backward pull with the arms and hands. Pull back as hard as possible for 6 seconds.

B. Interlock hands across the forehead. Pull head forward. Prevent this forward pull with the arms and hands. Pull forward as hard as possible for 6 seconds.

C. Place right hand on right side of head above, and in front of, the ear. Pull head to the right. Prevent the pull with the arm. Pull as hard as possible for 6 seconds.
D. Repeat C using left hand on left side of head.

3. Chest
Sitting or standing position:
Lift arms to shoulder height, flex elbows. Place palms together in front of chest, fingers up and interlocked. Push as hard as possible for 6 seconds.

4. Upper Back (Page 2)
Standing position:
Place hands on waist below lower ribs: place thumbs behind and fingers in front. Try to touch your elbows behind you. Push as hard as possible for 6 seconds.

5. Shoulders
Sitting or standing position:
A. Flex right elbow and lift to shoulder height. Place palm of hand across the front of left shoulder. Put left arm under the right arm and grasp the right elbow. Lift the right arm. Prevent the lift with the left arm. Lift as hard as possible for 6 seconds.
B. Repeat for left shoulder.

6. Upper arms
Sitting or standing position:
A. With arms at sides, flex right elbow to form approximately a 105 degree angle. Place left hand over the right hand and clasp hands. Flex the right elbow. Prevent this motion with the left arm. Apply as much pressure as possible for 6 seconds.
B. Repeat A for left arm.
C. Same position as in A. Allow the right arm to slowly overcome the force of the left arm. Repeat 10 times.
D. Repeat C for left arm.

7. Fore-arms (Page 3)
Sitting or standing position:
A. Arms at sides, flex elbows to approximately 110 degrees. Alternately clench and release fists at the rate of 2 per second. (30 repetitions)
B. Same position as A - Clench fists as hard as possible. Continue for 6 seconds.

8. Lower back
Standing position:
Place palms on buttocks, fingers down, approximately 4 inches apart. Bend over backward, resist the movement with the arms. Pull over backward as hard as possible for 6 seconds.

9. Abdomen
Normal relaxed standing position:
A. Tighten abdomen in normal position as hard as possible. Continue for 6 seconds.
B. Same position - Draw abdomen in as hard as possible. Try to touch the spinal column with the abdomen. Continue for 6 seconds.

10. Upper legs (Page 4)
Standing position:
A. Stand on right leg, lift left leg, and flex knee. Clasp hands across shin about half way down. Pull leg down and straighten knee joint. Resist this motion with hands and arms. Pull as hard as possible for 6 seconds.
B. Repeat for left leg.
C. Stand flat-footed, knee joint flexed at 150 degree angle, drop to 130 degrees. Repeat this up and down movement within this range. 30 repetitions at rate of 2 per second.

11. Lower legs
Standing position:
A. Stand in doorway with legs straight, arms overhead with hands touching top of doorway. Raise to tip toes and down. Resist this movement by pushing hard with hands. 30 repetitions at rate of 2 per second.
B. Lift as high as possible with toes. Resist this, by pushing with hands. Continue for 6 seconds.

12. Buttocks
Standing normal position:
Tighten muscles of upper legs; be sure buttocks muscles are tight. Tighten as hard as possible for 6 seconds.

13. Sitting or standing position:
Take a deep breath. Hold as long as possible.

EXERCISE DIARY (Back cover)

Mon.	Tues.	Wed.	Thurs.	Fri.	Sat.	Sun.
2/19	2/20	2/21	2/22	2/23	2/24	
2/26	2/27	2/28	3/1	3/2	3/3	
3/5	3/6	3/7	3/8	3/9	3/10	
3/12	3/13	3/14	3/15	3/16	3/17	
3/19	3/20	3/21	3/22	3/23	3/24	
3/26	3/27	3/28	3/29	3/30	3/31	
4/2	4/3	4/4	4/5	4/6	4/7	
4/9	4/10	4/11	4/12	4/13	4/14	
4/16	4/17	4/18	4/19	4/20	4/21	
4/23	4/24	4/25	4/26	4/27	4/28	
Final Tests 4/30	5/1					

If for some reason you miss a day it can be made up on Sunday. (Then fill in end box)

Each day after completing exercises mark an X through the correct box.

Figures 1, 2, 3, and 4 show subjects performing exercises from the battery.

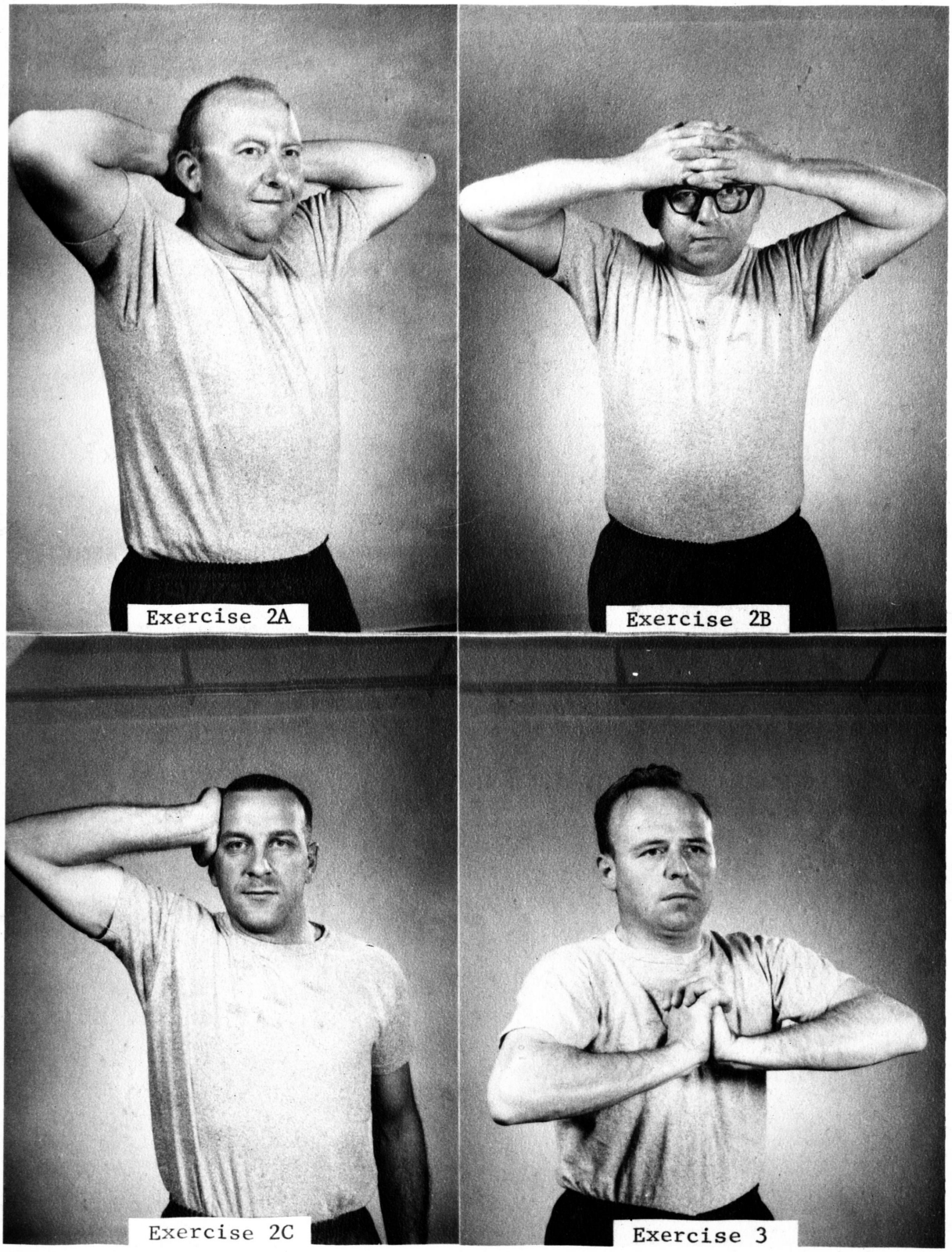

Figure 1 Exercises 2A, 2B, 2C, and 3

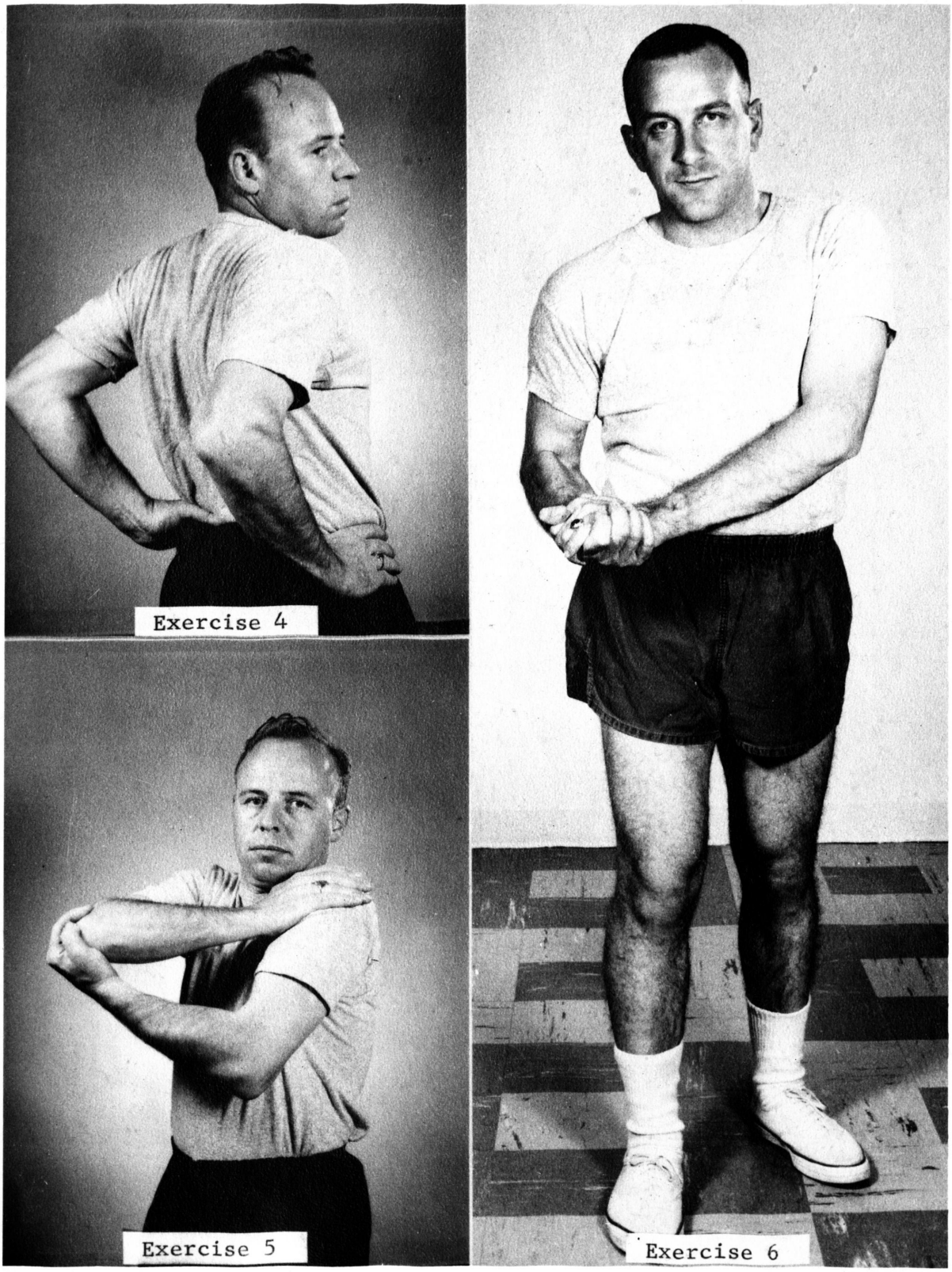

Figure 2 Exercises 4, 5, and 6

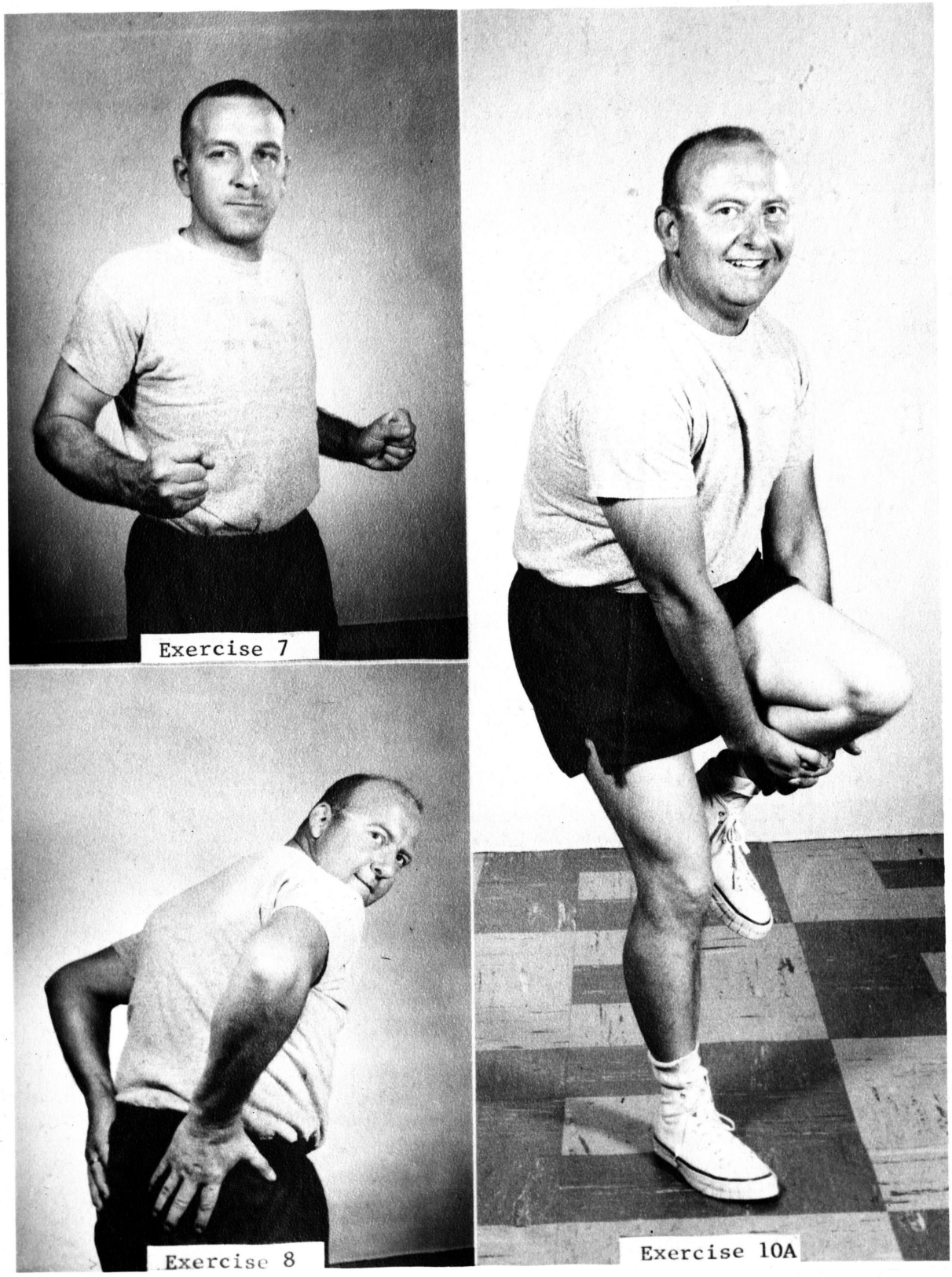

Figure 3 Exercises 7, 8, and 10A

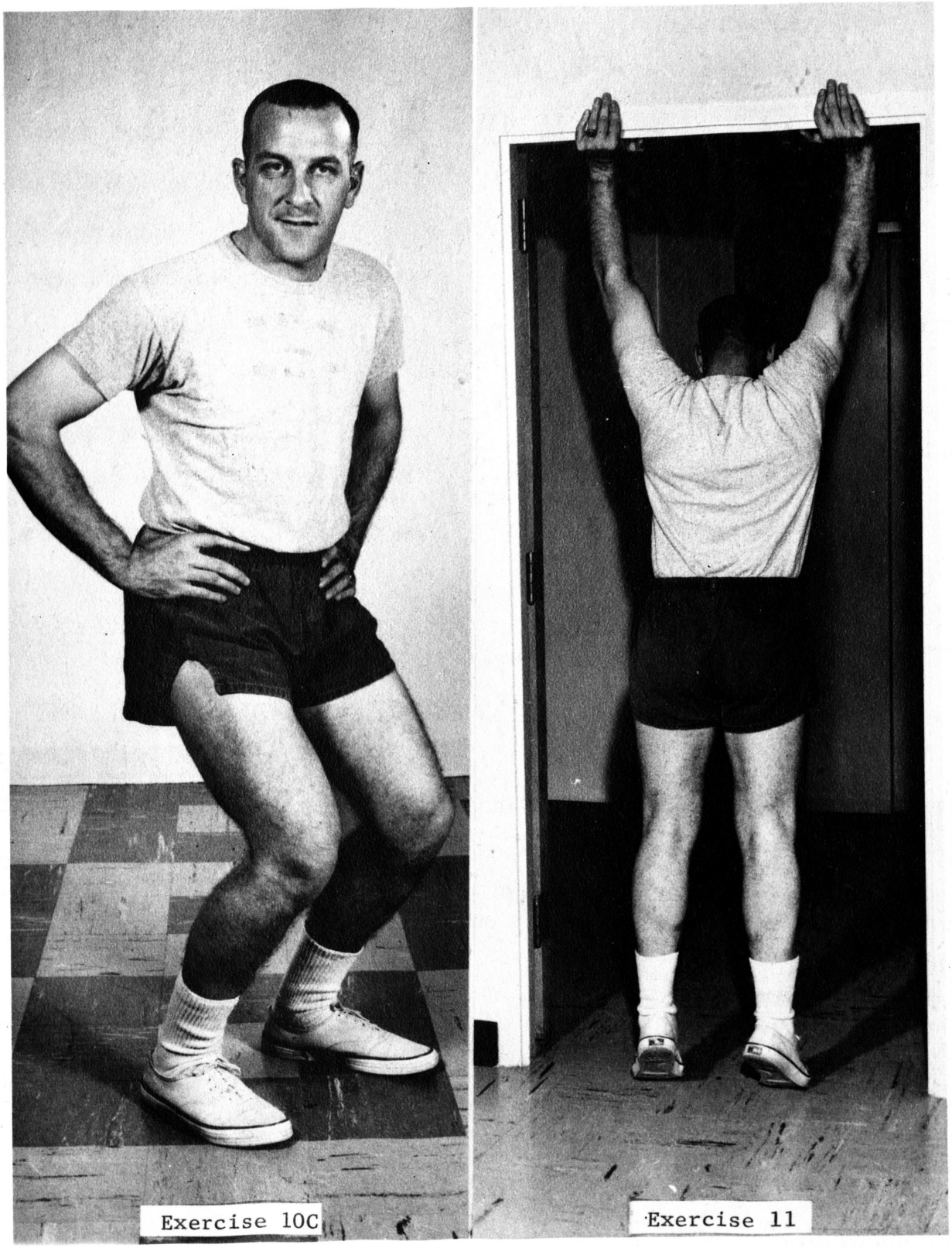

Figure 4 Exercises 10C and 11

A letter containing the results of his test was sent to each subject shortly after the completion of the initial test. It also contained instructions to follow in doing the exercises.

The training period lasted ten weeks with the exercises being done once each day, six days a week. During the ten-week period the author made no attempt to motivate the subjects to complete the program.

Toward the end of the ten-week period, another letter was sent to each subject informing him when to report for the final test. An attempt was made to schedule the same group at the same time; however, this was not successful, to any great degree, due to many subject conflicts and dropouts.

The Test Battery

An accepted measure of physical fitness is very difficult to obtain. One of the main reasons for this is the lack of a concise, generally accepted definition of physical fitness. Another difficulty is a lack of understanding of the interrelationship between the components of fitness.[57]

The items used in the test battery were chosen by the author according to those that best fit the following criteria:

1. Is it a measure of some aspect of physical fitness pertinent to the study?

2. Is it a feasible item in regard to administration and economy of time, keeping in mind that the subjects are volunteers and must take time from their busy schedules?

3. Is it a safe item, that is, can adult subjects safely perform the item?

4. Is the necessary equipment to administer the item available?

5. Has it been used in other tests and test batteries?

Normal sitting pulse rate was used as an indication of general physical fitness. Various sources mention it as useful in obtaining this measure.[58,59,60,61] However, its use as such has been questioned on the grounds that it is easily influenced by outside factors, such as emotional and nervous state, exercise or anticipation of exercise, loss of sleep, respiration, metabolism, season and climate, and temperature changes.[62,63]

The waist, weight, height, and age measurements were taken to determine what effects the exercise program would have on these measurements and/or for general information which may be useful later in the study.

Pull-ups (chins) and floor push-ups were administered as measures of muscular strength, as well as of muscular endurance, of the upper body.[64,65,66,67] Push-ups have been used in several test batteries including the Navy Standard Physical Fitness Test, the Army Physical Efficiency Test, the Army Specialized Training Program Physical Fitness Test, and the AAHPER Youth Fitness Test.

Pull-ups have also been used in several test batteries. The list includes the Navy Standard Physical Fitness Test, the Army Physical Efficiency Test, the United States Air Force Motor Fitness Test, the Oregon Motor Fitness Test, the Indiana Motor Fitness Test, the Roger's PFI Test, and the United States Office of Education Physical Fitness Test.

The grip test, leg and back lift tests are measures of the strength of those muscles.[68,69] These items have been used in the Roger's PFI Test and its modifications, and as individual strength test items in numerous studies.

Vital capacity (lung capacity) was used as a measure of respiratory condition. It has been used in the Roger's PFI Test, certain strength tests (mainly variations of the Rogers PFI) and has been included in various studies of strength and endurance.[70]

The Harvard Step Test is a cardiovascular test, but it also includes elements of muscular endurance of the legs and general endurance. It has been used to differentiate between gradations of physical condition.[71] Brouha and associates, the developers of the test, called it a measure of "the general capacity of the body to adapt itself to hard work and to recover from what it has done."[72]

CHAPTER IV

TREATMENT AND ANALYSIS OF DATA

The purpose of this study was to investigate the changes in the physical fitness of adult men as a result of a self-administered battery of isometric contraction, isotonic contraction, and breath-holding exercises. The difference between the means of the individual test items, as shown by the initial and final test results, was used to determine if any change or changes took place.

Since this study dealt with only an experimental group, the experimental design employed was the "single group" method. In using the "single group" method, a procedure called the "difference method" was followed to find the significance of the difference between the means. The use of the "difference method" is permissible and often preferred when the group is small.

In computing the $\underline{t}$ value, the following formulas were used:[73]

$$M_D = \frac{\Sigma D}{N}$$

$$SD_D = \sqrt{\frac{\Sigma x^2}{(N-1)}}$$

$$SE_{M_D} = \frac{SD}{\sqrt{N}}$$

$$\underline{t} = \frac{M_D - 0}{SE_{M_D}}$$

Table D in Garrett was used in determining the significance of the results.[74] The degrees of freedom used were (N-1).

The t value at the five percent level of confidence was accepted for this study, and the null hypothesis was applied to each item. A total of 14 subjects completed the study which allowed 13 degrees of freedom. The t value for 13 degrees of freedom at the five percent level was 2.65. Table I shows the statistical analysis of data obtained from the initial and final test battery.

Appendix B contains the raw scores from the initial and final test battery for each subject, the group mean of each item, and the number of exercise bouts performed.

Table I. Difference (Final and Initial) Between the Means, Standard Error of the Mean Differences, t values, and the Levels of Significance Computed from the Results of the Test Battery

Test Items	M_1 Final	M_2 Initial	Diff. (M_1-M_2)	SE_{M_D}	t	Level
Pull-ups	6.6785	5.0357	1.6428	.2310	7.0995	.01
Push-ups	21.6429	18.3571	3.2858	.8671	3.7942	.01
Leg Lift	924.2857	791.4285	132.8572	47.7272	2.7837	.02
Back Lift	378.5714	332.1428	46.4286	8.0250	5.7856	.01
Right Grip	116.9285	111.6428	5.2857	3.7303	1.4181	None
Left Grip	107.7142	109.5000	-1.7858	3.3841	- .5289	None
Vital Capacity	276.8571	274.5714	2.2857	2.9172	.7849	None
Step Test Index	48.4714	35.4571	13.0143	3.2273	4.0312	.01
Waist Meas.	34.2142	33.9642	.2500	.2080	1.2019	None
Weight	164.642	164.642	0.00	---	---	---
Pulse	79.7142	76.6428	3.0714	2.5537	1.2021	None

A mean improvement of 1.64 pull-ups was shown. Statistically this had a t value of 7.0995 which was significant at the one percent level. The null hypothesis was rejected, and the gain assumed to be real.

In the analysis of the push-ups a mean improvement of 3.29 push-ups was found. The t value for the improvement was 3.7942 and found to be significant at the one percent level. The null hypothesis was rejected, and a true gain was recognized.

The author believed the increase in the preceding two items indicated a gain in strength and muscular endurance of the upper trunk and arm muscles. There was no indication as to which item in the exercise battery was most effective in bringing about the increase.

The leg lift showed a mean increase of 132.86 pounds. This was found to be significant at the two percent level, since the t value was calculated to be 2.7837. The null hypothesis was rejected for this item, and a true gain in leg strength was indicated. Leg strength increased significantly, but there was no indication of which exercise or exercises was responsible for the increase.

A mean increase of 46.43 pounds was found in the back lift. The t value of 5.7856 was found to exceed that which was necessary for the one percent level of significance. Therefore, the null hypothesis was again rejected, and a true gain in back strength was shown. The factors which brought about this change are not indicated by the results.

In analyzing the right grip test results a mean increase of 5.29 pounds was found. This was represented by a t value of 1.4181, which does not meet or exceed the 2.16 necessary for significance at the five percent level. The null hypothesis was accepted for the right grip test.

The left grip test results showed a mean decrease of 1.79 pounds. The t value for this decrease was -.5289. Therefore, this loss was not significant, and the null hypothesis was also accepted for the left grip test.

The lack of a significant increase in right grip and a decrease in left grip indicated that the exercises for the development of grip strength was ineffective.

Vital capacity showed a mean increase of 2.29 cubic inches. The calculated t value of .7849 was not significant, and the null hypothesis was accepted.

Calculations on the Harvard Step Test results showed a mean gain of 13.01 points on the indices. The t value of 4.0312 was high enough to show significance at the one percent level. The null hypothesis was rejected for this item.

The significant gain in the Harvard Step Test Index indicated an improvement in cardiovascular condition and a gain in endurance and strength. This, in the opinion of the author, was a good indication of improved physical fitness. The results of the study did not indicate which exercise or exercises were most responsible for this gain.

A mean gain of .25 inch was shown in the waist measurement. However, the t value of 1.2019 was too low to be significant. The null hypothesis was accepted for the waist measurement.

No change in the mean weight resulted, and the null hypothesis was accepted.

The mean pulse rate increased 3.07 beats per minute. Since the null hypothesis was accepted, the t value of 1.2021 was not large enough to be significant.

In analyzing the "willingness to participate" the author found a gross drop-out rate of 46 percent. However, 31 percent of these had acceptable reasons for dropping out. A total of 15 percent were considered "drop-outs" for their failure to perform the exercises. The number of exercise bouts completed by each subject ranged from 62 to 27, with a mean of 47.79.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study investigated the changes in adult physical fitness resulting from a self-administered battery of selected isometric contraction, isotonic contraction, and breath-holding exercises.

The subjects were adult men from the Brookings Junior Chamber of Commerce and South Dakota State College faculty. Twenty-six subjects were administered the initial test, and 14 completed the program. Of the 12 drop-outs, seven were excused for various reasons.

The subjects trained for a period of 10 weeks, six days each week, on a selected battery of isometric contraction, isotonic contraction, and breath-holding exercises. These exercises were designed to develop strength and endurance of the principle muscles of the body, which includes the lower leg, upper leg, buttocks, abdominal, lower back, upper back, chest, shoulders, neck, upper arm, and lower arm muscles, and to improve general physical endurance. The exercises were administered by the subjects themselves, and no attempts to motivate the subjects to complete the exercise program were made.

A test battery was administered to the subjects at the beginning of the training period and again after the completion of the training period. The test battery included age, normal sitting pulse, waist measurement, push-up test, right and left grip test, vital capacity, leg lift test, back lift test, weight, pull-up test, and the Harvard Step Test.

The data from the individual test battery items were recorded. The difference between the means was used to determine what changes in physical fitness took place.

Conclusions

The following conclusions have been drawn from the data obtained from this study:

1. The strength and endurance of the upper trunk and arm muscles was increased significantly.

2. A significant gain in leg strength was obtained.

3. Back strength increased significantly.

4. A gain in right grip strength and a loss in left grip strength was shown; however, the changes were too small to be significant. Three possible explanations for this lack of significant change, all of which need further research and study, are presented by the author: (1) since the fatigue felt by the performer is brief and slight, it may be possible to overwork the muscles, and thus the muscle energy is used to recover from fatigue rather than to build muscle; (2) a continuing lack of normal hand exercise during the "winter" season of the year; (3) the lower arm muscles are relatively well-developed from normal exercise, and hence the effects of supplementary exercise would be less.

5. An increase was shown in vital capacity, but again no significance was shown. This, in the author's opinion, indicated that vital capacity is related to body size and not physical fitness, or it cannot be developed through exercise of this type, or that its development is counteracted by other factors, such as increased muscle tone of the

abdominal muscles.

6. The Harvard Step Test showed a significant improvement in the indices score.

7. An insignificant gain in waist measurement was shown. In the opinion of the author, this indicated that the exercises were ineffective, or that the loss of adipose tissue from the abdominal muscles was counteracted by the development of muscle tissue.

8. No change in weight was indicated; the two means showed no difference. The author believed this to be due to the replacement of adipose tissue with muscle tissue.

9. Normal sitting pulse increased, but the increase was not significant. The author offers three possible explanations for this increase: (1) some outside factor, such as anticipation of strenuous exercise, may have influenced the rate, (2) a change in the season of the year between the initial and final test, (3) there was no improvement in physical fitness.

10. An indication of an increase of height was found. This the author believed to be due to improved posture which resulted from greater strength and tonus of the neck, shoulder, and back muscles.

11. In analysis of the complete data, an improvement in physical fitness was indicated.

12. The exercise battery was 85 percent effective in regard to willingness to complete the program.

Recommendations

1. That similar studies be made with a larger group and that a control group be used.

2. That in further studies of this nature careful, precise measurements be taken of height to determine what effects exercise has on height due to improved posture.

3. That further studies be made using skinfold calipers to measure adipose tissue on certain areas of the body to determine the effects of exercise of this type on adipose tissue.

4. That a short, but complete, physical fitness test for adults be devised and norms formulated for the test.

5. That further study on the relationship of pulse rate and vital capacity to physical fitness be made.

6. That through further study individual analysis of each item in the exercise battery be made to determine its effectiveness and the factors involved in its effectiveness.

7. That further studies be made to determine the effectiveness of the exercise in relation to age.

8. That a similar study be made to determine the effectiveness of the exercises in relation to how often they are performed.

9. That a battery of isometric contraction, isotonic contraction, and breath-holding exercises be practiced by adults to develop and maintain their physical fitness.

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APPENDIX A

Description, Administration, and Scoring of the Test Battery

Age

The age of each subject was taken to the nearest full year.

Normal Sitting Pulse

Each subject was asked to sit quietly for a minimum of five minutes. If a subject had smoked within the last 15 minutes, he was asked to wait 15 minutes before starting the pulse rate test. After sitting quietly for five minutes a pulse count was taken at the wrist for one minute and recorded.

Waist Measurement

A Gulick tape was used to take the waist measurement. The measurement was taken 1/4 to 1/2 inch above the pelvic bone with the abdomen and trunk in a normal and relaxed position. This measurement was recorded to the nearest 1/4 inch.

Push-up Test

The directions for administering this item were taken from the Navy Standard Physical Fitness Test.

a. Starting position -- The subject laid face downward, with the hands on the floor beside the shoulders, fingers pointed forward, and the toes resting on the floor.

b. Movement -- The subject performed the following movement as many times as reasonably possible: (1) raised the body from the floor by straightening the arms so the body was straight from shoulders to heels, with the weight resting on the hands and toes, (2) lowered the

body by bending the elbows until the chest touched the floor.

c. Scoring -- One point was given every time the subject's arms were completely straightened and the exercise correctly performed. No scores were given if (1) the arms were bent at the top of the movement, (2) any part of the body other than hands, toes, and chest area touched the floor after the test was begun, (3) the shoulders were pushed up first while the hips remained stationary near the floor, or (4) the hips were raised upward and backward before the shoulders were pushed up. No pauses were allowed after beginning the movement.

Grip Test - right and left

This item was taken from the Roger's PFI, as were the directions for its administration. A grip dynamometer (manuometer) was used to measure the grip strength of the right and left hands.

a. Starting position -- The grip dynamometer was placed in the subject's hand with the dial toward the palm to prevent the fingers from stopping the dial. The convex edge of the dynamometer was between the first and second joints of the fingers and rounded edge was against the base of the hand. The subjects took any desired standing position, but with the elbow on the side being tested bent at approximately 90 degrees.

b. Movement -- The subject's arm swung in a downward arc as he squeezed the dynamometer. While the test was being administered, the hands were not allowed to touch the body, or any object.

c. Scoring -- The dial was read and recorded to the nearest pound. Three trials were allowed for each hand, and the highest of the three trials was used. The right hand was tested first, the left hand

second.

Vital Capacity

The administration of this item, and the item itself, was taken from the Roger's PFI. A wet spirometer was used to obtain the measure. Individual mouth pieces were used once and then destroyed.

a. Starting position -- The subject took any desired erect position in front of the spirometer.

b. Movement -- The subject took one or two deep breaths before the test. After deepest possible inhalation, he slowly and steadily exhaled into the mouth piece, while bending forward, until all the air within his control was expelled. Care was taken to see that there was no leakage of air.

c. Scoring -- At the instant the last bit of air was expelled from the lungs, the gauge on the spirometer was read and recorded in cubic inches. Three trials were allowed, and the best score was used.

Leg Lift Test

This item and the directions for its use came from the Roger's PFI. A back and leg dynamometer was used to measure the leg strength; the belt method was used in the leg lift.

a. Starting position -- The subject stood on the bench with his feet in position over the marks on the bench. While standing relaxed in this position he held the bar with his hands together and palms down at the junction of the thighs and trunk. The belt loop was slipped over one end of the bar and looped around his back. The free end of the belt was looped around the other end of the bar and tucked under. Next,

the subject flexed his knees to an angle of 115 to 124 degrees, and the chain was hooked to the belt.

b. Movement -- While keeping his back straight, chest and head up, the subject attempted to straighten his legs. No jerking or rocking was allowed.

c. Scoring -- Three trials, with adjustments if necessary, were allowed and recorded to the nearest 10 pounds. The best score of the three was used.

Back Lift Test

This item and its instructions for administration were also taken from the Roger's PFI.

The same instrument that was used in the Leg Lift Test was used for the Back Lift, but no belt was used.

a. Starting position -- The subject took an erect position on the bench with his feet covering the marks. His fingers were extended downward in front of his thighs. The chain was hooked to the bar so that the bar was just below the subject's finger tips. The subject then leaned over, keeping his knees straight, and grasped the bar with a hand over and hand under grip.

b. Movement -- With head up and eyes straight ahead the subject attempted to straighten his back. The knees remained straight, and no lifting from the toes was permitted.

c. Scoring -- Three trials, with adjustments if necessary, were allowed and recorded to the nearest 10 pounds. The best of the three trials was used.

Weight

The subjects, dressed in gym uniforms and in stocking feet, were weighed. Their weight was recorded to the nearest 1/4 pound.

Height

The subjects, dressed in gym uniforms and in stocking feet, were measured. Their height was recorded to the nearest 1/2 inch.

Pull-up Test

The directions for the administration of this item were taken from the Navy Standard Physical Fitness Test. A chinning bar at a height of 92 inches was used.

a. Starting position -- The subject hung from the bar, using a forward grasp in which the thumbs and palms faced away from the body with the elbows straight.

b. Movement -- The subject chinned himself as many times as reasonably possible in the following manner: (1) pull the body up until the chin is above the bar, (2) lower the body until elbows are straight.

c. Scoring -- Each time the subject pulled his chin above the bar, he was given credit for one pull-up. Half-counts, up to a maximum of four, were allowed if the pull-up was not complete. The number of pull-ups was recorded.

Harvard Step Test

A 20-inch bench, a metronome, and a stop watch were used to administer this test item.

a. Starting position -- The subject stood before the bench ready to begin stepping up onto the bench and down again. The metronome was

set at 120 beats (30 steps) per minute. The subjects were instructed to continue as long as they reasonably could up to a maximum of 5 minutes.

b. Movement -- The subjects stepped onto the bench and down again at the rate of 30 steps per minute, keeping time with the metronome. One of the test administrators intermittently called, "Up, two, three, four," in cadence with the metronome. The subjects stepped completely up on the bench and remained in an erect position while performing the test. After the first minute had lapsed, the time lapse was given every 30 seconds.

c. Scoring -- When a subject stopped stepping, the length of time he stepped was recorded. After 1, 2, and 3 minutes, a 30-second pulse rate count was taken and recorded. Each subject's Physical Efficiency Index (PEI) was calculated according to the following formula:

$$PEI = \frac{\text{Duration of Exercise in Seconds X 100}}{\text{2 X Sum of Pulse Counts in Recovery}}$$

APPENDIX B

Table I. Raw Scores from Initial and Final Tests

Subject		Pull-ups	Push-ups	Leg lift	Back lift	Grip right	Grip left	Vital cap.	Step test	Waist	Weight	Pulse	No. of Bouts	Age
E.D.	I	3	17	1000	330	124	118	246	23.3	36	161.50	71		
	F	4.5	17	1080	390	153	120	248	31.4	36.50	163.75	77	27	37
W.H.	I	6	17	850	310	90	99	250	30.2	34.50	157.50	66		
	F	7	23	840	310	95	84	254	70.4	34	154.50	83	27	33
H.B.	I	6	16	740	310	92	94	260	25.1	35	175.50	74		
	F	6	17	1090	370	117	90	270	26.7	34.75	173.50	85	32	35
J.O.	I	10	23	760	430	126	126	254	53.4	30.25	152.50	72		
	F	12	25	1150	450	133	123	260	67.9	31.25	150.50	80	39	28
T.P.	I	7	21	1380	460	140	154	322	37.9	32.75	174.50	80		
	F	9.5	25	1060	560	142	150	340	49.3	32.75	172.25	71	50	38
H.W.	I	6	26	950	400	142	124	350	45.7	30.25	158.50	91		
	F	8	32	1140	470	138	136	344	56.0	31.0	165.50	84	51	28
S.S.	I	1.5	16	710	270	109	90	212	20.1	37.25	166	89		
	F	2.5	16	810	340	106	91	228	30.2	38.25	167	86	56	34
B.D.	I	4	16	800	400	150	145	323	36.0	38.50	203.50	77		
	F	6	18	1110	430	144	126	312	39.5	37.75	200.50	84	57	31
M.S.	I	4.5	22	400	270	82	101	270	44.5	34.25	152	70		
	F	7	25	740	320	106	104	270	79.8	33.75	152.25	72	58	38
K.B.	I	6	20	610	280	90	96	237	44.8	29.25	136.50	85		
	F	6.5	21	650	320	102	89	230	39.0	29.50	137	95	59	25
F.D.	I	0	8	550	200	93	69	252	27.4	37.25	185.50	83		
	F	2.5	12	650	230	79	90	240	36.6	38.75	192	82	60	27
E.F.	I	5	20	630	250	78	77	262	43.5	30.25	138	78		
	F	6	19	560	270	87	87	274	60.6	29.75	135.75	62	60	36
R.L.	I	4	18	1010	400	122	123	252	26.3	37.25	176.50	74		
	F	7	28	1260	410	136	128	266	37.5	38.25	175.25	76	61	27
B.B.	I	7.5	17	690	340	125	117	354	38.2	32.75	168	63		
	F	9	25	800	430	99	90	340	53.7	32.75	165.25	79	62	27
Initial Mean		5.04	18.36	791.43	332.14	111.64	109.50	274.57	35.46	33.96	164.64	76.64	Mean	Mean
Final Mean		6.68	21.64	924.29	378.57	116.93	107.71	276.86	48.47	34.21	164.64	79.71	47.79	31.71

I = Initial Test F = Final Test