AN ABSTRACT OF THE THESIS OF

John D. LeMarr for the degree of Doctor of Philosophy in Education presented on May 21, 1987.

Title: Muscular Strength of Active Men: 25 to 64 Years of Age

Redacted for privacy

Abstract approved: ______________________

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This study measured muscular strength and perceived exertion of active men, 25 to 64 years old. The subjects were 80 members of a large YMCA, with 20 active men chosen from each of the following age groups: 25-34, 35-44, 45-54, and 55-64. Measurement of strength consisted of assessing the maximum weight that could be lifted, through a complete range of motion, 10 times (10-RM) for each of six strength exercises; leg press, leg extension, leg curl, decline press, seated rowing, and behind neck pulldown. Upon completion of the last strength test, each subject indicated a rating of perceived exertion (RPE) from the Borg scale.

Total Body Strength (TS) represented the sum of the weight lifted in each of the six strength tests. To adjust for body size, TS was divided by the subject's Body Mass

Index (BMI) and this ratio was termed Relative Strength (RS). The RS of the 55-64 age group was approximately 72 per cent of the value recorded by the 25-34 age group. This difference was significant ($p = .0000$) and linear ($p = .0000$). The means of the two older age groups were significantly different from the two younger groups, but not from each other. RPE for both the 25-34 and 35-44 age groups was significantly greater ($p = .0072$) than the RPE for either of the two older age groups; however, the difference between the means of any two age groups was less than 1.6, and the correlation between age and RPE was low (-.3139).

It was concluded that (1) RS was less for successively older age groups of active men. The difference between age groups followed a linear trend and by age 60, RS was 72 per cent of the value at age 30. (2) The RPE for the 10-RM strength tests was similar for all age groups.

Muscular Strength of Active Men: 25 to 64 Years of Age

by

John D. LeMarr

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy in Education

Completed May 21, 1987

Commencement June 1988

APPROVED:

Redacted for privacy

Professor of Physical Education in charge of major

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Date thesis is presented May 21, 1987

Typed by researcher for John D. LeMarr

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MUSCULAR STRENGTH OF ACTIVE MEN:25 TO 64 YEARS OF AGE

INTRODUCTION

Due, primarily, to advances in medical science, life expectancy since the turn of the century has increased from 48 to 78 years. As a result, people over 65 represent the fastest growing segment of the United States population.

Health problems resulting from cardiovascular disease, osteoporosis, diabetes, arthritis, cancer, etc. affect 86 percent of the population over 60 (Drummond, 1985). Consequently, rather than enjoying this life extension, some older adults are faced with the possible loss of personal independence, rising economic costs of prolonged health care, and increased fear of the process of dying.

Gerontologists view this potential decline in the "quality of life" with increasing age as a result of physiological, sociological, and psychological factors. There is a growing group of health practitioners that believe this decline may be delayed by lifestyle changes that result in improvement of the functional ability of the aging individual; that is, the ability to function independently with respect to daily social and recreational tasks is paramount to improving the quality of life. A decline in muscular strength is one of the physiological changes reported to occur with aging and results in a decrease in the functional ability of the individual.

Need for the Study

Since 1842, a number of cross sectional studies have reported a difference in muscular strength between age groups (Milne & Maule, 1984). Generally, from 12 to 25 years of age, older age groups are stronger. After 25, strength is less in consecutively older age groups (Ostrow, 1984).

Collectively, the studies on strength and aging may be characterized by the following similarities:

1. Muscular strength was defined as the force generated during a single maximum contraction of the muscle group being tested.

2. The strength of one muscle group was measured and results of this single test were applied to the whole body.

3. The subjects tested had a low level of occupational and spare time activity.

4. Strength was not adjusted for the subject's body size.

5. Unfamiliar testing equipment, procedures, and facilities were used.

6. Little, or no, time was allowed for practice.

Subject attitude and motivation are important factors in physiological response to testing and/or training. This area has not received much attention with respect to older adults. In a review of previous investigations, primarily involving inactive subjects, Ostrow (1984) concluded that older adults tend to overestimate the strenuousness of physical activity and thus, may overestimate the risks associated with participating in physical activity. This may be a negative factor in measuring a physical task.

To summarize, researchers have used testing methods similar to those used for assessing the strength of competitive weight lifters and/or athletes; that is, what is the maximum weight a subject can lift one time.

Statement of the Problem

The purpose of this study was to measure muscular strength and perceived exertion of active men, 25 to 64 years of age. Subsequently, four age groups (25-34, 35-44, 45-54, & 55-64) were compared in terms of strength and perception of effort. Taking into account some of the weaknesses of earlier investigations, this study has the following characteristics:

1. An equal number of active men were selected from each of the following age groups: 25-34, 35-44, 45-54, and 55-64.

2. Each subject completed a spare-time activity survey.

3. Total body strength was calculated as the sum of the weights lifted in six separate strength tests (3 upper body & 3 lower body).

4. Total body strength was adjusted to take into account each subject's height and weight.

5. Familiar surroundings, equipment, and procedures were used.

6. Each subject gave a rating of perceived exertion at the completion of the strength tests.

Analysis of the Data

The following hypotheses were tested:

1. There will be no difference in total body strength, when adjusted for height and weight, between age groups.

2. There will be no difference in the rating of perceived exertion of the strength test between age groups.

In addition, associations between the dependent variables (total body strength and rating of perceived exertion) and the independent variables (age, height, weight, length of time strength training, and frequency of strength workouts) were examined.

Limitations of the Study

The effective measurement of any physiological variable requires the control of many factors. Ostrow (1984) recommended that studies investigating the effects of aging control for previous physical activity, health status, and body size. This study attempted to control these variables as well as using a test protocol, equipment, and facilities that were familiar to all subjects. Consistency of test administration was accomplished by the author performing all orientation and data collecting procedures. However, in any exercise-related experimental condition involving human subjects, there are likely to be factors present that may limit the interpretation of the collected data. In this study, the following factors are considered as limitations:

1. Previous strength training experience. Six exercises comprised the strength test in this study. Each exercise involved a different body movement. Proficiency in performing any movement is skill related and skill is improved through practice; thus, subjects that were not using the weight room or performing a particular exercise may have had lower strength scores due to a lack of skill. Since strength training has achieved popularity recently, data for older subjects are more likely to be affected.

2. Type and intensity of primary activity. Subjects were required to be active to participate in this study, but the type of activity was not specified. Runners may have strong legs; swimmers strong upper bodies; racquetball players overall body strength, ect. Strength scores may have been affected by the type and intensity of activity.

3. Self motivation. Each individual has a personal

limit for the effort he will expend during a given physical task. Motivation may be affected by individual goals, health status, environmental conditions, prior experiences, ect. During the first half of this century, strength training received considerable negative publicity. Until recently, becoming "musclebound" from lifting weights was believed to result in less flexibility and slowness. Blood pressure may increase under certain conditions while lifting weights, a concern for many older individuals. Thus, strength scores may have been affected by motivational factors.

Definitions

Repetitions (reps) - The number of times an exercise is repeated using proper technique and without resting.

Repetition Maximum (RM) - The maximum weight that can be lifted in order to complete a certain number of repetitions; 1-RM = the weight used to complete one repetition; 10-RM = the weight used to complete 10 repetitions.

Set - The completion of one exercise activity; that is, the number of reps performed consecutively.

Strength - The weight used to complete one 10-RM set of an exercise.

Total Body Strength (TBS) - The sum of the weights lifted in the six 10-RM strength tests.

Body Mass Index (BMI) - The weight of the subject in kilograms divided by the subject's height (in meters) squared. BMI = WT/(HT x HT)

Relative Strength (RS) - The total weight lifted per unit of body size. Total Body Strength divided by the Body Mass Index (RS = TBS/BMI).

Isometric (iso = same; metric = measure) - A method of strength training in which muscle tension occurs, but there is no change in the position of the body segments involved. For example, to strengthen the muscles on the back of the upper arms, you may place your palms on the top of a desk or table and push down. No movement of your upper and lower arms occurs, but muscle tension is developed.

Isotonic (iso = same; tonic = tonus) - A widely used form of strength training for which the term, isotonic, is misleading. By definition, isotonic means a constant amount of muscle tension throughout the range of motion of an exercise. Isotonic is used to describe exercises with barbells (free weights) and calisthenics (body weight). In exercises using free weights or body weight, the resistance (barbell, body weight) is constant, but there is considerable variation in muscle tension (tonus) throughout the range of motion of the exercise.

Isokinetic (iso = same; kinetic = speed) - A relatively new method of strength training in which the speed of movement is held constant (electro-mechanically) throughout the range of motion of the exercise, regardless of the muscle tension developed. This equipment differs from traditional equipment in that no weights are lifted, and it is expensive with a basic unit costing $20-30,000. Cybex is the most familiar brand name, although there are several other manufacturers. Due to cost, isokinetic equipment is rarely seen in strength training facilities, but is often used by researchers for testing purposes.

Variable Resistance - In order to overcome weaknesses with isometric, isotonic, and isokinetic training, machines have been developed with cams, levers, hydraulic systems, and other mechanical arrangements that provide a variable resistance throughout the range of motion of an exercise. Nautilus and Universal are the most common brand names. With variable resistance equipment, the resistance (weight) that a muscle must overcome is automatically increased at those points where the muscle is strongest, and automatically decreased where the muscles are weakest.

REVIEW OF LITERATURE

Introduction

The literature on the subject of strength is voluminous. This appears to be a consequence of the many ways in which strength may be defined, developed, and measured. This review will focus on the research related to strength and aging, but will include a brief glimpse at the history, definition, development, and measurement of muscular strength.

A Brief Historical Review of Strength Training

The main principles of strength training have not changed for centuries. Wall paintings, statues, and other artifacts indicate that strength training was practiced 4000 to 5000 years ago. The Greeks were the first to learn the value of training to improve strength (Atha, 1981).

A Greek living in the sixth century, Milo of Crotona, is often credited with inventing progressive resistance exercise. Each day for four years, Milo reportedly lifted and carried a growing calf the length of the stadium at Olympia. As the calf grew, so did Milo's strength. His training method did not catch on with his contemporaries, and it was eventually the Romans who began structured strength training (Stafford, 1978; Todd, 1986).

With the fall of the Roman Empire, the practice of

Christian asceticism spread and strength training disappeared for almost 1000 years. Physical exercise was associated with those individuals training for warfare; however, during this period, the writings of the Greeks and Romans preserved the records and explanations of strength training.

In the sixteenth century there was a gradual increase in physical activities and occasional notices of "feats of strength" began to reappear. By the nineteeth century, physical education was a formal part of European schooling and gymnasiums for strength training and conditioning existed that would rival modern facilities (Todd, 1986).

Beginning in 1896, weightlifting was included in the Olympic games. Amateur lifting was gaining in popularity in the United States, and received perhaps its greatest boost when Alan Calvert founded the Milo Barbell Company in 1902. Calvert offered courses and wrote several books in an attempt to teach modern and productive methods of strength training (Stafford, 1978).

Regardless of the resurgence of interest in strength, by World War II the principles of strength training that existed were similar to those of the ancient Greeks; offer a progressive degree of resistance and, when working with heavy barbells, do not lift within 10 percent of maximum (Atha, 1981).

Prior to World War II, most of the information about strength training appeared in literature which was often commercially slanted. While the principles may have been valid, the source of strength training information was largely ignored by the medical profession and physical educators. Following the war, a series of medical experiments were performed to evaluate the use of strength training in rehabilitation. One of the experimenters, Dr. Thomas L. DeLorme, became famous for his use of "progressive resistance exercise" to improve strength. Consequently, the results of these experiments revolutionized the thinking of physicians and physical educators regarding the application of strength training (Todd, 1986).

During the first half of this century, coaches and physical educators believed that strength training would make a person "musclebound". Thus, individuals and athletes were told to avoid weightlifting at all costs. In the eary 50's and 60's a few individuals and teams began to experiment with strength training and demonstrated improved performance. This recent beginning has led to the current explosion of interest in strength training (Pearl & Moran, 1986).

The Definition of Strength

Researchers have been testing strength for more than 150 years, and it is only natural that a variety of speculations evolved in this period. Thus, a certain amount of confusion exists due to the lack of a precise definition of strength (Hunsicker & Greey, 1958).

The word "strength" has at least 12 definitions in the dictionary and many uses in the English language. Muscular strength is best defined as the greatest amount of force that muscles can produce in a single maximal effort (Lamb, 1978).

Strength is the ability of a muscle to produce force. It is measured by the amount of weight one can lift in a single repetition; for example, the most weight an individual can bench press (Pearl & Moran, 1986).

The conduct and evaluation of muscle strength tests are hampered by lack of standardization and by ambiguity in terminology, experimental procedure, and statistical treatment of the data (Kroemer & Howard, 1970). Kroemer and Howard evaluated 50 randomly selected studies on human strength (excluding studies on grip strength) that had been published between 1935 and 1968. In reviewing these reports, the authors concluded that only 5 out of 50 clearly stated how the subjects generated force and what index was selected to represent the subject's performance.

Based on this review, their own experiments, and discussions with other researchers, Kroemer and Howard defined strength as the maximal force muscles can exert isometrically in a single voluntary effort. Dynamic performance measures such as weightlifting, chinning, and the like were said to be measures of an individuals specific work capacity or power, not of one's static strength.

In an extensive review of the strength literature, Atha (1981) summarized the various definitions of strength that have been proposed as follows:

1. Strength is the maximum display of contractile power.

2. Muscular strength is the tension muscles can apply in a single maximum contraction.

3. Strength is the maximum force that can be exerted against an immovable resistance by a single contraction.

4. Strength is the maximum force muscles can exert isometrically in a single voluntary effort.

5. There is no single definition of strength, but as many definitions as there are conditions of measurement.

6. Muscular strength and muscular endurance are one and the same.

Atha's review concluded by defining strength as the ability to develop force against an unyielding resistance in a single contraction of unrestricted duration.

Bosco and Gustafson (1983) acknowledged the general confusion over the definition of strength and proposed that strength be defined as the muscular force utilized in the creation or prevention of movement. This definition implies a dynamic and static measure of strength is possible. The authors defined static (isometric) strength as the tension a single muscle or muscle group develops in a single maximum contraction against an immovable resistance. Dynamic strength was defined as the maximum tension a single muscle or groups of muscles can develop in a single maximum contraction through the full range of motion of the part or parts tested.

Kulig, Andrews, and Hay (1984) cited the definition of strength by Atha (1981) as one of the best proposed; however, they felt his definition was too restrictive to be generally useful in the wide variety of present-day exercise environments. For the purpose of developing human strength curves, they defined the strength of a muscle or homogenous muscle group (i.e., a group of muscles that have neighboring attachment sites, share a functional role, and act simultaneously) as the variable force that this contractile entity exerts on the skeletal system at the attachment site of interest.

Strength, as they defined it, was a variable quantity that may change with time at any particular attachment site and is not associated with one particular state of muscle activity (e.g., rest, isometric contraction, ect.). Thus, the authors concluded that there are as many ways for a muscle group to exhibit strength as there are different exercise environments.

The Development of Muscular Strength

The theory of strength development is based on the overload principle. This principle states that a muscle gains strength by requiring it to exert forces that exceed those that it normally exerts (Kulig, Andrews, & Hay, 1984). The factors that influence the development of strength may be categorized as follows:

1. Population - Strength development will vary according to the age, sex, and body type of the subject.

2. Psychological - Pertains to the degree of subject motivation.

3. Physiological - Muscle fiber type, cross sectional area of the muscle, number of motor units involved, and state of muscle fatigue influence strength development.

4. Geometric - Muscle attachment site, location of the axis of rotation of the joint being worked, muscle's line of pull, and the joint's range of motion.

5. Exercise conditions - Refers to the type of muscular contraction (isometric, isotonic, eccentric, concentric, ect.), speed of contraction, number of involved joints, direction of gravity force relative to the body's orientation, and the many types of external conditions (temperature, personnel, ect.) that may be present.

From the preceeding, it appears that there may be as many conditions for developing strength as there are individuals. The most important property of the strengthening stimulus remains the intensity of the loading on the muscle. The general properties of this stress have been known for at least 2000 years, but the details still remain obscure (Atha, 1981).

Strength development takes three common forms: isotonic, isometric, and isokinetic training. Regardless of the chosen method, Riley (1978) summarizes the seven variables of a strength training program along with his recommendations as follows:

1. Number of repetitions - (between 8 and 12)

2. How much weight - (an amount that causes the subject to reach muscular fatigue (failure) somewhere between 8 and 12 reps)

3. How many sets - (one, properly performed)

4. How much rest between exercises - (move from exercise to exercise without rest)

5. Number of workouts per week - (3, every other day)

6. Order of exrcises - (exercise large muscles first)

7. What exercises should be done - (one for each major muscle group, not to exceed 13-14 per workout)

<u>Strength Development in Older Subjects</u>. Due to the decrease of strength and atrophy of muscle observed in the aging process, a number of studies have examined the degree of strength development possible in older subjects (deVries,

1970; Liemohn, 1975; Moritani & deVries, 1980; Perkins & Kaiser, 1962).

The subjects in these studies ranged in age from 42 to 84 years. Protocols for strength development and measurement varied with the study, but all employed some combination of the preceeding principles of strength training. Strength increased in every case and the general conclusion is that strength may be developed in older subjects, although perhaps not as great as in the young.

Several studies used isometric exercise as a form of training and all used isometric testing procedures. The use of isometrics (tensing one body of muscles against another) with older individuals has been criticized due to the associated increase in systolic blood pressure ("Exercise Programs...", 1984; Shephard, 1984). The rise of blood pressure is a legitimate concern, but the danger is minimal if contractions are held for less than 10 seconds (Shephard, 1984). The longest isometric contraction time in any of the investigations cited in this review was six seconds.

The Measurement of Strength

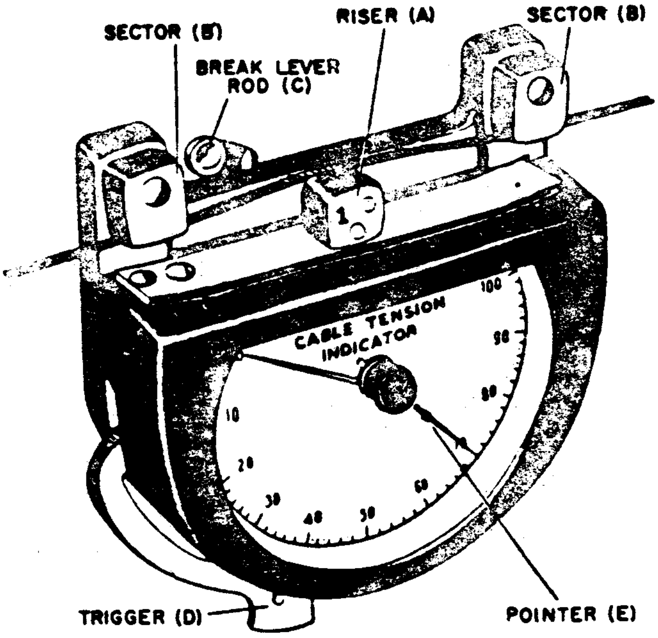
Although man has engaged in feats of strength for several thousand years, the first scientific study to measure human strength occurred in 1699. A French scientist, De La Hire, actually compared the strength of men lifting weights and carrying burdens with that of horses

(Hunsicker & Donnelly, 1955).

Measurements of strength have many uses. Physical educators use strength measurements as classifying devices. Medical workers use strength measurements as indicators of the rate of recovery from debilitating conditions. Strength tests have been used as an aid or requirement for numerous vocations (Hunsicker & Greey, 1958).

The evaluation of muscular strength is important for three principal reasons. First, tests of physical fitness are necessary to assess the need for a given type of training program. Second, tests results may be used to evaluate and revise a given training program. Third, regular testing and retesting provides motivation and establishes the effectiveness or inadequacy of a training program (Lamb, 1978). Estimates of strength can be obtained with isometric, isotonic or isokinetic contractions.

<u>Isometric Measurement</u>. In isometric tests, strength is measured as the peak force or torque developed during a maximal voluntary contraction (deVries, 1966; Sale & Norman, 1982). Of all the methods for measuring isometric strength, probably the most widely used is the cable tension testing method of Clarke. Figure 1 illustrates the cable tensiometer and shows the application of this method in testing elbow flexion strength.



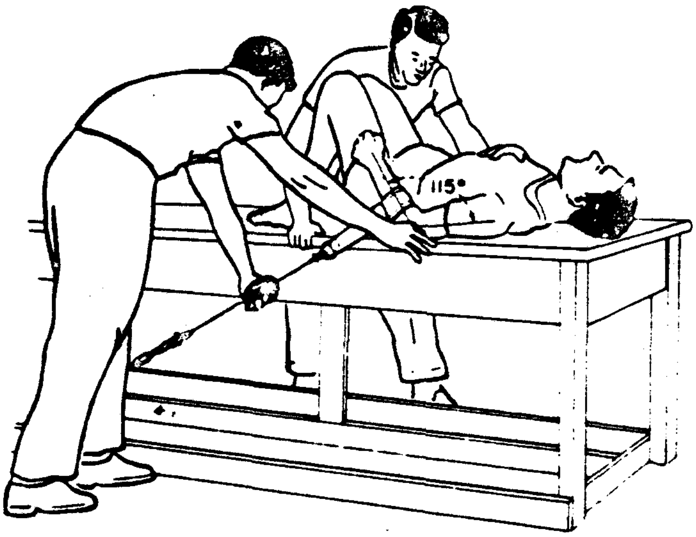


Figure 1. (a) Cable tensiometer - Tension on the cable depresses the riser and the force of muscle contraction is indicated by the pointer. (b) A subject positioned for the measurement of elbow flexion (de Vries, 1966).

In isometric testing, the subject is placed in the correct position for the joint movement to be tested and pulls with a maximal effort on a light cable. Cable tension is taken as the highest reading on the dial of the tensiometer. The cable tensiometer tests are probably the most reliable static strength tests in common use (Bosco & Gustafson, 1983).

Isotonic Measurement. Isotonic strength is usually measured as the maximal weight that can be lifted correctly once in a given movement. This weight is known as the 1-RM (one repetition maximum). The maximal weight that could be lifted correctly three consecutive times without significant rest would be known as the 3-RM (Lamb, 1978). The apparatus used for isotonic tests may consist of free weights (barbells and dumbbells) or weight lifting machines (either off the shelf machines or those specially constructed for testing). Calisthenics are a form of weight lifting. A test involving calisthenics (pushups, chinups, ect.) usually consists of counting the number of repetitions that are performed (Sale & Norman, 1982).

Berger (1962b), in one of his many articles on strength development, describes the 1-RM for the bench press as follows:

> The bench press lift was performed with the subject supine on a bench. A barbell was placed on the chest

with the hands grasping the bar shoulder width apart, palms facing upward. The bar was raised vertically until the arms were fully extended. The 1-RM was determined by increasing the load by 10 pounds after each successful lift until the load became difficult to raise. Then the load was increased 5 pounds until the maximum 1-RM was obtained. Subjects rested two to three minutes between attempts.

Isokinetic Measurement. In recent years, the measurement of muscle force under conditions of constant velocity (isokinetically) have become popular. This popularity is due, in part, to the ability of isokinetic dynamometers to provide information about dynamic muscular contractions. When velocity is not controlled during strength measurements, the changing mechanical advantage of the limb-lever system alters the force applied to the muscles through the range of motion. What is usually measured is the resistance weight and the completed number of repetitions (Osternig, 1986).

Isokinetic exercise is a new dimension in the field of resistive exercise and muscle evaluation. It is made possible by an electro-mechanical device which keeps limb motion at a constant predetermined velocity. Thus, increased muscular output produces increased resistance rather than increased acceleration, as would occur in a gravity-loaded system (free weights, calisthenics) of resistive exercise (Moffroid et al., 1969).

The speed of isokinetic exercise is expressed as angular degrees per second. The speed may vary from 0 to 360 degrees per second. Isometric exercises may be performed on isokinetic dynamometers by setting the speed at 0 degrees per second. Once a velocity has been selected, it remains constant despite any variation in magnitude of the torque (force times distance from the joint axis). Isokinetic dynamometers may be equipped with instrumentation to display and/or record the torque of the muscle group being measured. Only several manufacturers make these devices and they are quite expensive (Lamb, 1978; Sale & Norman, 1982). Figure 2 shows a subject positioned for performing knee extension and flexion on an isokinetic dynamometer.

<u>Specificity of Muscular Tests</u>. One of the early indications that strength training was very specific was reported by Rasch and Morehouse (1957). Subjects trained elbow flexion in a standing position. After six weeks of training, elbow flexion strength had increased considerably in the standing position. Measurements before and after training in an unfamiliar position (supine) revealed only a slight increase in strength. The authors concluded that higher scores in a strength test may be the result of the acquisition of skill.

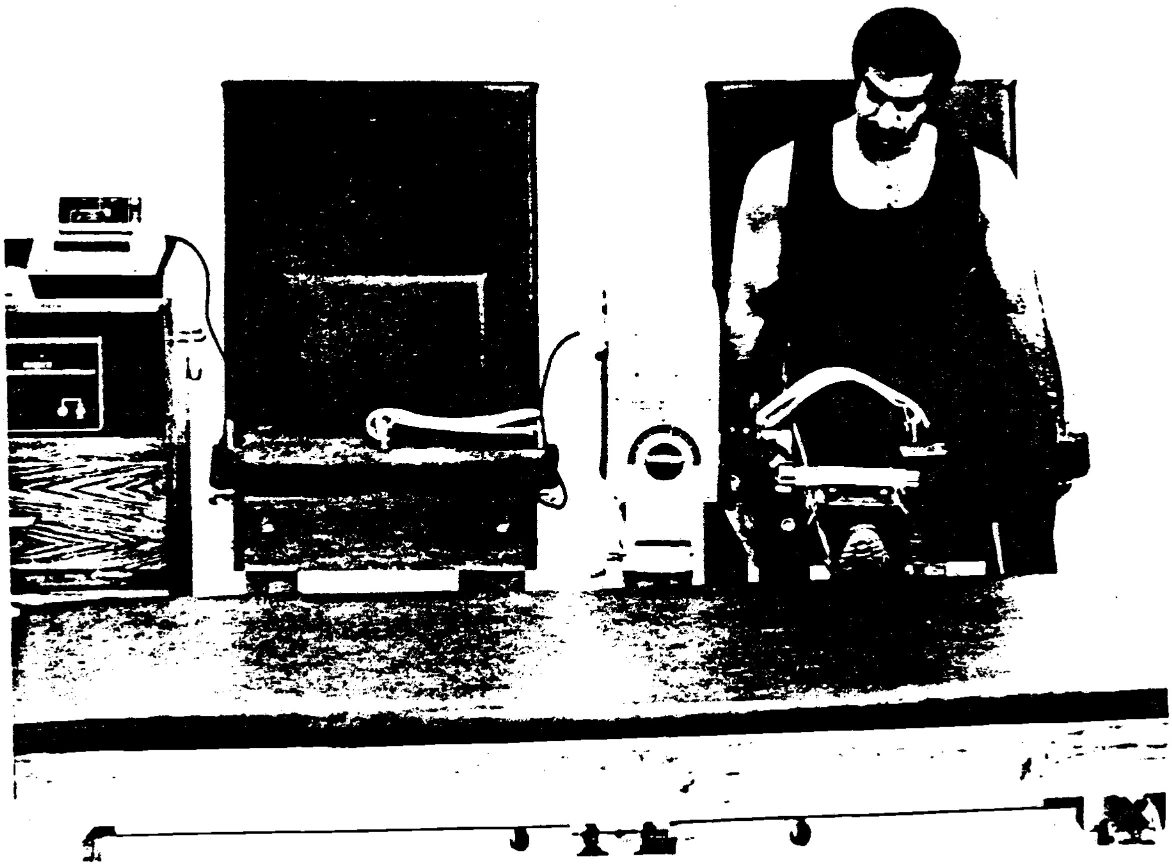


Figure 2. Measurement of knee flexion and extension strength using an isokinetic dynamometer. The force of contraction is recorded by the instrument to the far left (Lumex Inc., 1986).

Sale and MacDougall (1981) trained the triceps of subjects with a number of weight training exercises. Weight lifting strength and arm girth increased considerably; however, elbow extension strength measuresd on an isokinetic dynamometer did not increase significantly. In a second experiment, subjects performed the same weight training exercises and also practiced on the isokinetic dynamometer three times per week. After a similar period of training, improvements paralled those of the first test, but the isokinetic strength was also substantially improved. The authors concluded that strength testing was specific to the mode of training.

Many studies have been published to demonstrate specificity. As a result, a number of professionals have called for testing to be specific to the individual's training program. de Vries (1966) states that the result of isotonic programs should be measured isotonically, and the results of isometric programs should be measured isometrically. Riley (1978) emphasizes that the main concern of strength testing should be to evaluate the progress of each individual; use the same methods to test individuals as to train them. The testing for 1-RM is unreliable and increases the incidence of injury.

Kontor (1984) discussed the trend in athletic conditioning to use the 1-RM as a measure of athletic ability. There is no scientific evidence indicating a correlation between the ability to lift mamximum weight and the development of athletic ability. We should be training athletes to become better athletes less prone to injury, and not better weightlifters.

Variability of Testing Methods. Hunsicker and Greey (1958), after reviewing 89 strength studies, concluded that there is a difference between static and dynamic strength and the relationship between the two is not high. Ikai and Steinhaus (1961) measured maximum isometric effort of right forearm flexors with subjects exposed to a variety of psychologically induced conditions (shouting, firing a gun, hypnosis, alcohol consumption, injection of adrenaline, and taking amphetamines). Strength changes ranging from +26.5% to -31% were observed. According to the authors, their results supported the thesis that in every voluntarily executed, all-out maximal effort, psychologic rather than physiologic factors determine the limits of performance.

In a review of 50 published studies on strength, Kroemer and Howard (1970) concluded that the outcome of strength tests is affected significantly by the "technique of force generation" and statistical treatment of the raw data; that is, the selection of the index representing the subject's performance. The authors proposed that strength be measured isometrically and prepared a checklist to help report and control important experimental variables such as anthropometric data, body posture of the subjects, method of strength exertion, motivational aspects, ect.

Astrand and Rodahl (1977) cite a number of factors affecting the measurement of strength and conclude that even with correction for body size, age, and sex, large individual differences in muscle strength are observed, and a standard deviation from a mean value of +/- 15 to 20 percent must be accepted as a normal finding.

Atha (1981) summarized the results of isometric, isotonic, and isokinetic exercises as follows:

> There is suprisingly little to choose between these methods, for all three are about equally effective. Differences between methods appear to be swamped by differences within them, for the training effects produced are dominated by the chosen regimen.

The Research Consortium of the American Alliance for Health, Physical Education, Recreation and Dance ("The Value of," 1985) issued the following position statement:

> Based on an extensive evaluation of the literature concerning the effects of strength training on physical performance, there are no significant differences in training effects among various modes of concentric strength training where the loads are provided by free weights, body weight, isokinetic devices, and variable resistance machines.

Strength and Body Size

The two most common ways of expressing the results of strength measurements are absolutely and in relation to body mass. Thus, an individual with a mass of 75 kg (165 lbs) might have an absolute strength of 375 lb as a result of one or more strength movements; his strength/mass ratio would be 5 lb/kg. The interpretation of strength test results should take into consideration several individual characteristics including body size (Sale & Norman, 1982).

Hunsicker and Greey (1958) in a review of studies on strength measurement and body build concluded that body type is related to strength and those possessing a high mesomorphic component have the greatest amount of strength. Astrand and Rodahl (1977) suggest that a difference in body dimensions must necessarily be considered when evaluating the variation in strength with sex and age.

Keeney (1955) reviewed several previous strength studies and concluded that a strength/body weight ratio was associated with metabolic rate, thinness, and highly correlated with motor fitness. To investigate this ratio further, Keeney used the total strength and body weight of subjects in two groups; 7 world champion weightlifters and 114 competitors in the 1952 Olympic Weightlifting Championships.

The weightlifters competed in seven body weight categories ranging from less than 123 pounds to more than 199 pounds. Total strength was the sum of the weight lifted overhead in three lifts (2 hands clean and jerk, 2 hands military press, and 2 hands snatch). The total strength of each lifter was divided by the upper limit of his weight class (e.g., 615 (strength) divided by 123 (lbs) x 100 = % of body weight lifted).

Keeney found that contestants in lighter weight classes were stronger for their size with a linear relationship among the five classes within the 132 to 198 pound range. There was a drop off in linearity with the group at each extreme. Keeney suggested the strength/body weight ratio may be a concept of considerable significance in fitness testing and recommended more research in the area of non-competitive subjects.

Validity of Multiple Strength Tests

Astrand and Rodahl (1977) cite several studies to support the conclusion that general muscle strength should not be evaluated from the measurement of one single muscle group, but from a battery of selected well-standardized muscle tests. de Vries (1966) agrees and writes that the relationships of strength among the various muscles of any individual are not perfect, but there is a high degree of generality. Thus, strength tests that use the strength of several muscle groups can estimate the general strength quite accurately.

Wendler (1935) reviewed previous studies which validated total strength as a measure of general physical condition and potential athletic ability. These studies failed to indicate which muscle groups were most reliable for predictive purposes; therefore, Wendler designed a study to determine the muscle groups most valuable for predicting total strength in men and women.

Wendler measured the strength of 47 muscle groups in a sample of 474 men and women. Total strength of each subject was the sum of the 47 measurements. Regression analysis resulted in the selection of four muscle groups (hamstrings, quadriceps, deltoids, and pectoralis major) as predictors of total strength in men. This battery had a correlation of .933 with total strength. A similar battery was selected for women.

Berger (1963a) used 174 male college students to test the 1-RM of seven muscle groups. Total strength of each student was the sum of all lifts. Berger selected the exercise (military press) that correlated the highest with total strength as a device to separate the students into small groups of comparable total strength.

Jones (1978) does not recommend testing one muscle in isolation. He states that for valid results, a strength test should involve a variety of exercises; at least 8 basic exercises covering all the major muscular structures. Riley

(1978) employs the same methods in testing as in training, and warns that when a coach uses different methods to train and test, he can expect problems. Bosco and Gustafson (1983) do not believe the evaluation of total body strength requires the testing of a large number of muscle groups. In their opinion, sufficient research exists to demonstrate that a small number of properly selected strength tests will reflect total muscular strength.

Strength and Aging

Tests of strength have been given to subjects of all ages and under a variety of conditions. The result is a mass of information. Reviews of the literature have concluded that strength is greater in successively older age groups until age 30. No differences in strength occur for about 10 years, then strength is less in consecutively older age groups. By age 60, strength is about 80 per cent of the value at age 30 (Astrand, 1968; Hunsicker & Greey, 1958; Ostrow, 1984; Shephard, 1984).

Ostrow states that compared to other measures of physical fitness, strength is retained longer. Some studies indicate strength is greater in the legs, but this finding is controversial. Ostrow concludes that previous physical activity, health status, variations in body dimensions, and other factors need to be controlled if aging effects are to be interpretable.

The following studies on the relation between strength and aging, with one exception, are all cross sectional designs. No studies were found in which strength was measured isotonically (1-RM) or by use of variable resistance equipment. The preferred method of strength measurement is isometric and/or isokinetic.

Fisher and Birren (1947) reported the maximum grip strength of the dominant hand for 552 male industrial workers, 18 to 60 years of age. The test procedure required the subject to squeeze a hand dynamometer at three second intervals, beginning with a squeeze of 27 kg. The force exerted was increased by an increment of 3 kg with each attempt until the subject was unable to achieve the required increase in strength.

Their results indicated maximum strength (56.05 kg) occurred in the middle twenties. At age 60, the average grip strength (46.8 kg) was about 83 per cent of the younger subjects' strength. The authors graphically compared their results with data gathered by a number of researchers in the preceeding 100 years. The authors concluded that their data, indicating a difference in strength between age groups, were in agreement with others, and the occupational activity of their subjects had little bearing on the results.

Burke, Tuttle, Thompson, Janney, and Weber (1953) measured the grip strength of 311 normal males from 12 to 79 years of age. Using a specially designed hand dynamometer, each subject sat with his dominant arm resting on a table and squeezed the dynamometer with a maximum effort and continued to squeeze for a period of one minute. No mention was made if practice or more than one trial was allowed.

Strength was greater for each age group until age 25, then strength was less for each successively older age group. Grip strength at age 60 was 80 percent of the value at age 25. Grip strength for the 75 to 79 age group was similar to that of the 12 to 15 age group (about 58 percent of the maximum value at age 25).

Asmussen and Heeboll-Nielsen (1962) acknowledged the difference in strength between age groups reported by others, but noted that the age at which strength was less than the preceeding value was different for different muscle groups. Subsequently, they measured isometric muscle strength of 25 different muscle groups in a sample of 360 men and 250 women, aged 15 to 60 years. The subjects were described as randomly chosen, clinically sound persons. Using a strain gauge dynamometer, all measurements were made from standard, easily reproducible positions. The best of several attempts was taken to represent maximum strength.

The overall results for men were similar to previous reports. Women, on the average, had about 65 percent the strength of men. The authors attributed this difference to the smaller body size of women and made a correction in the strength measurements for the subject's height and muscle cross sectional area. This changed the strength of women to about 77 percent of that for men. They suggested this represented the true sex difference in strength.

When different muscle groups were examined, the authors discovered that maximum strength occurred at different ages. The hands and upper extremities reached maximum strength at about age 20. No differences between age groups were seen until 40, then strength was less in older age groups. For trunk and leg muscles, maximum strength occurred at about age 30, but was less in consecutively older age groups. By age 50, lower body strength was less than that of the arms. The authors were not sure of the reason for this difference, but speculated that the decrease in leg use for running and jumping versus continued use of the hands and arms in the daily life of older subjects was a reasonable explanation.

In a longitudinal study, Clement (1974) initially measured the grip strength of 2033 healthy males and females ranging widely in age and socioeconomic levels. Grip strength was measured according to the method of Fisher and Birren (1947) described previously. Five years later, 369 men and 162 women were retested and 10 years later, 109 men and 55 women were seen a third time. A few subjects were tested 15 years subsequent to the first test. Subjects ranged in age from 16 to 96 years.

The results of the initial cross sectional measurements were similar to those previously reported. The author used these initial measurements to calculate the estimated strength loss that would occur when subjects of a particular age were remeasured 5 and 10 years later. These estimates were compared to the strength measurements actually recorded in the subsequent 5 and 10 year retests.

Clement found that the decrease in strength that occurred longitudinally was much greater than what was expected from cross sectional data. Between the ages of 30 and 80, longitudinal data revealed a 60 per cent loss in strength after five years. From the cross sectional data, it was estimated to be only 40 percent. Clement attributed this finding to the likelihood that in cross sectional studies, the survivors at any age are more likely to be the stronger. He concluded that the under estimation of strength loss with age in cross sectional studies is due to natural selection which favors stronger individuals in elderly cohorts. Clement did not discuss results of the 10 and 15 year measurements.

Montoye and Lamphiear (1977) measured grip and arm strength of all persons (N=6,508) between the ages of 10 and 69 in a total community, Tecumseh, Michigan. Since the number of subjects represented almost everyone (82 percent) in the community without medical contraindications, the authors suggest their data more nearly represents the strength of healthy males and females than the findings of previous researchers.

Each subject's strength index resulted from the sum of isometric grip strength of each arm and the isometric strength of the flexors (biceps) of the upper arms. The strength index was divided by the subject's body weight. A difference in strength between age groups occurred which was similar to previous results; however, when body weight was considered, the difference in strength per unit of body weight in older age groups was greater than the difference in absolute strength of the same age groups. This finding was attributed to a gain in weight, particularly fat, of older subjects.

Petrofsky and Lind (1975a) measured the isometric grip strenght of 100, healthy industrial workers, 23 to 62 years of age. The test involved each man exerting two brief (about 2 sec) maximal voluntary contractions on a portable hand dynamometer. The authors state that every effort was made to exhort each subject to do his best, but no description of the tester's actions is given.

Although there was some variation in strength in each age group, no difference in strength was seen between age groups. The authors contend this resulted from the occupational homogenity of the subjects.

Petrofsky and Lind (1975b) repeated the previous study with a group of 83 female volunteers from a variety of occupations. The women ranged in age from 19 to 65. A difference in strength of about 20 percent occurred between the youngest and oldest age groups; consistent with previous studies. The authors attributed the difference in strength between age groups to less physically demanding occupations, menopause, and sex hormones, but recommended further research.

Larsson and Karlsson (1978) measured maximum isometric quadriceps strength of 50 healthy men, 22 to 65 years of age, with low daily physical activity levels (clerks). Results confirmed earlier reports, but the authors commented on the results of the preceeding study (no difference in strength between age groups). Larsson and Karlsson stated that if the strength measurements by Petrofsky and Lind were adjusted for the increase in weight of older subjects, a difference in strength between age groups would occur.

Cuddigan (1973) using a specially designed "stress cane", measured maximum isometric strength of the quadriceps in 100 normal subjects from 20 to 70 years of age. His purpose was to develop norms for comparison with subjects undergoing rehabilitation, so the topic of strength across age was not discussed. Cuddigan divided individual strength by body weight, and stated that this corrected measure of strength enables a comparison of strength to be made between people of different body size.

Larsson, Grimby, and Karlsson (1979) studied age differences for maximum isometric and dynamic strength of

114 healthy males, 11 to 70 years of age. Volunteers were chosen on the basis of a low level of physical activity as indicated by Saltin and Grimby's (1968) classification of occupational and spare time activity. Strength of the left quadriceps was measured using an isokinetic dynamometer (Cybex II, Lumex, New York).

The subjects were positioned in an experimental chair at a hip angle of 90 degrees and the axis of the knee joint aligned with the dynamometers axis of rotation. Strength measurements were made at knee angles of 30, 60, and 90 degrees. In addition, dynamic strength was measured at angular velocities of 30, 60, 120, and 180 degrees per second. Two attempts were made at each angle and velocity, and the highest value noted. To eliminate differences in body dimensions, strength measurements were presented per kilogram of body weight.

Isometric and dynamic strength values were greater for each successive age group into the twenties; no differences occurred until the forties, then strength was less in consecutively older age groups. A similar relation between strength and age was found when strength was corrected for body weight. Isometric strength was greater than dynamic strength for all age groups. No measurable external atrophy of the quadriceps muscle, which could have explained the difference in strength between age groups, could be seen in the older subjects. The authors discussed a number of possible alternative internal mechanisms responsible for the strength differences.

Murray, Gardner, Mollinger, and Sepic (1980) divided 72 normal, healthy men (20 to 86 years in age) into three groups and measured maximum isometric and isokinetic contractions of the right knee flexors (hamstrings) and extensors (quadriceps). Measurements were made on a modified Cybex II dynamometer with the subjects sitting and leaning against a backrest inclined 15 degrees from the vertical. Measurements were made at knee angles of 30, 45, and 60 degrees. Isokinetic contractions were done at a speed of 36 degrees per second. All measurements were corrected to account for the effect of gravity on the leg-foot segment. The authors stated that if gravity was accounted for, no adjustment is necesary for cuff placement, body size, or effect of shoes.

Maximum isometric values were greater than isokinetic values for all knee angles and age groups. The strength of the oldest group averaged 55 to 65 percent of that for the youngest group for both types of contractions. The authors cited the amount of time necessary for muscle cross bridge formation as possibly being the mechanism responsible for the difference in strength between the two types of contractions. The authors repeated this study (Murray et al., 1985) with female subjects and reported similar findings, though the women had less strength.

Strength of Non-sedentary Subjects. The preceeding studies have one thing in common; healthy, normal subjects with a low level of activity were tested. Only a couple of studies were found in which data were collected on more active individuals. Asmussen, Fruensgaard, and Norgaard (1975) administered a physiological test battery to former physical education students three times over a period of 40 years. Hand grip strength was one of the measurements.

The subjects, as students, were first tested in 1930-1935. Of the original group, 19 males and 6 females, were retested in 1959 and again in 1971. Testing occurred at about age 20, 50, and 60 respectively. In 1959, most of the subjects were active physical education teachers. By 1971, only a few were actively teaching physical education, but most remained active in the physical sense. In addition to a complete battery of cardiorespiratory tests, hand grip strength was measured several times on both hands by means of a Collin hand dynamometer. The mean of the three best attempts for the stronger hand was reported.

There was a steady decline in strength for both men and women. The strength for men at age 60 was about 73 percent of that at age 20; for women, about 63 percent. The authors noted that due to the difference in body size of individuals born at different times, cross sectional studies may overemphasize the effect of growing older. Their data seemed to show that this error is slight.

Dummer, Clarke, Vaccaro, Velden, Goldfarb, and Sockler (1985) designed a cross sectional study to examine age related strength differences among 73 female master swimmers, age 24 to 71 years. The authors cited the paucity of data available on the physical fitness characteristics of adults who do maintain an active lifestyle.

Grip strength of both arms was assessed using a Lafayette Instruments dynamometer. While standing, the subjects held the dynamometer at the side of the body, and were instructed to squeeze the dynamometer with as much force as possible. Flexion and extension strength of the shoulder and knee were measured using a Cybex II isokinetic dynamometer. Once positioned, each subject gave 5 continuous flexion-extension sequences through a full range of movement at maximal effort. The speed of the Cybex was set at 180 degress per second for shoulder measurements. Tests on the knee were done at speeds of 30 and 180 degrees per second.

Results indicated a difference in strength between age groups similar to that reported for less active subjects; however the strength of the swimmers was greater at all ages. For example, grip strength of subjects 60 years and older was equivalent to that of less active females in their twenties. Correlations for weight, height, or lean body mass with any strength measurement were not substantial. An aspect of interest, noted by the authors, was the ability of all subjects to give maximal effort and to complete all the tests through a full range of motion.

Dummer et al. concluded that activity helps adults to maintain high levels of muscular strength, but does not halt the age related loss of muscular strength. Additional research confirming the benefits of an active lifestyle were recommended.

Strength of Older Cohorts. The measurement of strength from younger to older age groups, has been documented by many researchers. A number of investigators have examined the relation between strength and age among cohorts 60 years and older (Amiansson, Grimby, Hedberg, Rundgren, & Sperling, 1978; Aniansson, Sperling, Rundgren, & Lehnberg, 1983; MacLennan, Hall, Timothy, & Robinson, 1980; Milne & Maule, 1984; Pearson, Bassey, & Bendall, 1985).

In these studies, subjects were those medically able to be tested and the level of activity generally referred to an individual as being functional. The favored test was an isometric measurement with equipment and protocol as varied as the populations studied. Results of these investigations revealed less strength in successively older age groups with the more active subjects maintaining a higher degree of strength longer.

Rating of Perceived Exertion

During recent decades, researchers have become more interested in how people feel, what aches and pains they have, and how difficult they perceive their work to be. Most scientists and practitioners in the health sciences agree that it is important to understand subjective symptoms and how they relate to objective findings. Medical assistance is most frequently sought by patients who have noted a severe decrease of their physical working capacity and a subsequent subjective strain. Perceived exertion is the single best indicator of the degree of physical strain (Borg, 1982).

The Swedish psychologist, Gunnar Borg, introduced his perceptual scale to American scientists in 1967 and 1968. It has been used primarily by researchers trained in exercise physiology who are concerned with the physiological basis of exercise perceptions. This requires a basic knowledge of psychophysics as well as a deep understanding of physiology (Noble, 1982).

The overall perception of exertion during physical exercise represents an individual's integration of various physiological sensations. It has been suggested that major sensory cues arise from feelings of strain in the exercising muscles and joints and from feelings involving the cardiopulmonary system. In addition, certain psychometric variables which result in alterations of emotional state may affect the overall cognitive processing of sensory information in the perception of effort during physical exercise. The exact manner in which these sensory cues are monitored and integrated in determining the perception of effort is not understood (Pandolf, 1983).

The Borg category scale (see Appendix A) for determining rated perceived exertion during exercise was developed to increase the linearity between perceptual ratings, heart rate, and exercise intensity. It is a 15 point scale, numbered from 6 to 20, with every odd number anchored by a verbal expression such as "very, very light" at 7 and "very, very hard" at 19.

Ostrow (1984) reviewed a number of studies on activity and aging, and reported that older adults tended to overestimate the strenuousness of physical activity. When relative training workloads were equated, older adults perceived that they were working harder than younger subjects. These studies involved tasks which stressed the cardiorespiratory system (treadmill walking/running, stationary cycling) and as the workload increased, so did heart rate and perception of effort. Ostrow recommended more research in this area with older subjects.

The research on perception of effort in the elderly is scarce. The following investigation is representative of the studies reviewed by Ostrow. Sidney and Shephard (1977) obtained ratings of perceived exertion during progressive bicycle ergometer and treadmill exercise from 26 men and 30 women, aged 60 to 70 years. Subjects were retired or engaged in sedentary employment and all had passed a medical examination and an exercise stress test.

During the last minute of exercise, subjects were shown Borg's scale of perceived exertion and indicated their perception of effort. The older group had a perception of effort two or three units above that of younger subjects for the same workload. Subsequently, 23 subjects were placed in a 34 week physical training protocol designed to elicit minimal pulse rates of 120 beats per minute. Tests were repeated after training. An unexpected result was a slight increase in rating of perceived effort although the subjects improved on all physiological measures. The authors were unable to explain this finding, but suggested possible psychological factors as the cause.

One study was found in which perception of effort was related to a strength training regimen. Hurley et al., (1984) studied 13 healthy, untrained males (age 40-55) to determine the effects of a 16 week high intensity, variable resistance, Nautilus strength training program on cardiovascular function. A control group of 10 males (age 40-64) underwent the same evaluation procedures as the training group.

After 10 weeks in the training program, physiological responses to a single Nautilus exercise workout were studied in 10 subjects. During the workout, the subjects performed one set of between 8 and 12 repetitions for each of 14 exercises. The subjects moved from exercise to exercise as fast as possible. A rating of perceived exertion was obtained from each subject immediately after the last exercise.

The mean value of perceived exertion for the Nautilus workout was 18. Treadmill walking at 4 miles per hour resulted in a mean perception of effort of 8. The information gathered regarding the rating of perceived exertion was reported, but not discussed by the authors. Their discussion centered around the cardiorespiratory responses to the strength training regimen.

Summary

Previous cross sectional strength studies, utilizing inactive subjects, are rather consistent with regard to the relation between strength and aging. Strength is greater in successively older age groups into the mid-twenties. No difference between age groups occurs for about 10 to 15 years; thereafter, strength is less in consecutively older age groups. By age 60, maximum strength is about 20 to 25 per cent less than the maximum value of the 25 year old.

Although strength measurements have been occurring for over 200 years, there is still a lack of standardization for the definition, measurement, and data interpretation of strength. This appears to be confounded by a rapidly changing technology which has resulted in the introduction of a variety of machines and instruments to develop and measure strength.

Consequently, two measurements of strength are usually reported in current strength research. Static strength is measured isometrically employing a variety of instruments. Dynamic strength is measured isokinetically using a device which controls the speed of movement. Of the two, isometric results in the largest strength values, but isokinetic is the most popular; however, isokinetic speed settings are not standardized and measurements of strength have occurred at a variety of settings between 30 and 180 degrees per second. Isotonic or variable resistance exercises which are favored forms of strength development, are not generally used to measure the strength of non-athletic individuals.

While each successive strength study has its own pecularities, collectively, the findings and recommendations of previous researchers may be generalized as follows:

1. Strength measurement is specific to the method of strength development; that is, an individual training isokinetically should be measured isokinetically, ect.

2. The sum of strength measurements on a number of muscle groups is more representative of total body strength than an individual strength measurement.

3. To allow comparisons between individuals, strength should be adjusted to take into account body size.

It has been reported that older inactive subjects perceive the same physical tasks as more strenuous than younger subjects. This has been demonstrated repeatedly using Borg's rating of perceived exertion (RPE) scale as the measuring instrument. There was no research located which compared the RPE of a physical task by active subjects from different age groups.

METHODOLOGY

This was a cross sectional study in which 80 recreationally active men, 25 to 64 years old, were administered strength tests for six separate muscle groups. After completing the last strength test, each individual gave a rating of perceived exertion. Comparisons, with respect to strength and perception of effort, were made between four age groups (25-34, 35-44, 45-54, & 55-64). The facilities and members of the Tacoma-Pierce County Family YMCA in Tacoma, Washington were used for data collection.

Selection of Subjects

Gerontologists commonly classify the elderly as young-old (65-74), middle-old (75-84), and the old-old (85+). To remain consistent with this 10 year pattern of separation, 20 active men were recruited from each of the following age groups; 25-34, 35-44, 45-54, and 55-64.

Each member, to qualify as a subject, met the following criteria:

1. Active for longer than a year with three or more periods of activity per week.

2. Free of any known cardiovascular, bone, muscle, or nerve condition that would limit and/or prevent execution of the selected strength exercises.

The definition of active resulted from two considerations. First, in a position statement on improving and/or maintaining cardiovascular fitness, the American College of Sports Medicine (ACSM) recommends a minimum of three periods of activity per week, 15 to 60 minutes in duration, at 60 to 90 per cent of maximum heart rate reserve ("Recommended quantity and," 1978). Second, the ACSM also suggests a minimum training period of 15 to 20 weeks for evaluating the effects of a cardiovascular fitness program. In addition, discussions with the Director of Fitness for the Tacoma Y confirmed that members who remained active for one year, or longer, were more likely to continue with an active lifestyle.

The Tacoma Y provided a membership roster, which indicated there were 2,986 male members between 25 and 64 years of age with the number of members in each age group as follows: 25-34, (1103); 35-44, (1134); 45-54, (474); 55-64, (275). Eighty subjects, 20 from each age group, were needed for testing.

Using the Y's membership roster and a random number table, twenty names from each age group were randomly selected and the following notice was stapled to their membership cards:

> The Y is evaluating a new technique for measuring muscular strength.
> Males that have been ACTIVE for longer than one year are needed for this study.

Your name was randomly selected.
If you qualify, please consider volunteering
and give this notice to locker control in
exchange for an explanation of the study.

On each visit to the Y, a member must show his membership card along with a picture ID, for admission. Once inside the workout area, membership cards are returned to a reception area known as locker control. The members who returned the notice to locker control were given a brief description of the study and, if interested, completed a contact questionnaire (see Appendix B). The preceeding process was repeated weekly. Each batch of notices was checked after two weeks, and the notice was removed if still attached to a membership card.

After repeating the weekly random selection procedure three times, the process was discontinued. The 240 notices had produced only 14 volunteers. In addition, about 65 per cent of the notices were still attached to membership cards after two weeks, indicating a large portion of the members would not satisfy the activity requirements of the study.

The balance of subjects needed for the study was obtained by visiting a variety of activity classes, briefly explaining the study, and asking for volunteers. This method of subject recruitment produced a sufficient number of volunteers to complete the study without any further difficulties.

Choice and Explanation of Strength Tests

Based on the experience and recommendations of previous researchers, total body strength resulted from measuring the strength of six separate muscle groups. The time necessary for testing and available equipment were additional considerations in the choice and number of tests. Last, the exercises (three upper body and three lower body) chosen for the strength tests utilized major anterior (front) and posterior (rear) muscle groups (see Figures 3 and 4). The strength tests were performed on equipment manufactured by Nautilus (Nautilus Sports/Medical Industries, Deland Florida) or Universal (Universal, Cedar Rapids, Iowa). The exercise associated with each strength test is common to most, if not all, strength training regimens.

1. Leg Press (LP) (see Figure 5-A) The LP is a two joint pushing movement consisting of hip and knee extension (straightening the leg). Hip extension is primarily done by the large muscles of the buttocks (gluteus maximus, with assistance from the gluteus medius and the gluteus minimus; see Figure 4). Knee extension is accomplished by the quadriceps, a four-muscle group on the anterior thigh consisting of the rectus femoris, vastus lateralis, vastus medialis, and the vastus intermedius (see Figure 3).

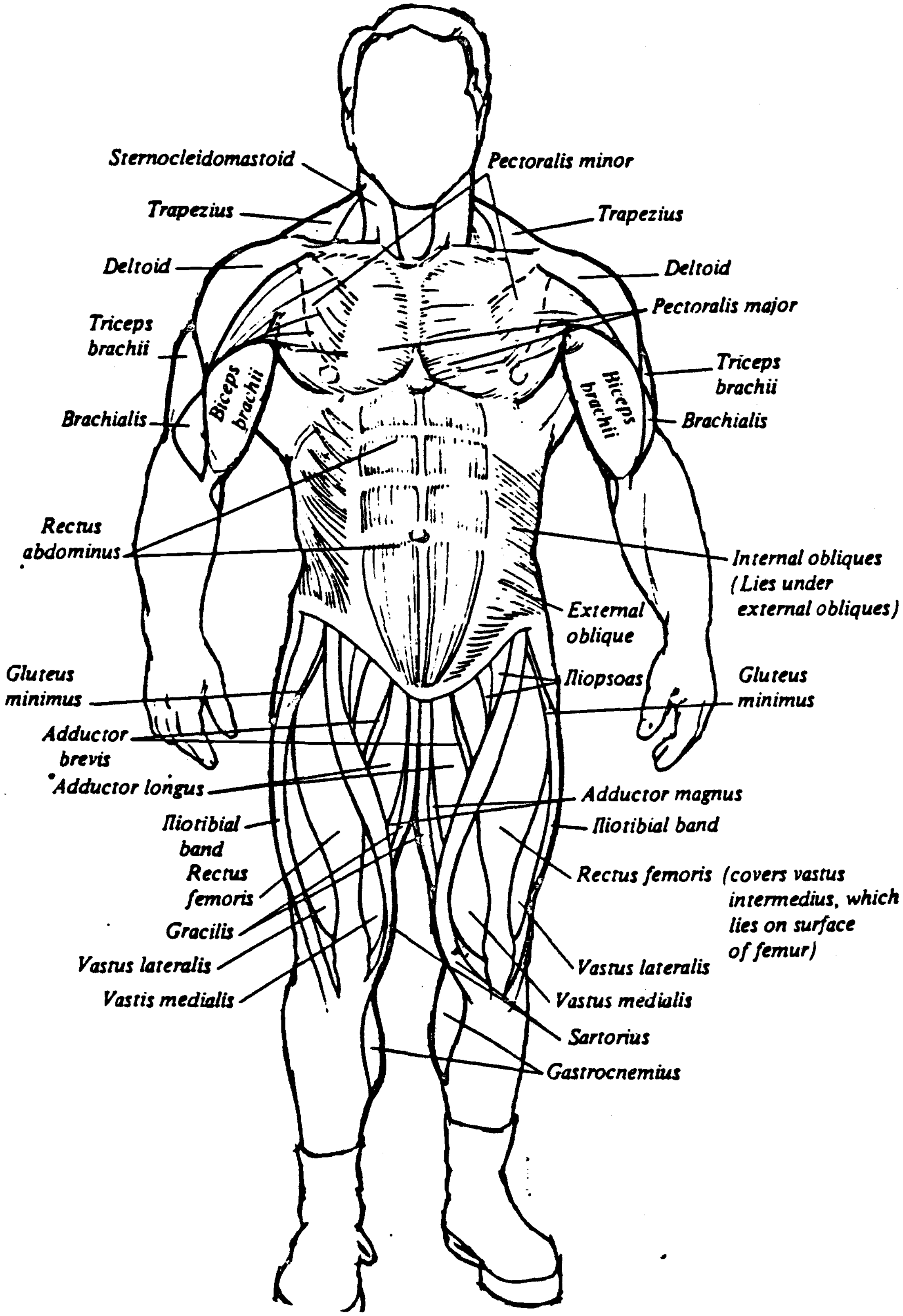


Figure 3. Anterior view of major muscles (Pearl & Moran, 1986).

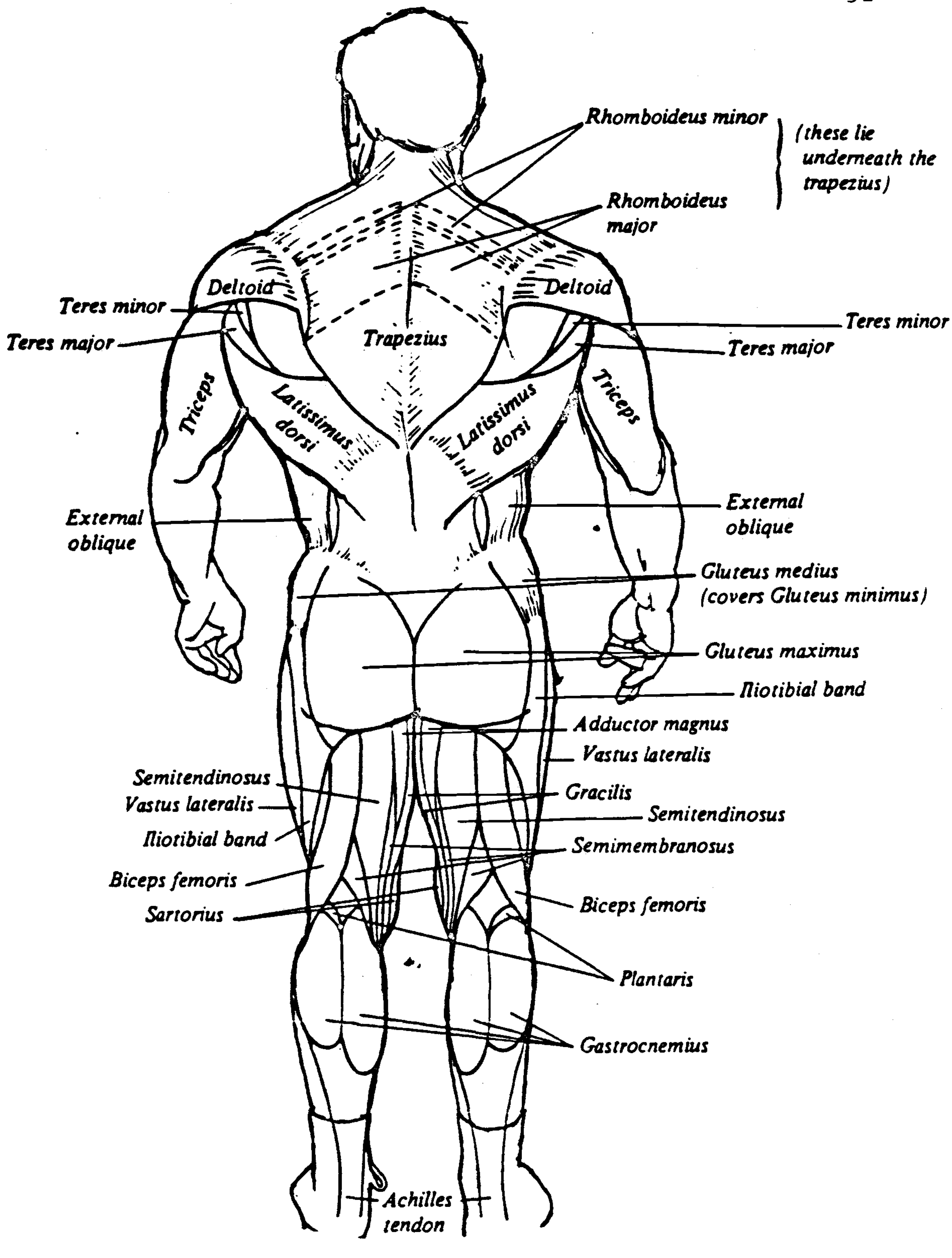


Figure 4. Posterior view of major muscles (Pearl & Moran, 1986).

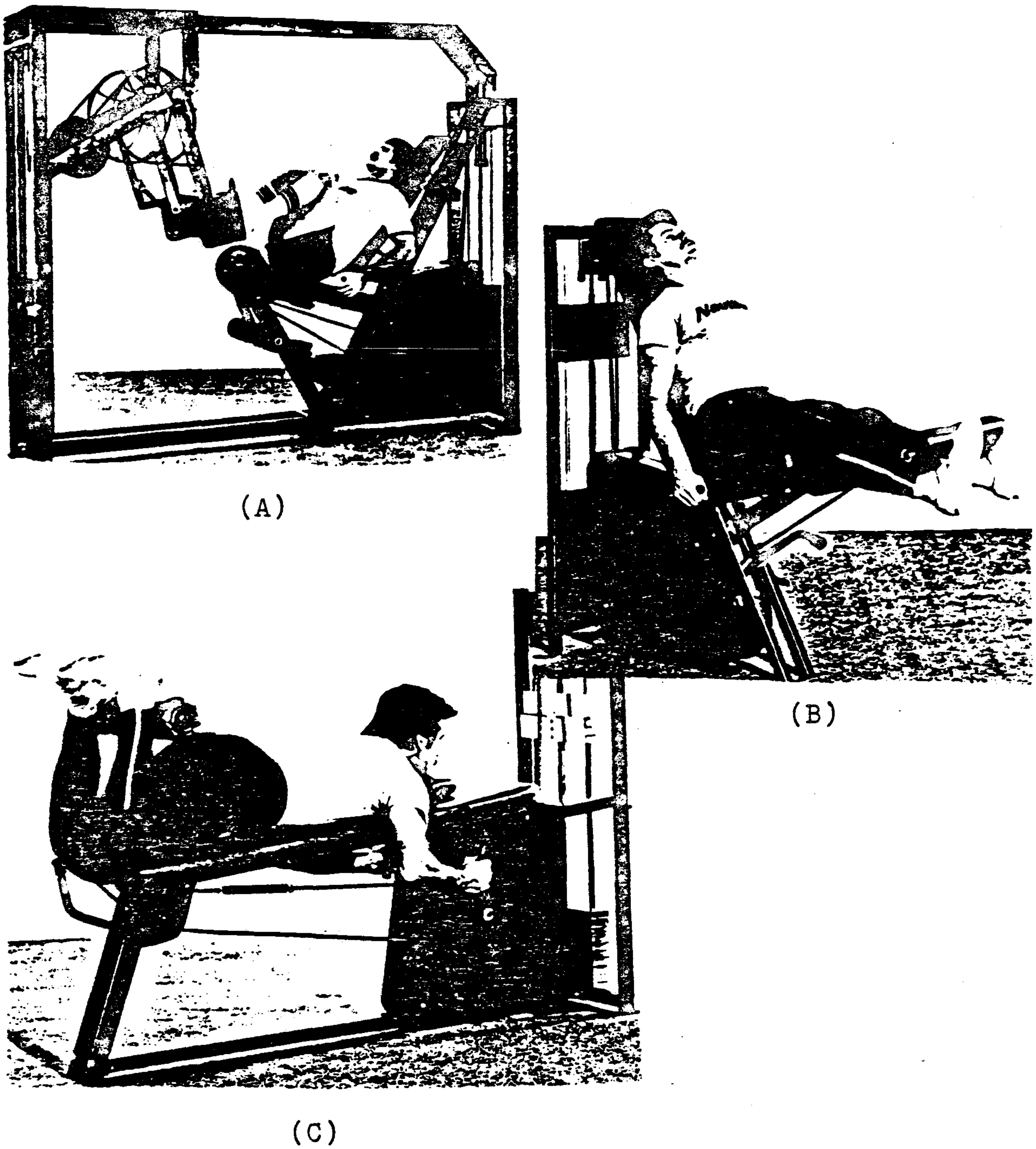


Figure 5. (A) Starting position for the leg press exercise on the Nautilus Compound Leg Machine. (B) Finishing position for the leg curl exercise on the Nautilus Leg Curl Machine. (C) Finishing position for the leg extension exercise on the Nautilus Leg Extension Machine.

2. Leg Curl (LC) (see Figure 5-B) The LC is a pulling movement (knee flexion) executed by the muscles of the posterior thigh. This three-muscle group (biceps femoris, semitendinosus, and semimembranosus) is commonly known as the hamstrings (see Figure 4).

3. Leg Extension (LE) (see Figure 5-C) The LE isolates the four muscles of the anterior thigh (quadriceps) and is a kicking movement (knee extension). As described previously in the LP exercise, LE is one of the most commonly performed exercises in developing and measuring lower body strength, regardless of the type of equipment or training regimen.

4. Decline Press (DP) (see Figure 6-A) The DP is a pushing movement (elbow extension and arm adduction) using the muscles of the posterior, upper arm (triceps, see Figure 4), and the muscles of the upper chest (pectoralis major and deltoid, see Figure 3). With free weights (barbells) and many machines, this exercise is called the bench press and is very popular for strength development and testing.

5. Seated Rowing (ROW) (see Figure 6-B) Seated rowing is a pulling movement (adduction of the scapula and extension of the arm) performed by the muscles of the upper back (trapezius, deltoid; see Figure 4).

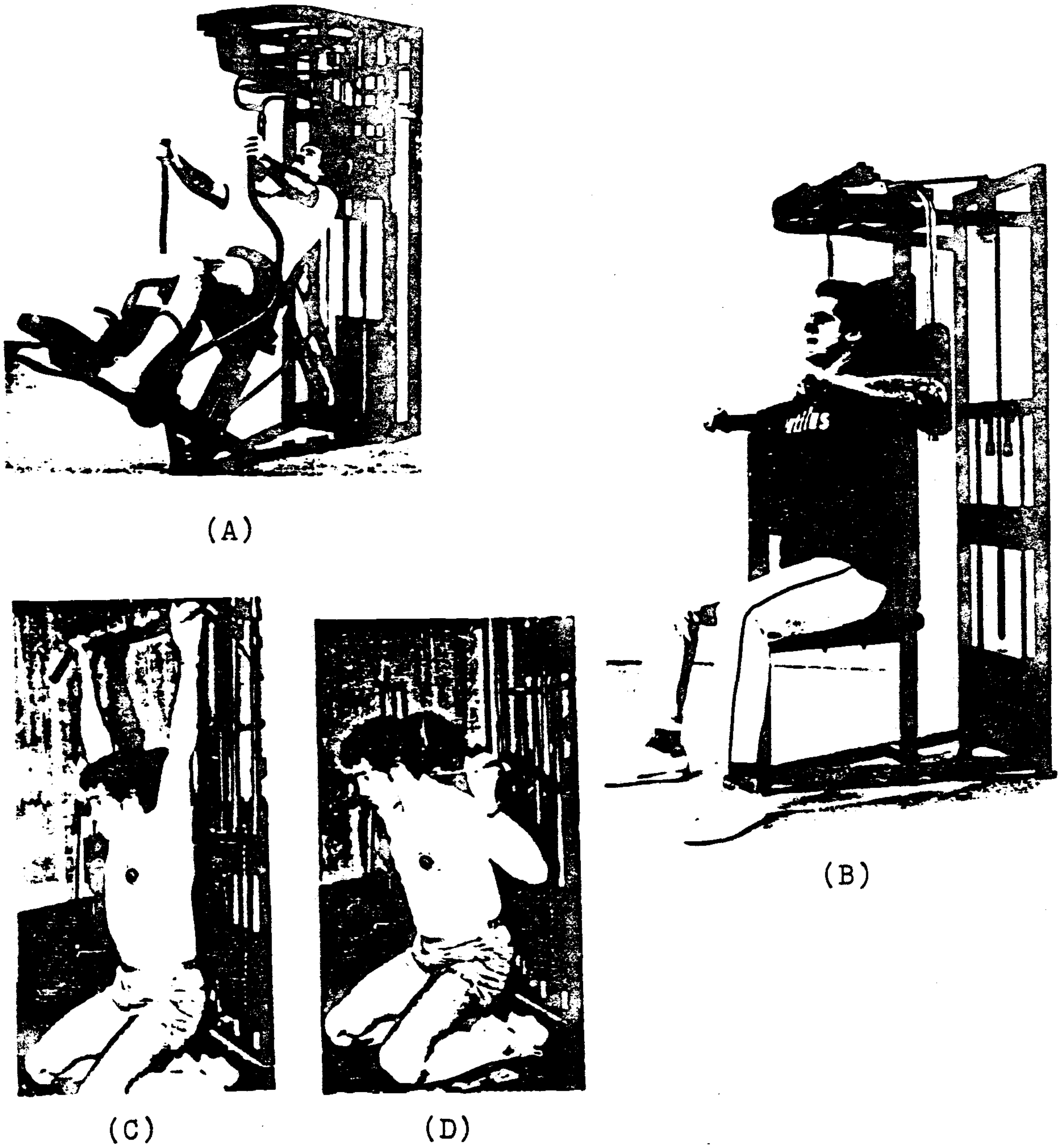


Figure 6. (A) Starting position for the decline press exercise on the Nautilus Double Chest Machine. (B) Finishing position for the seated rowing exercise on the Nautilus Rowing Torso Machine. (C) Starting and finishing (D) positions for the behind neck pulldown exercise on the Universal Multi-Station Machine.

6. Behind Neck Pulldown (BNP) (see Figures 6-C & 6-D) The BNP is a pulling movement (arm extension and elbow flexion) which isolates the large muscle of the mid and lower back (latissimus dorsi, see Figure 4) with assistance from the teres major and minor (upper back, see Figure 4) and the muscles of the anterior upper arm (biceps brachii and brachialis, see Figure 3).

The 10-RM Protocol for Measuring Strength

The 10-RM protocol is a common form of strength training and has been favorably used and compared to other methods of strength development (Berger, 1963, 1962a, 1962b; Johnson, 1972; Sale & MacDougall, 1981; Stull & Clarke 1970). The 10-RM protocol requires the individual to use a weight with which 8 to 12 repetitions of an exercise can be completed with proper technique. If more than 12 reps are completed, the weight is considered too light and is increased at the next workout; conversely, if fewer than 8 reps are performed, the weight is too heavy, and is decreased. This procedure for strength development has been recommended by the Tacoma Y during weight room orientations for 10 years. It is also the method of training recommended by Nautilus to purchasers of their equipment (see Appendix C).

In order to measure strength, regardless of age, safety is a major factor. There is no safe method to assess a subject's absolutely greatest muscle strength (Kroemer & Howard, 1970). Although the contractile force of an 8-10 RM set is smaller than a 1-3 RM set, maximal motor unit activation is achieved with the 8-10 RM routine and the risk of injury is less when using lighter weights (Sale & MacDougall, 1981). In addition to safety, a 10-RM routine has fewer psychological factors to control. Ikai and Steinhaus (1961) concluded that in every voluntarily executed, all-out maximum effort, psychologic rather than physiologic factors determine the limits of performance.

Due to the nature of this study, the 10-RM protocol was chosen because of the reduced likelihood of injury, the similarity to a normal strength training workout, and the ability of all subjects to perform each exercise; thus, the relations between total body strength, rating of perceived exertion, and age were able to be examined.

Test Administration

The volunteers were scheduled for testing during their normal workout time. Due to heavy use of the weight room during evening hours, most of the testing occurred between 6AM and Noon. Volunteers reported to the main weight room in appropriate clothing and prior to their workout. A private room, adjacent to the weight room, was used for orientation, height, and weight measurements. All tests were administered by the author and proceeded as follows:

1. An Informed Consent form (see Appendix A) was read and signed by each volunteer.

2. Each volunteer completed a Spare Time Activity Survey (see Appendix A). The purpose of the survey was to gather information about the volunteer's past 10 years level of activity as well as current and previous strength training experience. The levels of activity were similar to those used by Saltin & Grimby (1968), but modified to reflect current trends in American fitness. Completion of the activity survey resulted in the elimination of two volunteers who did not meet the activity requirement of the study.

3. Height and weight were measured according to procedures described in the Y's Way to Fitness (Golding, Myers & Sinning, 1982). Subjects stood in socks, stretching upward to the fullest extent. Heels, buttocks, and the upper back were pressed against a wall and the chin held level. A right angle was placed on top of the subject's head and against a wall-mounted ruler. Height was measured to the nearest quarter of an inch.

4. Weight was measured with the subject in t-shirt, shorts, and socks. A floor type bathroom scale was used to measure weight. The scale zero was adjusted daily to correspond with readings from a beam-type physician's scale. Measurements were recorded to the nearest pound.

5. The 10-RM protocol to be followed in the weight room was repeated and any questions were answered satisfactorily before proceeding. Each subject was allowed five minutes for a light warm-up (walk, easy jog, or stationary cycling) before returning to the weight room.

6. The exercises were done according to the manufacturer's recommendations (see Appendix C) and in the following order: leg press, leg curl, leg extension, decline press, seated rowing, and behind neck pulldown. If a machine was being used, the next exercise was performed. Generally, lower body exercises were completed first. The subject was positioned properly in the machine for each exercise, and 10-RM strength was measured as follows:

(a) If the subject was familiar with the exercise and gave an estimated 10-RM weight (pounds), the weight was initially set at 50% of this value; if not, a light weight, based on the tester's experience with the muscle group being measured, was selected.

(b) The manufacturer's recommended technique for performing the exercise was explained to the subject.

(c) In order to insure that the subject understood the proper technique, several reps were performed and corrections, if necessary, to his technique were made.

(d) Once the subject understood the correct technique, the weight was increased to the preselected value, or in the case of subjects who were not familiar with the strength exercise, the weight was increased according to the subject's reaction to the initial reps with the light weight.

(e) The subject was reminded to complete as many reps as possible, but to stop the exercise after several reps if the weight was too light (able to do more than 12 reps) or too heavy (unable to complete 8 reps). If the subject stopped, then the weight was increased or decreased according to the subject's perception.

(f) The exercise was performed and the number of complete reps recorded. If 8 to 12 reps were completed before failure, the selected weight was recorded as the 10-RM strength for the exercise. Using the preceeding procedure, all subjects completed more than 8 reps of each exercise.

(g) If 13 reps were completed, the exercise was stopped and the following procedure employed:

1. Based on the subject's reaction to the exercise and the tester's observation, the weight was increased one, or more, increments of 5 pounds.

2. After a rest of at least one minute, the exercise was repeated as described in step (f).

3. If necessary, the exercise was repeated a third, and final time. 10-RM strength was determined for all subjects with 3 or less trials.

(h) The remaining exercises were performed according to the preceeding procedure.

(i) Upon completion of the last test, the subject was shown a chart of Borg's Ratings of Perceived Exertion (see Appendix A). The subject was asked to indicate the number which represented his perception of the strenuousness of performing the six 10-RM strength tests. This concluded the data collection.

Analysis of the Data

Measurements for each subject were recorded on an individual data collection form (see Appendix A). At the conclusion of the study, all data, including answers to the activity survey, were combined and recorded by age group (see Appendix D). Statistical analysis of the data was accomplished through the use of the software package Statistical Package for the Social Sciences (SPSS).

Total Body Strength (TBS) was calculated as the sum of the 10-RM weights (pounds) for each of the six strength exercises. Body Mass Index (BMI) was calculated by dividing body weight (kilograms) by height (meters) squared (BMI = wt/(ht x ht)). In order to allow comparisons between individuals, TBS was divided by BMI and the value of this ratio was termed Relative Strength (RS = TBS/BMI). Mean, standard deviation (SD), and the range were calculated for all variables.

This was a cross sectional descriptive study with four levels of the independent variable, age. It was hypothesized that there would be no difference in (a) relative strength between age groups, and (b) rating of perceived exertion of the strength tests between age groups. Since the levels of age differed quantitatively, and the intervals between levels were specified, the relationships between age and each dependent variable, relative strength (RS) and rating of perceived exertion (RPE), were examined using trend analysis (Kirk, 1968). One-way analysis of variance (ANOVA), using orthogonal polynominals, was used to test each hypothesis for trends with respect to the following a priori contrasts:

1. There is not a linear relationship.
2. There is not a quadratic relationship.
3. There is not a cubic relationship.

The subjects were volunteers from different activity classes. Thus, subjects had different forms of activity, levels of exercise intensity, and experience with strength training; therefore, a large variability in strength between subjects was anticipated. Since variability and power (probability of rejecting a false null hypothesis) are inversely related, and the sample size was fixed (20 subjects per group), the level of significance (alpha) was evaluated to ascertain the power of the statistical test (Franks & Huck, 1986).

Allowing for an acceptable difference between means of one standard deviation, the methods of Kastenbaum, Hoel, and Bowman (1970) were used to select a level of significance (alpha) of .10. This resulted in the power of the ANOVA test being .83, which was acceptable. An alpha of .05 produced a power of .74, which was considered too low. In case of a significant difference between means, the Scheffe multiple comparison method was used to determine which means were significantly different (Winer, 1971).

The Pearson product-moment correlation coefficient (r) was calculated to examine the direction and degree of association between variables.

RESULTS AND DISCUSSION

This chapter is a presentation and discussion of the data obtained in the course of administering six strength tests to 80 active men, 25 to 64 years of age. The subjects were all members of the Tacoma-Pierce County Family YMCA, Tacoma, Washington. The Tacoma Y is one of the largest fitness facilities in the United States with over 100,000 square feet of space under roof. It has five separate weight rooms offering a variety of equipment manufactured by Nautilus, Universal, and Cam II. This study was carried out in the main weight room which contained 24 Nautilus and 2 Universal machines.

Description of the Subjects

Eighty male subjects volunteered for this study. Prior to measuring strength, height and weight were recorded and a spare time activity survey was completed. Descriptive data of the subjects by age group are shown in Table 1. Individual data may be found in Appendix D.

Examination of the individual data reveals an expected variation in height and weight between individuals in the same age group. This variation was not evident between age groups, with one exception. The mean weight of the 45-54 age group was about 20 pounds greater than the means of the other three groups. Since subjects were recruited with

Table 1

Descriptive Data of Men Participating in the Strength Study

Measure	Mean	SD	Range
25 to 34 Year Olds (N=20)			
Age (yr)	30.8	3.1	25-34
Height (in)	70.9	2.7	66.75-76.75
Weight (lb)	179	25.1	132-246
35 to 44 Year Olds (N=20)			
Age (yr)	38.8	2.7	35-43
Height (in)	69.7	2.2	66.00-74.50
Weight (lb)	176	21.8	140-213
45 to 54 Year Olds (N=20)			
Age (yr)	48.1	2.7	45-54
Height (in)	71.2	1.6	68.25-73.75
Weight (lb)	196	30.0	161-271
55 to 64 Year Olds (N=20)			
Age (yr)	60.5	2.4	55-64
Height (in)	69.7	1.8	65.25-72.50
Weight (lb)	171	17.6	147-225

Note. Statistics shown are the mean, standard deviation (SD), and range (minimum - maximum).

attention to age and primary activity, this finding was unexpected and not apparent until the data were analyzed.

Spare Time Activity Profile

After signing an informed consent form, each subject completed a five question spare time activity profile (see Appendix A). The survey was designed to gather some recent history about the subject's activity and strength training habits. Individual responses may be found in Appendix D. Information obtained from each question will be discussed separately.

Question #1. Which group best describes your activity for the past year?

To participate in the study, volunteers were required to have been active for at least three times per week for one year or longer. Question #1 confirmed this with two exceptions, and these volunteers were subsequently replaced. Thus, all subjects were active three or more times per week for the past year.

Question #2. Indicate the group that best describes your activity for the last ten years.

Surveys of lifetime activity patterns have been criticized because of the potential error due to recall. For this reason, the subjects were asked to choose an activity level for the two preceeding five year intervals. Observation revealed that this was not a problem for any of the subjects. The past year and previous 10 year activity levels for each age group are shown in Table 2.

The number of subjects that had an activity level required for the study (level 3) are fairly uniform across the three oldest age groups. Seven of the 12 subjects with a competitive level of activity (level 4) were in the youngest age group. This pattern was consistent for the preceeding five years of activity (1982-1986), but for the period 1977-1981, the youngest age group accounted for two-thirds of level 4 activity. This period corresponded to high school or college years for the 25-34 age group and a greater degree of activity would be expected. The period 1977-1981 also reveals that about one-third (27) of all subjects were only mildly active (level 2). This may be due to the lack of facilities since the Tacoma Y expanded from a small downtown operation to its present suburban site in 1977. It also raises the possibility that active adults may not be maintaining an active lifestyle for extended periods of time.

Question #3. Indicate your primary activity.

The purpose of Question #3 was to insure that a particular activity did not dominate the sample although no limit was pre-established. Results are shown in Table 3.

Question #4. Do you use the weight room on a regular basis? __Y __N If yes, how often? _____ Times/week How long have you lifted weights? _____________

Table 2

Activity Level of Men Participating in the Strength Study

Activity Level	All Ss	Age (yrs) 25-34	35-44	45-54	55-64
		1985 - 1986			
3	68	13	20	16	19
4	12	7	0	4	1
		1982 to 1986			
1	1	0	0	1	0
2	10	3	3	1	3
3	55	11	14	14	16
4	14	6	3	4	1
		1977 to 1981			
1	3	1	2	0	0
2	27	3	8	7	8
3	35	5	9	10	11
4	15	11	1	3	1

Note. A description of the activity levels corresponding to the numbers 1 to 4, may be found in Appendix A.

Table 3

Primary Activity of Men Participating in the Strength Study

		Age (yrs)			
Activity	All Ss	25-34	35-44	45-54	55-64
Aerobics	4	0	3	1	0
Cycling	1	1	0	0	0
Handball	3	0	0	1	2
Multiple	19	8	2	8	1
Racquetball	13	0	3	4	6
Running	26	4	10	6	6
Swimming	13	7	2	0	4
Walking	1	0	0	0	1

Note. Multiple means the subject participated in two or more activities.

Bodybuilders, weightlifters, and individuals engaged in a formal strength training program were not recruited as subjects; however, the Y encourages strength training as part of an active lifestyle and offers weekly weight room orientations. Thus, it was anticipated that active members might be doing some strength training. The strength training history of the subjects is shown in Table 4.

Fifty-two subjects were strength training with less participants in successively older age groups. The 55-64 age group had eight members using the weight room. In addition, 29 of the 52 subjects that were strength training, regardless of age, had been doing so for three years or less. This may be a reflection of the increased attention strength training has received in the last decade and/or the availability of facilities. By a narrow margin, two workouts per week were favored over three.

Question #5. If NO on #4, is there a particular reason that you don't use the weight room?

Twenty-eight subjects were not using the weight room and their reasons for this decision are listed in Table 5. No time and no specific reason accounted for 42 per cent of the answers; the rest being split among a variety of reasons. The men in the two older age groups accounted for the majority of those not strength training and while they volunteered for the study, their attitude generally was that strength training was more of a nuisance than an addition to

Table 4

Weight Room Utilization of Men Participating in the Strength Study

		Workout Frequency (times/wk)		
Age (yrs)	N	1	2	3
25-34	17	2	8	7
35-44	15	1	10	4
45-54	12	2	7	3
55-64	8	0	2	6

	Years of Strength Training
25-34	.5, 1, 2, 2, 2, 2.5, 3, 5, 5, 5, 7, 8, 8, 10, 10, 15, 17
35-44	.25, .25, 1, 1, 2, 2, 2, 3, 3, 5, 5, 15, 15, 18, 20
45-54	.25, .5, 1.5, 2, 2, 3, 3, 4, 7, 10, 12, 36
55-64	.5, 1.5, 1.5, 2, 3, 3, 20, 30

Table 5

Reasons for not Lifting Weights by Non-strength Training Men Participating in the Strength Study

Reason	Age (yrs)			
	25-34	35-44	45-54	55-64
Likes Aerobics	1			
Gets Strength from Primary Activity	1			
Dislikes Weightlifting	1			
Not Interested		1	1	1
Dislikes Machines		1		
No Time		1	1	4
Uses Calisthenics			1	1
Not Motivated			1	
Joint Injury				1
Afraid of Adding Bulk				1
No Specific Reason			3	3
No Need			1	
Just Began Lifting		2		1

their workouts.

Muscular Strength

All subjects were able to complete the six strength tests without incident. Statistical analysis of the data was accomplished using various computer software programs of SPSS (Statistical Package for the Social Sciences). The SPSS programs and output may be found in Appendix E.

Strength of Individual Muscle Groups. The results of each strength test by age group are shown in Tables 6 and 7. Individual data may be found in Appendix D. Examination of the mean strength value for each test indicates a difference in the strength of older subjects beginning with the 45-54 age group. One exception is the leg press, which is less in each older age group.

The difference in individual muscle group strength, from the youngest to oldest age group, was least for Rowing (17 per cent) and greatest for the Decline Press (34 per cent). Generally, the difference in individual muscle strength between the 25-34 and 55-64 age groups was closer to 30 per cent. This is greater than the 20 per cent difference between age groups cited in the literature, which was the result of maximum isometric values obtained with inactive subjects (Astrand & Rodahl, 1977; Ostrow, 1984; Shephard, 1984). The range in variation of strength

Table 6

Results of Lower Body Strength Tests on Active Men

Age (yrs)	N	Mean	SD	Range	%
		Leg Press (lbs)			
25-34	20	152	34	90-220	100.0
35-44	20	140	23	100-200	92.1
45-54	20	132	27	90-190	86.8
55-64	20	108	22	80-170	71.7
		Leg Extension (lbs)			
25-34	20	119	21	80-160	100.0
35-44	20	120	27	75-170	100.8
45-54	20	99	21	70-150	83.2
55-64	20	86	31	65-200	72.3
		Leg Curl (lbs)			
25-34	20	72	14	50-110	100.0
35-44	20	72	14	45-100	100.0
45-54	20	59	10	40-85	81.9
55-64	20	49	9	35-70	68.1

Note. Statistics shown are the mean, standard deviation (SD), and range (minimum - maximum). Per cent (%) equals (strength age group) divided by (strength 25-34 group).

Table 7

Results of Upper Body Strength Tests on Active Men

Age (yrs)	N	Mean	SD	Range	%
		Behind Neck Pulldown (lbs)			
25-34	20	117	17	75-150	100.0
35-44	20	116	14	90-150	99.1
45-54	20	100	19	75-150	85.5
55-64	20	88	17	70-140	75.2
		Decline Press (lbs)			
25-34	20	107	14	75-135	100.0
35-44	20	102	17	70-135	95.3
45-54	20	88	19	60-130	82.2
55-64	20	71	19	50-130	66.4
		Rowing (lbs)			
25-34	20	52	11	30-75	100.0
35-44	20	54	9	35-70	103.8
45-54	20	51	12	35-80	98.1
55-64	20	43	9	30-70	82.7

Note. Statistics shown are the mean, standard deviation (SD), and range (minimum - maximum). Per cent (%) equals (strength age group) divided by (strength 25-34 group).

differences between muscle groups suggests that different muscle groups may begin to lose strength at different ages, which agrees with the research of Asmussen and Heeboll-Nielsen (1962).

However, specificity may have been a factor in the varying strength differences between age groups, especially for the muscles used to perform the seated rowing exercise. As part of the testing protocol, each subject was asked if he was familiar with the exercise associated with each strength test. It was previously mentioned that the number of subjects strength training were less in older age groups (see Table 4). Generally, the subjects utilizing the weight room were familiar with the leg exercises and the decline press, and less familiar with the behind neck pulldown. Seated rowing was the least familiar exercise. Other researchers have recommended that testing methods simulate training methods (de Vries, 1966; Jones, 1978; Rasch & Morehouse, 1957; Riley, 1978; Sale & MacDougall, 1981), so practice (specificity) may have been as important a factor in these results as age.

The range values (minimum - maximum) for each exercise provided an unexpected result. The extreme strength measurements for each test in each age group were similar with the exception of the maximum values for the leg press and leg curl. In fact, the largest strength measurement for leg extension was in the 55-64 age group. These findings suggest that although mean strength values decreased in older age groups, there were individuals in each age group with comparative strength measurements. This suggests that factors other than age may affect strength.

Total Body Strength. Total Body Strength (TS) for each subject was determined by summing the 10-RM weights of the six strength tests. To adjust for body size, TS was divided by the Body Mass Index (BMI) of the subject. The BMI accounts for both the subject's weight and height and has been reported to be highly correlated with total body fat (Roche, Abdel-Malek, & Mukherjee, 1985). The ratio of TS to BMI was termed Relative Strength (RS). The values for BMI, TS and RS are shown in Table 8.

TS and RS were less for each older age group and both measures revealed an approximate 28 per cent difference in strength from the youngest to oldest age group. In testing the hypothesis that there was no difference between age groups, one-way analysis of variance was significant ($p = .0000$) for both TS and RS. Trend analysis indicated the linear term was significant for both TS and RS ($p = .0000$). For TS, the quadratic term was significant ($p = .0934$), and for RS, the cubic term was significant ($p = .0894$); however, the linear term accounted for 90 to 95 per cent of the variation between group means for TS and RS, respectively.

The Scheffe multiple comparison method was used to

Table 8

Body Mass Index, Total and Relative Strength of Active Men

Note. Statistics shown are the mean, standard deviation (SD), and range (minimum - maximum). Per cent (%) equals (value of age group) divided by (value of 25-34 group). Total Strength is the sum of the weights lifted in six separate strength tests. Relative strength is TS/BMI. (a, b, and c represent homogeneous subsets of means not significantly different for alpha = .10)

Table 8

Body Mass Index, Total and Relative Strength of Active Men

Age (yrs)	N	Mean	SD	Range	%
		Body Mass Index (kg/m x m) *			
25-34	20	25.1	2.9	20.3-31.7	100.0
35-44	20	25.5	2.6	20.9-30.4	101.6
45-54	20	27.3	4.2	22.4-38.1	108.8
55-64	20	24.9	2.8	21.1-28.9	99.2
		Total Strength (lbs) **			
25-34a	20	619	87	415-805	100.0
35-44a	20	602	79	435-735	97.3
45-54b	20	528	90	385-705	85.3
55-64c	20	444	97	350-780	71.7
		Relative Strength (lbs/BMI) **			
25-34a	20	24.7	2.7	18.5-29.0	100.0
35-44a	20	23.7	2.9	18.8-28.5	96.0
45-54b	20	19.6	3.6	13.5-27.6	79.4
55-64b	20	17.9	3.5	13.5-28.9	72.5

* $p = .0782$

** $p = .0000$

determine which means were significantly different. Multiple comparison procedures protect against calling too many differences significant. The Scheffe method is conservative for pairwise comparisons and requires larger differences between means for significance than most other methods (Winer, 1971). For example, ANOVA resulted in significance for BMI (p = .0782), but the difference between age group means was not large enough to satisfy the Scheffe criteria for significance. The output from the Scheffe test lists homogeneous subsets, with the difference between the means of groups in the subsets not significant at the prescribed level of alpha (.10) (see Appendix E).

For TS, the older age group (55-64) differed from the other three; the 45-54 age group differed from the younger two groups, and the 25-34 and 35-44 were not different. After adjustment for body size, analyis of RS resulted in the two older age groups (45-54 & 55-64) differing from the younger two groups, but not from each other. Examination of the per cent (%) column of Table 8 for TS and RS provides further insight into this finding. TS of the 45-54 group was 85 per cent of TS for the 25-34 group. After adjusting for body size, RS of the 45-54 group was 79 per cent of RS for the 25-34 group. Note that the adjustment for body size did not significantly alter the comparative strength of the other groups with respect to the youngest group. This agrees with the conclusions of Montoye and Lamphiear (1977), who suggested that the gain in weight by older adults may have been fat, which did not contribute to the strength of the individuals.

Rating of Perceived Exertion

Upon completion of the last strength test (usually BNP), each subject was shown Borg's scale of perceived exertion (see Appendix A) and asked to rate the strenuousness of the six strength tests. The results are listed in Table 9. Testing the group means by analysis of variance resulted in significance ($p = .0072$). Trend analysis was significant for the linear term only ($p = .0018$).

The Scheffe multiple comparison technique produced two homogenous subsets of means. The RPE of the two younger age groups (25-34 & 35-44) did not differ significantly, nor did the means of the three older age groups (35-44, 45-54, & 55-64). This result is in contrast to previous findings in which older, less active, subjects perceived the same workload as more strenuous than younger subjects (Ostrow, 1984; Sidney & Shephard, 1977). The finding in this study may be attributable to the subjects being familiar with active stress and to the tests being sub-maximal, which resulted in all subjects being able to complete the tests without any apparent discomfort.

Table 9

Perceived Exertion of Performing Six Strength Tests by Active Men: 25 to 64 Years Old

Age Group	N	Mean *	SD	Range
25-34a	20	13.4	1.9	9-16
35-44a,b	20	13.0	1.6	10-17
45-54b	20	11.8	1.4	9-14
55-64b	20	12.0	1.5	9-15

* $p = .0072$

Note. Statistics shown are the mean, standard deviation, (SD), and the range (minimum - maximum). (a & b are homogeneous subsets whose means do not differ significantly for alpha = .10)

Correlation Between Variables

In order to further evaluate the association between variables, Pearson product-moment correlation coefficients (r) and scattergrams of selected pairs of variables were produced. The Pearson product-moment correlation between a pair of variables is an indication of the strength of the linear relationship between the two variables. Table 10 lists r for selected pairs of variables.

A negative sign indicates that as the independent variable increases, the dependent variable decreases; a positive sign means both variables increase. The closer the value of r to zero, the less the linear relationship between variables; the closer the value of r to +1.0 or -1.0, the stronger the linear relationship (Nie et al., 1975). The difference in TS and RS between age groups may be seen in the scattergrams of Figures 7 and 8, respectively. The r for each is similar and represents a moderately strong association with age. Both scattergrams show individual extremes in strength for all age groups. The association between age and RPE is low (-.3139) and may be seen in Figure 9. Thus, although analysis of variance detected significance (see Table 9), the relative weakness of that finding is exposed by examining the scattergram.

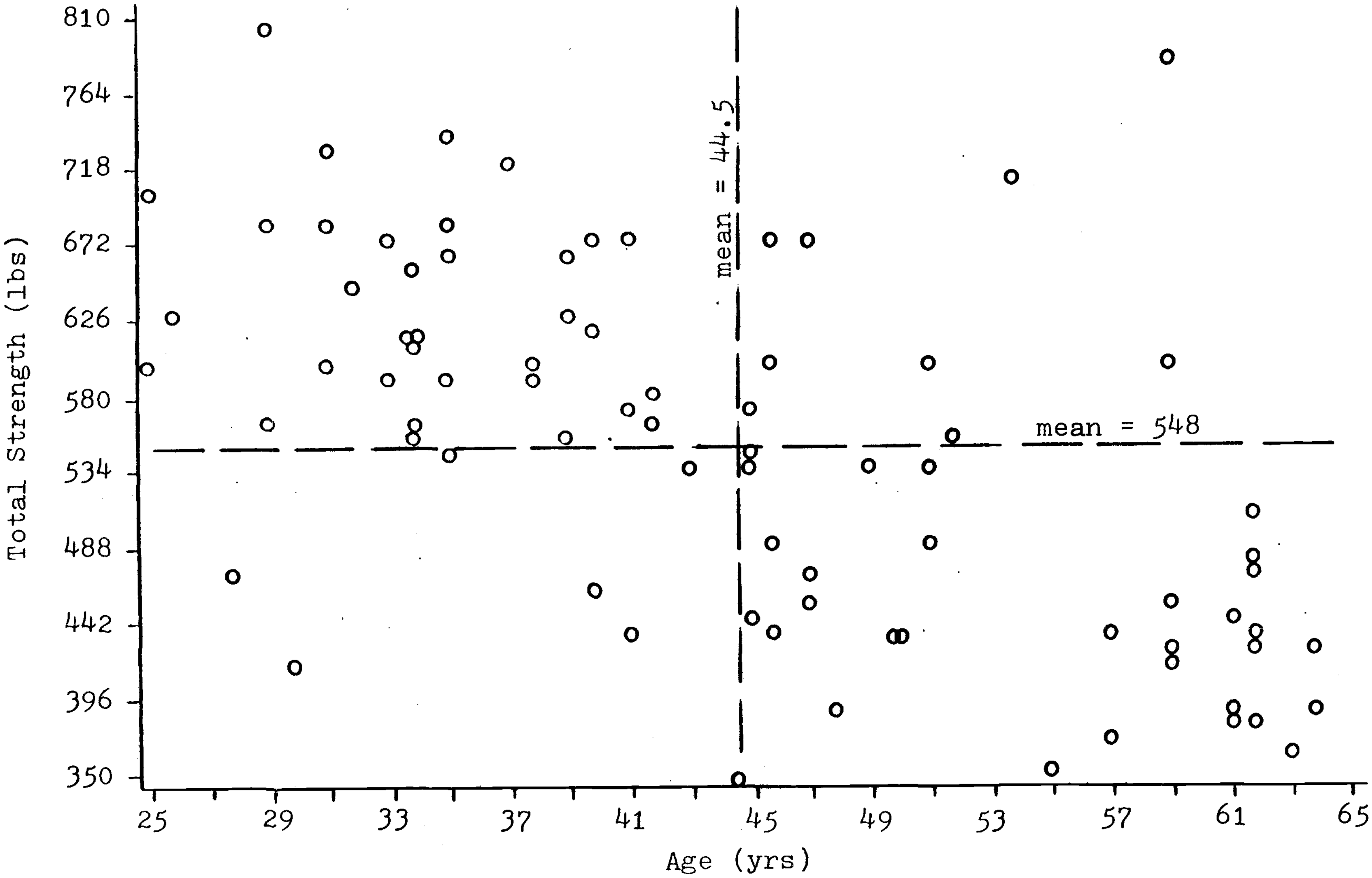
There is a strong association between TS and RS (.8258) and this may be seen in Figure 10, while both have relatively low associations with RPE. It might be argued

Table 10

Pearson Product-Moment Correlation (r) Between Pairs of Variables Measured in the Study on Strength of Active Men

Variable	Age	TS	RS	RPE
Age	xxxx	-.6162	-.6525	-.3139
RS	-.6525	.8258	xxxx	.4237
RPE	-.3139	.3398	.4237	xxxx
TS	-.6162	xxxx	.8258	.3398
BMI	.0279	.3156	-.2625	-.1217
YTR	xxxx	.4118	.3682	.1501
FREQ	xxxx	.3215	.3531	xxxx
HT	-.1152	.0636	.0818	xxxx
WT	-.0317	.3193	-.2011	xxxx
LP	-.5285	.8863	.6794	.1677
LE	-.4990	.8784	.7724	.2844
LC	-.6373	.8305	.6959	.3682
DP	-.6010	.8844	.7440	.3226
ROW	-.3275	.7327	.4858	.3158
BNP	-.5457	.8879	.7878	.4000

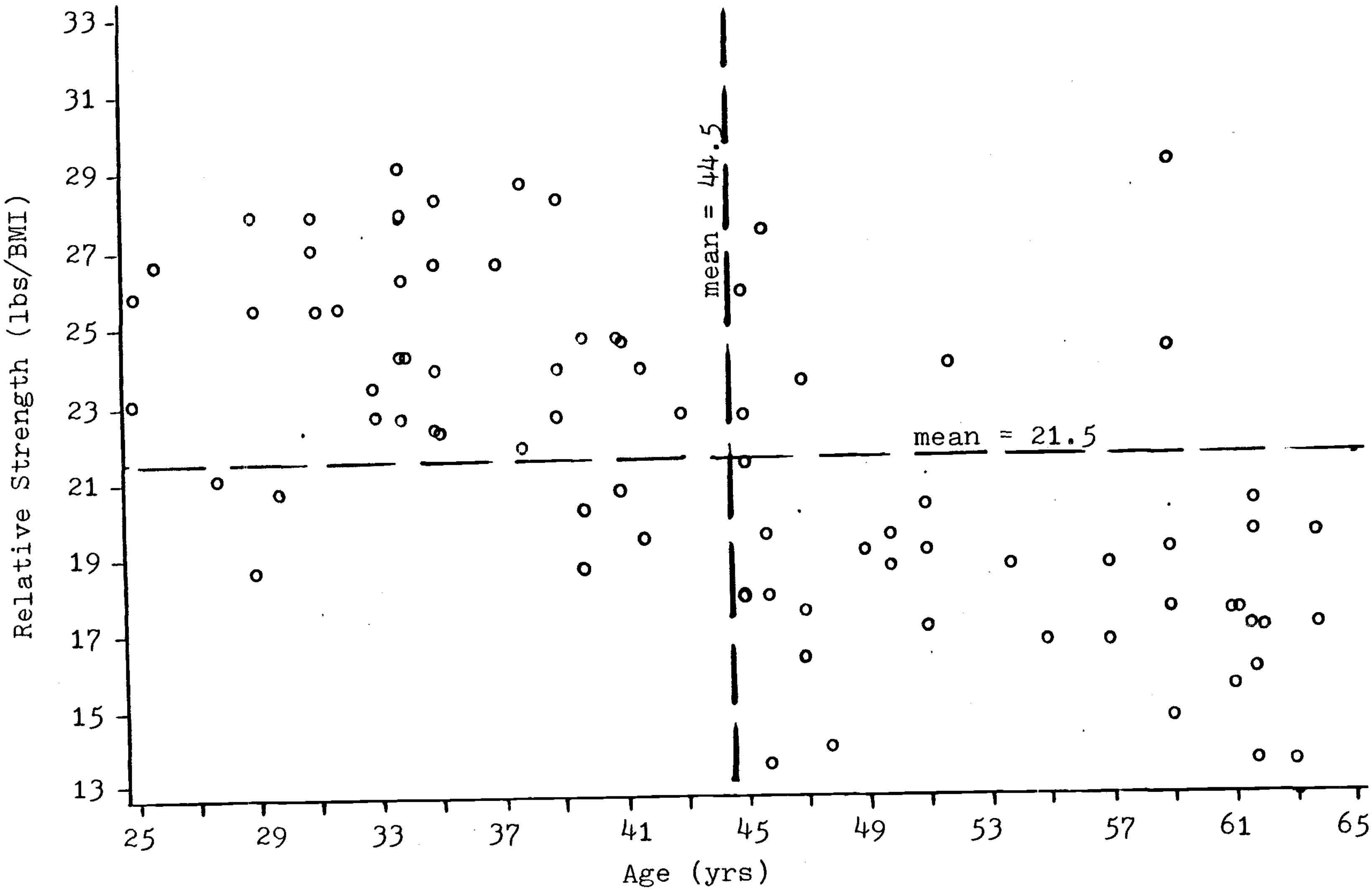
Figure 7. Scattergram of Total Strength and Age (N = 80; r = -.61625).



810
764
718
672
626
580
534
488
442
396
350
Total Strength (lbs)
mean = 44.5
mean = 548
25
29
33
37
41
45
49
53
57
61
65
Age (yrs)

Figure 7

Figure 8. Scattergram of Relative Strength and Age (N = 80; r = -.65245).



33
31
29
27
25
23
21
19
17
15
13
Relative Strength (lbs/BMI)
mean = 44.5
mean = 21.5
25
29
33
37
41
45
49
53
57
61
65
Age (yrs)

Figure 8

Figure 9. Scattergram of Rating of Perceived Exertion and Age (N = 80; r = -.31393).

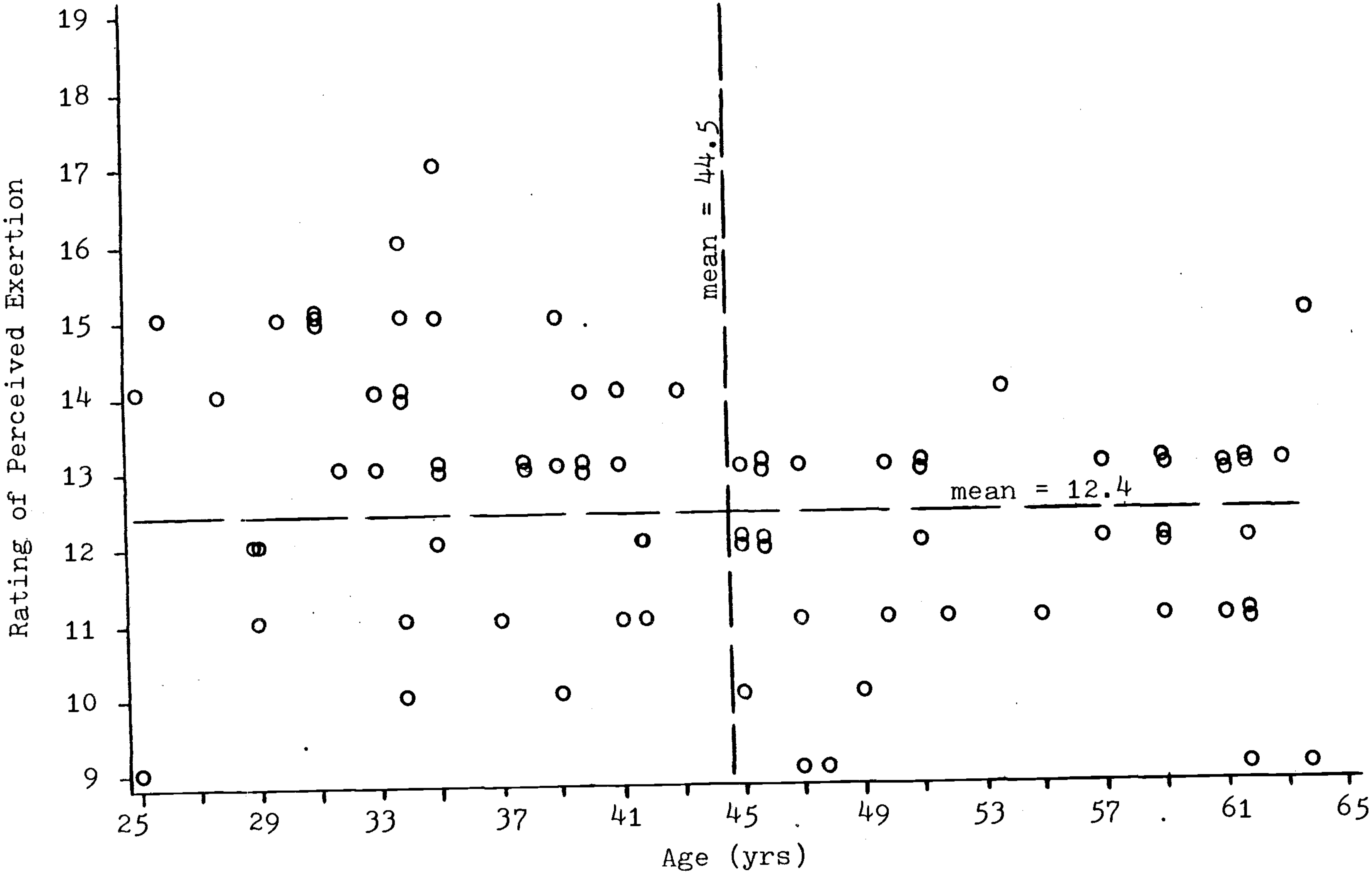

Rating of Perceived Exertion
19
18
17
16
15
14
13
12
11
10
9
mean = 44.5
mean = 12.4
25
29
33
37
41
45
49
53
57
61
65
Age (yrs)

Figure 9

Figure 10. Scattergram of Total Strength and Relative Strength (N = 80; r = .82577).

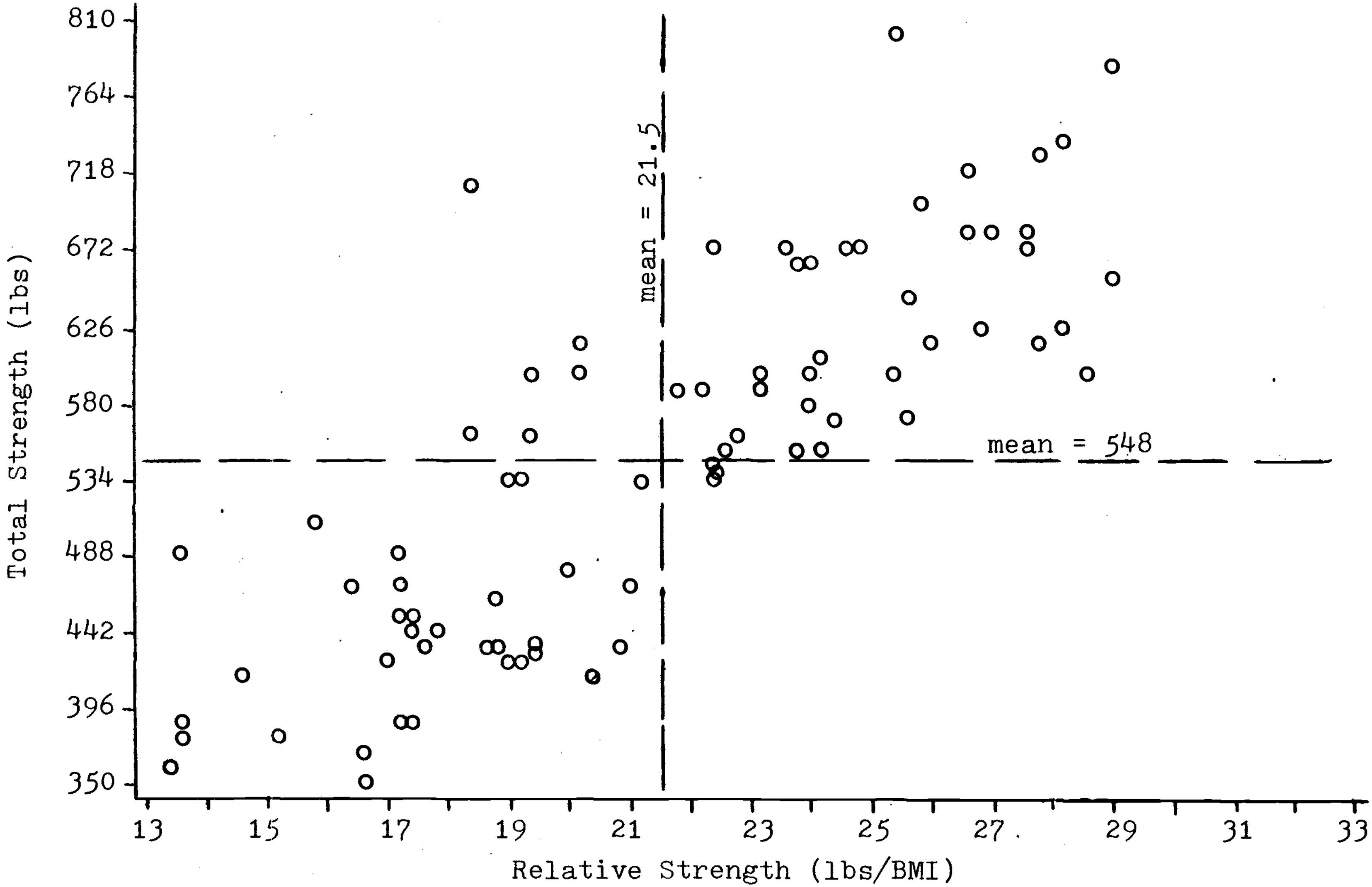

810
764
718
672
626
580
534
488
442
396
350
Total Strength (lbs)
mean = 21.5
mean = 548
13
15
17
19
21
23
25
27
29
31
33
Relative Strength (lbs/BMI)

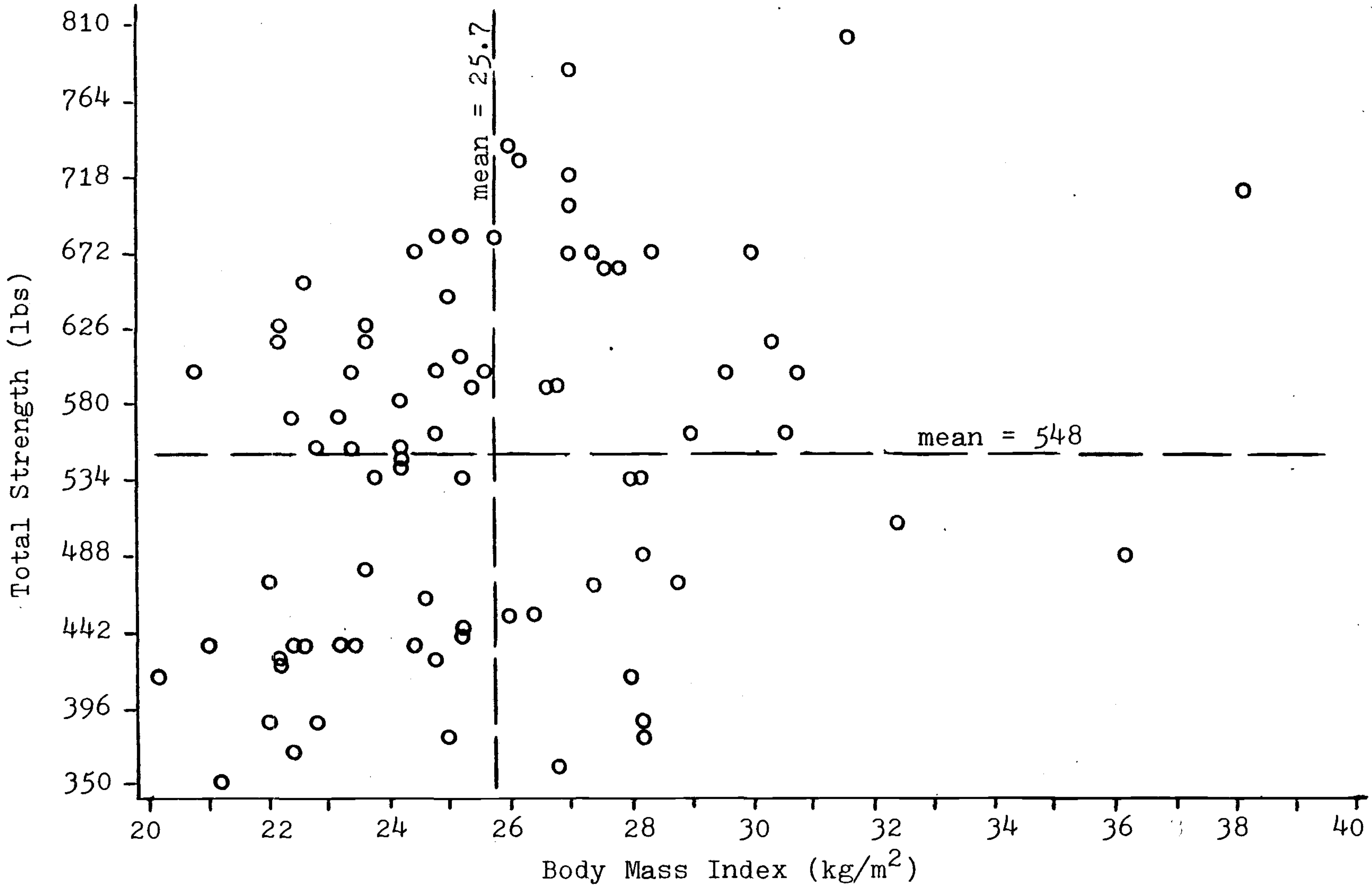
Figure 10

that either TS or RS would be acceptable for representing total body strength on the basis of their association with each other; however, TS and RS correlate +.3156 and -.2625 respectively, with BMI (see Figures 11 & 12). While these are both low correlations, it is further evidence that a larger BMI does not necessarily produce a corresponding increase in TS, as noted previously (see Table 8). Years of strength training (YTR) and frequency of workouts (FREQ) both had low associations with TS and RS. This may be an indication that active, non-competitive men are strength training at an intensity more likely to maintain than develop strength.

There is a strong association between each strength test and TS; the association with RS being somewhat less, but still moderately strong. An exception appears to be the seated rowing exercise; however, as explained earlier, this was the least practiced movement which may be the reason for the weaker correlation. The BNP has the highest correlation with both TS and RS. Berger (1963a) selected the military press from a group of strength measurements as the one strength test to be used in classifying students into groups with similar total strength. It is interesting to note that the military press and BNP involve similar joints (elbow & shoulder), but are opposing movements.

While the correlation between RPE and each strength test was low, the correlation was weakest (.1677) for the

Figure 11. Scattergram of Total Strength and Body Mass Index ($N = 80$; $r = .31562$).



mean = 25.7
mean = 548
Total Strength (lbs)
810
764
718
672
626
580
534
488
442
396
350
20
22
24
26
28
30
32
34
36
38
40
Body Mass Index (kg/m2)

Figure 11

Figure 12. Scattergram of Relative Strength and Body Mass Index (N = 80; r = -.26251).

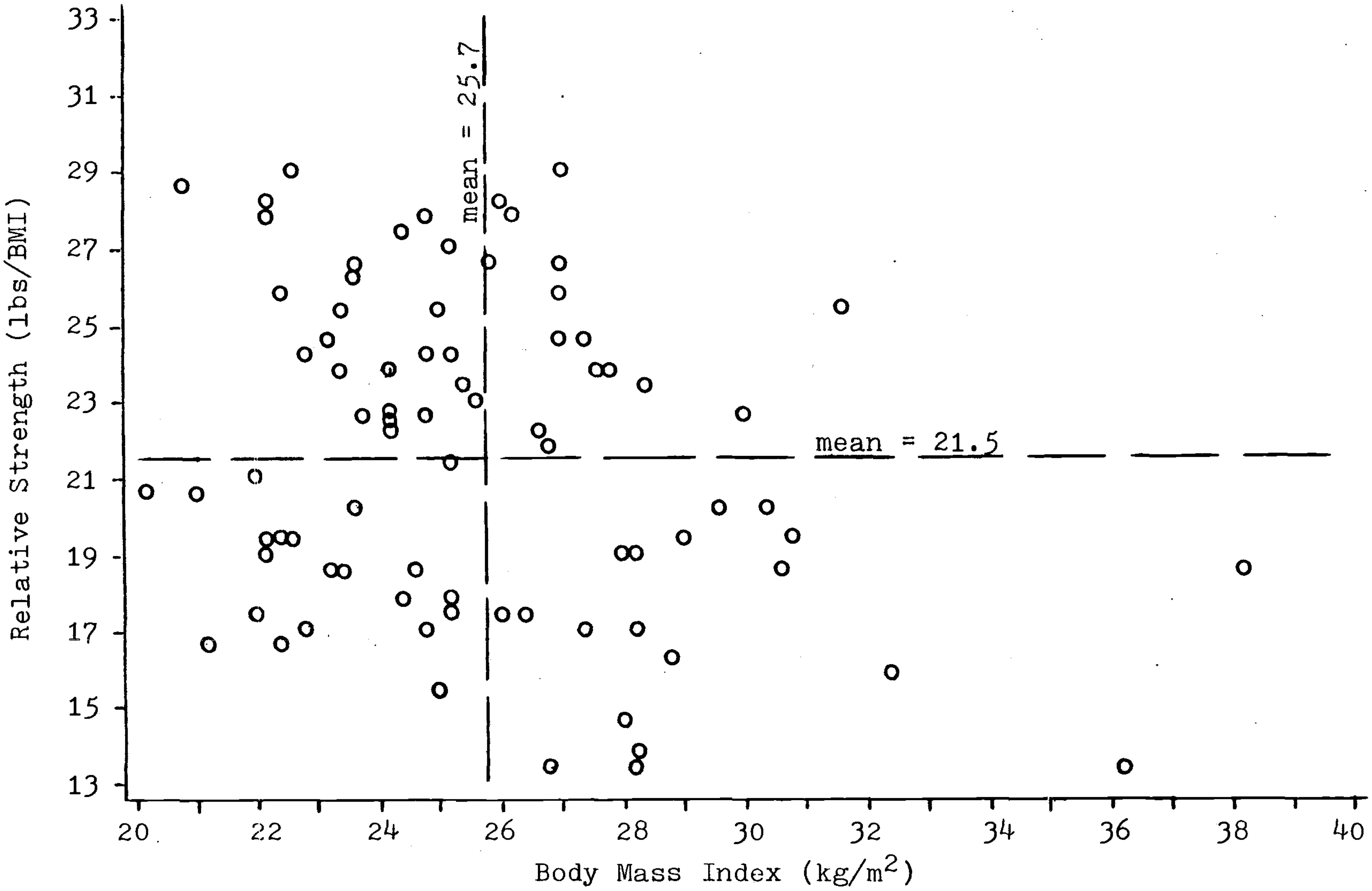

Relative Strength (lbs/BMI)
Body Mass Index (kg/m2)
mean = 25.7
mean = 21.5
13
15
17
19
21
23
25
27
29
31
33
20
22
24
26
28
30
32
34
36
38
40

Figure 12

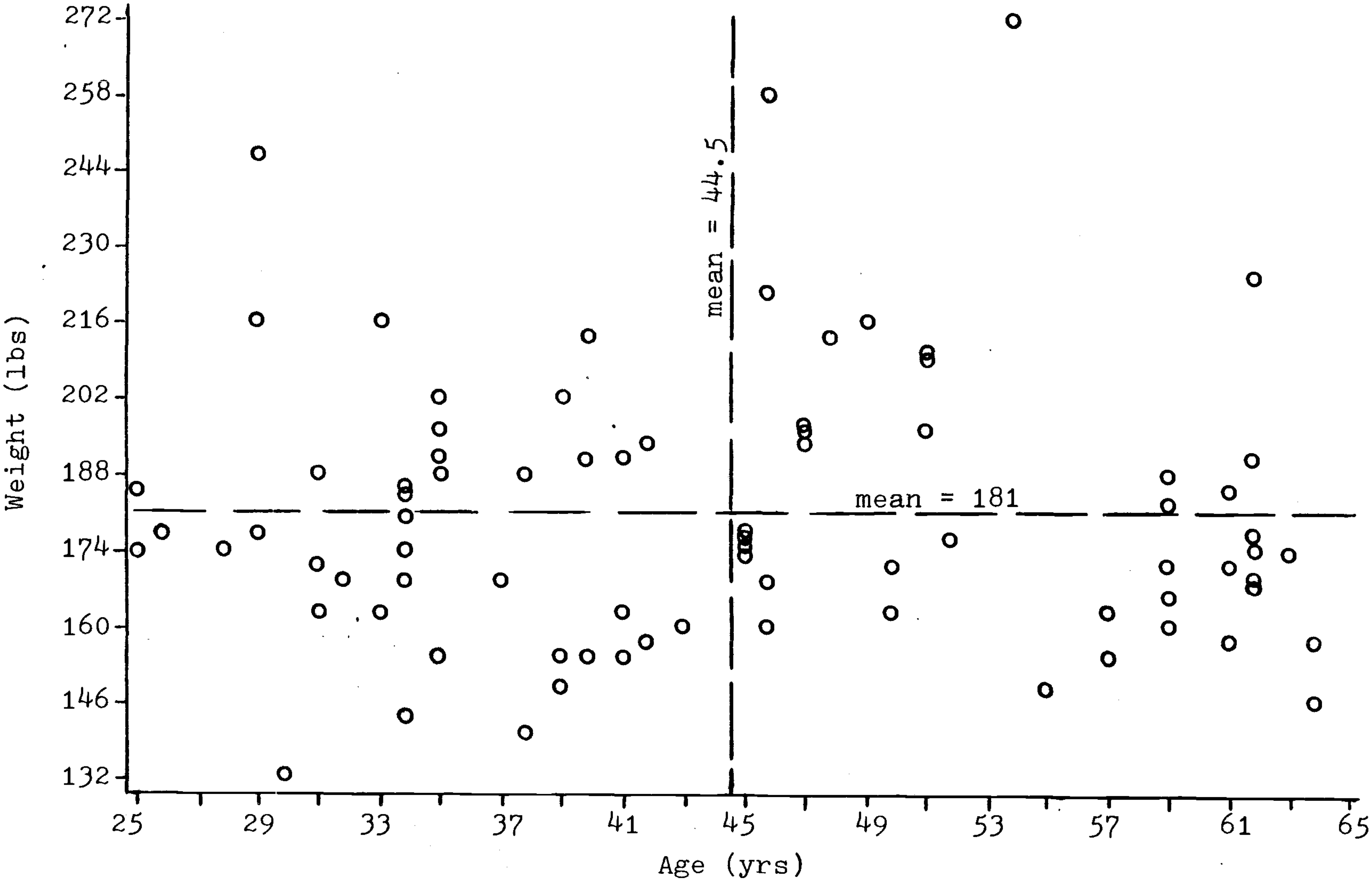
first test administered (LP) and strongest (.4000) for the last test (BNP). Since there was only one testing session in this study, it's possible that as the subjects performed each test they became more comfortable with the test protocol and may have worked harder in successive tests.

Last, there was no association between age and WT or BMI in this study. It has been reported that aging results in an increase in body weight, usually in the form of fat (Astrand & Rodahl, 1977; deVries, 1966; Lamb, 1978). Although the weight gain of the 45-54 age group has been previously discussed, overall, older subjects were not heavier than younger subjects (see Figure 13). This result, along with the RPE finding, supports the strength data which suggests that active subjects may respond to the aging process differently than their inactive counterparts.

Several members of the oldest age group had lifestyles which would seem to support this conclusion. One 59 year old was one of the two strongest subjects tested in the study (see Figures 7 & 8). This individual managed a sewing machine shop for over 30 years, and regularly played recreational handball and did non-competitive strength training, which he continues to do. Another 59 year old was a former physical education teacher and had always been mildly active including regularly lifting light weights.

After being tested, a number of subjects from the two older age groups (45-54 & 55-64) commented on several

Figure 13. Scattergram of Weight and Age (N = 80; r = -.03171).



272
258
244
230
216
202
188
174
160
146
132
Weight (lbs)
mean = 44.5
mean = 181
25
29
33
37
41
45
49
53
57
61
65
Age (yrs)

Figure 13

consequences of being part of the study. First, many of those not strength training prior to the study, began doing so. Second, on returning to the weight room, a number of subjects found they were able to lift considerably more weight than when they were tested. This last comment supports the concept of specificity (practice) which was discussed earlier with regard to results of the seated rowing test (see Table 7).

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The loss of muscular strength is one of the many consequences of aging cited by gerontologists. The general consensus of cross sectional studies performed during the past 150 years is that by age 60, inactive subjects have 80 per cent of the maximum isometric strength present at age 30. Efforts to encourage older inactive individuals to participate in physical activity are often hampered by their fear of the risks associated with exercise. This hesitancy has been linked to an underestimation of their physical abilities and an overestimation of the strenuousness of the activity.

The purpose of this study was to measure muscular strength and perceived exertion of active men, 25 to 64 years old. For comparative purposes, 20 apparently healthy men from four age groups (25-34, 35-44, 45-54, and 55-64) were recruited from the membership of a large YMCA. To qualify for the study, subjects were required to have been active a minimum of three times per week, for one year or longer. Bodybuilders, weightlifters, or individuals engaged in a formal strength training program were not recruited.

Each subject completed a five question spare time physical activity survey to gain information about the subject's past activity and strength training habits.

Strength measurement consisted of assessing the 10-RM strength of six different muscle groups (three upper body and three lower body). The exercises selected to represent the strength of each muscle group were, in the order of performance, leg press, leg curl, leg extension, decline press, seated rowing, and behind neck pulldown. The tests were administered in the YMCA's main weight room utilizing conventional Nautilus and Universal machines.

Upon completion of the last strength test, each subject indicated his perception of the strenuousness of the strength tests by selecting a number from Borg's scale of perceived exertion. All subjects completed the six strength tests without any apparent discomfort. The sum of the weights lifted in each 10-RM test represented the subject's Total Body Strength. To account for differences in body size, Total Body Strength was divided by the subject's Body Mass Index and this ratio was termed Relative Strength. Comparisons between age groups were made to ascertain if there was a difference in Relative Strength or Rating of Perceived Exertion.

Conclusions

Relative Strength was less for each successively older age group. The Relative Strength of the 55-64 age group was 72 per cent of the value for the 25-34 age group; however this difference may be exaggerated. The number of subjects using the weight room was less in the older age groups. Of the 20 subjects in each group, the 55-64 group had 8 members using the weight room regularly versus 17 for the 25-34 group; therefore, since there was one testing session, more of the older subjects were less skilled in performing the exercise movement for each strength test. Regardless, there were young and old subjects with similar Relative Strength values; in fact, the two strongest subjects were 35 and 59 years old.

There was a low correlation (.3682) between Relative Strength and the length of time (years) subjects had been using the weight room. This is contrary to what would be expected in a strength training program and suggests that a gap exists between performance and capacity for all subjects, regardless of their familiarity with the strength exercises. The width of this gap may depend on factors affecting the self motivation of each subject (goals, prior experiences, inhibitions, ect.).

The Rating of Perceived Exertion for the strength test was similar for all age groups. The two younger age groups perceived the strength test as "somewhat hard" (13 on the Borg scale), while the two older groups perceived the test about one unit less (12). A difference of one unit was not considered significant due to the subjective nature of the rating scale. In addition, subjects often responded with two consecutive numbers (10 or 11, 13 or 14, ect.) and the higher number was recorded.

The lower perception of effort by the older age groups may also be associated with the larger number of subjects in these groups that were unfamiliar with the weight room. During the test administration, it was obvious that subjects unfamiliar with the equipment and exercises were more hesitant to increase the weight. In fact, a number of subjects did not want to increase the light weight originally selected for demonstration purposes. This hesitancy appeared to result more from fear of failure to complete the activity than fear of the activity itself. Consequently, it's possible that some older and younger subjects completed the 10-RM strength tests with weights that were too light physiologically, but heavy enough psychologically.

Recommendations (Applied)

With respect to the data analyses, observations, and review of the literature that occurred during this study, the following recommendations are proposed:

1. Gerontologists, physical educators, and other health practitioners should use caution in claiming that age is the sole factor responsible for the difference in muscular strength between younger and older individuals. Level and type of physical activity, amount and intensity of

strength training, body fat, particular muscles tested, occupation, and testing protocol are additional factors that may affect the results of strength tests.

2. The 10-RM protocol, which is frequently used to develop strength, is acceptable for the strength evaluation of young and old individuals. In this study, 10-RM strength was determined in three or less trials, and all subjects completed the strength tests without any complaints or incidents.

3. Measurement of individual strength should reflect an adjustment for body size. Total Body Strength had a low positive correlation (.3193) with body weight; whereas, Relative Strength had a low negative correlation (-.2011) with body weight. This suggests that the additional body weight of some subjects may have been in the form of fat, which did not contribute sufficiently to the strength of all muscle groups.

4. Strength evaluation involving older sujects should represent the results of measuring the strength of major lower and upper body muscle groups. Differences in individual muscle group strength values between the 25-34 and 55-64 age groups varied from 17 per cent (seated rowing) to 34 per cent (decline press). Selection of one or two muscle groups for testing may significantly alter the outcome.

Recommendations (Research)

This study was one of the few attempts to gather strength information from a sample of active subjects. From the previous discussion, it is apparent that active older subjects may respond differently to physical evaluation than inactive older subjects; therefore, the following suggestions for future research on the relation between strength and aging are proposed:

1. Familiarity with the strength tests needs to be controlled. How much practice should be allowed before administering the test protocol needs to be investigated.

2. Subjects in this study were active non-competitive men. Relative Strength and Rating of Perceived Exertion comparative data needs to be collected from inactive and competitive male subjects, as well as from all three categories of female subjects.

3. Since the most popular forms of strength evaluation are isometric and isokinetic testing, a comparison with the 10-RM protocol is needed to examine the nature of the relationship between methods.

4. Develop Relative Strength and Rating of Perceived Exertion data on subjects with different primary physcial activities (running, swimming, racquetball, ect.). This would provide additional basis for recommending periodic changes to an individual's exercise program.

5. As with all of the physiological changes associated with aging, longitudinal data are needed to truly assess the effects of aging on muscular strength.

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APPENDICES

APPENDIX A

Muscular Strength of Active Men: 25 to 64 Years of Age

Informed Consent

The research project in which you will participate is designed to gather information about the strength of active men. Your height and weight will be recorded. For each of six exercises, you will estimate the weight that will allow one set of 8 to 12 repetitions to be performed. Upon completion of the six exercises, you will give a rating of perceived exertion.

The measurement of strength will proceed as follows:

1. You will be asked to warm-up for five minutes with a walk and/or easy jog and any stretching that you might normally do prior to a workout.

2. You will perform the following six exercises in the Nautilus weightroom: leg press, leg curl, leg extension, decline press, seated rowing, and behind neck pulldown.

3. An instructor will position you for each exercise and set the weight at 50 percent of the weight you selected for the exercise. You will perform several repetitions and corrections to your technique, if necessary, will be made.

4. The instructor will set the selected weight and you will perform the exercise. If less than 8 or more than 12 repetitions are done, the weight will be adjusted accordingly. After a rest of two minutes, the exercise will be repeated. This process will continue until 8 to 12 repetitions are done.

5. After the last exercise, you will indicate how you perceived the strenuousness of the exercises by selecting a number from a chart of perceived exertion ratings.

This is a measure of submaximal strength; however, there may be discomforts and possible dangers. If you hold your breath while performing an exercise, pressure inside your chest may increase. Lightheadedness, fainting, chest pain, and even heart attack may occur. Other risks of injury to bones, muscles, and connective tissue while performing the exercises are possible.

If a life-threatening situation should occur during testing, the Y's standard emergency procedure will be followed. Locker control, which ajoins the weight room, will be notified immediately that a Code 4 situation exists. Cardiopulmonary resuscitation (CPR), if necessary, will begin. Locker control will call the paramedics and announce over the public address system that a Code 4 exists in the Nautilus weight room. All Y staff are trained to respond immediately to this announcement. Paramedics may be expected to arrive in approximately two minutes.

You SHOULD NOT participate in this study if you have any of the following: high blood pressure, frequent nosebleeds or headaches, heart or circulatory problems, spinal (neck, back) or joint problems, seizures, recent concussion or any symptom or condition that might require medical examination or treatment.

Participation in this study is voluntary. You may stop or withdraw from the study at any time without prejudice. Your data will be kept confidential. Results of the study will be presented by group and individual performances will remain anonymous.

This project is being coordinated by John LeMarr (Dept. of Physical Education, Oregon State University), Steve Johnson, and Steve Triller (Tacoma YMCA). If you have any questions pertaining to the study, your rights as a participant, or should you suffer a research-related injury, contact one of these individuals.

In signing this consent form, you state that you have read and understand the description of the study. Any questions you may have were answered to your satisfaction. You agree to enter into the study voluntarily and understand that you may withdraw at any time without penalty. Every effort will be made to insure your health and safety.

PRINT NAME	SIGNATURE	DATE

Spare-Time Physical Activity

Four different activity levels are described below. Please read each and answer the questions that follow.

Group 1	Group 2
Almost completely inactive: Reading, watching TV, movies, etc.	Some mild physical activity once or twice weekly: riding a bike, walking, softball, yard work, etc.

Group 3	Group 4
Regular physical activity three or more times a week for general fitness: cycling, running, racquetball, etc.	Regular hard physical activity for competition in any sport, four or more times per week.

1. Which group best describes your activity for the past year? ____________

2. Indicate the group that best describes your activity for the last 10 years.

   1982 - 1986 __________ 1977 - 1981 __________

3. Indicate your primary activity. __ SWIMMING __ CYCLING __ RACQUETBALL __ RUNNING __ BASKETBALL __ HANDBALL __ AEROBICS (OTHER) ____________________________

4. Do you use the weight room on a regular basis? __Y __N

   If yes, how often? ____TIMES/WEEK ____ TIMES/MONTH

   How long have you lifted weights? ________________

5. If NO on (4), is there a particular reason that you don't use the weight room? ____________________

   ____

Data Collection Sheet

DATE ______________

NAME _________________________ AGE _____

HEIGHT: in socks, heels together & against wall, stretch, chin level, record to nearest 1/4 inch.

HEIGHT (48) + ______ = _______ in

WEIGHT: weigh in socks, shorts, & t-shirt (note difference), record to nearest 1/2 pound.

WEIGHT ________ lbs ______________________________________

* Subject estimates initial weight.

	* Weight/Reps	Weight/Reps	Weight/Reps
Leg Press	______/____	______/____	______/____
Leg Extension	______/____	______/____	______/____
Leg Curl	______/____	______/____	______/____
Decline Press	______/____	______/____	______/____
Rowing	______/____	______/____	______/____
Lat Pulldown	______/____	______/____	______/____

PERCEIVED EXERTION ______

1. Perform exercises in order listed.
2. Set weight at 50% of selected value.
3. Position subject properly and check technique with several reps; explain perceived exertion.
4. Set weight and record reps. If 8 to 12 reps completed go to next exercise.
5. Stop the exercise if 13 reps completed and adjust weight. Allow 2 minute rest and repeat.
6. When finished, get rating of perceived exertion.

PERCEIVED EXERTION SCALE

6
7 VERY, VERY LIGHT
8
9 VERY LIGHT
10
11 FAIRLY LIGHT
12
13 SOMEWHAT HARD
14
15 HARD
16
17 VERY HARD
18
19 VERY, VERY HARD
20

APPENDIX B

Muscular Strength of Active Men

The purpose of this study is to measure the strength of ACTIVE members, 25 to 64 years of age. This is NOT a test of how much weight you can lift.

You will select the weight for each of the six exercises shown on the following page. The weight you select should allow you to complete one set of 8 to 12 repetitions using good form. Your performance will be corrected for your height and weight to obtain a Personal Indicator of Effort.

Regardless of the outcome, your participation is important. Individual results will remain confidential, but all data will be combined to establish a basis for comparison with tests on INACTIVE individuals.

Volunteers should meet the following requirements:

1. You should have been ACTIVE for one (1) year or longer. Active means three (3) or more periods of recreational activity per week.

2. You should NOT be a power lifter, bodybuilder, or competitive athlete engaged in a formal strength training program.

****

If you would like to volunteer, please return this sheet to locker control with answers to the following:

NAME ______________________________ PHONE ______________

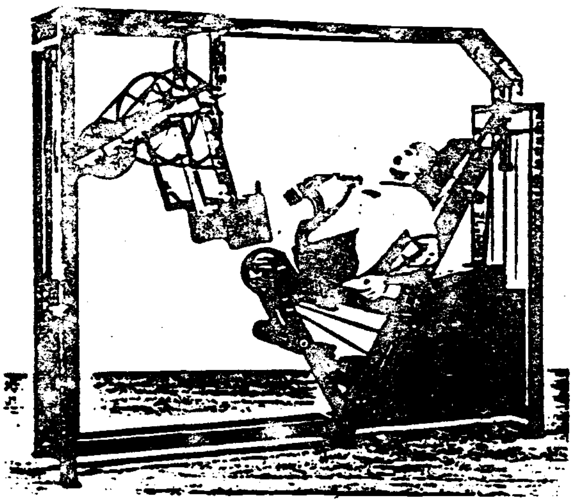
CIRCLE THE DAY(S) YOU VISIT THE Y.

SUN MON TUE WED THUR FRI SAT

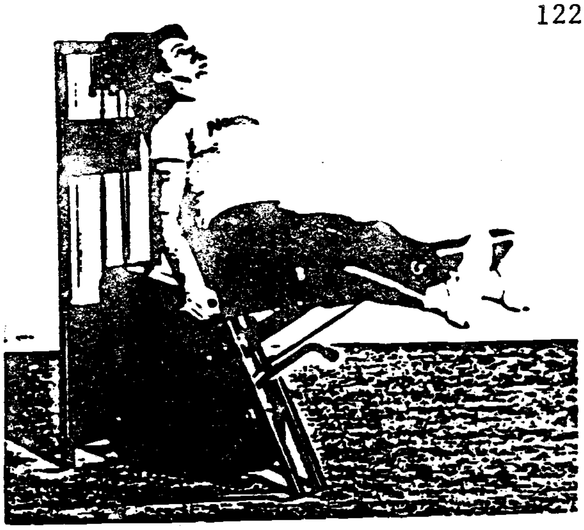
CIRCLE THE TIME OF YOUR VISIT.

Morning Afternoon Evening

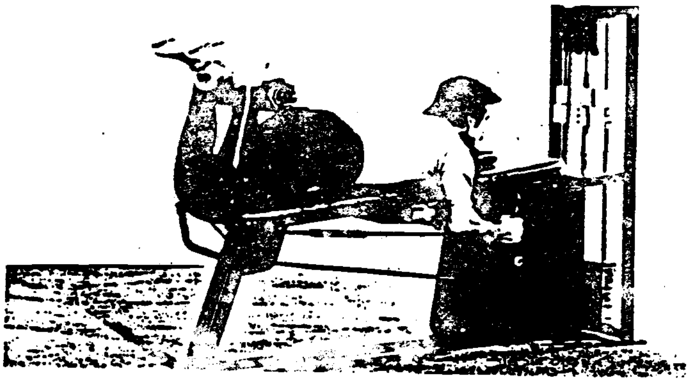
6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9



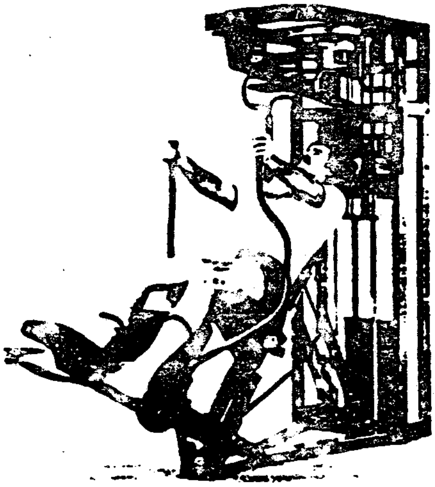
Leg Press (Nautilus)



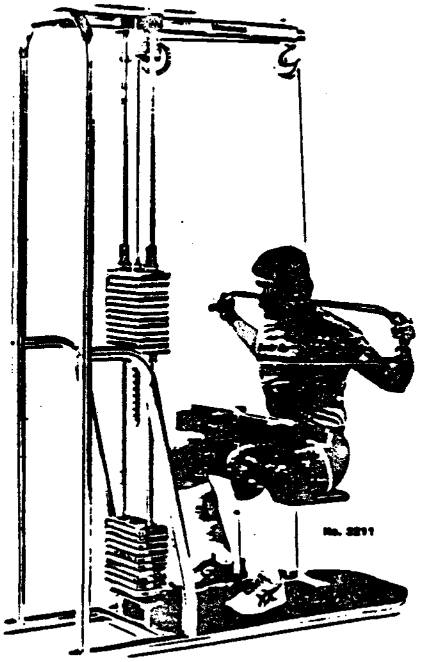
Leg Extension (Nautilus)



Leg Curl (Nautilus)



Decline Press (Nautilus)



Behind Neck Pulldown (Universal)

Rowing (Nautilus)

APPENDIX C

Nautilus Training Principles

General procedures to be followed on all machines where the "normal" (positive-negative) movements are performed:

1. Make certain that the rotational axis of the cam of all rotary exercises is in-line with the joint axis of the body part that is being moved.

2. Position your body in a straightly aligned manner. Avoid twisting or shifting your weight during the movement.

3. Maintain a loose, comfortable grip. Never squeeze the handgrips tightly as this results in elevated blood pressure.

4. Lift resistance or perform positive work to the count of two . . . pause . . . lower the resistance or perform negative work slowly and smoothly while counting to four.

5. Use as much of your range of motion as possible on each machine to develop full-range strength and flexibility.

6. Breathe normally. Try not to hold your breath while training.

7. Perform each exercise for 8 to 12 repetitions:

   a. Begin with a weight you can comfortably do 8 times.
   b. Stay with that weight until you can perform 12 strict repetitions. On the following workout, increase the weight by approximately 5% which should result in your inability to perform more repetitions than the minimum guideline dictates.
   c. Try to progress in repetitions and/or resistance in each successive workout.

8. Move quickly from machine to machine. The longer the rest between machines, the less effective the cardiovascular conditioning.

9. Follow your routine as the exercises are numbered on your workout sheet; however, any time the machine you are to do next is being used, go to another exercise and then return to the machine that was in use.

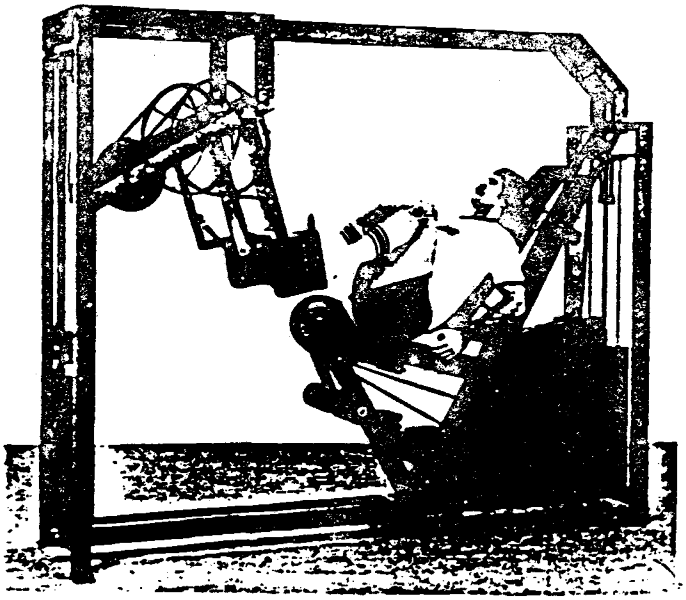
10. Move very quickly — in less than 3 seconds — from the primary exercise to the secondary exercise in all double Nautilus machines.

11. Include a maximum of 12 exercises, 4 to 6 for the lower body and 6 to 8 for the upper body.

12. Exercise the larger muscle groups first and proceed down to the smaller muscle groups. Example: hips, thighs, back, shoulders, chest, arms, and neck.

13. Finish your entire workout in 20 to 30 minutes.

14. Rest a minimum of 48 hours and not more than 96 hours between successive workouts.



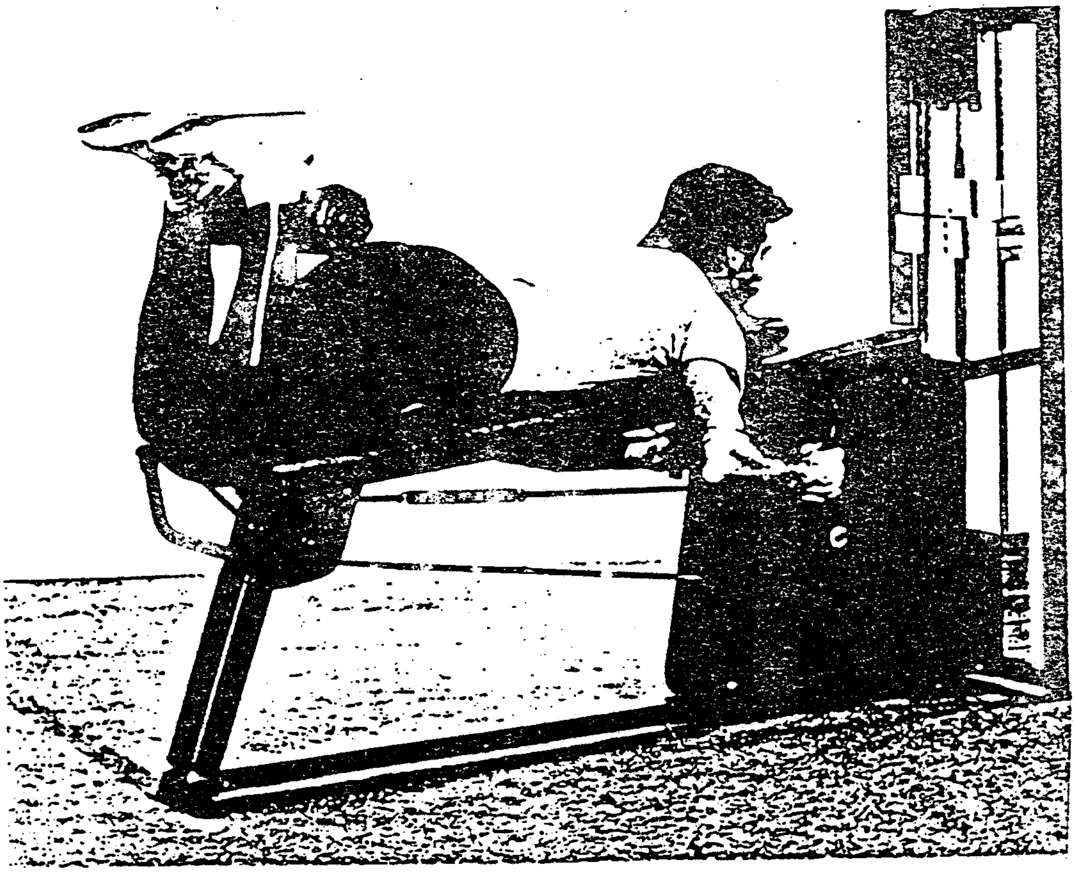
Compound Leg Machine

(Nautilus)

Leg Press (Quadriceps, hamstrings, and gluteus maximus)

1. Sit erect and pull seat back forward.
2. Flip down foot pads.
3. Place both feet on pads with toes pointed slightly inward.
4. Straighten both legs in a controlled manner.
5. Return to stretched position and repeat.

   Important: Avoid tightly gripping handles and do not grit teeth or tense neck or face muscles during either movement.



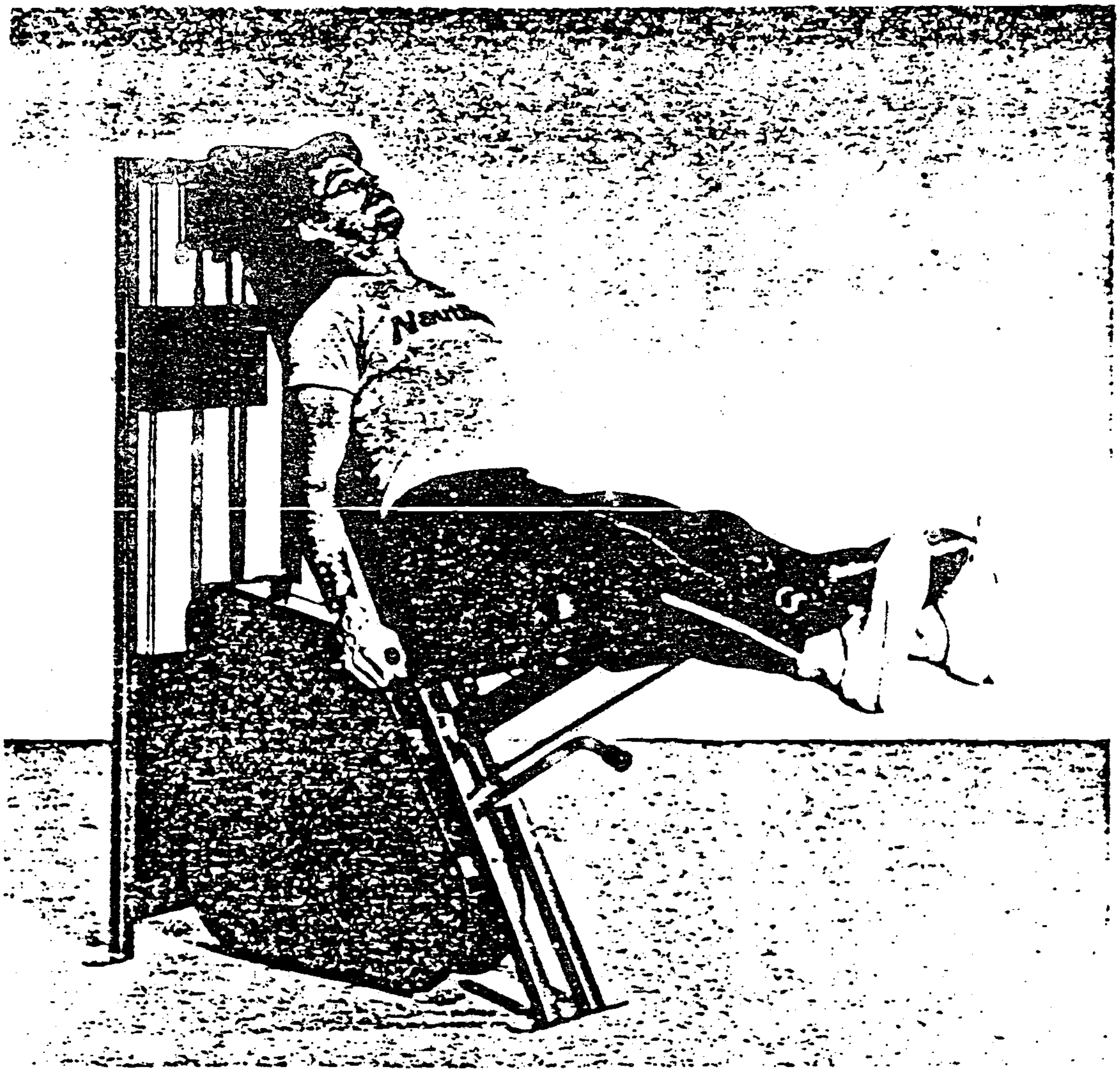
Leg Curl Machine

(Nautilus)

(Hamstrings)

1. Lie face down on machine.
2. Place feet under roller pads with knees just over edge of bench.
3. Grasp handles to keep body from moving.
4. Curl legs and try to touch heels to buttocks.
5. Lift buttocks to increase range of movement.
6. Pause at point of full contraction.
7. Lower resistance and repeat.

Important: Top of foot should be flexed toward knee throughout movement.

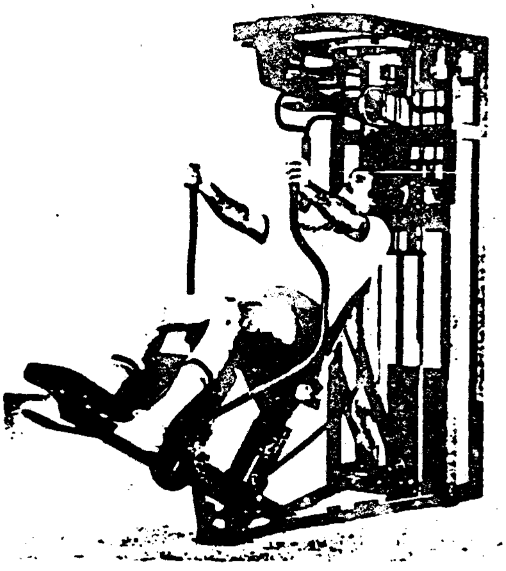


Leg Extension Machine
(Nautilus)

(Frontal thighs or quadriceps)

1. Place feet behind roller pads, with knees snug against seat.
2. Adjust seat back to comfortable position.
3. Keep head and shoulders against seat back.
4. Straighten both legs smoothly.
5. Pause.
6. Lower resistance slowly and repeat.

Important: Avoid tightly gripping handles and do not grit teeth or tense neck or face muscles during movement.



Double Chest Machine
(Nautilus)

Decline Press (Chest, shoulders, and triceps of arms)

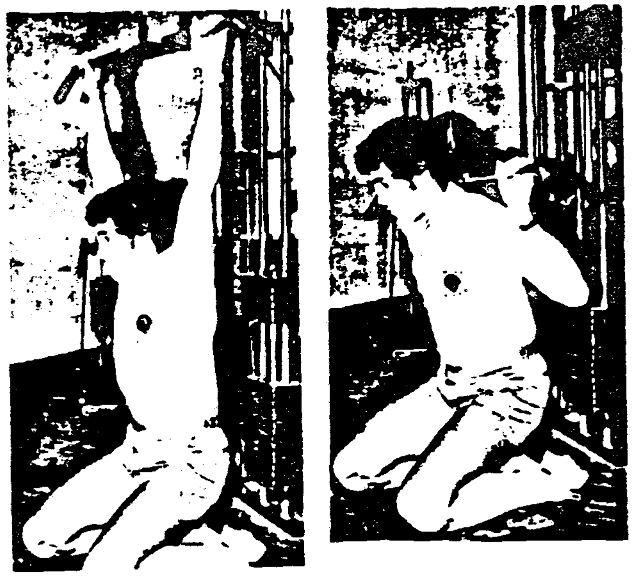
1. Use foot pedal to raise handles into starting position.
2. Grasp handles with parallel grip.
3. Keep head back and torso erect.
4. Press bars forward in controlled fashion.
5. Lower resistance slowly, keeping elbows wide.
6. Stretch in bottom position and repeat pressing movement.

Rowing Torso Machine
(Nautilus)

(Deltoids and trapezius)

1. Sit with back toward weight stack.
2. Place arms between pads and cross arms.
3. Bend arms in rowing fashion as far back as possible.
4. Pause.
5. Return slowly to starting position and repeat.

   Important: Keep arms parallel to floor at all times.



BEHIND NECK PULLDOWN

(Latissmus dorsi, posterior deltoid, biceps, brachialis, teres major, and teres minor)

The BNP was performed on a Universal high pulley exercise station. The subject sat on a small stool facing the weight stack and performed the exercise as follows:

1. An overhand, shoulder-width grip was used.

2. The subject leaned forward and pulled the bar downward to a position at the base of the neck.

3. After a brief pause, the bar was returned to the starting position.

* Pressure was applied to the subject's shoulders, if necessary, to keep him from raising off the stool.

APPENDIX D

10-RM Muscular Strength of Active Men

Data for Men 25 to 34 Years of Age

AGE (YRS); HT (IN); WT, LP, LE, LC, DP, ROW, BNP (LBS)

		AGE	HT	WT	LP	LE	LC	DP	ROW	BNP	RPE
1.	BA	33	67.25	163.0	125	115	65	95	60	130	14
2.	NB	31	69.00	170.0	190	120	80	120	45	125	15
3.	DB	34	70.00	175.0	140	130	75	115	40	110	10
4.	SC	34	66.75	143.0	170	160	70	100	55	100	14
5.	DC	33	71.50	217.0	170	115	85	105	65	130	13
6.	TC	28	74.50	174.0	110	85	55	95	45	75	14
7.	CF	25	67.50	175.0	180	145	90	115	45	125	9
8.	SF	31	71.00	188.0	155	135	80	135	75	150	15
9.	GG	26	72.50	176.0	145	130	70	115	50	120	15
10.	SJ	31	70.00	163.0	140	90	60	125	50	130	15
11.	AK	29	70.75	217.0	120	110	65	100	60	110	11
12.	ML	29	74.00	246.0	220	140	110	130	65	140	12
13.	JN	34	72.50	185.0	145	110	60	95	50	105	11
14.	DO	34	74.25	179.0	110	100	60	105	50	130	16
15.	SS	25	71.25	185.0	160	110	70	100	45	110	14
16.	MS	29	70.75	176.0	180	140	75	105	60	125	12
17.	CT	30	67.75	132.0	90	80	50	75	30	90	15
18.	DW	34	76.75	185.0	110	130	90	105	60	120	15
19.	DW	32	68.50	167.0	200	130	60	100	40	110	13
20.	BY	34	71.00	169.0	180	100	70	105	50	110	14

10-RM Muscular Strength of Active Men

Data for Men 35 to 44 Years of Age

		AGE	HT	WT	LP	LE	LC	DP	ROW	BNP	RPE
21.	AA	35	67.00	154.0	120	110	65	95	55	95	13
22.	JC	41	70.25	163.0	120	80	60	130	55	125	13
23.	SD	40	70.25	192.0	150	130	80	120	70	125	13
24.	JD	41	72.25	155.0	100	75	45	70	45	100	11
25.	DD	35	74.50	203.0	140	170	100	85	60	130	15
26.	BE	35	71.25	188.0	150	140	90	135	70	150	17
27.	WF	35	70.00	192.0	170	155	80	95	50	110	13
28.	JG	41	70.50	191.5	150	170	60	110	60	120	14
29.	RH	42	67.75	158.0	130	110	70	100	50	120	12
30.	MJ	39	66.00	150.0	135	100	70	90	50	105	13
31.	JM	38	70.00	187.0	140	100	70	110	55	110	13
32.	GM	39	70.00	155.0	150	150	60	105	45	120	10
33.	JM	40	70.25	213.0	160	120	75	100	50	110	13
34.	BP	37	66.50	169.0	200	120	70	130	65	130	11
35.	PR	42	68.75	194.0	130	100	65	100	55	110	11
36.	MR	40	66.75	155.0	100	90	60	75	45	90	14
37.	BS	39	71.25	201.0	150	130	100	100	65	120	15
38.	MS	38	68.75	140.0	140	120	70	100	35	130	13
39.	SS	35	72.25	197.0	140	115	75	95	55	110	12
40.	BW	43	68.75	160.0	125	110	65	85	50	100	14

10-RM Muscular Strength of Active Men

Data for Men 45 to 54 Years of Age

		AGE	HT	WT	LP	LE	LC	DP	ROW	BNP	RPE
41.	MB	46	71.00	221.0	165	120	75	90	50	100	12
42.	TC	50	70.25	164.0	100	70	50	90	40	85	13
43.	WD	50	73.5	172.0	115	85	55	60	40	80	11
44.	GD	46	68.25	161.5	100	85	50	70	40	85	12
45.	JE	51	70.5	197.0	110	90	60	95	80	100	13
46.	GF	49	73.50	216.0	145	110	55	75	55	95	10
47.	JF	46	71.00	259.0	120	90	60	75	55	90	13
48.	JH	45	70.25	176.0	110	90	60	65	45	75	12
49.	WH	52	73.00	177.0	130	100	60	100	45	120	11
50.	PH	45	71.75	177.0	135	100	70	75	50	115	13
51.	GH	51	72.50	211.0	130	80	65	80	45	85	12
52.	LJ	51	70.75	211.0	140	130	60	110	45	115	13
53.	JK	47	69.50	195.0	190	130	60	120	60	110	13
54.	HL	48	73.00	213.0	90	80	40	60	35	80	9
55.	JL	45	73.75	173.0	145	100	60	95	55	120	12
56.	BM	54	70.75	271.0	180	110	60	130	75	150	14
57.	RS	45	69.50	173.0	135	95	55	100	40	110	10
58.	AV	46	69.75	169.0	165	150	85	95	65	115	13
59.	PW	47	69.25	196.0	120	75	45	100	50	80	9
60.	CZ	47	72.50	194.0	110	90	50	70	45	90	11

10-RM Muscular Strength of Active Men

Data for Men 55 to 64 Years of Age

	AGE	HT	WT	LP	LE	LC	DP	ROW	BNP	RPE
61. JB	61	71.75	184.0	100	80	50	75	45	90	13
62. PB	61	71.00	158.0	90	75	50	50	40	80	13
63. RB	59	65.25	159.0	110	75	45	80	50	95	12
64. TC	64	67.50	147.0	95	70	50	55	40	80	9
65. JE	62	69.00	190.0	90	75	35	65	40	75	9
66. DE	62	70.75	168.0	130	80	40	70	45	110	13
67. RG	63	67.50	173.0	100	70	40	50	30	70	13
68. BH	59	72.50	165.0	100	70	45	80	40	85	11
69. KH	55	70.25	148.0	80	65	45	55	35	70	11
70. IK	59	69.75	171.0	140	130	70	95	60	100	13
71. JK	62	70.00	225.0	130	100	60	90	40	90	11
72. JM	64	70.50	156.0	90	90	50	70	35	90	15
73. LN	59	68.50	187.0	105	90	50	55	40	70	12
74. CN	57	70.50	164.0	125	80	45	65	40	80	12
75. LN	59	68.75	181.0	170	200	70	130	70	140	13
76. PR	57	69.75	154.0	105	65	45	50	35	70	13
77. DS	62	72.50	168.0	110	75	45	75	40	90	13
78. JS	62	70.25	174.0	90	70	45	65	50	100	11
79. BS	62	67.50	177.0	110	85	50	85	40	100	12
80. RZ	61	69.75	172.0	90	65	55	60	40	70	11

Activity Levels and Strength Training History of Active Men: 25 to 34 Years of Age

		Primary Activity	Activity Level '86	'82-'86	'77-'81	Strength Training Time (yrs)	Frequency Times/Wk
1.	BA	Swimming	3	4	4	17	2-3
2.	NB	Swimming	3	2	2	1	3
3.	DB	Cycling	3	2	2	.5	3
4.	SC	Multiple	4	3	3	2	2-3
5.	DC	Multiple	3	3	3	2	2
6.	TC	Multiple	4	4	4	2.5	2-3
7.	CF	Swimming	3	3	4	10	3
8.	SF	Swimming	4	3	4	15	1
9.	GG	Running	3	2	2	7	3
10.	SJ	Swimming	3	3	4	0	0
11.	AK	Multiple	3	3	1	3	3
12.	ML	Multiple	3	3	4	10	2
13.	JN	Running	4	4	3	0	0
14.	DO	Multiple	4	4	4	5	3
15.	SS	Swimming	4	4	4	5	2-3
16.	MS	Swimming	3	3	4	0	0
17.	CT	Running	3	3	3	5	2
18.	DW	Running	4	4	4	8	3
19.	DW	Multiple	3	3	3	2	1-2
20.	BY	Multiple	3	3	4	8	2

Activity Levels and Strength Training History of Active Men: 35 to 44 Years of Age

	Primary Activity	Activity Level '86	'82-'86	'77-'81	Strength Training Time (yrs)	Strength Training Frequency Times/Wk
21. AA	Racq'ball	3	4	4	0	0
22. JC	Running	3	3	1	1	3
23. SD	Running	3	3	2	2	2
24. JD	Swimming	3	3	3	2	3
25. DD	Running	3	3	3	0	0
26. BE	Multiple	3	3	3	5	2
27. WF	Running	3	3	2	15	1-2
28. JG	Aerobics	3	3	3	20	3-4
29. RH	Running	3	2	3	0	0
30. MJ	Aerobics	3	2	2	1	2
31. JM	Racq'ball	3	4	3	.25	2
32. GM	Racq'ball	3	3	2	5	3
33. JM	Multiple	3	3	2	2	2
34. BP	Running	3	3	3	15	2
35. PR	Running	3	3	2	0	0
36. MR	Swimming	3	2	1	0	0
37. BS	Aerobics	3	3	2	3	2
38. MS	Running	3	3	3	18	2-3
39. SS	Running	3	3	2	.25	2-3
40. BW	Running	3	4	3	3	2

Activity Levels and Strength Training History

of Active Men: 45 to 54 Years of Age

	Primary Activity	Activity Level '86	'82-'86	'77-'81	Strength Training Time (yrs)	Frequency Times/Wk
41. MB	Aerobics	3	3	2	0	0
42. TC	Multiple	3	3	4	0	0
43. WD	Racq'ball	3	1	2	0	0
44. GD	Running	3	3	3	0	0
45. JE	Running	4	4	3	4	3-4
46. GF	Multiple	3	3	3	1.5	2
47. JF	Racq'ball	3	3	3	.5	2
48. JH	Multiple	3	3	2	3	1
49. WH	Running	3	3	2	.25	2
50. PH	Multiple	3	3	3	7	2-3
51. GH	Multiple	3	3	3	2	2
52. LJ	Multiple	4	4	3	36	2
53. JK	Multiple	4	4	4	10	2
54. HL	Running	3	3	3	0	0
55. JL	Multiple	3	3	3	12	3
56. BM	Racq'ball	3	2	2	0	0
57. RS	Running	3	3	4	0	0
58. AV	Handball	4	4	3	2	1
59. PW	Running	3	3	2	3	3
60. CZ	Racq'ball	3	3	2	0	0

Activity Levels and Strength Training History of Active Men: 55 to 64 Years of Age

	Primary Activity	Activity Level '86	'82-'86	'77-'82	Strength Training Time (yrs)	Frequency Times/Wk
61. JB	Racq'ball	3	3	2	3	3
62. PB	Running	3	3	2	0	0
63. RB	Racq'ball	3	3	3	0	0
64. TC	Handball	4	4	4	0	0
65. JE	Racq'ball	3	3	3	0	0
66. DE	Racq'ball	3	2	2	2	2-3
67. RG	Swimming	3	3	2	0	0
68. BH	Running	3	3	3	0	0
69. KH	Swimming	3	3	3	0	0
70. IK	Multiple	3	3	3	3	3
71. JK	Walking	3	3	3	0	0
72. JM	Running	3	2	2	0	0
73. LN	Racq'ball	3	3	2	1.5	2-3
74. CN	Running	3	3	3	.5	3-4
75. LN	Handball	3	3	3	30	3
76. PR	Swimming	3	3	2	0	0
77. DS	Swimming	3	3	3	0	0
78. JS	Running	3	3	3	20	3
79. BS	Running	3	3	2	0	0
80. RZ	Racq'ball	3	2	3	1.5	3

10-RM Strength of Active Men: 25 to 64 Years of Age

(Reasons for not Strength Training)

	Age	Primary Activity	Reason for not Strength Training
10. SJ	31	Swimming	Likes aerobic type exercises
13. JN	34	Running	Gets strength from kayak paddling
16. MS	29	Swimming	Hates weights
21. AA	35	Racq'ball	Lack of interest
25. DD	35	Running	Just began lifting
29. RH	42	Running	Dislikes machines
35. PR	42	Running	No time
36. MR	40	Swimming	Just began lifting
41. MB	46	Aerobics	No specific reason
42. TC	50	Multiple	Does calisthenics
43. WD	50	Racq'ball	No specific reason
44. GD	46	Running	No time
54. HL	48	Running	Doesn't feel it's necessary
56. BM	54	Racq'ball	No specific reason
57. RS	45	Running	Lack of motivation
60. CZ	47	Racq'ball	Not interested
62. PB	61	Running	No specific reason
63. RB	59	Racq'ball	Not interested
64. TC	64	Handball	Does calisthenics
65. JE	62	Racq'ball	No specific reason
67. RG	63	Swimming	Just began lifting
68. BH	59	Running	No time

(continued)

Reasons for not Strength Training

	Age	Primary Activity	Reason for not Strength Training
69. KH	55	Swimming	No time
71. JK	62	Walking	No time
72. JM	64	Running	No time
76. PR	57	Swimming	Joint problems
77. DS	62	Swimming	No specific reason
79. BS	62	Running	Don't want to increase bulk

APPENDIX E

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COMPUTING CENTER
UNIVERSITY OF NEVADA SYSTEM

S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 8.3 (NOS) -- MAY 04, 1982

161500 CM MAXIMUM FIELD LENGTH REQUEST


                 RUN NAME        10-RM STRENGTH OF ACTIVE MEN
                 FILE NAME       ACTMEN
                 DATA LIST       FIXED(1)/1 ID 1-2 GROUP 5 AGE 8-9 HT 12-15 (2) WT 18-20
                                 LP 23-25 EL 28-30 LC 33-35 DP 38-40 ROW 43-44
                                 BNP 47-49 RPE 52-53 YTR 56-59 (2) FREQ 62 ACT 65

THE DATA LIST PROVIDES FOR   15 VARIABLES AND   1 RECORDS PER CASE.
A MAXIMUM OF  65 COLUMNS ARE USED ON A RECORD.

                 INPUT MEDIUM    DISK
                 N OF CASES      80
                 VAR LABELS      AGE SUBJECT'S AGE IN YEARS/
                                 HT HEIGHT IN INCHES/
                                 WT WEIGHT IN POUNDS/
                                 LP LEG PRESS/
                                 EL LEG EXTENSION/
                                 LC LEG CURL/
                                 DP DECLINE PRESS/
                                 ROW SEATED ROWING/
                                 BNP BEHIND NECK PULLDOWN/
                                 RPE RATING OF PERCEIVED EXERTION/
                                 YTR YEARS OF STRENGTH TRAINING/
                                 FREQ NUMBER OF STRENGTH WORKOUTS PER WEEK/
                                 ACT PRIMARY ACTIVITY/
                 VALUE LABELS    GROUP (1)25 TO 34 YEARS (2)35 TO 44 YEARS
                                 (3)45 TO 54 YEARS (4)55 TO 64 YEARS/
                                 ACT (1)AEROBICS (2)CYCLING (3)HANDBALL (4)MULTIPLE
                                 (5)RACQUETBALL (6)RUNNING (7)SWIMMING (8)WALKING
                 COMPUTE         TS=LP+EL+LC+DP+ROW+BNP
                 COMPUTE         KILOS=WT/2.2
                 COMPUTE         METERS=HT*.0254
                 COMPUTE         BMI=KILOS/(METERS**2)
                 COMPUTE         RS=TS/BMI

CPU TIME REQUIRED..       .499 SECONDS


                 ONEWAY          TS,RPE,RS BY GROUP(1,4)/POLYNOMIAL=3/
                                 RANGES = SCHEFFE (.10)/
                 OPTIONS         6
                 STATISTICS      1
                 READ INPUT DATA

        00045100 CM NEEDED FOR ONEWAY


        OPTION - 1
        IGNORE MISSING VALUE INDICATORS
        (NO MISSING VALUES DEFINED...OPTION 1 MAY HAVE BEEN FORCED)

        OPTION - 6
        USE VALUE LABELS OF INDEPENDENT VARIABLE AS GROUP LABELS
```

VARIABLE TS
BY GROUP

ANALYSIS OF VARIANCE

	SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN	GROUPS	3	383490.9375	127830.3125	16.315	.0000
	LINEAR TERM	1	358501.5625	358501.5625	45.754	.0000
	DEV.FROM LINEAR	2	24989.3750	12494.6875	1.595	.2097
	QUAD. TERM	1	22612.8125	22612.8125	2.886	.0934
	DEV.FROM QUAD.	1	2376.5625	2376.5625	.303	.5834
WITHIN	GROUPS	76	595488.7500	7835.3783		
TOTAL		79	978979.6875			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN		
25 TO 34	20	619.0000	86.8695	19.4246	415.0000	805.0000	578.3439	TO	659.6562
35 TO 44	20	602.5000	78.9487	17.6535	435.0000	735.0000	565.5509	TO	639.4491
45 TO 54	20	528.0000	89.7573	20.0703	385.0000	705.0000	485.9924	TO	570.0076
55 TO 64	20	444.2500	97.4987	21.8014	350.0000	780.0000	398.6192	TO	489.8808
TOTAL	80	548.4375			350.0000	805.0000			
	UNGROUPED DATA		111.3200	12.4460			523.6644	TO	573.2106

- -

FILE ACTMEN (CREATION DATE = 87/04/22.)

- O N E W A Y -

VARIABLE TS

MULTIPLE RANGE TEST

SCHEFFE PROCEDURE
RANGES FOR THE .100 LEVEL -

3.60 3.60 3.60

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
62.5914 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET 1

GROUP	55 TO 64
MEAN	444.2500

SUBSET 2

GROUP	45 TO 54
MEAN	528.0000

SUBSET 3

GROUP	35 TO 44	25 TO 34
MEAN	602.5000	619.0000

VARIABLE RS
BY GROUP

ANALYSIS OF VARIANCE

SOURCE		D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS		3	632.5100	210.8367	20.398	.0000
	LINEAR TERM	1	599.6670	599.6670	58.016	.0000
	DEV.FROM LINEAR	2	32.8430	16.4215	1.589	.2109
	QUAD. TERM	1	2.2380	2.2380	.217	.6430
	DEV.FROM QUAD.	1	30.6050	30.6050	2.961	.0894
WITHIN GROUPS		76	785.5585	10.3363		
TOTAL		79	1418.0686			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN		
25 TO 34	20	24.7157	2.7496	.6148	18.4983	28.9666	23.4289	TO	26.0026
35 TO 44	20	23.7079	2.8779	.6435	18.7680	28.5118	22.3609	TO	25.0548
45 TO 54	20	19.5994	3.6105	.8073	13.5364	27.5801	17.9096	TO	21.2892
55 TO 64	20	17.9225	3.5309	.7895	13.4572	28.9102	16.2700	TO	19.5750
TOTAL	80	21.4864			13.4572	28.9666			
	UNGROUPED DATA		4.2368	.4737			20.5435	TO	22.4292

- -

- O N E W A Y -

VARIABLE RS

MULTIPLE RANGE TEST

SCHEFFE PROCEDURE
RANGES FOR THE .100 LEVEL -

3.60 3.60 3.60

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
2.2734 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET 1

GROUP	55 TO 64	45 TO 54
MEAN	17.9225	19.5994

SUBSET 2

GROUP	35 TO 44	25 TO 34
MEAN	23.7079	24.7157

VARIABLE RPE RATING OF PERCEIVED EXERTION
BY GROUP

ANALYSIS OF VARIANCE

SOURCE	D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS	3	34.1375	11.3792	4.329	.0072
LINEAR TERM	1	27.5625	27.5625	10.487	.0018
DEV.FROM LINEAR	2	6.5750	3.2875	1.251	.2921
QUAD. TERM	1	1.5125	1.5125	.575	.4504
DEV.FROM QUAD.	1	5.0625	5.0625	1.926	.1692
WITHIN GROUPS	76	199.7500	2.6283		
TOTAL	79	233.8875			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
25 TO 34	20	13.3500	1.9273	.4309	9.0000	16.0000	12.4482 TO 14.2518
35 TO 44	20	13.0000	1.6222	.3627	10.0000	17.0000	12.2408 TO 13.7592
45 TO 54	20	11.8000	1.4364	.3212	9.0000	14.0000	11.1278 TO 12.4722
55 TO 64	20	12.0000	1.4510	.3244	9.0000	15.0000	11.3209 TO 12.6791
TOTAL	80	12.5375			9.0000	17.0000	
UNGROUPED DATA			1.7206	.1924			12.1546 TO 12.9204

- -

FILE ACTMEN (CREATION DATE = 87/04/22.)

- O N E W A Y -

VARIABLE RPE RATING OF PERCEIVED EXERTION

MULTIPLE RANGE TEST

SCHEFFE PROCEDURE
RANGES FOR THE .100 LEVEL -

3.60 3.60 3.60

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
1.1464 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO
NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A
SUBSET OF THAT SIZE)

SUBSET 1

GROUP	45 TO 54	55 TO 64	35 TO 44
MEAN	11.8000	12.0000	13.0000

SUBSET 2

GROUP	35 TO 44	25 TO 34
MEAN	13.0000	13.3500

VARIABLE BMI
BY GROUP

ANALYSIS OF VARIANCE

SOURCE		D.F.	SUM OF SQUARES	MEAN SQUARES	F RATIO	F PROB.
BETWEEN GROUPS		3	71.9412	23.9804	2.359	.0782
	LINEAR TERM	1	1.2316	1.2316	.121	.7288
	DEV.FROM LINEAR	2	70.7095	35.3548	3.478	.0359
	QUAD. TERM	1	39.3660	39.3660	3.872	.0527
	DEV.FROM QUAD.	1	31.3435	31.3435	3.083	.0831
WITHIN GROUPS		76	772.6697	10.1667		
TOTAL		79	844.6109			

GROUP	COUNT	MEAN	STANDARD DEVIATION	STANDARD ERROR	MINIMUM	MAXIMUM	95 PCT CONF INT FOR MEAN
25 TO 34	20	25.1040	2.9126	.6513	20.2612	31.6536	23.7409 TO 26.4672
35 TO 44	20	25.4382	2.5540	.5711	20.8686	30.4086	24.3039 TO 26.6935
45 TO 54	20	27.2888	4.2086	.9411	22.4095	38.1440	25.3191 TO 29.2535
55 TO 64	20	24.8771	2.8192	.6304	21.1290	32.3516	23.5577 TO 26.1965
TOTAL	80	25.6920			20.2612	38.1440	
UNGROUPED DATA			3.2638	.3656			24.9644 TO 26.4197

10-RM STRENGTH OF ACTIVE MEN   87/04/26.   15.57.48.   PAGE 3

FILE ACTMEN (CREATION DATE = 87/04/26.)

- - - - - - - - - - O N E W A Y - - - - - - - - - -

VARIABLE BMI

MULTIPLE RANGE TEST

SCHEFFE PROCEDURE
RANGES FOR THE .100 LEVEL

3.60 3.60 3.60

THE RANGES ABOVE ARE TABULAR VALUES.
THE VALUE ACTUALLY COMPARED WITH MEAN(J)-MEAN(I) IS..
2.2546 * RANGE * SQRT(1/N(I) + 1/N(J))

HOMOGENEOUS SUBSETS (SUBSETS OF GROUPS, WHOSE HIGHEST AND LOWEST MEANS DO NOT DIFFER BY MORE THAN THE SHORTEST SIGNIFICANT RANGE FOR A SUBSET OF THAT SIZE)

SUBSET 1

GROUP	55 TO 64	25 TO 34	35 TO 44	45 TO 54
MEAN	24.8771	25.1040	25.4982	27.2888

CPU TIME REQUIRED.. 1.286 SECONDS

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PEARSON CORR   AGE WITH HT TO RPE,TS,BMI,RS/TS,RS WITH YTR,FREQ,RPE,
               BMI,HT,WT
OPTIONS        3,6
```

00043500 CM NEEDED FOR PEARSON CORR

OPTION - 1
IGNORE MISSING VALUE INDICATORS
(NO MISSING VALUES DEFINED...OPTION 1 MAY HAVE BEEN FORCED)

OPTION - 3
TWO-TAILED TEST OF SIGNIFICANCE

OPTION - 6
USE SERIAL STRING PRINT FORMAT

FILE ACTMEN (CREATION DATE = 87/04/22.)

- - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - -

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
AGE WITH HT	-.1152 N(80) P=.309	AGE WITH WT	-.0317 N(80) P=.780	AGE WITH LP	-.5285 N(80) P=.000	AGE WITH EL	-.4990 N(80) P=.000	AGE WITH LC	-.6373 N(80) P=.000	AGE WITH OP	-.6010 N(80) P=.000
AGE WITH ROW	-.3275 N(80) P=.003	AGE WITH BMF	-.5457 N(80) P=.000	AGE WITH RPE	-.3139 N(80) P=.005	AGE WITH TS	-.6162 N(80) P=.000	AGE WITH BMI	.0279 N(80) P=.806	AGE WITH RS	-.6525 N(80) P=.000

A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

- - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - -

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
TS WITH YTR	.4118 N(80) P=.000	TS WITH FREQ	.3215 N(80) P=.004	TS WITH RPE	.3398 N(80) P=.002	TS WITH BMI	.3156 N(80) P=.004	TS WITH HT	.0636 N(80) P=.575	TS WITH WT	.3193 N(80) P=.004
RS WITH YTR	.3682 N(80) P=.001	RS WITH FREQ	.3531 N(80) P=.001	RS WITH RPE	.4237 N(80) P=.000	RS WITH BMI	-.2625 N(80) P=.019	RS WITH HT	.0818 N(80) P=.470	RS WITH WT	-.2011 N(80) P=.074

CPU TIME REQUIRED.. 1.733 SECONDS

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PEARSON CORR   RS,TS WITH LP,EL,LC,DP,ROW,BNP,RS
OPTIONS        3,6
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004350J0 CM NEEDED FOR PEARSON CORR

OPTION - 1
IGNORE MISSING VALUE INDICATORS
(NO MISSING VALUES DEFINED...OPTION 1 MAY HAVE BEEN FORCED)

OPTION - 3
TWO-TAILED TEST OF SIGNIFICANCE

OPTION - 6
USE SERIAL STRING PRINT FORMAT

- -

FILE ACTMEN (CREATION DATE = 87/04/23.)

- - - - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - - - -

VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR		VARIABLE PAIR	
RS WITH LP	.6794 N(80) P=.000	RS WITH EL	.7724 N(80) P=.000	RS WITH LC	.6959 N(80) P=.000	RS WITH DP	.7440 N(80) P=.000	RS WITH ROW	.4858 N(80) P=.000	RS WITH BNP	.7878 N(80) P=.000
RS WITH RS	1.0000 N(80) P=*****	TS WITH LP	.8863 N(80) P=.000	TS WITH EL	.8784 N(80) P=.000	TS WITH LC	.8305 N(80) P=.000	TS WITH DP	.8844 N(80) P=.000	TS WITH ROW	.7327 N(80) P=.000
TS WITH BNP	.8079 N(80) P=.000	TS WITH RS	.8258 N(80) P=.000								

A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.

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10-RM STRENGTH OF ACTIVE MEN                                              87/04/24.   09.15.03.    PAGE   5

FILE   ACTMEN   (CREATION DATE =  87/04/24.)

- - - - - - - - - - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - - - - - - - - - - -

VARIABLE             VARIABLE             VARIABLE             VARIABLE             VARIABLE             VARIABLE
PAIR                 PAIR                 PAIR                 PAIR                 PAIR                 PAIR
--------             --------             --------             --------             --------             --------

RPE         .1677    RPE         .2844    RPE         .3662    RPE         .3226    RPE         .3158    RPE         .4000
WITH     N(   80)    WITH     N(   80)    WITH     N(   80)    WITH     N(   80)    WITH     N(   80)    WITH     N(   80)
LP        P=.137     EL        P=.011     LC        P=.001     DP        P=.004     RCM       P=.004     BMF       P=.000

RPE        -.1217    RPE         .1501
WITH     N(   80)    WITH     N(   80)
BMI       P=.282     YTR       P=.184

A VALUE OF 99.0000 IS PRINTED IF A COEFFICIENT CANNOT BE COMPUTED.


10-RM STRENGTH OF ACTIVE MEN                                              87/04/24.   09.15.03.    PAGE   6

CPU TIME REQUIRED..        .201 SECONDS

                  FINISH

TOTAL CPU TIME USED..       2.247 SECONDS

RUN COMFLETED

NUMBER OF CONTROL CARDS READ   36
NUMBER OF ERRORS DETECTED       0
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150

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COMPUTING CENTER
UNIVERSITY OF NEVADA SYSTEM

S P S S - - STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES

VERSION 8.3 (NOS) -- MAY 04, 1982

101500 CM MAXIMUM FIELD LENGTH REQUEST


                    RUN NAME         10-RM STRENGTH OF ACTIVE MEN
                    FILE NAME        ACTMEN
                    DATA LIST        FIXED(1)/1 ID 1-2 GROUP 5 AGE 8-9 HT 12-15 (2) WT 18-20
                                     LP 23-25 EL 28-30 LC 33-35 DP 38-40 ROW 43-44
                                     BNP 47-49 RPE 52-53 YTR 56-59 (2) FREQ 62 ACT 65

THE DATA LIST PROVIDES FOR   15 VARIABLES AND   1 RECORDS PER CASE.
A MAXIMUM OF  65 COLUMNS ARE USED ON A RECORD.

                    INPUT MEDIUM     DISK
                    N OF CASES       80
                    VAR LABELS       AGE SUBJECT'S AGE IN YEARS/
                                     HT HEIGHT IN INCHES/
                                     WT WEIGHT IN POUNDS/
                                     LP LEG PRESS/
                                     EL LEG EXTENSION/
                                     LC LEG CURL/
                                     DP DECLINE PRESS/
                                     ROW SEATED ROWING/
                                     BNP BEHIND NECK PULLDOWN/
                                     RPE RATING OF PERCEIVED EXERTION/
                                     YTR YEARS OF STRENGTH TRAINING/
                                     FREQ NUMBER OF STRENGTH WORKOUTS PER WEEK/
                                     ACT PRIMARY ACTIVITY/
                    VALUE LABELS     GROUP (1)25 TO 34 YEARS (2)35 TO 44 YEARS
                                     (3)45 TO 54 YEARS (4)55 TO 64 YEARS/
                                     ACT (1)AEROBICS (2)CYCLING (3)HANDBALL (4)MULTIPLE
                                     (5)RACQUETBALL (6)RUNNING (7)SWIMMING (8)WALKING
                    COMPUTE          TS=LP+EL+LC+DP+ROW+BNP
                    COMPUTE          KILOS=WT/2.2
                    COMPUTE          METERS=HT*.0254
                    COMPUTE          BMI=KILOS/(METERS**2)
                    COMPUTE          RS=TS/BMI

CPU TIME REQUIRED..        .495 SECONDS

                    SCATTERGRAM      BMI,LC WITH AGE/
                    OPTIONS          7
                    STATISTICS       1
                    READ INPUT DATA

          GIVEN   3 VARIABLES, INITIAL CM ALLOWS FOR  3673 CASES
                               MAXIMUM CM ALLOWS FOR 10313 CASES

          OPTION - 1
          IGNORE MISSING VALUE INDICATORS
          (NO MISSING VALUES DEFINED...OPTION 1 MAY HAVE BEEN FORCED)

          OPTION - 7
          USE INTEGER SCALING
```