Comparison of responses to weight training in prepubescent and adult males

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COMPARISON OF RESPONSES TO WEIGHT TRAINING IN
PREPUBESCENT AND ADULT MALES

A Thesis
Presented to the
School of Health, Physical Education and Recreation
and the
Faculty of the Graduate College
University of Nebraska

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
University of Nebraska at Omaha

by
Margaret M. Sailors

July 1983
Acknowledgement

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CHAPTER I

INTRODUCTION

The effect of overload training on adults has been considered for thousands of years. Centuries before Christ, Milo of Crotona carried a calf on his back daily until the animal was full-grown, resulting in one of the earliest accounts of the overload principle (Bergan & Scoles, 1979). Results of overload training on adults have been well documented (Tanner, 1952; Hellebrandt & Houtz, 1958; Berger, 1962a; 1962b; Rasch & Pierson, 1963; Berger & Hardage, 1967; Stull & Clark, 1970; Leighton, Holmes, Benson, Wooten & Schmerer, 1967; Wilmore, 1975; Gettman, Ward & Hager, 1982). However, how overload affects children and adolescents is barely touched upon in the literature. The concept of an overload training threshold age or point of threshold maturity is virtually a matter of speculation.

There is general agreement that there are certain indicators which are at least moderately related to strength, including maturity and structural measures (Jones, 1946; Wickens, 1958; Hunsicker & Greey, 1957; Clarke & Petersen, 1961; Clarke & Harrison, 1962; Rarick & Oyster, 1964). Although not logically developed by exercise these traits should be considered when judging the physical potential of boys and girls. On the contrary, muscular strength is a developmental trait which can be improved through the right kind and amount of exercise (President's Council on Physical Fitness and Sports, 1974). The value of overload training in both a rehabilitative and developmental
sense has been noted for teenage boys (Gallagher, Andover & Delorme, 1949; Fisher, 1966). Unfortunately, it was not documented whether any or all of these boys had reached puberty. Since puberty has generally been considered to be that point at which strength gains are enhanced (Jones, 1946; Miller & Keane, 1978; Wilmore, 1982), the question arises as to the worth of earlier weight training. It has been noted that strength training for prepubescent children in the hope of increasing size and/or the strength of their muscle is probably of little benefit, since there is no predictable response (Round Table Discussion, 1977). However, when reviewing the literature one finds that this allegation is one that has not been clearly investigated.
CHAPTER II

THE PROBLEM

Purpose

The purpose of this study was to compare the differences in muscular strength/endurance between prepubescent and adult males. Specifically, gains via free weights along with girths, weight, skeletal widths, skinfolds, and somatotype changes were compared between the two groups before and after an eight week weight training program. Both groups contained both control and training subjects in order to determine changes attributable to training. Differences between the mean gains in performance, after adjusting for initial differences, were analyzed to shed some light on the effects of puberty.

Hypotheses

For all measurements, the .05 level of probability (non-directional) was used as the criterion for significance.

Research Hypothesis

The following hypotheses were proposed and then analyzed:

1. Both training groups would show a significant increase in weight lifting performance after eight weeks of training.

2. The increase in weight lifting would be greater in the adult group after training when compared to the prepubescent boys.

3. Neither control group would significantly increase in weight lifting performance.
4. The mesomorphic somatotype component would show a significant increase in the training groups.

5. The mesomorphic somatotype component would show a significant increase in the adult training group when compared to the prepubescent boys.

6. The mesomorphic somatotype component would show no change within the control groups.

7. The mean somatoplot will not be significantly different among groups before training.

8. The mean somatoplot will not be significantly different among groups after training.

**Delimitations**

Subjects consisted of eleven prepubescent and nine adult males from Bancroft Junior High School and the University of Nebraska at Omaha, respectively. Each of the two groups had five training subjects; there were six and four control subjects in the boys' and men's group, respectively. The treatment groups weight trained for an eight week period. Muscle performance, girths, diameters, body weight, body height, subcutaneous fat measurements, and somatotype were assessed before and after treatment to determine the response and compare the groups.

**Limitations**

1. All subjects were volunteers and were therefore not representative of all males in the respective schools.

2. Because of the very small sample sizes, inferences drawn after statistical analysis are extremely limiting.

3. Control subjects were not chosen by random selection, so they could not be considered equivalent to the training subjects in extraneous variables, such as, motivation.

**Definition of Terms**

Body composition: the relative amounts of the structural components of the body including muscle, bone, vital organs and fat.
Isometric: a muscle contraction with the muscle generating force that does not allow shortening of the muscle; also referred to as a static contraction. The force of this contraction is equal to the resistance.

Isotonic: a muscle contraction involving a shortening and/or lengthening of the muscle; also referred to as a dynamic contraction. The force of this contraction is not equal to the resistance.

Muscle performance: a combination of strength and local muscle endurance as measured by the heaviest load which can be lifted five repetitions.

Overload principle: a systematic plan of increasing the load on muscles so as to increase strength and local endurance.

Repetitions: the number of consecutive contractions performed during each weight training exercise.

Repetitions maximum: the maximum load that can be lifted a given number of times for a weight training exercise.

Set: the number of executions of an exercise.
CHAPTER III

REVIEW OF RELATED LITERATURE

Introduction

This chapter is divided into the following categories: Ambiguities discussed, properties of muscle tissue, biological maturity, the effect of puberty, training studies, rehabilitative and developmental aspects, longitudinal studies, cross-sectional studies and additional factors modifying strength. Each of these categories will be considered separately and then summarized at the end of this section.

Ambiguities Discussed

The definitions of muscular strength and muscular endurance have purposely been avoided in the previous section on Definition of Terms so that some of the inherent ambiguities concerning the two terms can be discussed here. The problem is twofold in that: (1) overload training for endurance has been shown to result in increased strength, and (2) the testing mode of many studies has been one meeting the criteria for strength measurement while training was essentially of an endurance nature. Atha (1981) has recently discussed the many definitions of strength and their limitations. After intense scrutiny he adopted the following definition: "Strength can be defined simply as the ability to develop force against an unyielding resistance in a single contraction of unrestricted duration".
On the other hand, the term endurance has generally been accepted as the ability to develop force repeatedly or to maintain a forceful contraction. Theoretically, any more than one repetition (rep) would be encroaching on muscular endurance. After reviewing studies considering different numbers of repetitions for developing strength, Atha (1981) claimed that tension and not fatigue is the critical strengthening stimulus. With this in mind, it appears logical that maximal tension induced by one repetition maximum (RM) would be the appropriate training mode for building strength. However, it is generally accepted that overloading the muscle at a smaller percentage of the 1 RM is more beneficial in that the heaviest loads do not produce the highest gains. For instance, the use of a 5 RM load would develop strength more than a 1 RM load. After determining the mean overall percentage gains per session for more than 30 studies, Atha (1981) described the functional relationship between load and strength as a curve that rises from zero when the load is low, reaches a rather flat peak at a high submaximum load, and finally, falls moderately as the load reaches maximum. This conclusion assumes that as the load is reduced more repetitions are performed. Theoretically, it could be argued that, if more than one contraction is performed, training is of an endurance nature.

One study comparing strength and endurance gains (p < .05) from weight training led the authors to conclude that in the end "the endurance group had as much strength as the strength group, and the strength group had as much endurance as the endurance group" (Stull & Clarke, 1970). The group they referred to as the strength group had
a training protocol which consisted of three sets of 10 reps of PRE (progressive resistance exercise). The difference between the two groups involved increasing tension for the strength group while increasing repetitions for the endurance group. One of the drawbacks of this study is that testing was administered statically while performance was of a dynamic nature. The relationship between increases in static and dynamic strength has not been shown to be significantly related (p>.05) (Berger, 1962).

The literature shows that strength can be gained by overloading the muscle even when the repetitions number more than one (Berger, 1962a; 1962b; Berger & Hardage, 1967; Wilmore, 1974), although theoretically this would be an endurance task. One factor that seems to have been overlooked in these studies is the relationship between training and testing protocol. Since testing is specific to the property being tested, i.e., strength, endurance, or some point in between, testing should be administered using the training program protocol in order to actually test and measure the property that training affected.

Properties of Muscle

Some basic considerations about muscle tissue are reviewed below. These properties are relevant to the established research and the conclusions that have been drawn from it.

The ultimate limit for strength is established by anatomical and physiological parameters within the muscle, although psychological factors play a part in the individual's expression of his/her limit. Human muscle can produce approximately three to four kg of force per
cm² of muscle cross section. However, the output capacity is dependent on the arrangements of the bony levers (McArdle, Katch & Katch, 1981).

Hettinger and Mueller speculated that when training with a load which is about two-thirds of maximum, a training effect occurs from the established O₂ debt (cited in Hunsicker & Greey, 1957). However, Hettinger (1955) soon ruled this out through studies showing no relationship between experimental occlusion and training effect (as cited in deVries, 1980).

A noteworthy response of the muscle to overload is the process of hypertrophy. This accommodation is made by increasing the size of existing cells and not their number (Hunsicker & Greey, 1957; McArdle & others, 1981). This process results in the synthesis of cellular material, particularly the protein of the contractile elements. Inside the cell, the myofibrils increase in size and number, and protein breakdown decreases (McArdle & others, 1981).

Individual differences in strength may reflect the contributions of muscle mass, somatotype, and innervation. Also, differences in strength within individuals throughout the day have been reported (Hunsicker & Greey, 1957). These factors in combination with the growth process further complicate the study of pubescent muscular development.

**Biological Maturity**

There are different biological systems in the body including the skeletal, muscular, nervous, endocrine, respiratory, reproductive and cardiovascular systems. These systems mature at different periods
of the life cycle, resulting in different methods of assessing maturity. The four commonly accepted means are dental, morphological, skeletal and sexual maturation ages (Hebbelinck, 1978).

The two methods for dental age assessment are visual emergences or eruption age and radiographic formation age (Hebbelinck, 1978). However, these techniques can only be used over limited age ranges. Additionally, it is very difficult to be accurate near puberty when assessing age, since nearly all the teeth are by this time either calcified or erupted (Hebbelinck, 1978).

After determining dental age through radiographs in 699 French Canadian children, 50 to 150 months in age, it was found that chronological age was overestimated by 2.6 years ± 9.5 months (p < .001), with a correlation coefficient of 0.909 between the two variables. In the older children sampled, there was a trend for underestimation of chronological age (Shephard, Lavallée, Rajie, Jéquier, Brisson & Beaucage, 1978).

One method of morphological measurement has been the use of height-weight charts. However, charts of these and other anthropometric measures need continuous revision because of secular growth trends (Tanner, 1962; Hebbelinck, 1978; Vajda & Hebbelinck, 1978), and they should be population specific (Hebbelinck, 1978). It is also most important to use longitudinal records which extend over the adolescent phase (Hebbelinck, 1978). Another confounding factor is that rate and size show little relationship, so two children with equal potential for adult size may reach this final size at different rates and will have different places on growth charts (Bayley, 1949; Tanner, 1962).
The value of height, weight and age when used as a classification device for secondary school students in the seven AAHPER youth fitness tests was evaluated by Gross and Casiani (1962). Approximately 16,000 students representing 50 of the 67 counties in Pennsylvania were scored and ranked in the AAHPER tests of pull-ups, sit-ups, shuttle run, broad jump, 50-yd. dash, softball throw and 600-yd. run-walk. Simple correlations, multiple correlations and regression coefficients for the variables height, weight and age with the seven components of the AAHPER test were calculated. For junior high boys the highest r between age, height and weight and any of the response variables was .48 between height and the softball throw. The highest r was .57 between age and height. The highest R was .51 between the combination of the independent variables to the softball throw. For the senior high boys the highest r between age, height or weight and any of the seven youth fitness tests was .26 between height and weight. The range of the seven R's was .05 to .30.

Another type of morphological assessment is the somatotyping of individuals by categorizing them into three components with the particular characteristics of ectomorph, mesomorph and endomorph. These assessments have generally been shown to be moderately correlated with strength (Clarke, Irving & Heath, 1961; Watson & O'Donovan, 1977). The modified somatotype method of Heath and Carter (1967) was used in this study to determine the somatotype relationship with strength. This method of assessing somatotype has been validated for both sexes and all ages (Heath & Carter, 1967; Carter; 1975).
Skeletal maturity is most often assessed by radiography, judging age by the number of ossification centers present and the stage of development of each. The standard assessment is made by comparing the given radiography with a series of standards. There is a problem with objectivity between observers reading the X-rays, although a skilled observer can reach a high degree of reliability on repeated measurement (Hebbelinck, 1978). Skeletal maturity assessment remains the most valid indicator of biological maturity (Hebbelinck, 1978), although Canadian data have shown an increase in the variance of the discrepancy as puberty is approached (Shephard & others, 1978).

Although skeletal maturity is the most useful means of assessing biological maturity, sexual maturation is the phase at which strength gains are reportedly expected (Miller & Keane, 1978; Vrijens, 1978; Wilmore, 1982). During prepubescence, muscle weight is approximately 27% of the total weight while after sexual maturation percentage of muscle weight is increased to > 40% (Vrijens, 1978).

Hebbelinck (1978) noted that sexual maturation is generally appraised by investigators in the English-speaking world with application of the criteria used by Greulich, Dorfman, Catchpole, Solomon & Culotta (1942) or Tanner (1962), but in middle and eastern Europe, the criteria of Zeller (1938) or Schwidetsky (1950) are commonly used.

Sexual maturation as designated by Greulich & others (1942) distinguishing features is the criterion used in this study and is described as follows:
Group 1. The penis, testes, and scrotum of boys in Group 1 are of about the size and proportion which characterize those organs during early childhood. The vellus over the pubic region is no better developed than is that over the contiguous portion of the ventral abdominal wall. The face is free from hair other than the very fine, short downy that has been present since infancy. There is no definitive circumanal, perineal or axillary hair.

Group 2. The testes of boys in Group 2 are usually definitely larger than those of boys in Group 1 and the penis also shows evidence of accelerated growth. The vellus at, and immediately lateral to, the base of the penis has developed sufficiently to form a conspicuous growth of long, lightly pigmented, downy hair. Facial hair remains much the same as in Group 1 and definitive circumanal, perineal, and axillary hair is still absent.

Group 3. By the time the degree of development which characterizes Group 3 is attained, the penis has increased further in size, especially in length, and the testes have also become somewhat larger. At and lateral to the base of the penis the lightly pigmented downy hair has increased in length, coarseness, and in amount and is now interspersed with occasional long, coarse, pigmented hairs which are somewhat straighter and finer than the pubic hair of the adult.
Group 4. In boys of Group 4 the testes are usually somewhat larger—occasionally, considerably larger—than those of boys in Group 3. The penis, too, has increased further in size, especially in diameter. The hair on the pubic region resembles that of the adult in type but the pubic-hair-covered area is not so extensive as it is in the adult and does not extend laterally onto the adjacent medial surface of the thighs. Its upper border is at first slightly concave in outline but soon becomes approximately horizontal. The facial hair is only slightly more developed than in boys of Group 3. There is usually a small to moderate amount of short, lightly pigmented coarse down on the upper lip and a similar amount of long, fine unpigmented hair on the cheeks. A few moderately long, coarse, pigmented hairs are occasionally present along the borders of the chin. There is usually no terminal hair on the throat and sub-mandibular region in boys of this group.

Group 5. The penis and testes of boys in Group 5 have usually attained almost the maximum size proper to the individual. The genitalia occasionally appear disproportionately large, especially in boys who achieve this degree of sexual maturation rather early. The pubic hair is typically adult in quantity and in type. In moderately hairy and hairy strains terminal hair occurs along the linea alba extending for a variable distance from the pubic region towards or beyond the umbilicus. There is usually a
conspicuous growth of hair on the upper lip and this adolescent mustache contains a variable proportion of fairly well differentiated terminal hairs. Relatively long, moderately coarse, lightly pigmented hairs interspersed with terminal beard hairs are present on the sides of the face, especially just in front of the ears. A sparse to moderate growth of terminal hair occurs on the chin being most marked along its sides and lower border. In boys who are destined to have moderately heavy or heavy beards there is usually light growth of terminal hair over the throat and sub-mandibular region at this stage of development. Circumanal and axillary hair is present and well developed.

The Effect of Puberty on Muscle Performance

The effect that puberty has on strength development has been examined by comparing 16 prepubescent and 12 postpubescent Belgium boys (Vrijens, 1978). Both groups of boys trained isotonically at 75% of 1 RM working the arm extensors, arm flexors, leg extensors, leg flexors, abdominal and back muscles. Training extended over an eight week period, three times weekly. Body weight, standing height, arm and thigh circumferences, and skinfold thicknesses were measured before and after training along with muscle changes as defined by soft tissue roentgenography. Strength was tested statically before and after for all the muscle groups trained. All differences in the postpubescent group were significant (p<.05), while in the
prepubescent group the only significant changes were for the abdomen and back muscles (p<.01). The mean cross sectional area of muscles in the arm and thigh were significantly increased in the adolescent group only (p<.05). Weight and arm girth increased in both groups, height in the prepubescents, and thigh girth in the adolescents (p<.05).

It is unfortunate that this study did not take into consideration the effects of growth and specificity of exercise. For the former, the lack of a control group leads one to question how much of the strength gain was due to the training and how much was due to normal growth. The latter consideration, specificity of exercise, implies that static strength will not necessarily increase with dynamic training. When comparing static strength to dynamic strength in a seven-year longitudinal study, one researcher concluded that the former is more closely related to constitutional factors (Jones, 1946).

Sady and Katch (1981) looked at the different responses between male children and adults, and later compared them to adolescents in both relative endurance and physiological responses (Sady, Berg, Sailors, Katch & Villanacci, 1983). All subjects, prepubescents (n=21), adolescents (n=22) and adults (n=21) performed two bicycle tests on different occasions with a workload theoretically 105% of $\dot{V}O_2$ max (maximal $O_2$ uptake per minute). $\dot{V}O_2$ max was initially determined from an incremental bicycle test. The two tests were eight minutes in duration but the length of time left in the test was never revealed to the subjects to avoid any pacing by the subjects. No group differences were detected in the total revolutions turned or the total % dropoff from the initial rate (p<.05). Reliability of total revolution scores was found to be high for each
group, \( r = .84, r = .89 \) and \( r = .82 \) for the youngest to oldest males, respectively. Minute-by-minute RPM were found to be stable in all groups, \( r = .69, r = .70 \) and \( r = .76 \) for prepubescents, adolescents and adults, respectively. The within-individual variation (Si) for HR was found to be greater in the prepubescents (47%) than either the adolescents (13%) or the adults (11%). A trend of increasing within-individual stability was found for \( \dot{V}O_2 \) response to the exercise. The average total within-individual variability was the least for adolescents, equalling 9%, while the young boys and adults were 26% and 16%, respectively. Interestingly, the \( \dot{V}O_2 \) pattern for the adolescents was found to resemble the prepubescents during the first half of the test and the adults during the last half. The authors indicated that the data seem to point to a maturity effect on response pattern of the physiological parameters of HR and \( \dot{V}O_2 \) during relative endurance performance.

**Training Studies**

The general effect that weight-training has on the physique was examined in 10 males, ages 18 to 25, over a 16 week period (Tanner, 1952). Attendance was variable, ranging from 23 to 44 sessions with an average of 31. The subjects trained progressively performing the two hands press, straight-arm pull-over, two-hands curl and the deep knee bend. The results after four months were a significant increase for all subjects in the circumference of the upper arm, both loose and contracted (\( p<.05 \)), but thigh circumference was extremely variable among subjects.
Rarick and Larsen (1952) studied two methods for increasing isometric strength in the wrist flexors of postpubescent males. Group 1 (n=10) performed a 67% maximum static contraction for six seconds Monday through Thursday. Group 2 (n=10) performed an 80% maximum contraction for five reps on Monday, six reps on Tuesday, seven reps on Wednesday and eight reps on Thursday. Group 3 (n=10) was the control group and did no training. Fridays were used as the day to determine the following week's new training intensity. Training extended over a four week period. Four weeks after training a significant increase (p<.01) was found for Groups 1 and 2. There was no difference found between these two groups in the end but the significant difference between group 2 and Group 3 (p<.02), while none between Group 1 and Group 3, led the authors to conclude that strength retention was slightly higher in Group 2. Unfortunately, the authors mixed the variables of frequency and intensity in the study, so it is impossible to infer whether the greater intensity or frequency or their interaction caused a trend of greater retention in Group 2.

A study to determine the optimum number of repetitions for strength development was examined by Berger (1962b). One hundred and ninety-nine college males were divided into groups utilizing either 2, 4, 6, 8, 10 or 12 RM for one set three times weekly for 12 weeks. Results from ANCOVA showed that the groups that trained at 4, 6, and 8 repetitions had greater mean gains than those who trained at 2, 10 or 10 repetitions (p<.05).

In a two month, three times weekly training study, Berger and Hardage (1967) studied the effect of maintaining a maximum effort.
They divided 50 untrained college males into two groups: Group 1 performed 10 repetitions with 10 RM for one set and Group 2 performed 10 repetitions for one set, each repetition requiring a maximum effort. A significant difference between the groups was found in favor of Group 2 (p<.05) using the 1 RM for assessment.

The results of a 10-week program were compared for 47 women and 26 men who weight trained twice weekly for 40 minutes (Wilmore, 1974). At least four training sessions before baseline strength tests were given were allowed to eliminate practice or learning effects. Lean and fat body weight, via hydrostatic weighing and anthropometric measurements, including skinfolds, girths, circumferences and diameters, were also taken before and after treatment. Total body weight did not change, but lean weight increased by 2.4% and 1.9% and fat weight decreased by 7.5% and 9.3% for the men and women respectively (p<.05). Skinfolds showed significant decreases for all seven of the sites in the women (p<.05), but the men showed a mean decrease only in the suprailliac measurement, although their fat loss was significant. Both men and women had significant gains in shoulder, chest, deltoid, biceps flexed and extended, and forearm girths. The strength measures for leg press, curl, bench press and grip strength showed increases in all for both men and women (p<.05). The authors found a higher relationship between absolute strength and girth sizes for the men (r = .63 to r = .77) than for the women (r = .09 to r = .42). They concluded that although it is obvious that a bulkier muscle will have a tendency for greater strength, hypertrophy is not a consistent or absolute consequence of strength training.
Rehabilitation and Development

The effects of progressive resistive exercise on 25 adolescent boys with knee injuries, low-back pain or poorly developed upper bodies has been monitored (Gallagher & others, 1949). Prescription was based upon the amount of weight the subject could lift 10 times. Three sets of 10 reps were performed, the first at 50%, the second at 75% and the third at 100% of 10 RM. The subjects were reevaluated weekly until the strength attained in their injured or underdeveloped body part(s) was within normal range. Reevaluation two to 12 months after training showed little if any decrement (p>.05), so the authors concluded that the retention of strength is obviously greater than cardiovascular-pulmonary endurance. However, they failed to take into account the greater room for improvement in these subjects just to bring them to within normal standards.

The California Performance Test was given to 400 junior high school boys (Fisher, 1966). This test includes pull-ups, bent knee sit-ups for time, standing broad jump, 50-yard dash, shuttle run and softball throw for distance. The lowest 20%, classified as "underdeveloped", were divided into two groups of 40 boys each, Group 1 as a control group in the regular physical education classes and Group 2 performing weight training three times weekly for 10 weeks. Comparing pretest to posttest results showed a significant improvement in Group 2 for all components (p<.01), while Group 1 improved in all but the pull-ups and the standing broad jump. Final results showed no significant differences between the groups in any of the seven items.
The effects of weight training versus a basketball program on basketball skill test scores were compared in seventh grade boys (Ford & Pickett, 1980). For a two month, three times weekly, training period, Group 1 boys weight trained, \( n = 26 \), Group 2 boys played basketball, \( n = 24 \), and Group 3 boys participated in the regular physical education classes, \( n = 26 \). The front shot, speed pass, jump and reach, and the dribble were evaluated before and after training. Results of ANCOVA and Scheffe multiple comparison showed a significant mean difference (\( p < .05 \)) on the front shot between the basketball group and the weight training group, in favor of the former.

**Longitudinal Studies**

Some of the studies discussed in this and the next section make use of the Strength Index and the Physical Fitness Index, so a brief discussion of them is in order. The Strength Index includes height, weight, vital capacity, shoulder girdle, upper arm, forearm, back and leg strength. The index is \((\text{weight}/10 \times \text{height} - 60)\) times the sum of the scores for pull-ups and push-ups, plus the scores for lung capacity, right and left grips and back and leg lifts. The Physical Fitness Index is the achieved Strength Index divided by the Strength Index norm, based on sex, age and weight, times 100. The validity of these measures when compared to "general athletic ability" has been discussed in detail (Wickens, 1958). However, the actual validity of these indices to absolute or relative strength is questionable. Nonetheless, their utilization in the Medforth Growth Study is substantial, so they are considered here.
In 1946 a report was published concerning the relationship between skeletal age and strength (Jones, 1946). In this study 62 boys were followed from age 11 through 17.5 years. The data collected included skeletal roentgengrams and static dynamometric strength measures. The results indicated that the mean grip strength for the early-maturing boys was greater than the mean for the late maturing boys (p<.01), maturity defined as skeletal age. The author noted that in both the early- and late-maturing boys, strength growth came slightly after the first signs of postpubescence.

Watt (1963) made use of the convergence or "accelerated-longitudinal" approach in his study of 203 males, ranging from seven to 17 years of age. He looked at 62 boys, age seven to nine years, 48 boys, age nine to twelve years, 41 boys, age 12 to 15 years and 52 boys, age 15 to 17 years. He yearly measured their progress in skeletal age, the structural measures of height, weight, lung capacity and upper arm girth, the strength measures of Strength Index, pull-ups, hip flexion, trunk flexion and ankle plantar flexion and the motor measures of the 60 yard shuttle run and standing broad jump. When, for instance, the first group had aged up to the initial age of the next oldest group, if no mean differences were found in a measure, it was assumed that these overlapping age groups could be considered representative of measurements that could have been obtained from a single group over the entire age range. Complete convergence analyses from seven to 17 years were possible for six of the measures included in this study, since there were no significant differences at the overlapping ages of 9, 12 and 15 years (p>.05). The mean growth curves
were straight-line in form for skeletal age and standing height and concave in form for weight, lung capacity, pull-ups and Strength Index. The greatest acceleration in growth of the Strength Index, pull-ups and ankle plantar flexion occurred between the skeletal ages of 13 and 15.

Parizkova (1968) followed a group of 96 boys from similar backgrounds and environments over a five year period from age 11 through age 15 years. The boys were divided into the following categories:

Group 1, n = 15: Boys trained regularly all five years and also participated in more than six hours weekly of unorganized sports.

Group 2, n = 32: Boys trained in sport clubs only.

Group 3, n = 28: Boys trained quite irregularly, but lasted in all instances over two years.

Group 4, n = 21: Systematic sport activity did not exceed two years.

Measurements were taken yearly of height, weight, chest circumference, bi-acromial breadth, pelvic breadth, lean body mass, relative and absolute body fat via hydrostatic weighing and skeletal age by roentgengram. The percentage of lean body mass significantly increased (p. ? ) between the first and fifth year in Group 1 but remained unchanged in Group 4. The absolute amount of lean body mass increased mostly in Group 1; there was a significant difference between Groups 1 and 4 in the last year. The proportion of the skeleton expressed in indices, pelvic breadth x 100/height and pelvic breadth x 100/bi-acromial breadth, displayed a significant mean difference (p<.05) between Group 1 and Group 4, Group 1 being lower. It was unfortunate
that this author did not always clarify the word "significant" in his tables and text; the longitudinal response to greater activity, as shown in this study, is something researchers have barely touched upon.

Carron and Bailey (1974) looked at the longitudinal data of 99 boys in the Saskatchewan Child Growth and Development Study who were measured yearly from age 10 to 16. Small but significant correlations (p<.01) between strength and both height and weight were found. The increments in strength from year to year were statistically significant (p<.001), and were approximately 11% greater than would be geometrically predicted from growth in a linear fashion (see next section). The maximum spurt in strength growth was found one year following both peak height and peak weight growth. However, these latter two measurements were found to be extremely variable among the boys.

Cross-Sectional Studies

A dimensional examination of physical performance and growth in 400 Danish school boys, ages seven to 17 years, was published in 1955 (Asmussen & Nielsen). An interesting analysis was performed based on the assumption of geometrical similarity among children in this age range. That is, the physical changes that occurred which did not follow from certain geometric facts were examined. They assumed that (1) if one linear dimension, such as height, is increased a certain percentage, another linear dimension, such as length of legs, would increase the same percentage, proportionally to the height (h); (2) all the areas, such as the cross section of muscles would increase with the second power of body height \( h^2 \), along with muscular strength;
and (3) all volumes and weights, such as total body weight, would vary with the third power to the linear dimension of height \((h^3)\).

The data were split into 10 cm. classes of heights. The mean values were plotted on log-log paper with body height, \(h\), as abscissa. The formula \(\log y = \log a + b \log h\) was expressed where \(h\) was the height, \(y\) the function tested, and \(a\) and \(b\) constants. The results showed that where \(h^3\) was expected, there was discrepancies between the actions produced by muscle groups in different tests: leg extensors to \(h^{2.89}\); leg muscles (running) to \(h^{3.04}\); leg muscles (jumping) to \(h^{3.27}\); and leg muscles (acceleration in running) to \(h^{4.54}\). Because the muscles responded differently in varied situations, and the muscular strength increases were more than could be expected from the increase in height, the authors concluded that the maturation of the nervous system played a part in the display of strength.

Wickens (1958) measured 280 boys from the Medford Growth Study. He obtained skeletal age, structural and strength measures for boys nine to 15 years in age, 40 boys from each year of age. He calculated curves for the mean measures. He determined that skeletal age represented a nearly straight line rise, the variability decreasing abruptly at age 15 years. All the structural measures but lung capacity showed a decrease in variability at age 15, including girths, weight, height and hip width. For right and left grip strength there was a rapid rise at ages 13 and 14 and a slight deceleration at 15 years. For back and leg lifts, the curves rose nearly straight-line from 11 to 14 years of age and decelerated at 15 years. Push-ups and pull-ups curves rose at age 10, dropped at age 11, rose at 12, dropped at 13 and rose sharply
at 14 years with push-up curve continuing to rise at 15 while the pull-up curve dropped off. Unlike the skeletal and structural measures, the variability for the strength measures increased with age, the amounts were generally greater at age 14 than at any other age.

Clarke and Harrison (1962) examined 273 Caucasian boys of any of nine, 12 or 15 years of age, and put them into groups rating them as retarded, normal or advanced based on skeletal age. The greatest variance for all measurements among the groups was found in the older boys. From highest the greatest differences were found between the mean body weights at all ages followed by hip width and grip strength. In general, the researchers found a tendency for the chronologically older boys to be taller and stronger when the retarded older boys were compared to the advanced younger boys.

Clarke and Degutis (1962) compared skeletal, physical and motor factors with the pubescent development of 10 (n = 86), 13 (n = 65) and 16 (n = 86) year old boys. The ratings (from Greulich & others) and n size were as follows: age 10, 72 in Group 1 and 14 in Group 2, age 13, two in Group 1, 25 in Group 2, 26 in Group 3, 8 in Group 4 and 4 in Group 5; and for age 16, 12 in Group 4, and 74 in Group 5. Because of the small numbers in Groups 1, 4 and 5 of the age 13 group, the authors chose to drop Group 1 and merge Group 4 and 5. For the strength measurements in the 10 year olds, there was a significant difference found between Group 1 and Group 2 boys in the mean cable-tension strength battery score (p<.05). Between Group 4 and 5 and Group 3 groups in the 13 year old boys, left grip, back lift, leg lift, Strength Index, Physical Fitness Index and the mean of 12
cable-tension tests were different, while between Group 2 and Group 3, left grip, elbow flexion and the mean cable-tension scores were found different (p<.05). In the 16 year old group, between the two pubescent groups, there were found differences in back lift, left grip, leg lift, Strength Index and the mean cable-tension scores (p<.05). The only difference the authors noted in physique was a greater percentage of ectomorphs in Group 4 than Group 5 of the 16 year olds (p<.05).

When comparing identical pubescent groups at different ages, the following differences were found: (1) when comparing Group 2 boys from ages 10 and 13 years all structural measurements were different, all but the back lift and Physical Fitness Index were different for the nine strength measures and both mean standing broad jump and mean 60 yard shuttle run were different (p<.01), and (2) when comparing Group 4 and 5 boys at age 13 to Group 4 boys at age 16 there was a difference found in the Strength Index, shoulder inward rotation measure, Physical Fitness Index, standing height, lung capacity, hip width and upper arm girth (p<.01). For all these measures but the Physical Fitness Index between 13 and 16 year olds, the older boys had the greater mean score when there was a difference.

Skinfold measures were taken on 212 twelve year old boys from the Medford Growth Study (Geser, 1965). Three skinfold sites were measured: (1) triceps, (2) apex of scapula on the back and (3) mid-axillary line at the level of the umbilicus. The relationship between total fat and abdomen fat was r = .961. Arm and abdomen fat was found to correlate r = .995. Adding the back fat measure did not increase the magnitude of the multiple correlation.
A study of 500 boys and girls revealed that the factors of age, height and weight in combination accounted for approximately 70 to 80 percent of the variance in isokinetic scores (Molnar & Alexander, 1974). Since the difference between predicted and observed values was normally distributed, the authors considered this a good indication that no other factors of consistent influence could be specified that would reduce the remaining variance and further increase the multiple correlation coefficient.

In a study of 53 postpubertal male subjects, ages 16 through 18, a combination of somatotype components, bone widths and muscle circumferences was shown to be the best indicator of the influence of anthropometric factors on muscular strength (Watson & O'Donovan, 1977). The authors concluded that the strength of postpubertal male adolescents is determined primarily by parameters of body size but that body shape also has an important influence. These two factors together appeared to account for 78 percent of the observed variance in the strength of the subjects, and the level of their activity had no significant influence on strength. The subjects in this examination were not and reported to never have been involved in any type of strength building program.

Modifying Factors

In 1920 results were reported about several thousand Boston school children who were weighed each month of the school year from age 60 months to age 176 months (Porter, 1920). It was found that by blocking the children into groups which shared the same month of birthday, a
pattern could be depicted which showed a seasonal variation in weight gain. A trend of an accelerated weight gain from August through December was shown, while the months of January through May showed a deceleration in weight gain.

Ikai and Steinhaus (1961) examined some factors that influenced the psychological limit. Arm strength was measured under normal conditions, after a pistol shot, while the subject screamed, and under the influence of alcohol, amphetamines or hypnosis. The sample sizes for each of the different experiments ranged 10 to 35. In all cases, except when influenced by alcohol or adrenaline, the subjects were consistently stronger, including after taking tablets of amphetamine sulphate (p<.05). Percent changes from initial strength ranged from +7.4% after the pistol shot to +26.5% after a hypnotic suggestion of strength. The examiners speculated that most people normally function at a level of neural inhibition that prevents them from expressing their true strength capacity. Under the influence of excitement, disinhibitory drugs or hypnotic suggestion, the inhibition was apparently removed.

McArdle and others (1981) discussed the neural facilitation involved in the so-called unexplainable feats of men and women in emergency situations. They hypothesized that changes in this disinhibition probably also occur in the early stages of strength training and may largely account for the rapid improvement ratio in the early phase of the program.
Summary

There are some generalizations that can be concluded from the research in the areas of strength and growth and development. Strength has been shown to correlate moderately with maturity indicators such as bone widths, weight and skeletal age. However, its relationship to measures such as height, limb segments and chronological age is not linear. Since performance has been shown to be enhanced by age in greater proportions in some motor movements, some investigators have concluded that neural development plays a part in the display of greater strength. Additionally, neuromuscular responses are apparently altered by an inhibition that can be reduced by psychologic influence. Finally, the specific effect that puberty has on the development of strength has been generally accepted to be one of acceleration. The positive effective of this maturation on strength development through weight training is one of speculation.
CHAPTER IV

METHODS

Subjects

The subjects for the study were volunteers from Bancroft Junior High School and the University of Nebraska at Omaha. Table 1 describes the subjects.

Table 1. Descriptive data of subjects (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Boys (n=11)</th>
<th>Men (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>12.6 (0.69)</td>
<td>24.0 (5.12)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>154.8 (5.68)</td>
<td>174.4 (5.90)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>47.4 (8.63)</td>
<td>70.3 (8.66)</td>
</tr>
</tbody>
</table>

Volunteers for an eight week training program were difficult to find, so all those who volunteered were placed into the training groups. Control subjects were thereafter found by asking them to be control subjects. It was explained to them that it would only be necessary to be measured before and after an eight week period.

The boys were all seventh graders either in Groups 2 or 3 of Greulich's rating scale of sexual maturity (refer to pages 13-15). The ratings were assigned by a male graduate student who obtained the subject's nude body weights before and after the eight week period. The graduate student was thoroughly trained on the characteristics of
the various groups in the rating scale, and the excellent photographs of Greulich and others (1942) were used as an aid in visual learning.

Loss of subjects was a major problem in the junior high school boys. Out of 10 original training subjects four lost interest and quit coming, one boy matured to level 4 of Greulich's classification and one boy failed to fulfill the training program. There were also 10 original control subjects in the boys' group. Four of these boys failed to return for posttesting.

**Measurement**

All subjects participated for four sessions in the free weight training program before any baseline measurements were taken. This procedure was used to reduce the learning effect associated with lifting weights (Tanner, 1952; Wilmore, 1974; McArdle & others, 1981). After the four weight training sessions used as an adjustment period, measurements were made, both for performance and anthropometrics. After the eight week period all measurements were repeated. All measurements were taken at the same time of day.

**Performance measures**

Each weight training session was supervised by the investigator. Testing was administered with the assistance of a male graduate student, who also served as a demonstrator for all the exercises. All testing was administered in the sequence of squat, bench press and arm curl. Following is a description of the exercises and the way they were performed in order to be counted as an "acceptable repetition" for training and testing purposes.
1. **Squat.** The subject stood with the feet parallel and about shoulder width apart. The toes were placed outward at an approximate 35 to 45 degree angle. The bar was held across the shoulders and behind the neck. The hands maintained a firm grip in order to balance and control the weight. The buttocks were lowered until the thighs were parallel to the floor where the subject paused briefly, and then returned to the starting position. It was emphasized that the subjects keep his head up, back straight, mouth open (to equalize pressure within the chest cavity) and refrain from bouncing at the bottom of the squatting movement. The subject was told to inhale on the way down and exhale upon recovery.

2. **Bench press.** The subject faced up on the bench with knees bent and feet flat on the floor. The head was next to the weights and the hands were on the bar so that the heels of the hand were toward the feet (radioulnar joint pronated). The subject was handed the bar off the rack, and movement consisted of the subject pushing the bar up by extending the elbows until locked and then returning to the starting position. The subjects were cautioned against arching the back and bouncing the bar off the chest. They were told to lower the bar to the chest and push it overhead upon hearing a hand clap made by the tester.

3. **Arm curl.** A curling bench was used for all training and testing sessions to isolate the movement to the elbow flexors. The subject sat at the curling bench with his
feet flat on the floor and his triceps completely flattened against the pad on the angled curling bench. The height was adjusted so there was no gap between the armpit and the bench. The movement consisted of flexing the elbows without moving the rest of the body.

Both training and testing were performed in the above order. Since all sessions were supervised it was possible to continually remind the subjects of proper form and make sure that their exercises were done correctly. All subjects were encouraged to follow the stretching routine described in Appendix A both before and after testing and training.

When tested, the subjects were told initially that the goal was to lift a maximum amount of weight five times (5 RM). The one repetition maximum (1 RM) was avoided purposely to reduce the likelihood of injury (Jesse, 1977). During the four practice sessions, the weights handled by the subjects for the three weight training exercises: squat, bench press and arm curl, were recorded. This facilitated selection of the 5 RM load. A warmup of 50% of the estimated 5 RM was allowed for each subject on each exercise. The 5 RM that the student had reached during the practice sessions was used first. The instructions were for the student to lift this weight as many times as he could. If he lifted it six times he was told to stop. A recovery period of five minutes was allowed and another trial was administered with additional poundage, depending on the ease with which the subject handled the first load. If on the second trial the subject lifted the weight less than five times, another recovery period was allowed and a last trial was
administered with a decrease in load. Many subjects were able to raise the first load more than five repetitions and not able to lift the second or third loads a minimum of five repetitions. In such cases an estimated weight was extrapolated and used as their 5 RM score. Two days, with a least one day in between, were spent obtaining 5 RM data for the bench press, arm curl and squat. The two sets of 5 RM obtained for each exercise were averaged for the analysis.

Anthropometrics

Body weight was measured via a balance scale; height was assessed using a Seiber-Hegner anthropometer. For the height measurement the subject was standing, feet flat, eyes looking straight ahead, and the back in contact with the measuring bar. The subject was told to take a deep breath and stand tall. Harpenden calipers were used to measure skinfolds, with a caliper pressure of 10 gr/cm². Diameters were measured with the Seiber-Hegner anthropometer. The following is a description of each girth, skinfold and diameter measurement (taken directly from Carter, 1975).

1. Muscle Girths

Definition of measurement: The maximum girth of the muscle when measured at right angles to its long axis.

Technique: The tape was passed around the limb and the region of the muscle explored with the tape always at right angles to the long axis of the bone, until the largest reading was obtained. The tape was in light contact with the skin (so as not to produce deformation of the tissues),
and maximum girth was recorded to the nearest 0.1 cm.
Measurements were taken on both limbs, and the larger
girths were recorded.

**Biceps**

Posture: The arm of the subject was horizontal, the forearm
supinated and the elbow fully flexed. The subject was
instructed to clench his fist and contract his biceps
as strongly as possible.

Technique: The tape was passed around the arm approximately
midway between the acromion and the elbow, at right angles
to the axis of the arm.

**Calf**

Posture: The subject stood on a table with his feet six to
nine inches apart, with his weight equally distributed
through both lower limbs.

Technique: The tape was passed around the leg near the top
of the calf muscle and lowered until the greatest girth
was located, at right angles to the long axis of the leg.

2. **Skinfolds**

Technique: The objective was to measure the thickness of a
complete double layer of skin and subcutaneous tissue
without including any underlying muscle tissue. A double
layer of skin and subcutaneous tissue was grasped with the
thumb and forefinger, the fold being large enough to get a
complete double layer, but not so large as to get so much
skin and fat causing excessive amounts of tension beyond the
fingertips. The fold of skin and fat was held somewhat loosely while the centers of the caliper faces were 1.0 cm from the edges of the thumb and forefinger.

The reading on the dial of the caliper was taken after applying the full spring pressure of the instrument for all measurements. Time was allowed for the full pressure of the caliper to take effect, but not so long that the fat was "squeezed out" of the skinfold. The measurement was recorded to the nearest 0.1 mm.

**Triceps**

**Posture:** The subject stood with the arm by the side and the elbow extended but relaxed. (Muscle fibers were excluded, if necessary, by locking the elbow joint momentarily in full extension.)

**Technique:** The skinfold was raised with the thumb and forefinger of the left hand over the triceps muscle on the back of the right arm, halfway between the acromion and the elbow. The skinfold ran parallel to the long axis of the arm.

**Subscapular**

**Posture:** The subject stood with shoulders erect but relaxed and arms by the sides.

**Technique:** The skinfold was raised with the thumb and forefinger of the left hand lateral to the inferior angle of the right scapula, the skinfold running downward and outward in the direction of the ribs.
Suprailiac
Posture: The subject stood in normal erect posture.
Technique: The subject was instructed to draw in a medium
breath and hold it. The skinfold was raised with the
thumb and forefinger of the left hand in a position one
to two inches above the right anterior superior iliac
spine so that the fold ran forward and slightly downward.

Calf
Posture: The subject sat on a chair with his foot on the
floor and the leg vertical.
Technique: The skinfold was raised with the thumb and fore-
finger of the left hand on the medial side of the right
calf just above the level of the maximum calf girth so
that the fold ran vertically.

3. Bone Diameters
Definition of Measurement: Bi-epicondylar diameter of the
distal extremity of the humerus and femur.
Landmarks. The points on either epicondyle of the distal
eextremity of the humerus or femur most lateral to the
medial plane of the bone.
Technique: The discs on the branches of the calipers were
applied against the epicondyles in such a manner as to
bisect the angle of the joint and to lie in the same
plane as the limb. Firm pressure was applied and the
measurement was recorded to the nearest .05 cm.
Measurements were taken on both limbs, and the larger measurements were recorded.

**Humerus**

Posture: The arm of the subject was raised forward to approximately the level of the shoulder and the forearm was flexed upward at a right angle to the arm.

Technique: The discs were applied to the epicondyles, bisecting the angle of the elbow, and lying in the same plane as the arm and forearm.

**Femur**

Posture: The subject sat on a chair with his foot on the floor and the leg vertical.

Technique: The investigator knelt in front of the subject and applied the discs to the epicondyles, bisecting the knee angle and keeping the caliper branches in a plane parallel to the thigh and the leg.

For all girth, skinfold and diameter measurements, if the first two varied by more than 5% a third measurement was taken; the two closest measures were averaged and used for calculations in accordance with instructions for measuring the Heath-Carter somatotype (Carter, 1975). All of the height, weight, diameter, girth and skinfold measurements were taken by the author.

**Treatment**

After initial measurements were made, the treatment groups began an eight week weight training program. The boys trained
immediately after school at 2:15, and the men trained during the noon hour. All training sessions adhered to the following pattern: Mondays and Wednesdays were considered normal training days and three sets of each exercise were performed. The entire workout was based upon the previously established 5 RM for each subject. A warmup was given for each exercise which was composed of 10 repetitions of a weight which corresponded to 50% of the 5 RM. Set 1 was nine repetitions of 65% of the 5 RM, set 2 was seven repetitions of 80% of 5 RM and set 3 was five repetitions of the 5 RM. Each Friday a new 5 RM was established. The format for this day was exactly like the testing days in which a 5 RM was found or extrapolated after 3 trials. The following Monday the workout was based upon the new 5 RM. For all training sessions the Olympic free weights were used. No more than two absences were allowed before a subject's data were deleted from the study. To minimize this happening, makeup sessions were allowed.

**Statistical Treatment**

The statistical treatment was divided into three sections: reliability of measurements, comparisons within and among groups, and regression models used to explain the variance in performance scores.

The anthropometric measurements obtained were used to estimate the somatotype of the individual. The rating was established according to the Modified Heath-Carter method (Carter, 1975). A computer program for somatotype was obtained from the University of Utah (Latin, 1982), and was rewritten and adapted for the Tektronix 4050 by the author. This was helpful in avoiding any human error inherent in long
computations. Furthermore, SPSS (Statistical Package for the Social Sciences) was used by the author on the VAX-11 system at the University of Nebraska at Omaha for the statistical analyses.

The reliability of measurements was obtained by using both a Pearson 'r' correlation coefficient and a paired t-test to check for significant differences. ANCOVA was used to compare the effects of puberty and weight training upon the dependent variable, muscle performance. A 2 (weight training or no weight training) by 2 (boys and men) factorial design using repeated measures was used (Figure 1). ANCOVA was employed with the initial score used as the covariate and the posttest score as the variable of interest.

![Figure 1. Repeated measures factorial design for comparing the men with the boys.](image)

Although analyses of the somatotype changes were performed by examining the three components separately, it was also necessary to compare the groups in regard to their relative dominance. Carter (1975) has emphasized that dividing the somatotype into components for analytical purposes destroys the integrity of the somatotype rating. Therefore, this analysis has also included somatocharts of the individuals and the groups' means. This is useful in providing a visual interpretation of the results. The somatocharts are divided into sectors by three axes which intersect at the center of the "Reuleaux triangle". The three axes are labeled the endomorphy,
mesomorphy and ectomorphy axes; as the values for the component rating increase from the center of the chart along any of the axes, the somatotypes become more polar.

With respect to the above discussion on relative dominance, group dispersions were analyzed using a method of analysis of variance (Ross, Carter & Wilson, 1974). This analysis is different from the usual ANOVA model in that the variance about the grand mean (\(\bar{M}\)) of the somatoplots cannot be obtained directly from the computational elements for the groups. The total variance in this model is accounted for by: (1) taking the variance of the somatotypes about the mean of all the somatotypes (\(\bar{M}\)), and (2) by taking the variance of the somatotypes in each group about their means (\(\bar{S}\)). All of the variances are determined in terms of somatotype dispersion distances. This analysis was calculated by hand and is displayed in detail in Appendix D.
CHAPTER V

RESULTS

Reliability Measurements

Table 2 illustrates the reliability of test-retest for the anthropometric measurements and the corresponding somatotype component rating taken on six of the boys and six of the men. The correlation coefficients ranged from 0.907 for the femur diameter to 0.999 for height, weight and biceps girth. No significant differences were found using the paired t-test.

Table 2. Reliability of test-retest data for anthropometric measurements (boys: n=6; men: n=6). Skinfolds and girth measures are in mm and cm, respectively.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test mean (SD)</th>
<th>Retest mean (SD)</th>
<th>r</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>height (cm)</td>
<td>165.78 (11.0)</td>
<td>165.51 (11.1)</td>
<td>0.999</td>
<td>-1.54</td>
</tr>
<tr>
<td>weight (kg)</td>
<td>59.90 (13.0)</td>
<td>59.84 (13.1)</td>
<td>0.999</td>
<td>-1.34</td>
</tr>
<tr>
<td>triceps</td>
<td>11.73 (5.4)</td>
<td>11.71 (5.0)</td>
<td>0.996</td>
<td>-0.15</td>
</tr>
<tr>
<td>subscapular</td>
<td>9.31 (3.4)</td>
<td>9.44 (3.4)</td>
<td>0.990</td>
<td>0.97</td>
</tr>
<tr>
<td>suprailiac</td>
<td>9.53 (6.0)</td>
<td>9.56 (5.6)</td>
<td>0.963</td>
<td>0.05</td>
</tr>
<tr>
<td>calf skinfold</td>
<td>12.85 (5.1)</td>
<td>12.83 (5.3)</td>
<td>0.913</td>
<td>-0.04</td>
</tr>
<tr>
<td>biceps</td>
<td>29.38 (3.9)</td>
<td>29.38 (3.8)</td>
<td>0.999</td>
<td>0.00</td>
</tr>
<tr>
<td>calf girth</td>
<td>34.60 (3.0)</td>
<td>34.53 (3.1)</td>
<td>0.982</td>
<td>-0.45</td>
</tr>
<tr>
<td>humerus</td>
<td>6.60 (0.4)</td>
<td>6.63 (0.3)</td>
<td>0.910</td>
<td>-0.47</td>
</tr>
<tr>
<td>femur</td>
<td>9.27 (0.5)</td>
<td>9.25 (0.6)</td>
<td>0.907</td>
<td>-0.26</td>
</tr>
<tr>
<td>sum of skinfolds</td>
<td>43.56 (16.3)</td>
<td>43.53 (15.5)</td>
<td>0.991</td>
<td>-0.04</td>
</tr>
<tr>
<td>Endomorphy</td>
<td>3.04 (1.5)</td>
<td>3.04 (1.4)</td>
<td>0.990</td>
<td>0.00</td>
</tr>
<tr>
<td>Mesomorphy</td>
<td>4.66 (1.4)</td>
<td>4.71 (1.4)</td>
<td>0.978</td>
<td>0.61</td>
</tr>
<tr>
<td>Ectomorphy</td>
<td>2.75 (1.3)</td>
<td>2.67 (1.3)</td>
<td>0.988</td>
<td>-1.48</td>
</tr>
</tbody>
</table>
Recall that two performance tests were administered and averaged for both the pre and posttests. Test-retest for these measures are displayed in Table 3. Test-retest refers to Test 1 and Test 2 for both the pretest and posttest measures. Not all measurements were obtained for both Tests 1 and 2 of the pretest and Tests 1 and 2 of the posttest for various reasons. The most frequent reason for reporting only one value was the difficulty in obtaining the squat measurement in three trials. Rather than having the subject attempt to squat a very heavy load, a more conservative incremental approach was used, resulting in the subjects many times being able to squat the weight six times on trial three. Since it was already established that not more than three trials were to be administered, the measurement was forfeited and the subject's score was the 5 RM recorded on the second pretest.

For example, assume a subject used a warmup for the squat of 75 lbs. He was then told to lift 150 lbs. until he was told to stop or until he could no longer lift it. Assuming he managed to lift it six times, he was given a rest and was asked how he felt lifting the 150 lb. weight. If it felt fairly heavy he was encouraged to try an additional 10 lbs. If he successfully lifted the weight six times, more weight was added. For the third trial, if he was able to lift the 170 lb. weight six times then a 5 RM was not obtained for that test. At the second pretest, after adequate warmup, a 5 RM was determined at 185 lbs. Since the subject had only one score for the squat, the second pretest score, the 185 lb. score, was used as his baseline squat poundage.
Obtaining a value too low was the major problem causing only one pretest or posttest value. Additionally, one of the training subjects had a sore elbow and could not bench press or curl any weight on Test 2 of the posttest. The significant differences between Tests 1 and 2 for the pre-bench, pre-curl, post-squat and post-bench scores demonstrate why it was necessary to obtain more than one measurement. Although there were significant differences between tests, the correlation coefficients were extremely high (0.982 to 0.997).

The correlation between test and retest for maturity rating on the 11 boys was 0.83. All of the 11 ratings were the same the second day, except one rating of a two was thereafter noted as a three, resulting in six boys in Group 2 and five boys in Group 3.

Table 3. Reliability of test-retest data for performance measures (lbs.)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Test mean (SD)</th>
<th>Retest mean (SD)</th>
<th>r</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat 1  (n=8)</td>
<td>120.10 (54.4)</td>
<td>127.44 (50.0)</td>
<td>0.982</td>
<td>1.93</td>
</tr>
<tr>
<td>Bench 1  (n=18)</td>
<td>86.29 (41.4)</td>
<td>89.47 (42.2)</td>
<td>0.997</td>
<td>3.78*</td>
</tr>
<tr>
<td>Curl 1   (n=15)</td>
<td>42.80 (18.0)</td>
<td>45.68 (17.9)</td>
<td>0.982</td>
<td>3.31*</td>
</tr>
<tr>
<td>Squat 2  (n=13)</td>
<td>175.58 (60.7)</td>
<td>179.17 (58.6)</td>
<td>0.997</td>
<td>2.72*</td>
</tr>
<tr>
<td>Bench 2  (n=19)</td>
<td>97.08 (44.0)</td>
<td>98.78 (43.2)</td>
<td>0.997</td>
<td>2.32*</td>
</tr>
<tr>
<td>Curl 2   (n=15)</td>
<td>48.95 (23.0)</td>
<td>48.44 (22.2)</td>
<td>0.996</td>
<td>-0.92</td>
</tr>
</tbody>
</table>

*Significant at the .05 level

**Squat, bench and curl 1 refer to pre scores (test-retest) while squat, bench and curl 2 refer to post scores (test-retest)
Table 4. Changes within the boys' groups. Skinfold and girth measures are in mm and cm, respectively, while performance measures are in lbs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys' Control (n=6)</th>
<th>Boys' Training (n=5)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre</td>
<td>post</td>
<td>t-value</td>
</tr>
<tr>
<td>Height (cm)</td>
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</tr>
<tr>
<td>Mean</td>
<td>153.27</td>
<td>155.07</td>
<td>4.63**</td>
</tr>
<tr>
<td>SD</td>
<td>6.68</td>
<td>6.90</td>
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</tr>
<tr>
<td>Weight (kg)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>46.28</td>
<td>48.23</td>
<td>4.88**</td>
</tr>
<tr>
<td>SD</td>
<td>11.91</td>
<td>11.71</td>
<td></td>
</tr>
<tr>
<td>Triceps skinfold</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>11.77</td>
<td>11.48</td>
<td>-0.31</td>
</tr>
<tr>
<td>SD</td>
<td>7.31</td>
<td>7.04</td>
<td></td>
</tr>
<tr>
<td>Subscapular skinfold</td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>9.23</td>
<td>8.12</td>
<td>-1.73</td>
</tr>
<tr>
<td>SD</td>
<td>5.75</td>
<td>4.18</td>
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</tr>
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<td>Suprailiac skinfold</td>
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<td>9.62</td>
<td>-1.58</td>
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<tr>
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<td>8.22</td>
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<td>Mean</td>
<td>17.63</td>
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<td>-1.02</td>
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<tr>
<td>SD</td>
<td>10.12</td>
<td>8.82</td>
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</tr>
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<td>Sum of skinfolds</td>
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</tr>
<tr>
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<td>-1.37</td>
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<td>SD</td>
<td>31.62</td>
<td>27.73</td>
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<tr>
<td>Biceps girth</td>
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<td>Mean</td>
<td>25.27</td>
<td>25.27</td>
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<td>SD</td>
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<td>Calf girth</td>
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<tr>
<td>Mean</td>
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<td>31.63</td>
<td>0.25</td>
</tr>
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<td>SD</td>
<td>2.38</td>
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<tr>
<td>Humerus diameter</td>
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<td>6.14</td>
<td>6.27</td>
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<td>SD</td>
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<tr>
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<tr>
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<td>3.00</td>
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<tr>
<td>SD</td>
<td>1.77</td>
<td>1.87</td>
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<tr>
<td>Squat</td>
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</tr>
<tr>
<td>Mean</td>
<td>97.28</td>
<td>108.82</td>
<td>2.26</td>
</tr>
<tr>
<td>SD</td>
<td>17.92</td>
<td>23.18</td>
<td></td>
</tr>
<tr>
<td>Bench</td>
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</tr>
<tr>
<td>Mean</td>
<td>52.45</td>
<td>56.47</td>
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</tr>
<tr>
<td>SD</td>
<td>8.12</td>
<td>10.27</td>
<td></td>
</tr>
<tr>
<td>Curl</td>
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<td>SD</td>
<td>3.80</td>
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</tr>
</tbody>
</table>

*p<.05  **p<0.01
Table 5. Changes within the mens' groups. Skinfold and girth measures are in mm and cm, respectively, while performance measures are in lbs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mens' Control (n=4)</th>
<th>Mens' Training (n=5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pre</td>
<td>post</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
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<tr>
<td>Mean</td>
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<td>172.30</td>
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<td>9.92</td>
</tr>
<tr>
<td><strong>Weight (kg)</strong></td>
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<td>9.91</td>
</tr>
<tr>
<td><strong>Triceps skinfold</strong></td>
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<td></td>
</tr>
<tr>
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<td>11.35</td>
</tr>
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<td>SD</td>
<td>4.96</td>
<td>3.97</td>
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<tr>
<td>SD</td>
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<td>3.32</td>
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<td><strong>Suprailiac skinfold</strong></td>
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<td>12.78</td>
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<td>SD</td>
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<td>3.98</td>
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<tr>
<td><strong>Calf skinfold</strong></td>
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<td>Mean</td>
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<td>11.90</td>
</tr>
<tr>
<td>SD</td>
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<td>1.25</td>
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<td><strong>Sum of skinfolds</strong></td>
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<td>37.05</td>
</tr>
<tr>
<td>SD</td>
<td>3.78</td>
<td>3.92</td>
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<td><strong>Humerus diameter</strong></td>
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<td></td>
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<tr>
<td>Mean</td>
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<td>6.69</td>
</tr>
<tr>
<td>SD</td>
<td>0.45</td>
<td>0.50</td>
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<tr>
<td><strong>Femur diameter</strong></td>
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</tr>
<tr>
<td><strong>Bench</strong></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>137.00</td>
<td>138.55</td>
</tr>
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<td>SD</td>
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<td>36.86</td>
</tr>
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<td><strong>Curl</strong></td>
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</tr>
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<td>SD</td>
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</tr>
</tbody>
</table>

**p<0.01 **
Group Comparisons

Tables 4 and 5 show the within group changes which occurred over the eight week period. It can be seen that both treatment groups had significant increases in the squat, bench press and arm curl. The control groups showed no differences in these measures. Both boys' groups increased in height, and the boys' control group also increased in weight (p<.01). The boys' training group decreased in the mean subscapular skinfold (p=.026), sum of skinfolds (p=.042), and displayed a decrease in the mesomorphic component (p=.005). The men's control group had no changes in any variable.

ANCOVA was used to compare groups using the initial score as the covariate and the posttest score as the variable of interest. Comparison of all four groups indicate differences among the groups in the subscapular skinfold (p=.012), the mesomorphic component (p=.043), and all three performance measurements (p<.002). All variables were first analyzed to see if the basic assumption of parallel slopes was met. Only the femur diameter measurement showed an interaction among the groups, so further analysis was not indicated for this variable.

Table 6. Results of analysis of covariance among all groups (N=20). Skinfolds and girth measures are in mm and cm, respectively; performance measures are in lbs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>F value</th>
<th>Variable</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1.822</td>
<td>sum of skinfolds</td>
<td>0.318</td>
</tr>
<tr>
<td>weight (kg)</td>
<td>1.021</td>
<td>humerus</td>
<td>1.350</td>
</tr>
<tr>
<td>triceps</td>
<td>0.587</td>
<td>endomorphy</td>
<td>0.902</td>
</tr>
<tr>
<td>subscapular</td>
<td>5.209*</td>
<td>mesomorphy</td>
<td>3.478*</td>
</tr>
<tr>
<td>suprailiac</td>
<td>0.035</td>
<td>ectomorphy</td>
<td>1.002</td>
</tr>
<tr>
<td>calf skinfold</td>
<td>0.754</td>
<td>squat</td>
<td>18.719**</td>
</tr>
<tr>
<td>biceps girth</td>
<td>0.696</td>
<td>bench</td>
<td>21.051**</td>
</tr>
<tr>
<td>calf girth</td>
<td>1.636</td>
<td>curl</td>
<td>7.767**</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01
Further ANCOVA analysis comparing only the two training groups demonstrated no differences in performance gains or the subscapular skinfold decrease (Table 7). A difference was found in the mesomorphic component, however (p=.001). Referring to Tables 4 and 5 it can be seen from the t-values that the boys decreased in this component (t-value = -5.58) while the men showed a nonsignificant increase (t-value = 2.16).

Table 7. Results of analysis of covariance between training groups (N=10). Skinfold is in mm and performance measures are in lbs.

<table>
<thead>
<tr>
<th>Variable</th>
<th>F value</th>
</tr>
</thead>
<tbody>
<tr>
<td>squat</td>
<td>0.006</td>
</tr>
<tr>
<td>bench</td>
<td>1.642</td>
</tr>
<tr>
<td>curl</td>
<td>0.271</td>
</tr>
<tr>
<td>mesomorphy</td>
<td>26.918**</td>
</tr>
<tr>
<td>subscapular skinfold</td>
<td>4.488</td>
</tr>
</tbody>
</table>

*p<0.01

Ross and others' (1974) method of analysis of variance was used to compare the groups (see Appendix D) and yielded the results shown in Table 8 for pretest somatotypes. The F value is not significant (p>.05) and implies there are no differences among groups in the mean somatotype. Figures 2 and 3 display the individual and group somatoplots. Figure 3 also contains the SDD's (somatotype dispersion distances) between all the pairs of groups. Table 9 demonstrates that there were no differences among groups in the final mean somatoplots (p>.05), and Figures 4 and 5 visually describe the similarities.
Boys' control (n=6): 
Boys' training (n=5): 
Adult control (n=4): 
Adult training (n=5): 

Figure 2. Pretest somatoplots of individual somatotypes.
Boys' control (n=6): 1
Boys' training (n=5): 2
Adult control (n=4): 3
Adult training (n=5): 4
Grand mean (N=20): $\bar{y}$

<table>
<thead>
<tr>
<th>SDD's BETWEEN MEANS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) 1.31 2.88 1.64</td>
</tr>
<tr>
<td>(2) 2.36 1.06</td>
</tr>
<tr>
<td>(3) 3.41</td>
</tr>
</tbody>
</table>

Figure 3. Pretest somatoplots of mean somatotypes. Somatotype dispersion distances are shown to the right.
Boys' control (n=6): 1
Boys' training (n=5): 2
Adult control (n=4): 3
Adult training (n=5): 4

Figure 4: Posttest somatoplots of individual somatotypes.
Boys' control (n=6): 1
Boys' training (n=5) 2
Adult control (n=4): 3
Adult training (n=5) 4
Grand mean (N=20): $\bar{y}$

<table>
<thead>
<tr>
<th>SDD's BETWEEN MEANS</th>
<th>(1) 0.40</th>
<th>(2) 3.80</th>
<th>(3) 1.22</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2) 4.19</td>
<td>1.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(3) 3.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5: Posttest somatoplots of mean somatotypes. Somatotype dispersion distances are shown to the right.
Table 8. ANOVA table for pretest somatoplot values among the four groups (N=20).

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>38.09</td>
<td>3</td>
<td>12.70</td>
<td>1.81</td>
</tr>
<tr>
<td>Within</td>
<td>111.99</td>
<td>16</td>
<td>7.00</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>150.08</td>
<td>19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F.05 (3, 16) = 3.24

Table 9. ANOVA table for posttest somatoplot values among the four groups (N=20).

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>59.36</td>
<td>3</td>
<td>19.79</td>
<td>2.67</td>
</tr>
<tr>
<td>Within</td>
<td>118.42</td>
<td>16</td>
<td>7.40</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>177.78</td>
<td>19</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

F.05 (3, 16) = 3.24

Regression Models

Table 10 exhibits the high and significant interrelationships among the pretest performance measures.

Table 10. Intercorrelations among performance measures (N=20).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Squat</th>
<th>Bench</th>
<th>Curl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squat</td>
<td>------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Bench</td>
<td>0.94*</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Curl</td>
<td>0.95*</td>
<td>0.93*</td>
<td></td>
</tr>
</tbody>
</table>

*p<0.01

Table 11 illustrates the stepwise regression analysis results for the squat using: (a) all other variables;(b) all other variables with
exclusion of the bench press and arm curl; and (c) all variables with exclusion of the bench press, arm curl and age variables. For each of these models, further variables were not used when they no longer contributed significantly in explaining further variance.

Table 11. Regression analysis for the squat using three different approaches (a, b, c) (N=20).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multiple R</th>
<th>R Square</th>
<th>Simple R</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) all other variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curl</td>
<td>0.951</td>
<td>0.904</td>
<td>0.951</td>
<td>2.359</td>
</tr>
<tr>
<td>Age</td>
<td>0.963</td>
<td>0.928</td>
<td>0.888</td>
<td>2.617</td>
</tr>
<tr>
<td>Suprailiac skinfold</td>
<td>0.972</td>
<td>0.945</td>
<td>0.142</td>
<td>1.194</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -10.522</td>
</tr>
<tr>
<td>(b) all other variables excluding the other two performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.888</td>
<td>0.789</td>
<td>0.888</td>
<td>2.935</td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.939</td>
<td>0.882</td>
<td>0.838</td>
<td>7.081</td>
</tr>
<tr>
<td>Calf skinfold</td>
<td>0.962</td>
<td>0.925</td>
<td>-0.429</td>
<td>-3.807</td>
</tr>
<tr>
<td>Suprailiac skinfold</td>
<td>0.974</td>
<td>0.948</td>
<td>0.142</td>
<td>2.242</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -83.668</td>
</tr>
<tr>
<td>(c) all other variables excluding age and the other two performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.838</td>
<td>0.702</td>
<td>0.838</td>
<td>10.093</td>
</tr>
<tr>
<td>Calf skinfold</td>
<td>0.940</td>
<td>0.883</td>
<td>-0.429</td>
<td>-5.275</td>
</tr>
<tr>
<td>Suprailiac skinfold</td>
<td>0.956</td>
<td>0.913</td>
<td>0.142</td>
<td>2.561</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -100.958</td>
</tr>
</tbody>
</table>

This type of comparison of excluding variables indicates also some of the interrelationships which exist between variables which come into effect when others are taken out. When the curl is eliminated from the regression model in (b), biceps girth and calf skinfold are
significant contributors. However when age is eliminated in (c), no other variables enter into the resulting model. At that point, however, 91.3% of the variance is explained as compared to 92.5% using model (b). Tables 12 and 13 demonstrate the relationships which exist among the bench press and the arm curl, respectively, with the other variables.

Table 12. Regression analysis for the bench press using three different approaches (a, b, c) (N=20).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multiple R</th>
<th>R Square</th>
<th>Simple R</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) all other variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squat</td>
<td>0.940</td>
<td>0.884</td>
<td>0.940</td>
<td>0.581</td>
</tr>
<tr>
<td>Humerus diameter</td>
<td>0.954</td>
<td>0.911</td>
<td>0.553</td>
<td>17.653</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -110.741</td>
</tr>
<tr>
<td>(b) all other variables excluding the other two performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.871</td>
<td>0.759</td>
<td>0.871</td>
<td>6.728</td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>0.950</td>
<td>0.902</td>
<td>-0.182</td>
<td>-1.922</td>
</tr>
<tr>
<td>Age</td>
<td>0.966</td>
<td>0.933</td>
<td>0.864</td>
<td>1.772</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -116.732</td>
</tr>
<tr>
<td>(c) all other variables excluding age and the other two performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.871</td>
<td>0.759</td>
<td>0.871</td>
<td>8.909</td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>0.950</td>
<td>0.902</td>
<td>0.143</td>
<td>-2.811</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>constant -137.749</td>
</tr>
</tbody>
</table>
Table 13. Regression analysis for the arm curl using three different approaches (a, b, c) (n=20).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Multiple R</th>
<th>R Square</th>
<th>Simple R</th>
<th>B</th>
<th>constant</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) all other variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squat</td>
<td>0.951</td>
<td>0.904</td>
<td>0.951</td>
<td>0.281</td>
<td>-0.096</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) all other variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excluding the other two</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.847</td>
<td>0.717</td>
<td>0.847</td>
<td>0.516</td>
<td></td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.916</td>
<td>0.839</td>
<td>0.840</td>
<td>3.233</td>
<td></td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>0.973</td>
<td>0.947</td>
<td>-0.284</td>
<td>-1.294</td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>-47.573</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) all other variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>excluding age and the other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>two performance measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biceps girth</td>
<td>0.840</td>
<td>0.706</td>
<td>0.840</td>
<td>4.370</td>
<td></td>
</tr>
<tr>
<td>Triceps skinfold</td>
<td>0.966</td>
<td>0.933</td>
<td>-0.284</td>
<td>-1.660</td>
<td></td>
</tr>
<tr>
<td>Humerus diameter</td>
<td>0.975</td>
<td>0.951</td>
<td>0.523</td>
<td>-7.663</td>
<td></td>
</tr>
<tr>
<td>constant</td>
<td>-17.103</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figures 6 (a, b, c) graphically display the relationships which exist between the performance measures and the single best predictor for each of these measures. Adjacent to each graph is the multiple regression equation which best describes the variance of that measure.
Figure 6. Relationship of performance measures to predictors. Graphs illustrating the relationship between performance measures and their single best predictor for (a) squat, (b) bench press and (c) arm curl are shown. Adjacent to each graph are the single and multiple regression equations which best explain the variance for that measure.
CHAPTER VI

DISCUSSION

Out of 20 seventh grade junior high school boys, none were found to be in Group 1 of Greulich's rating scale. All subjects were in Groups 2 and 3, representing that point of pubescence which is before maturity. It appears it may be necessary to use elementary school-aged boys to obtain subjects from Group 1.

Comparing the boys to the men in this study resulted in no significant differences in increase for squat, bench press and arm curl scores, after adjusting for initial differences (p>.24). One wonders if differences would have been found if the boys had been from Group 1. On the other hand, it might be that obtaining boys from Groups 4 and 5 and comparing them to these boys and men would show a training effect that was greatest in the adolescents. This speculation would seem worth investigating when considering Carron & Bailey's research (1974). In a seven year longitudinal study, their descriptive data showed the average peak increase in strength development was one year after the peaks for height and weight gain. Since both boys' groups in this immediate study had an increase in height over the eight week period (p<.01), it could be that they would be peaking in strength development in another year.

With the very small sample sizes, inferences are difficult to make. This problem is of course compounded by the motivational
factors which are inherent in this type of study. Figure 2 illustrates the somatotypes of the individuals before the eight week training period. It is interesting that the boys who volunteered for training are basically clustered together and might seem on the average more of a balanced mesomorphic group (balanced mesomorphy means that the other two components are equal in magnitude with mesomorphy being dominant). And, except for the one deviant somatoplot toward the ectomorph pole, the training men are similar in body shape to the boys. It seems that individuals with similar physiques were interested in joining the program. However, when comparing means (see Figure 3), there were no significant differences found among any of the groups in the relative dominance of somatotype at the initiation of training (one way ANOVA, p>.05). After the eight weeks the groups were again found to have no differences among their means (p>.05). Figure 5 illustrates the proximity of the group means at the posttest.

ANCOVA for all four groups showed that there were significant differences among groups for mesomorphy, subscapular skinfold and all three performance measures (p<.05) after the eight weeks. When comparing just the training groups no differences were found, except in the mesormorphic component (p<.001). Tables 4 and 5 demonstrate that while the training men gained nonsignificantly (t=2.16, p=.097) in mesomorphy, the boys actually lost in that component (t=5.58, p=.005). Comparison of Figures 3 and 5 illustrates the mean changes within these groups. Although the boys gained strength comparable to the men, it was not reflected by an increase of maintenance of mesomorphy. The training boys did have significant decreases in both subscapular
skinfolds (p=.026) and in the sum of skinfolds (p=.042), whereas the training men did not. The loss in the mesomorphic component by the training boys was not paralleled by their control counterparts (t=0.68, p=.529).

There could be several reasons for this inconsistency between the control and training boys. The boys' control group had demonstrated an increase in weight (p<.001), yet the boys' training group had no change (p=.36). In the same light, since the training group showed a decrease in the sum of skinfolds, it is possible that with the increase in height, the spread of muscle along the bone may have been greater for the training boys. This would imply a decrease in mesomorphy. One must consider what measurements constitute the mesomorphic component in order to understand this logic. Biceps and calf girth, minus the triceps and calf skinfold, respectively, and humerus and femur diameter, along with height, form a model where the way in which muscle lies upon the bone is rated. In other words, the higher the ratio of muscle girth, minus subcutaneous fat, to bone, the greater the mesomorphic rating. Therefore, if a boy grows taller, loses fat and gains no weight, it is possible that, even if he grows stronger, his mesomorphic rating could decrease.

Another consideration involving the decrease in mesomorphy by the training boys is the activity level of these boys. The only restriction placed upon the boys was that they were to do no strength training outside of the study. In the training group, three of the boys were active in organized baseball and the other two were participating in track and field events during the course of this study. In
retrospect, this author's opinion is that the training boys were a more active group when compared to the control boys. This would also explain why they volunteered for the training. At any rate, these boys may have been maintaining a higher metabolic rate throughout their day, implying a greater amount of energy (and fat) being burned. The control group seemed to be a less active group on the whole, but it could be that the activity that they did indulge in was of a great enough intensity to develop or maintain the ratio of muscle girth to bone length and width, yet minimize reduction of fat.

Another point to consider is that while the mesomorphic component independently showed a change in only the training boys' group (decrease), when the somatotype was compared as a whole among groups, no differences were detected in either pre or posttest values. The type of analysis of variance used deviated from the normal model, and it was only appropriate to compare the groups before the treatment and then again after treatment. There is not an established model for repeated measures of somatotype as a whole that would allow changes within the groups over the eight week period to be analyzed. Therefore paired t tests were used to compare each component separately and are of course very susceptible to both Type I and Type II error with the very small degrees of freedom used.

One final speculation concerning the difference in the mesomorphic rating for the training boys when compared to their controls is the concept of specificity of exercise. One might assume that the boys who trained should increase in mesomorphy or at least maintain their initial rating, since the control boys showed no decrease.
However, it might be that although the control boys did not change in performance measures (p>.05), they may have developed strength which was not specific to the isotonic exercises that were administered in this study. Static strength measurements may have shown a greater increase for the boys' control group, if it had been measured. Jones (1946) noted that static strength is more closely related to constitutional factors, so it may be that static strength changes are more closely related to changes in somatotype.

In this study the mode of strength testing was found to be highly intercorrelated. Table 10 displays the correlations among squat, bench press and arm curl (all higher than r=.93). It is further illustrated in Figure 6 where squat is the leading predictor of bench press and arm curl, and arm curl explains most of the variance in the squat (88.4%). Biceps girth was found to be moderately correlated with each of the performance measures (with squat, r=0.84; with bench press, r=0.87; with arm curl, r=0.84). Age was also a significant contributor for the squat (p<.05), and is the leading predictor for squat and arm curl and a significant contributor (p<.05) when the other performance measures are excluded. This final note is interesting and shows that while there were no differences between the men and boys' strength gains, there is obviously high correlation for age with the squat, bench press and arm curl (0.89, 0.86 and 0.85, respectively).
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to compare the differences in performance gains between prepubescent and adult males after an eight week weight training program using Olympic free weights. In addition, changes in somatotype and anthropometric measurements due to training were examined. Both the training groups, boys and men, contained five subjects. There was also a control boys' group of six subjects and a control mens' group of four subjects. All of the boys in the study were either in Group 2 or 3 of Greulich's rating scale (1942).

The variables measured were height, weight, skinfolds (triceps, subscapular, suprailiac and calf), girths (biceps and calf), diameters (humerus and femur) and the 5 RM for squat, bench press and arm curl. These were measured before and after the eight weeks to see if there were any significant (p<.05) differences within and among the groups. Data were also used to predict performance.

Training consisted of three sets three times weekly of the squat, bench press and arm curl using Olympic free weights. The first set was nine repetitions at 65% of the 5 RM; the second set was seven repetitions at 80% of the 5 RM; and the third set was five repetitions.
at 100% of the 5 RM. Every third session new 5 RM values were established so that the intensity would be continually maintained.

A summary of the results is as follows:

1. Both of the training groups showed a significant increase in the squat, bench press and arm curl.

2. The increase in all of the performance measures was no different in the mens' group when compared to the boys after adjusting for initial differences.

3. Neither control group had significant gains in weight lifting performance.

4. Both boys' groups had significant increases in height.

5. Only the boys' control group had a significant increase in weight.

6. The boys' training group showed a significant decrease in both the subscapular skinfold and in the sum of skinfolds.

7. The mesomorphic component was significantly reduced in the boys' training group.

8. The mesomorphic component did not change in the mens' control group or either of the mens' group.

9. The somatoplot means did not differ among groups either before or after training.

10. All three of the performance measures were found to be highly intercorrelated.

11. Both age and biceps girth were found to moderately correlate with all three of the performance measures.
Conclusions

The following conclusions are warranted on the basis of the results of this investigation.

1. Both men and boys can significantly increase the values of their 5 RM for the squat, bench press and arm curl using Olympic free weights over an eight week, three times weekly, training period.

2. Boys in Groups 2 and 3 of Greulich's pubescent rating scale have comparable gains to men in muscle performance after training with Olympic weights.

3. The mesomorphic component will not necessarily increase with isotonic training even when significant strength gains occur.

4. Each of the squat, bench press and arm curl are strong predictors of performance for the other two when using Olympic free weights.

5. Age and biceps girth are moderate predictors of the 5 RM for the squat, bench press and arm curl.

Recommendations

The following recommendations for future research can be made:

1. A similar study using a larger number of subjects should be undertaken.

2. A study which randomly divides subjects into control and treatment groups should be conducted.
3. A similar study using a training period of greater than eight weeks should be carried out.

4. A study comparing training effects on different levels of pubescent maturity should be undertaken.

5. Future research should maintain stricter limitations on outside activity.
REFERENCES


Sady, S. P., Berg, K., Sailors, M. M., Katch, V., Villanacci, J.


Wickens, J. S. Maturity, structural, muscular strength, and motor ability growth curves of boys nine to fifteen years of age. Microfiche dissertation, University of Oregon, 1958.


Appendix A
Stretching Routine*

1. 15 Seconds
   Each arm
2. 20 Seconds
3. 15 Seconds
4. 30 Seconds
5. 20 Seconds
6. 30 Seconds
7. 25 Seconds
   Each leg
8. 30 Seconds

*Taken from Anderson, 1982.
9. 10 Seconds
   Each side

10. 15 Seconds
    Each leg

11. 3 Times
    5 seconds each

12. 25 Seconds

13. 20 Seconds

14. 20 Seconds
    Each leg

15. 5 Times

16. 15 Seconds
    Each arm
Appendix B
ANTHROPOMETRIC DATA FORM

NAME__________________________AGE:_______ Date of Birth ____________

Circle: PRE POST Ethnic Group_________Date_________

Height:

in________
cm________

Weight:

lb________
kg________

Skinfolds (trials and average)

Triceps ____ ____ ____ ____
Subscapular ____ ____ ____ ____
Suprailiac ____ ____ ____ ____
Calf ________ ________
Biceps ________ ________

Diameters:

Humerus ____ ____ ____ ____
Femur ____ ____ ____ ____
Biacromial ____ ____ ____ ____
Bideltoid ________ ________
Chest ________ ________
Bi-iliac ________ ________

Girths:

Biceps flexed _____ _____ _____
Biceps stretched ____ ____ ____
Calf _____ _____ _____
Chest _____ _____ _____
| NAME __________________________ | Circle: Pre | Post |
| DATE of TEST __________________  | DATE of TEST __________________ |
| TEST 1 TIME __________ | TEST 2 TIME __________ |
| Squat (weight and reps) | Squat (weight and reps) |
| Warmup ____ ____ | Warmup ____ ____ |
| Trial 1 ____ ____ | Trial 1 ____ ____ |
| Trial 2 ____ ____ | Trial 2 ____ ____ |
| Trial 3 ____ ____ | Trial 3 ____ ____ |
| 5 RM ____ | 5 RM ____ |
| Bench press (weight and reps) | Bench press (weight and reps) |
| Warmup ____ ____ | Warmup ____ ____ |
| Trial 1 ____ ____ | Trial 1 ____ ____ |
| Trial 2 ____ ____ | Trial 2 ____ ____ |
| Trial 3 ____ ____ | Trial 3 ____ ____ |
| 5 RM ____ | 5 RM ____ |
| Arm curl (weight and reps) | Arm curl (weight and reps) |
| Warmup ____ ____ | Warmup ____ ____ |
| Trial 1 ____ ____ | Trial 1 ____ ____ |
| Trial 2 ____ ____ | Trial 2 ____ ____ |
| Trial 3 ____ ____ | Trial 3 ____ ____ |
| 5 RM ____ | 5 RM ____ |
# Training Schedule

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<tr>
<td>Arm curl</td>
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BASIC Program for Computing the Heath-Carter Somatotype

10 REM HEATH-CARTER ANTHROPOMETRIC SOMATOTYPE
20 REM WRITTEN BY RICK LATIN, 11/25/82
30 REM MODIFIED FOR TEKTRONIX BY MARGE SAILORS, 3/83
100 PRINT "***************************
110 DIM XS(30)" "
120 PRINT "***********III " **
130 PRINT "***THIS PROGRAM WILL COMPUTE A HEATH-CARTER ANTHROPOMETRIC ");
140 PRINT "SOMATOTYPE *"
150 PRINT "*** III " **
160 PRINT "III **"
170 PRINT "THE FOLLOWING ANTHROPOMETRIC DATA ARE REQUIRED:");
180 PRINT "III "
190 PRINT "***********
200 PRINT "WEIGHT (KG); HEIGHT (CM); SKINFOLDS (MM); TRICEP, "
210 PRINT "Calf, Suprailiac, "
220 PRINT "AND SUBSCAPULAR; DIAMETERS (CM); ELBOW, AND KNEE; "
230 PRINT "CIRCUMFERENCES (CM):"
240 PRINT "BICEP AND CALF"
250 PRINT "III **"
260 PRINT "***********
270 PRINT "***********
280 PRINT "PLEASE INPUT THE FOLLOWING INFORMATION:" 
290 PRINT "JNAME: ";
300 INPUT NS
310 PRINT "JAGE (YRS): ";
320 INPUT A
330 PRINT "JDATE (XX-XX-XX): ";
340 INPUT DS
350 PRINT "HEIGHT (CM): ";
360 INPUT H
370 PRINT "JWEIGHT (KG): ";
380 INPUT W
390 PRINT "JSKINFOLDS (MM); JTRICEP: ";
400 INPUT T
410 PRINT "JISUBSCAPULAR: ";
420 INPUT S1
430 PRINT "JISUPRAILIAC: ";
440 INPUT S2
450 PRINT "JI CALF: ";
460 INPUT C
470 PRINT "JDIAMETERS (CM); JHUMERUS: ";
480 INPUT E
490 PRINT "JIPEWUR: ";
500 INPUT K
510 PRINT "JCIRCUMFERENCES (CM): JHBBICEP: ";
520 INPUT B
530 PRINT "JI CALF: ";
540 INPUT C1
550 PRINT "IS THE ABOVE INFORMATION CORRECT? (Y OR N): ";
560 INPUT X$ 570 GO TO POS("NOYES",X$,1) OF 2010,550,580,550,550
580 PRINT "PRESS RETURN TO PRINT EVALUATION ";
590 INPUT B$ 600 S3=S1+S1+S2 610 H1=H/2.54
620 W=W*2.2 630 B=B-T/10 640 C1=C1-C/10
650 P=H1/W^(1/3) 660 REM ENDOMORPHY COMPONENT
670 IF S3>10.4 THEN 700
680 S3=0.5
690 GO TO 1390
700 IF S3>14.4 THEN 730
710 S3=1
720 GO TO 1390
730 IF S3>18.4 THEN 760
740 S3=1.5
750 GO TO 1390
760 IF S3>22.4 THEN 740
770 S3=2
780 GO TO 1390
790 IF S3>26.4 THEN 820
800 S3=2.5
810 GO TO 1390
820 IF S3>31.2 THEN 850
830 S3=3
840 GO TO 1390
850 IF S3>35.8 THEN 880
860 S3=3.5
870 GO TO 1390
880 IF S3>40.7 THEN 910
890 S3=4
900 GO TO 1390
910 IF S3>46.2 THEN 940
920 S3=4.5
930 GO TO 1390
940 IF S3>52.2 THEN 970
950 S3=5
960 GO TO 1390
970 IF S3>58.7 THEN 1000
980 S3=5.5
990 GO TO 1390
1000 IF S3>65.7 THEN 1030
1010 S3=6
1020 GO TO 1390
1030 IF S3>73.2 THEN 1060
1040 S3=6.5
1050 GO TO 1390
1060 IF S3>81.2 THEN 1090
1070 S3=7
1080 GO TO 1390
1090 IF S3>89.7 THEN 1120
1100 S3=7.5
1110 GO TO 1390
1120 IF S3>98.9 THEN 1150
1130 S3=8
1140 GO TO 1390
1150 IF S3>107.9 THEN 1180
1160 S3=8.5
1170 GO TO 1390
1180 IF S3>120 THEN 1210
1190 S3=9
1200 GO TO 1390
1210 IF S3>131 THEN 1240
1220 S3=9.5
1230 GO TO 1390
1240 IF S3>141 THEN 1270
1250 S3=10
1260 GO TO 1390
1270 IF S3>157 THEN 1300
1280 S3=10.5
1290 GO TO 1390
1300 IF S3>172 THEN 1330
1310 S3=11
1320 GO TO 1390
1330 IF S3>188 THEN 1360
1340 S3=11.5
1350 GO TO 1390
1360 IF S3>188 THEN 1370
1370 S3=12
1380 REM MESOMORPHY COMPONENT
1390 HL=H1+4
1400 E=E*70/6.8+1.5
1410 K*K=70/9.71+1.5
1420 R=R*70/31+1.5
1430 C1=C1*70/36.3+1.5
1440 G1=E*K+B+C1
1450 G2=(G1-H1)/12+4
1460 G2=INT(G2*10+0.5)/10
1470 REM ECTOMORPHY COMPONENT
1480 IF P>11.94 THEN 1510
1490 P=0.5
1500 GO TO 2830
1510 IF P>12.324 THEN 1540
1520 P=1
1530 GO TO 2830
1540 IF P>12.514 THEN 1570
1550 P=1.5
1560 GO TO 2830
1570 IF P>12.744 THEN 1600
1580 P=2
1590 GO TO 2830
1600 IF P>12.854 THEN 1630
1610 P=2.5
1620 GO TO 2830
1630 IF P>13.154 THEN 1660
1640 P=3
1650 GO TO 2830
1660 IF P>13.364 THEN 1690
1670 P=3.5
1680 GO TO 2830
1690 IF P>13.564 THEN 1720
1700 P=4
1710 GO TO 2830
1720 IF P>13.774 THEN 1750
1730 P=4.5
1740 GO TO 2830
1750 IF P>13.984 THEN 1780
1760 P=5
1770 GO TO 2830
1780 IF P>14.194 THEN 1810
1790 P=5.5
1800 GO TO 2830
1810 IF P>14.394 THEN 1840
1820 P=6
1830 GO TO 2830
1840 IF P>14.514 THEN 1870
1850 P=6.5
1860 GO TO 2830
1870 IF P>14.804 THEN 1900
1880 P=7
1890 GO TO 2830
1900 IF P>15.014 THEN 1930
1910 P=7.5
1920 GO TO 2830
1930 IF P>15.224 THEN 1960
1940 P=8
1950 GO TO 2830
1960 IF P>15.424 THEN 1990
1970 P=8.5
1980 GO TO 2830
1990 P=9
2000 GO TO 2830
2010 PRINT "IF THE FOLLOWING INFORMATION IS CORRECT PRESS RETURN "
2020 PRINT "IF IT NEEDS EDITING REPLY BY PRESSING THE LETTER Y "
2030 DELETE X$
2040 PRINT "NAME = "; N$; " (EDIT?) "
2050 INPUT X$
2060 IF X$="Y" THEN 2080
2070 GO TO 2100
2080 PRINT "NAME: ";
2090 INPUT N$
2100 PRINT "AGE = "; A; " (EDIT?) ";
2110 INPUT X$
2120 IF X$="Y" THEN 2140
2130 GO TO 2160
2140 PRINT "AGE: ________________________________
2150 INPUT A
2160 PRINT "DATE (XX-XX-XX) = "; D$; " (EDIT?) ";
2170 INPUT D$
2180 PRINT "DATE (XX-XX-XX): ";
2190 PRINT "HEIGHT = "; H; " (EDIT?) ";
2200 INPUT X$
2210 IF X$="Y" THEN 2230
2220 GO TO 2250
2230 INPUT D$
2240 PRINT "DATE (XX-XX-XX): ________________________________
2250 PRINT "HEIGHT = "; H; " (EDIT?) ";
2260 PRINT "HEIGHT: ________________________________
2270 INPUT H
2280 PRINT "WEIGHT = "; W; " (EDIT?) ";
2290 INPUT X$
2300 IF X$="Y" THEN 2320
2310 GO TO 2340
2320 PRINT "WEIGHT: ";
2330 PRINT "TRICEP SKINFOLD = "; T; " (EDIT?) ";
2340 PRINT "TRICEP SKINFOLD: ";
2350 INPUT T
2360 IF X$="Y" THEN 2380
2370 GO TO 2400
2380 PRINT "TRICEP SKINFOLD: ";
2390 INPUT T
2400 PRINT "SUBSCAPULAR SKINFOLD = "; S1; " (EDIT?) ";
2410 PRINT "SUBSCAPULAR SKINFOLD: ";
2420 IF X$="Y" THEN 2440
2430 GO TO 2460
2440 PRINT "SUBSCAPULAR SKINFOLD: ";
2450 INPUT S1
2460 PRINT "SUPRAILIAC SKINFOLD = "; S2; " (EDIT?) ";
2470 INPUT S$
2480 IF X$="Y" THEN 2500
2490 GO TO 2520
2500 PRINT "SUPRAILIAC SKINFOLD: ";
2510 PRINT "CALF SKINFOLD = "; C; " (EDIT?) ";
2520 PRINT "CALF SKINFOLD: ";
2530 INPUT C
2540 IF X$="Y" THEN 2560
2550 GO TO 2580
2560 PRINT "CALF SKINFOLD: ";
2570 INPUT C
2580 PRINT "HUMERUS DIAMETER = "; E; " (EDIT?) ";
2590 PRINT "HUMERUS DIAMETER: ";
2600 IF X$="Y" THEN 2620
2610 GO TO 2640
2620 PRINT "HUMERUS DIAMETER: ";
2630 INPUT E
2640 PRINT "FEMUR DIAMETER = "; K; " (EDIT?) ";
2650 PRINT "FEMUR DIAMETER: ";
2660 IF X$="Y" THEN 2680
2670 GO TO 2700
2680 PRINT "FEMUR DIAMETER: ";
2690 INPUT K
2700 PRINT "BICEP CIRCUMFERENCE = ";B," (EDIT?) ";
2710 INPUT X$  
2720 IF X$="Y" THEN 2740
2730 GO TO 2760
2740 PRINT "BICEP CIRCUMFERENCE: ";
2750 INPUT B
2760 PRINT "CALF CIRCUMFERENCE = ";C1," (EDIT?) ";
2770 INPUT X$  
2780 IF X$="Y" THEN 2800
2790 GO TO 2800
2800 PRINT "CALF CIRCUMFERENCE: ";
2810 INPUT C1
2820 GO TO 2840
2830 PRINT "*********************
2840 PRINT "THE UNIVERSITY OF NEBRASKA AT OMAHA ";
2850 PRINT "* I HEATH-CARTER SOMATOTYPE RATING **
2860 PRINT "* "
2870 PRINT "*********************
2880 PRINT "** * HEATH-CARTER SOMATOTYPE RATING **
2890 PRINT "* III "
2900 PRINT "*********************
2910 PRINT "**";
2920 PRINT "J Name: ";N$;"HHHHH" Weight: ";W/2.2;
2930 PRINT "**
2940 PRINT "** Height: ";H," cm"
2950 PRINT "**
2960 PRINT "** Age: ";A;"IDate: ";D$  
2970 PRINT "**
2980 PRINT "**
2990 PRINT "**
3000 PRINT "JENDOMORPHY COMPONENT: ";S3," <RANGE: 1-12>");
3010 PRINT "characterized by roundness and softness, the fatness ";
3020 PRINT "component of ";
3030 PRINT "the body"
3040 PRINT "IMESOMORPHY COMPONENT: ";G2," <RANGE:1-4>"
3050 PRINT "characterized by a 'square body' with large bones ";
3060 PRINT "and hard, rugged ";
3070 PRINT "and prominent musculature"
3080 PRINT "JECTOMORPHY COMPONENT: ";P," <RANGE: 1-9>"
3090 PRINT "characterized by linearity, fragility, and delicacy ";
3100 PRINT "of the body: ";
3110 PRINT "the leanness component of the body"
3120 PRINT "J CHARACTERISTICS **
3130 PRINT "J AND > very strong"
3140 PRINT "6 TO 8 strong"
3150 PRINT "3 TO 5 moderate"
3160 PRINT "2 AND < weak"
3170 COPY
3180 END
*************

* THIS PROGRAM WILL COMPUTE A HEATH-CARTER ANTHROPOMETRIC SOMATOTYPE *

* THE FOLLOWING ANTHROPOMETRIC DATA ARE REQUIRED: *

* WEIGHT (KG); HEIGHT (CM); SKINFOLDS (MM); TRICEP, CALF, SUPRAILIAC, *
* AND SUBSCAPULAR; DIAMETERS (CM); ELBOW, AND KNEE; CIRCUMFERENCE (CM): *
* BICEP AND CALF *

*************

PLEASE INPUT THE FOLLOWING INFORMATION:

NAME: KENNETH SAILORS
AGE (YRS): 29
DATE (XX-XX-XX): 17-MAY-83
HEIGHT (CM): 167.1
WEIGHT (KG): 79.6
SKINFOLDS (MM):

TRICEP: 7.0
SUBSCAPULAR: 7.2
SUPRAILIAC: 5.5
CALF: 5.4

DIAMETERS (CM):

HUMERUS: 6.65
FEMUR: 9.15

CIRCUMFERENCE (CM):

BICEP: 38.9
CALF: 39.8

IS THE ABOVE INFORMATION CORRECT? (Y OR N)
**THE UNIVERSITY OF NEBRASKA AT OMAHA**
**HEATH-CARTER SOMATOTYPE RATING**

Name: KENNETH SAILORS Weight: 79.6 kg  Height: 167.1 cm

Age: 29  Date: 17-MAY-83

**SOMATOTYPE RATING: * 2 - 7.3 - 0.5 * **

ENDOMORPHY COMPONENT: 2 <RANGE: 1-12>
characterized by roundness and softness, the fatness component of the body

MESOMORPHY COMPONENT: 7.3 <RANGE:1-9>
characterized by a 'square body' with large bones and hard, rugged and prominent musculature

ECTOMORPHY COMPONENT: 0.5 <RANGE: 1-9>
characterized by linearity, fragility, and delicacy of the body: the leanness component of the body

* CHARACTERISTICS *

9 AND > very strong
6 TO 8 strong
3 TO 5 moderate
2 AND < weak
Appendix D
Somatotype Computations*

Regardless of the method used, any three component somatotype may be located as \((X, Y)\) coordinates on the Heath-Carter somatochart shown as Figure 7, using the following formulae:

\[
X = \text{III} - \text{I} \\
Y = 2\text{II} - (\text{I} + \text{II})
\]

where \(X\) and \(Y\) are the coordinates, \(\text{I}, \text{II}, \text{III}\), represent first, second and third component ratings. The location of the somatotype in terms of \((X, Y)\) coordinates on the somatochart is referred to as its somatoplot.

Mean Somatotype

The mean somatotype is obtained by finding the mean for each component.

\[
\overline{S} = \frac{\sum_{i=1}^{n} S_i}{n} \quad \ast \quad \frac{\sum_{i=1}^{n} \text{II}_i}{n} \quad \ast \quad \frac{\sum_{i=1}^{n} \text{III}_i}{n}
\]

where \(\overline{S}\) is the mean somatotype expressed as a three digit rating obtained by finding the sum of each of the components divided by the number of subjects in the sample. The asterisk (*) indicates the components are treated independently.

Somatotype Dispersion Distance

A somatotype dispersion distance (SDD) is a quantification of how far on the somatochart one somatoplot is from another. A somatotype dispersion distance or the chart-distance between somatoplots

*Taken directly from Ross & Others, 1974.
expressed in Y-axis units may be obtained by the following formula:

\[ SDD = \sqrt{3 \left( X_1 - X_2 \right)^2 + \left( Y_1 - Y_2 \right)^2} \]

where SDD is the somatotype dispersion distance, (an application of the Pythagorean theorem), 3 is a constant which converts X into Y-units when it is under the square root sign and \((X_1, Y_1)\) and \((X_2, Y_2)\) are coordinates of any two somatoplots. Any distance between somatoplots may be quantified by an SDD.

**Somatotype Dispersion Index**

A somatotype dispersion index (SDI) is the mean SDD of the somatoplots in a distribution from the \(\bar{S}\) somatoplot. This may be obtained by the following formula:

\[ SDI = \frac{\sum_{i=1}^{n} SDD_i}{n} \]

where SDI is the somatotype dispersion index and the SDD's are the somatotype dispersion distances from the plot of the calculated mean somatotype \(\bar{S}\) of the distribution to each somatoplot for any given number of subjects (\(n\)) in the distribution.

**Somatotype Dispersion Variance**

The somatotype dispersion distance and somatotype dispersion index are analogous to individual and mean values in ordinary parametric statistics. The somatotype dispersion variance (SDV) for a given somatochart distribution is obtained as follows:

\[ SDV = \frac{\sum_{i=1}^{n} (SDD_i - SDI)^2}{n - 1} \]
where SDV is a sample somatotype dispersion variance, SDD's are the individual's somatotype dispersion distances obtained from individual somatoplots to the mean somatoplot, and SDI is the somatotype dispersion index or the mean of the SDD values. In accordance with sampling theory, the best unbiased estimate of the population SDV is obtained with \((n-1)\) in the denominator. Analogous to usual statistical procedures, the sample somatotype dispersion distance standard deviation (DSD) is found by taking the square root of the obtained SDV. For computational purposes, the following formula for SDV is more convenient than the above:

\[
SDV = \frac{1}{n-1} \left[ \sum_{i=1}^{n} SDD_i^2 - \frac{\left( \sum SDD_i \right)^2}{n} \right]
\]

where SDD_i again are the individual somatotype dispersion distances from each somatoplot to the mean somatoplot. When the samples are being compared directly \(1/n\) rather than \(1/n-1\) is appropriate.

**Analysis of Variance**

It is possible to test the hypothesis that all the samples were from the same population by an analysis of variance (ANOVA). Essentially, this involves expressing total variance in two parts: that within samples and that between samples. This provides for two independent estimates of the population variance which can be treated as an F-ratio and tested for significance in a table of F for the appropriate degrees of freedom at some predetermined probability level.

**Sum of Squares Within Sample:**

\[
SS_w = \sum_{j=1}^{k} \sum_{i=1}^{n} (SDD_{ij} - SDI_j)^2 = \sum_{j=1}^{k} \left[ \sum_{i=1}^{n} (SDD_{ij})^2 - (\sum SDD_{ij})^2/n_j \right]
\]
where $SS_w$ is the sum of squares within samples obtained by 1) finding the SDD's of each individual's somatoplot from its sample mean somatoplot, 2) determining the squared deviations of the sample SDD's around the SDI, 3) adding the sums of squares thus obtained for each of $k$ samples. A computational formula shown on the right (above) facilitates calculation.

**Sum of Squares Between Samples**

$$SS_b = \frac{k}{\bar{n}} \sum_{j=1}^{k} (SDD_j - \bar{M})^2$$

where the $SS_b$ is the sum of the squares between samples. Each of the three components for each sample mean somatotype ($\bar{S}$) is multiplied by $n_j$, is summed, and then divided by $N$ to yield a combined samples mean somatotype ($\bar{M}$). The SDD's in this formula are the distances between each sample mean somatoplot and combined samples mean somatoplot. If $n$ for each sample is not related to the hypothesis being tested, it is desirable to give each sample equal weight in determining the $SS_b$. The harmonic mean ($\bar{n}$) as shown in the following formula below rather than $n$ is appropriate. This, in essence, provides for a comparison of sample prototypes regardless of how these are obtained.

$$\bar{n} = \frac{1}{\frac{1}{n_1} + \frac{1}{n_2} + \cdots + \frac{1}{n_k}}$$

where $k$ is the number of samples and $n_1$, $n_2$, ..., $n_k$ are the number of subjects comprising each sample. If the samples are to be weighted according to sample size, $SS_b$ would be obtained by the following formula:

$$SS_b = \sum_{j} n_j (SDD_j - \bar{M})^2$$
Significance

A test of the hypothesis that all sample dispersion effects are equal is given by the F-ratio:

\[ F = \frac{SS_b/(k-1)}{SS_w/(N_k)} = \frac{MS_b}{MS_w} \]

where \( MS_b \) is the mean square between samples obtained by dividing the \( SS_b \) by \( k-1 \) degrees of freedom and the \( MS_w \) is the mean square within samples obtained by dividing the \( SS_w \) by \( N-k \) degrees of freedom.

Although not entering into the F-ratio, the degrees of freedom for \( SS_t \) is \( N-1 \).

If the obtained F ratio equals or exceeds the critical value in the table of F for the appropriate degrees of freedom in the numerator and denominator for some predetermined probability level, the null hypothesis is rejected. Thus, we may conclude that the S of our samples differ among themselves, that is, they show more variation than attributable to random sampling from a single population.
Figure 7. Heath-Carter somatocart with superimposed XY grid for plotting individual somatotypes.

I = first component; II = second component; III = third component.

\[(\text{III} + I) - II Z = \lambda\]
ANOVA for Pretest Somatoplot Differences

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<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
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<tr>
<td></td>
<td>Boys Control</td>
<td>Boys Training</td>
<td>Adult Control</td>
<td>Adult Training</td>
</tr>
<tr>
<td></td>
<td>n=6</td>
<td>n=5</td>
<td>n=4</td>
<td>n=5</td>
</tr>
<tr>
<td>εSDD</td>
<td>46.19</td>
<td>13.74</td>
<td>21.52</td>
<td>17.15</td>
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<td>396.84</td>
<td>43.38</td>
<td>138.46</td>
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<tr>
<td>(εSDD)^2/n</td>
<td>355.59</td>
<td>37.76</td>
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<tr>
<td>εd^2</td>
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<td>SD1</td>
<td>7.70</td>
<td>2.75</td>
<td>5.38</td>
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\[ \overline{s}_1 = 3.2 - 4.2 - 2.9 \]
\[ \overline{s}_2 = 3.2 - 4.9 - 3 \]
\[ \overline{s}_3 = 2.5 - 4.4 - 2.9 \]
\[ \overline{s}_4 = 3.5 - 4.9 - 2 \]

\[ G = 98.6 = \varepsilon(SDD_j) \]

\[ \varepsilon(SDD_j)^2 = 679.94 = \varepsilon(SDD_j)^2 \]

\[ \varepsilon(\sum \frac{t^2_j}{n_j}) = 567.95 = \varepsilon(\sum \frac{(SDD_j)^2}{n_j}) \]

\[ n = \frac{k}{\frac{1}{n_1} + \frac{1}{n_2} + \frac{1}{n_3} + \frac{1}{n_4}} = 4.898 \]

SS\(_b\) = \[ n \varepsilon(SDD_j - \overline{M})^2 \]

SS\(_w\) = 111.99

\[ = 4.898 \varepsilon(1.11^2 + 0.40^2 + 1.39^2 + 2.11^2) = 4.898 (7.776) = 38.09 \]

ANOVA for pretest somatoplot differences

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
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<td>Between</td>
<td>38.09</td>
<td>3</td>
<td>12.70</td>
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<tr>
<td>Within</td>
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<tr>
<td>Total</td>
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\[ F_{.05} (3, 16) = 3.24 \]
### ANOVA for Posttest Somatoplot Differences

<table>
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<th>F</th>
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<tbody>
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<td>Between</td>
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<td>Within</td>
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<tr>
<td>Total</td>
<td>177.78</td>
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</tr>
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</table>

\[ F_{0.05}(3, 16) = 3.24 \]
Appendix E
Subject Informed Consent Form
The Effect of a Weight Training Program on Body Composition and Muscle Performance

You are invited to participate in a project in which we are studying the effects of a weight training program on body composition and the ability to lift weights. We are also studying the relationship between body measurements and strength. If you have any type of congenital heart disease you will not be able to participate. If you have no congenital heart disease, you are asked to join in a pre and a post muscle test and be willing to have body measurements taken. This paper will tell you what is involved if you choose to participate.

Dr. Kris Berg, Marge Sailors and other graduate students from the University of Nebraska at Omaha will give the following tests and measurements:

Muscle Performance Test. The heaviest weight you can lift between 3 and 7 times will be recorded for the squat, bench press and arm curl. All of the measurements will be taken using Olympic free weights.

Body Measurements. Your exact height and weight will be taken. Your calf, chest and arm will be measured with a tape measure. The width of your knee, elbow, shoulder and hips will be determined. Finally, the amount of body fat you have will be measured with a skinfold caliper. This instrument measures the thickness of a fold of skin. The folds of skin measured are from the back of the arm, the shoulder blade, the side of the navel and the back of the lower leg. There is no discomfort from the calipers.

For all of the measurements taken, except your body weight, you will need to be dressed in T-shirt, shorts and athletic shoes. Your nude body weight will be measured by your physical education teacher or a male graduate student. As a subject you must agree to the following:
1) to be either in a group which will weight train or be in a group which will not weight train.
2) not to lift weights or do any other strength training outside of class.
3) not to change your normal eating habits.
4) not to miss more than 3 weight training sessions if you are in the weight training group.

You will be assigned to either the group that weight trains or the group that does not. If chosen for the weight training group, you will train on Monday, Wednesday and Friday of each week for a period of 8 weeks. The length of each training session will be about 45 minutes. All sessions will be supervised by Marge Sailors and another graduate student.
Understand that you may drop out of this project any time you wish without hurting your relationship with us or the University of Nebraska. We will provide a written copy of all your test results and results of the total group and will also explain them to you. No one but you and the investigators will have access to your test scores.

Risks and Discomforts

During the muscle performance test, you will be breathing deeply and you will be straining your muscles. There may be some muscle soreness a day or two following the test. A muscle strain is possible but not likely.

If injury occurs as a direct consequence of these procedures, the emergency medical care required to treat the injury will be provided at the University of Nebraska at no expense to you, providing that the cost of such medical care is not reimbursable through your own health insurance. However, no additional compensation for medical care, hospitalization, loss of income, pain, suffering, or any other form of compensation will be provided as a result of such injury.

If you have any questions you will be expected and encouraged to ask us. You may feel free to call us if you have any questions. You should discuss with your parents whether or not to participate before signing this form.

Participation is voluntary. Your decision whether or not to participate will not affect your relationship with the University of Nebraska at Omaha. If you decide not to participate, you are free to withdraw your consent and to discontinue participation at any time.

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE HAVING READ THE INFORMATION PROVIDED ABOVE. THE SECOND COPY OF THIS FORM IS FOR YOU TO KEEP.

Subject's Signature _________________________________________ Date _____________
Witness __________________________________________________ Date _____________
Investigator _______________________________________________ Date _____________

Marge Sailors, B.G.S.               Kris Berg, Ed.D
342-6184 (home)                    391-4516 (home)
554-2670 (office)                  554-2670 (office)
Parent Informed Consent Form
The Effect of a Weight Training Program on Body Composition and Muscle Performance

Your son is invited to participate in a project in which we are studying the effects of a weight training program on body composition and the ability to lift weights. We are also studying the relationship between body measurements and strength. If your son has any type of congenital heart disease he will not be able to participate. If he has no congenital heart disease he is asked to join in a pre and post muscle test and be willing to have body measurements taken at these times. This paper will tell you what is involved if your son chooses to participate.

Dr. Kris Berg, Marge Sailors and other graduate students from the University of Nebraska at Omaha will give the following tests and measurements:

Muscle Performance Test. The heaviest weight your son can lift between 3 and 7 times will be recorded for the squat, bench press and arm curl. All measurements will be taken using Olympic free weights.

Body Height. Your son's exact height will be measured with a device called a Seiber-Hegner anthropometer. This is done by having your son stand tall and take a deep breath. The anthropometer is placed against his back and the arm is slid down over the top of his head.

Body Weight. Your son's physical education teacher or a male graduate student will record his nude body weight from a standard balance scale.

Girth Measurements. The size of his calf, chest and bicep will be measured with a tape measure.

Diameter Measurements. The width of his knee, elbow, shoulder and hips will be taken using the anthropometer. It is fitted around the body part and the slide-arm is pushed inward for a close fit.

Skinfold Measurements. The amount of body fat your son has will be measured with a device called a Harpenden skinfold caliper. This instrument measures the thickness of a fold of skin. The measurements taken are folds of skin from the back of the arm, the shoulder blade, the side of the navel and the back of the lower leg. There is no discomfort from the calipers.
Parent Informed Consent Form
Page 2

For all of the measurements taken, except his body weight, he will need to be dressed in T-shirt, shorts and athletic shoes. As a subject he must agree to the following:
1) to be either in a control group, in which he will not weight train, or an experimental group, in which he will weight train.
2) not to lift weights or do any other strength training outside of class.
3) not to change his normal eating habits.
4) not to miss more than 3 weight training sessions if he is in the weight training group.

Your son will be assigned to either the control or experimental group. If chosen for the weight training group, he will train on Monday, Wednesday and Friday of each week for a period of 8 weeks. The length of each training session will be about 45 minutes. If chosen for the control group, he will attend regular physical education classes during these times.

Understand that he may drop out of this project any time he wishes without hurting his relationship with us or the University of Nebraska. We will provide a written copy of all your son's test results and results of the total group and will also explain them to him. No one but your son and the investigators will have access to his test scores.

Risks and Discomforts
During the muscle performance test, your son will be breathing deeply and he will be straining his muscles. There may be some muscle soreness a day or two following the test. A muscle strain is possible but not likely.

If injury occurs as a direct consequence of these procedures, the emergency medical care required to treat the injury will be provided at the University of Nebraska at no expense to your son, providing that the cost of such medical care is not reimbursable through your own health insurance. However no additional compensation for medical care, hospitalization, loss of income, pain, suffering, or any other form of compensation will be provided as a result of such injury.

If you have any questions you will be expected and encouraged to ask us. You may feel free to call us if you have any questions.

Participation is voluntary. Your son's decision whether or not to participate will not affect his relationship with the University of Nebraska at Omaha. If he decides not to participate, he is free to withdraw his consent and to discontinue participation at any time.
YOU ARE MAKING A DECISION WHETHER OR NOT TO ALLOW ____________________________
(NAME OF MINOR) TO PARTICIPATE. YOUR SIGNATURE INDICATES THAT, HAVING
READ THE INFORMATION PROVIDED ABOVE, YOU HAVE DECIDED TO PERMIT ________________
(NAME OF MINOR) TO PARTICIPATE. THE SECOND COPY OF THIS FORM
IS FOR YOU TO KEEP.

_________________________________________  ________________________________
Signature                                          Date

_________________________________________
Relationship to Subject

_________________________________________
Witness (if required)  Signature of Investigator

Marge Sailors, B.G.S.  Kris Berg, Ed.D.
342-6184 (home)       391-4516 (home)
554-2670 (office)     554-2670 (office)
1. Personal

Name ____________________________ Address ____________________________

Phone ____________________________ ____________________________

Age ___________ Birthdate ____________________________

Height ___________ Weight ____________________________

II. Medical History

A. Check any of the following which has occurred in your child’s medical history. List the age of occurrence.

1. High Blood Pressure ( ) Age of occurrence ____________

2. EKG Abnormality ( ) Age of occurrence ____________

3. Obesity ( ) Age of occurrence ____________

4. Diabetes ( ) Age of occurrence ____________

5. Asthma ( ) Age of occurrence ____________

6. Emphysema ( ) Age of occurrence ____________

7. Other ( ) Age of occurrence ____________

B. If any of your child’s relatives (brother, sister, father, mother, grandfather, grandmother) have had any of the following, please check the approximate age space. Use the following 2 sets of medical problems. Space is available for only the 2 closest relatives for any one area.

<table>
<thead>
<tr>
<th>Relationship to your child</th>
<th>Approximate age of occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01. Heart attack</td>
</tr>
<tr>
<td></td>
<td>02. High Blood Pressure</td>
</tr>
<tr>
<td></td>
<td>03. Angina Pectoris</td>
</tr>
<tr>
<td></td>
<td>04. ECG Abnormality</td>
</tr>
<tr>
<td></td>
<td>05. Obesity</td>
</tr>
<tr>
<td></td>
<td>06. Diabetes</td>
</tr>
<tr>
<td></td>
<td>07. Asthma</td>
</tr>
<tr>
<td></td>
<td>08. Emphysema</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Relationship to your child</th>
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<th>55-59</th>
<th>60-64</th>
<th>65+</th>
</tr>
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<tbody>
<tr>
<td>01. Heart attack</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>02. High Blood Pressure</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>03. Angina Pectoris</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>04. ECG Abnormality</td>
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</tr>
<tr>
<td>05. Obesity</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>06. Diabetes</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>07. Asthma</td>
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<td>( )</td>
</tr>
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<td>08. Emphysema</td>
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<td>55-59</td>
<td>60-64</td>
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<td>-------</td>
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<tr>
<td>09. Stroke</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Too much Cholesterol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Other</td>
<td></td>
<td></td>
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</tr>
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<td>01. Heart Attack</td>
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<tr>
<td>02. High Blood Pressure</td>
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</tr>
<tr>
<td>03. Angina Pectoris</td>
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<td>04. ECG abnormality</td>
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<td>10. Too Much Cholesterol</td>
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<tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Approximate age of occurrence

C. List any medications your child is presently taking and the condition being treated.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

D. List and describe any condition your child has which may affect his/her ability to participate in a program of weight training.

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
III. Smoking History

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<tr>
<td></td>
<td>( )</td>
<td>1-2 packs a day</td>
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<tr>
<td></td>
<td>( )</td>
<td>more than 2 packs a day</td>
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</tbody>
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<thead>
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<th>No</th>
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<td>Ever?</td>
<td>( )</td>
<td>( )</td>
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<tr>
<td>How much?</td>
<td>( )</td>
<td>less than 1 pack a day</td>
</tr>
<tr>
<td></td>
<td>( )</td>
<td>1-2 packs a day</td>
</tr>
<tr>
<td></td>
<td>( )</td>
<td>more than 2 packs a day</td>
</tr>
</tbody>
</table>

IV. Activity Profile

A. Rate your child's activity level

|   | ( ) | very active |
|   | ( ) | active |
|   | ( ) | moderate |
|   | ( ) | some activity |
|   | ( ) | inactive |

B. Has your child ever been involved in a consistent weight training program?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
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<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>(month/year)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For how long?</td>
<td>( )</td>
<td>less than 3 months</td>
</tr>
<tr>
<td>( )</td>
<td>3 months or more</td>
<td></td>
</tr>
<tr>
<td>Times per week?</td>
<td>( )</td>
<td></td>
</tr>
</tbody>
</table>

C. Is your child currently involved in a consistent training program for any of the following activities?

|   | ( ) | Cycling |
|   | ( ) | Jogging/running |
|   | ( ) | Swimming |

If yes, for how long? ( ) less than 3 months  Times per week? ( ) 3 months or more  Distance per time? ___

__________________________
Signature

__________________________
Date

__________________________
Relationship to Child