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A comparison of two shoulder exercises utilizing isotonic, isokinetic, and electromyographic analyses

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A Comparison of Two Shoulder Exercises Utilizing Isotonic, Isokinetic, and Electromyographic Analyses

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ABSTRACT

A Comparison of Two Shoulder Exercises Utilizing Isotonic, Isokinetic, and Electromyographic Analyses

David L. Durbin

This purpose of this study was to compare the seated side-lateral raise to the seated behind-the-neck press exercises, utilizing isotonic, isokinetic, and electromyographic analyses. Sixty-four male students participated in this study. Experimental group A (N = 22) used the seated side-lateral raise exercise. Experimental group B (N = 23) used the seated behind-the-neck press exercise. Control group C (N = 19) used no treatment.

Subjects for the experimental groups performed 10 pretest and posttest repetitions at maximum weight with their particular exercise. The difference determined isotonic gains. Experimental groups A and B and control group C were tested for shoulder abduction isokinetic strength on the Cybex 340 at 60 degrees per second and 180 degrees per second.

The pretest was followed by a 10-week treatment period for experimental groups A and B. The treatment for both experimentals group A and B consisted of three sets of 10 repetitions of the seated side-lateral raise. The treatment for experimental group B consisted of three sets of 10 repetitions. Control group C had no treatment for the 10-week period. Five volunteers participated in the

electromyography study. The muscles analyzed were the anterior, middle and posterior deltoids; the triceps; and the supraspinatus. Each subject performed three repetitions for the seated side-lateral raise and the seated behind-the-neck press.

Results showed that after a 10-week treatment period, both experimental groups A and B showed significantly greater weight gains isotonically. Isokinetically, there was no significant difference at 60 degrees per second among groups A, B, and C. At 180 degrees per second, there was no difference between groups A and B. There was significance between groups A and C and significance between groups B and C.

The results of the electromyographic analyses showed that during the seated side-lateral raise, the posterior deltoid and the triceps were the least involved. The supraspinatus was the most involved, followed by the anterior and middle deltoids. During the seated behind-the-neck press, the posterior deltoid was the least involved, followed by the anterior and middle deltoids. The muscles most involved were the triceps and supraspinatus for this exercise.

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DEDICATION

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CHAPTER 1

Introduction

Muscular strength and muscular endurance are two components of physical fitness, while flexibility, speed, power, agility, balance, and coordination are other components. Muscular strength is defined as the ability of a muscle to contract maximally against a resistance, and muscular endurance is identified as the ability to exert a force separately and to hold a static contraction for a longer time period. Weight training is the best way to develop muscular fitness. Free weights are the oldest form of weight training in contrast to the newer Universal and Nautilus machines (Sharkey, 1984).

The shoulder region is always emphasized in a good weight-training program. It needs to be well structured and durable as it controls all upper arm movements. The shoulder region has a remarkable structure with the anterior region muscle consisting of the pectoralis major, coracobrachialis, subscapularis, and biceps brachii. The posterior region is comprised of the infraspinatus and teres minor, and the superior region consists of the deltoid and the supraspinatus. The latissimus dorsi and brachii long head compose the inferior region (Luttgens & Wells, 1982). Two of the most popular exercises used to develop the deltoid and other muscles of this region are the seated side-lateral raise and the seated behind-the-neck press (Massey, Freeman, Manson, & Wessel, 1959).

Free weights consist of dumbbells and barbells. Dumbbells are used for the development of the upper body, providing greater freedom of movement with the arms. Lessening the restriction of movement, they are less likely to cause injury; however, a barbell restricts the movement which places the ligaments, tendons, and joints in an uncomfortable position. The side-lateral raise is a dumbbell exercise, while the seated behind-the-neck press is a barbell exercise. Information on these two exercises is limited, and the researcher found no in-depth analyses for either exercise.

Statement of the Problem

This study compared: (1) the seated behind-the-neck press to the seated side-lateral raise in order to determine muscle involvement and (2) the isotonic and isokinetic strength gains resulting from these two exercises as used by college males.

Purpose of the Study

The purpose of this investigation was to compare the two shoulder exercises, utilizing isotonic, isokinetic, and electromyographic analyses and using two treatment groups and one control group.

Definitions of Terms

Barbell--a steel bar five to seven feet long on which circular iron plates of known weight may be placed (Massey et al., 1959).

Cybex--a machine that measures and records maximal output of a muscle contraction throughout the full range of motion (Davies, 1987).

Dumbbell--a short barbell 12 to 16 inches, with fixed or removable weight plates (Massey et al., 1959).

Electromyography (EMG)--a machine that records function of nerve impulses during muscle contractions (McArdle, Katch, & Katch, 1991).

Free weights--barbells and dumbbells in which coordination and balance are emphasized more than with machines.

Isokinetic--constant motion; an isotonic contraction in which the speed of movement remains steady (Rasch, 1983).

Isotonic--constant tension; a contraction in which the angles between the bony levers change (Rasch, 1983).

Muscular endurance--ability to repeat productions of force sustained at low to moderate intensities over extended intervals of time (American Alliance for Health, Physical Education, Recreation and Dance [AAHPERD], 1988).

Muscular fitness--refers to three components of muscles: (1) strength, (2) endurance, and (3) flexibility (AAHPERD, 1988).

Muscular strength--the ability of muscles to produce force of high intensities over short intervals of time (AAHPERD, 1988).

Physical fitness--a set of attributes that relate to the ability of people to perform physical activity. Attributes include cardiorespiratory endurance, muscular endurance, muscular strength, body composition, and joint flexibility (McArdle et al., 1991).

Seated behind-the-neck press--exercise with a barbell in which the arms press the weight from the shoulders until the arms are fully extended overhead (Massey et al., 1959).

Seated side-lateral raise--exercise used with dumbbells in which the arms are abducted while seated (Massey et al., 1959).

Null Hypotheses

The following null hypotheses were tested:

Hypothesis 1: There will be no significant difference between the pretest and posttest of experimental group A after 10 weeks of treatment using the seated side-lateral raise with the dumbbell.

Hypothesis 2: There will be no significant difference between the pretest and the posttest of experimental group B after 10 weeks of treatment using the seated behind-the-neck press with the barbell.

Hypothesis 3: There will be no significant differences between experimental groups A and B testing with the Cybex isokinetic machine, analyzing the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (6) torque at 80 degrees of abduction, (5) torque acceleration energy, and (7) power after a 10-week period.

Hypothesis 4: There will be no significant differences between experimental group A and control group C testing with the Cybex isokinetic machine, analyzing the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period.

Hypothesis 5: There will be no significant differences between experimental group B and control group C testing with the Cybex isokinetic machine, analyzing the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period.

Hypothesis 6: There will be no significant differences between experimental groups A and B testing with the Cybex isokinetic machine, analyzing the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period.

Hypothesis 7: There will be no significant differences between experimental group A and control group C testing with the Cybex isokinetic machine, analyzing the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period.

Hypothesis 8: There will be no significant differences between experimental group B and control group C testing with the Cybex isokinetic machine, analyzing the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period.

Research Discussion

Electromyography testing of five selected shoulder muscles performing two shoulder exercises was analyzed to determine each muscle's degree of contribution to performing the exercise.

CHAPTER 2

Review of the Literature

The review of literature relevant to this study includes information concerning: (1) the seated side-lateral raise exercise and the seated behind-the-neck press, (2) the shoulder-joint muscles, (3) electromyographic analyses of the shoulder muscles involved in various physical activities, (4) common shoulder injuries, and (5) Cybex isokinetic testing.

Seated Side-Lateral Raise and Seated Behind-the-Neck Press

Abduction, one of the most common movements of the upper arm, is the sideward movement away from the mid-line of the body (Luttgens & Wells, 1982). The seated side-lateral raise basically involves the abduction of the upper arm. In the starting position, the body is seated with the hands holding the dumbbells with palms facing the body (Massey et al., 1959). The movement includes lifting the dumbbells sideways until they are sightly above horizontal at approximately 100 degrees while maintaining control of the weights, then lowering them back to the starting position. The major muscles exercised in the shoulder joint are the supraspinatus, deltoid (middle and anterior), trapezius, and serratus anterior muscles of the shoulder girdle. Stabilization of this exercise is the responsibility of the pelvic and thoracic region (Massey et al., 1959). Proper breathing while performing this exercise includes exhaling as the weights are abducted and inhaling as the weights are adducted (Jones, Barnes, & Johnson, 1989). The seated behind-the-neck press has many names, such as seated shoulder press, posterior shoulder press, overhead press, and posterior military press. The National Strength and Conditioning Association calls this exercise the seated behind-the-neck press (Stiggens & Allsen, 1983).

In the starting position, the bar rests on the posterior deltoids and base of the neck with the body erect and the head tilted forward slightly. The eyes look straight ahead, while the bar is pressed overhead until the arms are fully extended and braced at the elbow joint. The shoulders are then pulled back to the starting position which results in a greater involvement of the trapezius rotating the shoulder girdle upward as the arms push overhead. While performing these exercises, the mouth should always be kept open to equalize pressure in the chest cavity. Proper breathing includes exhaling as the bar is pushed up and inhaling as the bar is lowered. The body regions developed are the shoulder, upper back, and back of the upper arm. The major muscles exercised in the shoulder joint are the middle and anterior deltoids, supraspinatus, and pectoralis major (clavicular portion). Shoulder-girdle muscles exercised are the trapezius and the serratus anterior; the elbow-joint muscle involved is the triceps; and stabilization is in the legs, hips, and trunk. Common errors lifters make while performing the seated behind-the-neck press include: (1) improper balance; (2) rounded back; (3) poor head position; (4) misalignment of wrist, elbow, shoulder, and hip; (5) absence of belt when using heavy weights; (6) loose back and abdominal muscles; (7) lack of control of the bar throughout movement, and (8) an excessive arching of the back (Stiggens & Allsen, 1983).

The National Strength and Conditioning Association has published a checklist of the proper techniques for this exercise:

1. <u>The Start</u>
    1. Load bar evenly with collar.
    2. Sit with legs to the side with feet flat.
    3. Grip hands evenly slightly wider than the shoulders.
    4. Face palms always (pronated) with thumbs around the bar.
    5. Rest bar on posterior deltoid and base of neck in the starting position.
    6. Hold wrists firmly.
    7. Place elbows under the bar.
    8. Tilt head slightly forward.

2. <u>The Ascent</u>
    1. Push bar upward.
    2. Keep head slightly forward, so the bar will not hit the head.
    3. Provide upward force with shoulders and arms.
    4. Do not lean forward or backward.
    5. Keep feet motionless.
    6. Use a smooth motion (do not accelerate the weight).
    7. Fully extend arms and raise the bar directly above the top of the head in the top position.

8. Pause at the top position momentarily.

3. <u>The Descent</u>
   1. Lower weight under control.
   2. Do not bounce the bar on posterior deltoid.
   3. Inhale when the top of the bar is on the posterior deltoid.
   4. Inhale at the top of the motion, hold breath as the bar is lowered, and exhale while pressing the bar to the starting position. (Jones et al., 1989, p. 25)

The seated behind-the-neck press and the seated side-lateral raise work the shoulder, which is used in any upper arm movement. These two exercises will help strengthen this region which will help in any of the following pushing or extending activities: (1) breast stroke in swimming, (2) canoe paddling, (3) shot putting, (4) tennis and badminton strokes, (5) pole vaulting, (6) archery, (7) batting, (8) golf swing, (9) hand shoves in football, and (10) defensive stance in basketball, as well as in any everyday activity, such as reaching for a box on a closet shelf (Stiggens & Allsen, 1988).

Humphrey (1988) lists a variety of exercises that work the anterior and posterior areas of the shoulder region. Humphrey observes that by performing a diversity of exercises the shoulder region is worked in many areas; thus, muscle fatigue and joint stiffness may be prevented in everyday routines, as well as in sports and recreational activities. Humphrey advises athletes to progress slowly while exercising and to work out three to five times per week for strength gains.

Shoulder Muscles

Hogfors, Sigholm, and Herberts (1987) describe the muscles of the shoulder complex. There are 21 muscles of the shoulder complex:

> Twelve of these muscles connect to the scapula: 1) latissimus dorsi, 2) levator scapulae, 3) omohyoid, 4) greater pectoral, 5) smaller pectoral, 6) greater rhomboid, 7) smaller rhomboid, 8) anterior serrate, 9) sternocleidomastoid, 10) sternohyoid, 11) subclavian, and 12) trapezius. The clavicle and humerus bones are joined by the 13) deltoid and part of the greater pectoral, and connecting the scapula and the humerus bones are the 14) coracobrachial (part of the deltoid), 15) infraspinatus, 16) subscapular, 17) supraspinatus, 18) teres major, and 19) teres minor. The scapula is attached to the forearm by the 20) biceps and 21) triceps. (Hogfors et al., 1987, p. 158)

Hogfors et al. (1987) found that the supraspinatus and deltoid muscles are equally responsible for producing torque about the shoulder joint in the functional planes of motion, as well as the torque generated at the shoulder in the planes of forward flexion and elevation in the plane of the scapula.

Dvir and Berme (1978) built a kinematical model for the shoulder complex in elevation, believing such a model is needed because of the inaccessibility of the shoulder region and the inaccuracy of following bone movements. This model will give a better understanding of the actual movements of the shoulder so the application of this knowledge will help prevent injuries to this area. The completion of the model shows the two mechanisms of the shoulder complex to be:

(1) skeleton, clavicle, and scapula and (2) scapula and humerus. Elevation of the arm is achieved by a coordinated action of these two mechanisms; however, the arm can only be elevated by a simultaneous stability and moveability. As the arm is raised, the moveable links are aligned, and elevation is achieved.

Christensen (1986) evaluated the degree of muscle activity and muscle fatigue in shoulder muscles during a whole working day of workers performing monotonous and repetitive work. Seven male subjects between the ages of 25 and 54 participated in this study in which they were either standing or seated, while their right hand pushed down the lever of a pillar drill. Muscular fatigue was defined as a contraction against a constant external load, and the EMG recording showed an increase in amplitude associated with a decrease in the mean power frequency of the power spectrum. The results showed the amplitude distribution probability function of EMG from the three muscles investigated (deltoids, infraspinatus, and trapezius), indicating that the static contraction level and the medium contraction level of all three muscles were high. With this elevated level of activity, a decrease in mean power frequency was observed in the trapezius, suggesting muscular fatigue in these muscles.

Electromyography

The purpose of a study conducted by Oda and Miyashita (1980) was to identify the difference in EMG changes in fatigue between repeated and maintained isometric contractions. Their experimental study investigated muscle fatigue in relation to EMG during repeated and sustained contractions. Six subjects used in test 1 were asked to repeat maximal isometric contractions of the right knee joint fixed at 90 degrees, using five seconds as the approximately time for each contraction. In test 2, the same subjects were asked to maintain maximal isometric contractions for two minutes, and EMG electrodes were attached to the vastus lateralis. In the first test, force output decreased progressively until reaching a stability of about 45 percent of maximum voluntary contraction (MVC), while in the second test, EMG recordings decreased along with the force output which stabilized at 20 percent. These contrasting results indicated that prolonged isometric contractions fatigue muscles sooner.

Chaffin, Lee, and Freivalds (1980) investigated the relationship between EMG amplitudes of isometric exertion of a five-second duration and a 50 percent maximum voluntary contraction endurance hold. Twenty-two subjects participated in this study with 18 males in one group and 4 males in the other. The subjects were randomly assigned to one of two groups which were designated false or sincere.

True maximum strength was tested and recorded before the experiment began. The sincere group demonstrated their true strength at all times, while the false group produced 50 percent to 75 percent of their true strength. The subjects were tested while they were seated with their forearms held at 90 degrees to test the biceps brachii as it pushed the forearms upward. Contraction was recorded for five seconds; each testing period lasted for approximately 10 minutes; and the subjects were given three trials.

Analyzing the EMG recordings was the next step. The authors needed to make a distinction on the readout between slow-twitch and fast-twitch muscle fibers. The slow-twitch fibers would appear as low exertions, and the fast-twitch ones would record high exertions. The transition point should naturally occur progressively from 0 percent to 100 percent maximum voluntary contraction of a sincere subject, and the readout would be interpreted by observing the speed of the twitch fibers. Involving fast-twitch fibers for five seconds produced fatigue that appeared on the readout. On the other hand, the slow-twitch fibers would not cause fatigue, thus exposing the false subjects. All false subjects were revealed, while 11 of the 12 sincere participants were identified correctly. The findings of this study showed the EMG amplitudes are a consistent and sensitive measure of motor unit recruitment, which is beneficial in evaluating the actual muscle strength capability of a person. However, not all EMG machines can incorporate the two types of motor units and proportion each type being recruited as did the one in this study.

Moynes, Perry, Antonelli, and Jobe (1986) reviewed results of studies of EMG and high-speed cameras in analyzing the upper extremity in sports, specifically, baseball pitching, swimming, tennis, and golf. The purpose of this study was to enhance the ability for both injury prevention and rehabilitation strategies. Baseball-pitching muscles fall into two categories. First, there are those that laterally rotate and abduct the humerus and flex the elbow for a maximum forward thrust, including the deltoid trapezius, supraspinatus, infraspinatus, teres minor, and biceps brachii. The second group includes the subscapularis, serratus anterior, pectoralis major, latissimus dorsi, and triceps brachii which have greater activity as the hand and baseball are thrust forward.

In swimming, subjects performed the freestyle stroke both in and out of water, while dry-land peak activity was evident during the last half of recovery as the arm was moved from 90 percent of abduction to full abduction. No muscle activity was recorded during the recovery phase because of the lack of resistance. The supraspinatus and infraspinatus were strong and continuous throughout all stages except the last half of the pull. The latissimus dorsi was involved in the last quarter of the pull, while the serratus anterior had the highest level of activity of any muscle during the hand entry. The pool analysis was similar to that of the dry-land results except for the recovery phase in which the supraspinatus and infraspinatus muscles were active throughout the entire recovery stage.

It was also determined that involving the muscles of the legs, trunk, shoulder, and upper extremity in the tennis serve consists of four stages: (1) wind up, (2) cocking, (3) acceleration, and (4) follow-through. The wind-up stage is composed of all eight shoulder-girdle muscles, and the cocking stage includes abduction of the shoulder, lateral rotation, and elbow flexion. Acceleration is the most intense of the stages and lasts the shortest time. The serratus anterior has maximal activity during this stage, and the infraspinatus muscles and the biceps brachii are both involved. High activity characterizes the follow-through during the early part of the stage with both the subscapularis and pectoralis major muscles having a high level of activity in the early portion of the movement.

The golf swing is comprised of the following: (1) take-away, (2) forward swing, (3) acceleration, and (4) follow-through. Electrodes of the EMG were placed on the following muscles: subscapularis; supraspinatus; infraspinatus; clavicular head of pectoralis major; latissimus dorsi; anterior, middle, and posterior deltoids. On the left side, all muscles recorded low activity during the backswing. Forward swing recordings were moderate for the latissimus dorsi muscle and subscapularis, while the acceleration phase produced high activity of the pectoralis major, latissimus dorsi, and subscapularis muscles. The subscapularis muscles maintained high activity into the follow-through; however, all other muscles maintained a low level of activity.

On the right side during take-away, moderate activity was recorded in the supraspinatus, but all other muscles maintained low activity. The forward swing produced activity in the supraspinatus; all deltoids were recorded at low activity. Pectoralis major muscles increased activity, and the subscapularis and latissimus muscles began firing at a moderate level. The acceleration phase increased the activity level of the latissimus dorsi, pectoralis major, and subscapularis; low-level activity occurred in the supraspinatus, infraspinatus, and anterior deltoid during the follow-through.

Elert and Gerdle (1989) investigated whether high EMG activity between contractions had a negative effect on mechanical performance during repeated shoulder flexions. Twenty healthy women performed maximal forward shoulder flexions at four different angular velocities. The EMG electrodes were hooked to the following four shoulder flexors: the trapezius, anterior deltoid, infraspinatus, and biceps brachii. The purpose of this study was to increase knowledge of strength, endurance, and coordination in the shoulder muscles during dynamic contractions in normal females. The results indicated a decrease in mechanical performance as recorded throughout the test for repeated shoulder flexions at two angular velocities. Moreover, the single maximal shoulder flexions showed a decrease in mechanical performance.

De Freitas and Vitti (1981) were interested in identifying the role of the trapezius and rhomboid muscles during the movement of the arm. Conducting the study with an EMG machine and 40 adult volunteers, the results revealed that during free lateral rotation, the trapezius and rhomboid major muscles were inactive during this movement. Free medial and lateral rotation also showed little involvement of these muscles.

Pink, Perry, Browne, Scovozza, and Kerrigan (1991), using an electromyographic and cinematographic machine, studied 12 muscles of the normal shoulder during freestyle swimming. Because the shoulder region has a major role in swimming, it is subject to injury. Understanding how the shoulder moves during swimming is therefore important in preventing injuries.

Twenty collegiate and master's level competitive swimmers volunteered for this study, and the students were divided into two groups. Muscles tested for group A consisted of the anterior, middle, and posterior deltoids;

serratus anterior; trapezius (upper); and rhomboid major. Muscles tested for group B consisted of the subscapularis, supraspinatus, infraspinatus, teres minor, latissimus dorsi, and pectoralis major. Two pools were equipped with underwater windows, and the researchers used a 16 mm. high-speed motion picture camera.

The results of the research revealed that the patterns of muscular activity at hand entry and exit were similar. The action of the trapezius and rhomboids complemented one another. The rhomboids retracted the scapula which was upwardly rotated by the upper trapezius, while the three heads of the deltoid were active in lifting and placing the arm in position for the exit. The supraspinatus, anterior deltoid, and middle deltoid worked together to abduct the humerus at hand entry and exit. The propulsive phase was initiated by the pectoralis major and latissimus dorsi, involving both the serratus anterior and teres minor during the propulsive phase. The stroke cycle involved the subscapularis and serratus anterior.

Adelsberg (1986) investigated an EMG analysis of selected muscles with tennis rackets of increasing grip size. The purpose of his study was to analyze the effect of different racket grip sizes on the muscle activity of the forearm and shoulder. The EMG was used to assess the muscle activity of the anterior deltoid and forearm extensor muscles during the forehand and backhand strokes of tennis in a group of subjects. Racket size grips of 4.75, 4.5, and 4.25 inches were used.

The forearm extensor muscles showed a decrease in force output with the middle-size grip racket and then an increase in force output with the large-size grip racket in the forehand stroke. In the backhand stroke, the anterior deltoid showed a decrease in the EMG activity with an increase in racket-grip size. The forearm extensor muscles remained relatively unchanged in EMG activity during the backhand stroke. The data suggested that when a racket of increasing grip size is used, the force generated in the forehand stroke and the anterior deltoid is reduced. The middle-size grip racket showed a slight decrease in force output at the forearm. The backhand stroke data also indicated that when a racket of increasing grip is used, EMG output is decreased.

Jobe, Tibone, Perry, and Moynes (1983) examined the shoulder in throwing and pitching, using an electromyography machine. Five male subjects were analyzed while they were throwing and pitching, with electrodes inserted into their deltoid and rotator cuff muscles. The purpose was to determine muscle activity patterns during throwing and pitching. The EMG recorded the following: (1) both the wind-up pitch and easy throw had similar activity patterns, (2) all three heads of the deltoid were similar in patterns with peak activity in the early cocking and follow-through stages. The subscapularis had peak activity at the end of the cocking stage and in the follow-through stage.

Jarvholm, Palmerud, Herberts, Hogfors, and Kadefors (1989) recorded the intramuscular pressure and EMG in the supraspinatus muscle at shoulder abduction. Fourteen male and five female students with normal healthy shoulders participated in this study. EMG electrodes were inserted in the supraspinatus muscle and the pressure recording catheter in the same part of the muscle. The arm of the subject was 45 degrees to the frontal plane. Part B of this study included intramuscular pressure and EMG recordings in different abducted arm positions and with different hand loads in 12 students. The arm was abducted at 0, 20, 60, 90, and 135 degrees. Each position was maintained for 10 to 30 seconds, and the arm was relaxed 15 to 60 seconds between each position. Part A pointed toward a strong correlation between normalized intramuscular pressure and EMG in isometric contraction at 45 degrees of abduction. In part B, however, the intramuscular pressure at shoulder abduction with a straight elbow was high in all positions over 30 degrees.

Ringelberg (1985) conducted an EMG study of force production of some human shoulder muscles during isometric abduction. The purpose of this study was to evaluate the possible influence of the plane in which abduction is performed upon the EMG activity, involving four healthy men.

EMG was recorded at five different angles both with and without weight in the subject's hand. Surface electrodes were placed above the middle of the muscle belly of the three parts of the deltoid, the clavicular head of the pectoralis major, and the infraspinatus muscles. A ground electrode was placed at the forearm, detecting the anterior part of the deltoid muscle as less active in the unloaded situation than in the loaded one. Deltoid muscle parts between loaded and unloaded conditions at one position of abduction are significant, as well as the differences in activity for abduction in the front or scapular plane. The infraspinatus muscle shows more activity under loaded conditions; however, the clavicular part of the pectoralis major shows no activity. The middle deltoid and posterior deltoid are significantly less active at the same angle of abduction in the scapular plane than in the frontal plane. The anterior deltoid and the infraspinatus are slightly more active in the scapular plane, and the pectoralis major clavicular part shows little or no activity during abduction.

Clarys et al. (1988) investigated three different EMG applications related to the sport environment, employing three different EMG registration and data approaches. The first study compared swimming in water to swimming simulation on land. Isokinetic equipment was used in the land simulation, but despite this EMG activity, water EMG yielded a higher level of activity. The purpose of the second study was to determine the influence of ski materials on EMG muscle activity of skiers. Using racing, soft, and compact skis, this study systematically showed soft skis are more beneficial than compact or racing skis for general and competitive use. Clarys et al. maintains that in order to measure muscle activity in complex sport movements, the following factors must be considered: (1) electrodes should not restrict movement, (2) setup should accommodate long-term activity, and (3) six or seven muscles should be monitored simultaneously.

Shoulder Injuries

The primary injuries to the shoulder region are a consequence of a direct blow, while strains to the muscles, tendons, and ligaments are secondary reasons. The seated side-lateral raise and the seated behind-the-neck press are exercises designed to, when performed correctly, strengthen muscles, ligaments, and tendons. However, common injuries which may occur during exercise can be attributed to the following: (1) improper technique, (2) use of weights which are too heavy, (3) incorrect warm-up, (4) absence of a spotter, (5) failure to properly stretch the area being exercised, and (6) not performing a full range of motion (Simmons & Garhammer, 1986).

In the seated side-lateral raise, the deltoids and supraspinatus muscles abduct the arm, but these muscles must overcome poor mechanical advantage in order to lift the arm. The seated behind-the-neck press seems to incur more injuries because of the particular position of the elbow and shoulder joint. Joints which are stretched when pushed backward are, in fact, pushed down with weight. These joints must follow the path of the barbell and so lack the freedom of motion that dumbbells provide. It is believed that barbells, in contrast to dumbbells, produce more strength because more weights may be added and both sides of the body are working together. With the dumbbells, however, each side has to push straight up to balance itself. People desiring to build strength are thus more likely to use barbells.

Jacobson, Lockwood, Hoefner, Hogfors, and Kadefors (1989) report that the supraspinatus muscle and its tendon, when frequently subjected to exertion or sustained contractions without adequate rest, are subject to injury. This article offers insight into the nature of injuries of the supraspinatus and how to treat these injuries. The supraspinatus is vulnerable to repetition strain injuries because of its role throughout the entire abduction movement.

Both the supraspinatus and the deltoid are equally responsible for abducting the arm. The supraspinatus tendon must pass under the coracoacromial through a rigid and inextensible canal, and it is during the elevated arm positions that the supraspinatus is the first muscle to show signs of fatigue. Patients with an injury to the supraspinatus muscle will therefore be unable to perform abduction and internal rotation or touch their fingers to the inferior angle of the opposite scapula. Strength testing of the muscle would include having the patient abduct the arm 90 degrees; then the person assessing the test would push down as the patient resisted.

Treating a strained supraspinatus involves four steps. In step 1, the scapula motion is improved by someone gently moving the scapula in three directions as follows: superior-inferior glide, medial-lateral glide, and clockwise-counterclockwise rotation. Second, the strain in the supraspinatus muscle is reduced by a physician who locates and gently pushes the point of tenderness as the arm is moved in different directions. Although the muscle will still be sore after this procedure, the acute pain will be relieved. In step 3, stretching exercises are performed at home for 15 to 30 seconds at a time. The patient is seated in a chair, placing the injured arm behind his back and gently pushing the elbow against the back of the chair. The second exercise is performed in the same position as the first one, but the additional movement of rotating the torso against the injured side provides a better stretch. In step 4, positive motivation is used in which the patient analyzes what caused the problem and either eliminates the problem or changes the negative effect on the shoulder.

Cybex Related Literature

The Cybex machine is one of several machines that measures strength isokinetically. Isokinetics have fixed speeds with a variable resistance. The subject exerts maximal force throughout the range of motion, but the speed does not change. The measure of the true strength of a muscle at different degrees gives isokinetics an advantage over isotonics.

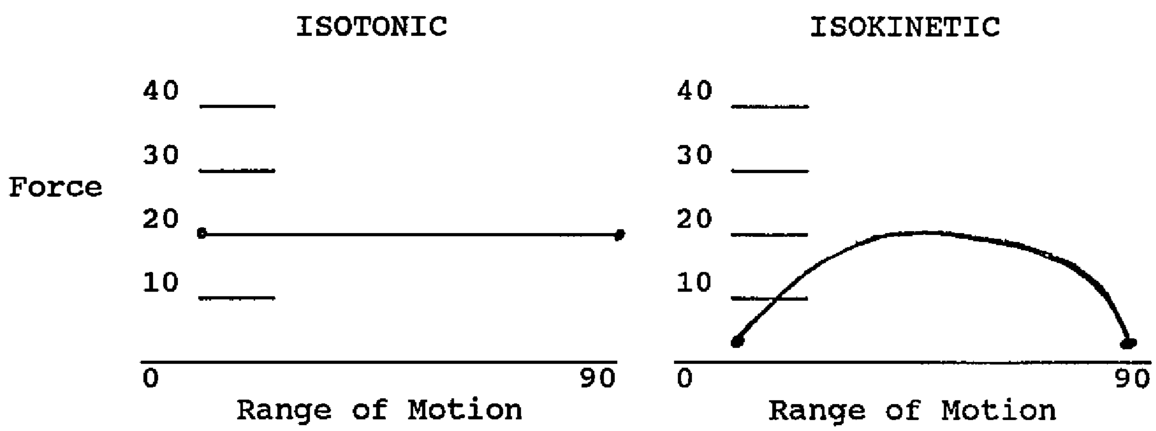


Figure 2.1. A Comparison of Isotonic and Isokinetic Force in Relating to the Range of Motion (Davies, 1987)

As a joint moves in motion, the muscle groups involved may change so the investigator may analyze the torque of these different groups. The Cybex measures strength in foot-pounds per square inch. Normal data for shoulder abduction at 60 degrees per second are shown in Figure 2.2.

Peak Torque	44.6 ± 18.0
Peak Torque Percentage of Body Weight	26.6 ± 9.4
Average Power	42.5 ± 21.4
Torque Acceleration Energy	3.1 ± 1.3

Figure 2.2. Normal Data for Shoulder Abduction at 60 Degrees Per Second in Foot-Pounds (Davies, 1987)

The normal data for shoulder abduction of 180 degrees per second are shown in Figure 2.3.

Peak Torque	32 ± 15
Peak Torque Percentage of Body Weight	19 ± 8
Average Power	80 ± 40
Torque Acceleration Energy	9 ± 3

Figure 2.3. Normal Data for Shoulder Abduction at 180 Degrees Per Second in Foot-Pounds (Davies, 1987)

Cybex Terminology

Angle of peak torque--the angle at which peak torque was produced.

Peak torque--the highest torque value from all points in a range of motion.

Peak torque (percentage bodyweight)--the peak torque value is divided by the patient's bodyweight x 100. This number indicates how much people produce as a percentage of their body weight, allowing the comparison of people of different bodyweights.

<u>Power</u>--gives an indication of the physiological efficiency of the muscle by measuring work done per unit of time; power = work/time. The higher the muscular work rate, the higher the metabolic rate within the muscle. This places higher demands on chemical energy supply conversion and intracellular energy source transportation. Power is calculated from the best work repetition and is reported in watts. As speed increases, the power will also increase. However, there is an optimal speed, beyond which power will fall.

<u>Torque</u>--measures the force of a rotational movement in foot-pounds. Torque = Force x Distance where distance is perpendicular distance from the axis of rotation to the application of force.

<u>Torque acceleration energy (TAE)</u>--is a measurement of muscular explosiveness. It is measured in foot-pounds of work during the first one-eighth of a second.

<u>Torque at — and — degrees</u>--the Cybex allows the investigator to select two angles that are of interest to the study. This allows the investigator to see maximum torque production at specific angles.

CHAPTER 3

Methods and Procedures

This experimental study compared two weight-lifting procedures: the seated side-lateral raise and the seated behind-the-neck press. Isotonic workouts, isokinetic testing, and electromyographic analyses of the muscles involved were used to examine the similarities of the two exercises. The study was conducted over a period of 12 weeks during the fall semester of 1992 at Middle Tennessee State University in Murfreesboro, Tennessee. The first and twelfth weeks were used for pretest and posttest. The second through eleventh weeks were used for treatment. The EMG testing was conducted at nearby Alvin C. York Veterans Administration Hospital, also in Murfreesboro, Tennessee. Hospital administrators and Dr. Paisal Jirut, M.D., gave their permission for the use and supervision of this machine (see Appendix A). Muscles analyzed by the EMG machine were the anterior, middle, and posterior deltoids, the triceps, and the supraspinatus. The isokinetic testing using the Cybex was performed in the Human Performance Laboratory in the Alumni Memorial Gym at Middle Tennessee State University. The 10-week isotonic workouts were performed in the weight rooms also located in the Alumni Memorial Gym.

Sample and Population

This study included three groups: two experimental groups (A and B) and one control group (C). Experimental group A performed the seated side-lateral raise, and experimental group B performed the seated behind-the-neck press. Group C, the control group, was asked to not work out during this time period. All groups were composed of volunteers that met set criteria for this experiment. Experimental groups A and B were selected from physical education weight-training courses offered in the university's physical education activity program and performed their exercises during regularly scheduled class times, plus one extra meeting, for a total of three meetings weekly. Control group C consisted of volunteers from various physical education activity classes, not including weight-training classes, and the volunteers met the same criteria for acceptance into the study. To qualify for acceptance for this study subjects had to: (1) be male; (2) be between 18 and 35 years of age; (3) have no health problems; (4) not be involved in competition in any organized weight-lifting, power-lifting, or body-building competitions; (5) not be participating in any varsity sports at the university; (6) be enrolled in a beginning weight-training class at Middle Tennessee State University during fall semester 1992; and (7) anticipate not missing more than three workouts throughout the duration of the study, as this would result in terminating their participation in the study.

Format

All testing and experimental research using human subjects was approved by the Research Ethics Committee at Middle Tennessee State University (see Appendix B). All groups went through an orientation that reviewed and described the qualifications necessary to participate in this study. All subjects met these requirements. After the orientation, students that met the qualifications and were willing to participate in the study were asked to sign information and waiver forms (see Appendices C and D).

Instruments

Cybex Testing Procedures

The Cybex is designed to investigate isokinetic strength. The Cybex allows us to investigate peak torque, peak torque percentage of bodyweight, angle of peak torque, peak torque at 15 degrees of abduction, peak torque at 80 degrees of abduction, torque acceleration energy, and power. A pretest and posttest were performed by all groups on the Cybex to determine changes in isokinetic strength.

Subjects were scheduled for an appointment time for the Cybex testing. Upon arriving, students were asked to sign informed consent forms (see Appendix E). The next step entailed taking the person's bodyweight, height, and arm length. These measurements provided baseline data. Height and bodyweight were typed into the Cybex which calculated these measurements, ensuring that no subject had an unfair advantage, thus maintaining the accuracy of the data. The measurements from the thumb-web space to the acromion process in the shoulder area were needed to position the bar used in testing as it was either lengthened or shortened to reach full extension for each subject at an angle of 90 degrees. The investigator conducted all Cybex tests. Two tests were needed: one for strength and the second for endurance. During testing, the students were asked to abduct and adduct the arm through the full range of motion from 0 degrees (located at lower hip) to 180 degrees (located above the head) with the elbow joint fully extended. The subjects performed all tests while seated. Four repetitions at 60 degrees per second velocity were used as a warm-up, followed by another four repetitions which represented the actual testing process. A 30-second rest period was then given to each subject. In the second test, an endurance test was performed in which the subject performed four repetitions as a warm-up. Following the warm-ups, 10 repetitions at 180 degrees per second were used as the actual test.

The investigator typed in the command for the Cybex printer which then printed out the data. Each student was given a printout sheet of their pretest and posttest scores. The Cybex printed out a comparison between peak torque, peak torque percentage of bodyweight, angle of peak torque, peak torque at 15 degrees of abduction, peak torque at 80 degrees of abduction, torque acceleration energy, and power.

Electromyography Testing

The electromyography machine used was a Disa-type 05a02 trolly. Although it is a four-channel system, for the purpose of the study only two channels were used. The sweep speed was measured in 10 milliseconds per division. The high frequency was set at 20 hertz, and the low frequency was set at 10 hertz (anything between 10 and 20 hertz was not be recorded). The electrodes used included one ground electrode (3 cm. in diameter) and a disc-surface electrode (1 cm. in diameter). The electrodes were placed on the tendon of the muscle being recorded. For the EMG analysis, five volunteers were used. The EMG test for each subject was approximately one hour long, and only one test was needed for each subject.

For EMG testing, all subjects were asked to sign an informed consent form (see Appendix E). The investigator assisted Dr. Jirut in performing the tests. Dr. Jirut attached the electrodes to the skin in the following order and location: (1) anterior and posterior deltoids and (2) triceps and supraspinatus. Surface electrodes picked up electrical impulses from the nerves located in the muscles being tested, except for the supraspinatus. It was necessary to insert a flexible needle in the supraspinatus because the trapezius muscle blocks the surface electrode from picking up signals from the supraspinatus. The electrodes had a conduction cream applied to the disc before being attached to the skin, and the electrode wires were taped to the skin to prevent any slipping. Subjects performed a maximum one-repetition lift for each exercise prior to the test. This maximum amount of weight was multiplied by .50 for each subject, assigning each person a test weight of 50 percent of his maximum to be used when performing the EMG. The purpose of the EMG was to determine the muscle and its degree of involvement in both eccentric and concentric contractions of the two shoulder exercises.

The Program

Isotonic Workouts and Testing

To determine the effects of the strength and endurance gains of the shoulders, the amount of weight lifted on the third set of 10 repetitions of the first workout was subtracted from the third set of 10 repetitions of the last workout. The subjects were instructed to increase the weight on every set for the shoulder exercise from the first to the third repetition. Subjects were to judge the amount of weight to be used. The third set may not have been completed for the full 10 repetitions as the subjects may have misjudged their strength for that day. A pretest and posttest were performed by experimental groups A and B only on free weights to determine changes in isotonic strength.

Exercises in this workout were identical for both experimental groups A and B (see Appendix F), with the exception of the shoulder exercises. The shoulder was exercised with free weights first followed by the other exercises, using a Universal machine. The other exercises did not have to be performed in any particular sequence. Experimental group A performed three sets of 10 repetitions of the seated side-lateral raise. Experimental group B also performed three sets of 10 repetitions, but performed the seated behind-the-neck press. The workouts occurred three times per week for 12 weeks. Two of these workouts were performed during the regularly scheduled class times, while the third workout was performed on Friday or Saturday. Sets and repetitions were recorded, and attendance was taken for each workout. Control group C was encouraged to not participate in any weight-training exercise programs for the duration (12 weeks) of this study.

Data Analyses

A matched-pair t-test for all variables was computed for all three groups to determine the difference between the pretest and posttest. The mean difference of each variable from pretest to posttest was compared with the same mean difference variable of each group, using a one-way analysis of variance. If the analysis of variance showed a significant difference (0.5 level), then a Tukey honest significant difference test was computed to determine where the significance was among the three groups.

CHAPTER 4

Results

In this chapter the results are examined. This chapter contains three parts. The first part examines the isotonic matched-pair t-test. The second part examines isokinetic variables, using a matched-pair t-test for each of the 14 variables per group. An analysis of variance was used to compare the three groups per variable. The third part of this chapter reports the electromyographic analyses.

Isotonics

Results of the t-test for experimental group A (N = 22), performing the seated side-lateral raise with the dumbbell, showed a mean gain of 31.818 pounds and a standard deviation of 10.527. The t-value was 14.18 with a probability of 0.000, showing there was significance. The probability of these results without the treatment would be less than .0001. A .05 level of confidence was used to determine statistical significance. The actual mean weight-lifting gain for subjects ranged between 27.15 and 36.48 pounds for experimental group A (see Table 1).

Results of the t-test for experimental group B (N = 23), performing the seated behind-the-neck press with the barbell, showed a mean gain of 39.348 pounds and a standard deviation of 12.995. The t-value was 14.52 with a probability of 0.000, showing there was significance. The

Table 1

Pretest to Posttest Results of T-Tests for Experimental Group A Performing the Seated Side-Lateral Raise with the Dumbbell

	N	Mean	SD	T	P
Seated side-lateral raise	22	31.818	10.527	14.18	0.000*

*Significance at the .05 level.

probability of these results without the treatment would be less than .0001. The actual mean weight-lifting gain fell between 33.73 and 44.95 pounds for experimental group B (see Table 2).

Table 2

Pretest to Posttest Results of T-Tests for Experimental Group B Performing the Seated Behind-the-Neck Press with the Barbell

	N	Mean	SD	T	P
Seated behind-the-neck press	23	39.348	12.995	14.52	0.000*

*Significance at the .05 level.

Isokinetics

The matched-pair t-test was used to determine if there were significant gains from pretest to posttest for each group. A t-value of 2.080 or higher was needed to determine significance in experimental group A; 2.074 or higher was needed to indicate significance for experimental group B; and 2.101 or higher was needed for statistical significance for control group C.

For experimental group A, of the 14 variables only three indicated no significant differences: 60 degrees-per-second peak torque at 80 degrees of abduction, 180 degrees-per-second peak torque at 15 degrees of abduction, and 180 degrees-per-second peak torque at 80 degrees of abduction. For experimental group B, only two variables indicated no significant differences: 180 degrees-per-second peak torque at 80 degrees of abduction and 180 degrees-per-second angle of peak torque. For control group C, only one variable revealed significance, and it was negatively significant: 180 degrees-per-second peak torque at 15 degrees of abduction.

Results of T-Tests for Cybex Measures at 60 Degrees Per Second

For the Cybex measure at 60 degrees-per-second peak torque, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 6.68 foot-pounds with a standard deviation of 7.96 foot-pounds was realized. A t-value of 3.94 was recorded, indicating a probability of 0.0008 (see Table 3).

For the Cybex measure at 60 degrees-per-second peak torque, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 5.70 foot-pounds with a standard deviation of 6.83 foot-pounds was realized. A t-value of 4.00 was recorded, indicating a probability of 0.0006 (see Table 3).

For the Cybex measure at 60 degrees-per-second peak torque, control group C (N = 19), performing no treatment, realized a mean gain of 2.32 foot-pounds with a standard deviation of 9.44 foot-pounds. A t-value of 2.17 was recorded, indicating a non-significant probability of 0.30 (see Table 3).

Table 3

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Peak Torque for all Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	6.68	7.96	1.70	3.94	0.0008
Seated behind-the-neck press	B	23	5.70	6.83	1.42	4.00	0.0006
No treatment	C	19	2.32	9.44	2.17	1.07	0.30

For the Cybex measure at 60 degrees-per-second peak torque percentage of bodyweight, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 3.05 foot-pounds with a standard deviation of 4.20 foot-pounds was realized. A t-value of 3.40 was recorded, indicating a probability of 0.0027 (see Table 4).

For the Cybex measure at 60 degrees-per-second peak torque percentage of bodyweight, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 3.09 foot-pounds with a standard deviation of 3.98 foot-pounds was realized. A t-value of 3.72 was recorded, indicating a probability of 0.0012 (see Table 4).

Table 4

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Peak Torque Percentage of Bodyweight for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	.05	4.20	0.90	3.40	0.0027
Seated behind-the-neck press	B	23	3.09	3.98	0.83	3.72	0.0012
No treatment	C	19	1.74	5.45	1.25	1.39	0.18

For the Cybex measure at 60 degrees-per-second peak torque percentage of bodyweight, control group C (N = 19), performing no treatment, realized a mean gain of 1.74

foot-pounds with a standard deviation of 5.45 foot-pounds. A t-value of 1.39 was recorded, indicating a probability of 0.18 (see Table 4).

For the Cybex measure at 60 degrees-per-second angle of peak torque, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean of -1.0 degrees with a standard deviation of 98.3 degrees was realized. A t-value of -0.05 was recorded, indicating a probability of 0.96 (see Table 5).

For the Cybex measure at 60 degrees-per-second angle of peak torque, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean of -15.0 degrees with a standard

Table 5

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Angle of Peak Torque for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	- 1.0	98.3	21.0	-0.05	0.96
Seated behind-the-neck press	B	23	-15.0	50.4	10.5	-1.43	0.17
No treatment	C	19	-24.0	65.8	15.1	-1.59	0.13

deviation of 50.4 degrees was realized. A t-value of -1.43 was recorded, indicating a 0.17 (see Table 5).

For the Cybex measure at 60 degrees-per-second angle of peak torque, control group C (N = 19), performing no treatment, realized a mean of -24.0 degrees with a standard deviation of 65.8 degrees. A t-value of -1.59 was recorded, indicating a probability of 0.13 (see Table 5).

For the Cybex measure at 60 degrees-per-second peak torque at 15 degrees of abduction, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 8.45 foot-pounds with a standard deviation of 8.33 foot-pounds was realized. A t-value of 4.76 was recorded, indicating a probability of 0.0000 (see Table 6).

For the Cybex measure at 60 degrees-per-second peak torque at 15 degrees of abduction, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 9.00 foot-pounds with a standard deviation of 8.35 foot-pounds was realized. A t-value of 5.17 was recorded, indicating a probability of 0.0000 (see Table 6).

For the Cybex measure at 60 degrees-per-second peak torque at 15 degrees of abduction, control group C (N = 19), performing no treatment, realized a mean gain of 2.84 foot-pounds with a standard deviation of 9.62 foot-pounds. A t-value of 1.29 was recorded, indicating a probability of 0.21 (see Table 6).

Table 6

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Peak Torque at 15 Degrees of Abduction for all Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	8.45	8.33	1.77	4.76	0.0000
Seated behind-the-neck press	B	23	9.00	8.35	1.74	5.17	0.0000
No treatment	C	19	2.84	9.62	2.21	1.29	0.21

For the Cybex measure at 60 degrees-per-second peak torque at 80 degrees of abduction, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 4.00 foot-pounds with a standard deviation of 9.16 foot-pounds was realized. A t-value of 2.05 was recorded, indicating a probability of 0.053 (see Table 7).

For the Cybex measure at 60 degrees-per-second peak torque at 80 degrees of abduction, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 3.74 foot-pounds with a standard deviation of 9.83 foot-pounds was realized. A t-value of 1.82 was recorded, indicating a probability of 0.082 (see Table 7).

For the Cybex measure at 60 degrees-per-second peak torque at 80 degrees of abduction, control group C (N = 19), performing no treatment, realized a mean gain of 0.79 foot-pounds with a standard deviation of 6.95 foot-pounds. A t-value of 0.50 was recorded, indicating a probability of 0.63 (see Table 7).

Table 7

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Peak Torque at 80 Degrees of Abduction for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	4.00	9.16	1.95	2.05	0.053
Seated behind-the-neck press	B	23	3.74	9.83	2.05	1.82	0.082
No treatment	C	19	0.79	6.95	1.59	0.50	0.63

For the Cybex measure at 60 degrees-per-second torque acceleration energy, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 0.82 foot-pounds with a standard deviation of 0.73 foot-pounds was realized. A t-value of 5.24 was recorded, indicating a probability of 0.0000 (see Table 8).

For the Cybex measure at 60 degrees-per-second torque acceleration energy, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 0.78 foot-pounds with a standard deviation of 0.67 foot-pounds was realized. A t-value of 5.59 was recorded, indicating a probability of 0.000 (see Table 8).

Table 8

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Torque Acceleration Energy for all Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	0.82	0.73	0.16	5.24	0.0000
Seated behind-the-neck press	B	23	0.78	0.67	0.14	5.59	0.0000
No treatment	C	19	0.37	0.90	0.21	1.79	0.090

For the Cybex measure at 60 degrees-per-second torque acceleration energy, control group C (N = 19), performing no treatment, realized a mean gain of 0.37 foot-pounds with a standard deviation of 0.90 foot-pounds. A t-value of 1.79

was recorded, indicating a probability of 0.090 (see Table 8).

For the Cybex measure at 60 degrees-per-second power, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 6.55 watts with a standard deviation of 9.82 watts was realized. A t-value of 3.13 was recorded, indicating a probability of 0.0051 (see Table 9).

For the Cybex measure at 60 degrees-per-second power, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 6.30 watts with a standard deviation of 9.38 watts was realized. A t-value of 3.22 was recorded, indicating a probability of 0.0039 (see Table 9).

Table 9

Posttest to Pretest Results of Matched Pair T-Tests for the Cybex Measure at 60 Degrees-Per-Second Power for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	6.55	9.82	2.09	3.13	0.0051
Seated behind-the-neck press	B	23	6.30	9.38	1.96	3.22	0.0039
No treatment	C	19	0.00	9.79	2.25	0.00	1.00

For the Cybex measure at 60 degrees-per-second power, control group C (N = 19), performing no treatment, realized a mean gain of 0.00 watts with a standard deviation of 9.79 watts. A t-value of 0.00 was recorded, indicating a probability of 1.00 (see Table 9).

Results of T-Tests for Cybex Measures at 180 Degrees Per Second

For the Cybex measure at 180 degrees-per-second peak torque, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 9.14 foot-pounds with a standard deviation of 5.63 foot-pounds was realized. A t-value of 7.61 was recorded, indicating a probability of 0.0000 (see Table 10).

For the Cybex measure at 180 degrees-per-second peak torque, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 7.78 foot-pounds with a standard deviation of 8.39 foot-pounds was realized. A t-value of 4.45 was recorded, indicating a probability of 0.0002 (see Table 10).

For the Cybex measure at 180 degrees-per-second peak torque, control group C (N = 19), performing no treatment, realized a mean gain of 1.58 foot-pounds with a standard deviation of 8.35 foot-pounds. A t-value of 0.82 was recorded, indicating a probability of 0.42 (see Table 10).

Table 10

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Peak Torque for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	9.14	5.63	1.20	7.61	0.0000
Seated behind-the-neck press	B	23	7.78	8.39	1.75	4.45	0.0002
No treatment	C	19	1.58	8.35	1.92	0.82	0.42

For the Cybex measure at 180 degrees-per-second peak torque percentage of bodyweight, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 4.68 foot-pounds with a standard deviation of 2.75 foot-pounds was realized. A t-value of 7.99 was recorded, indicating a probability of 0.0000 (see Table 11).

For the Cybex measure at 180 degrees-per-second peak torque percentage of bodyweight, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 4.35 foot-pounds with a standard deviation of 4.91 foot-pounds was realized. A t-value of 4.24 was recorded, indicating a probability of 0.0003 (see Table 11).

For the Cybex measure at 180 degrees-per-second peak torque percentage of bodyweight, control group C (N = 19), performing no treatment, realized a mean gain of 1.58 foot-pounds with a standard deviation of 4.97 foot-pounds. A t-value of 1.38 was recorded, indicating a probability of 0.18 (see Table 11).

Table 11

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Peak Torque Percentage of Bodyweight for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	4.68	2.75	0.59	7.99	0.0000
Seated behind-the-neck press	B	23	4.35	4.91	1.02	4.24	0.0003
No treatment	C	19	1.58	4.97	1.14	1.38	0.18

For the Cybex measure at 180 degrees-per-second angle of peak torque, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of -27.59 degrees with a standard deviation of 44.52 degrees was realized. A t-value of -2.91 was recorded, indicating a probability of 0.0084 (see Table 12).

For the Cybex measure at 180 degrees-per-second angle of peak torque, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of -22.65 degrees with a standard deviation of 58.50 degrees was realized. A t-value of -1.86 was recorded, indicating a probability of 0.077 (see Table 12).

For the Cybex measure at 180 degrees-per-second angle of peak torque, control group C (N = 19), performing no treatment, realized a mean gain of -18.68 degrees with a standard deviation of 40.84 degrees. A t-value of -1.99 was recorded, indicating a probability of 0.061 (see Table 12).

Table 12

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Angle of Peak Torque for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	-27.59	44.52	9.49	-2.91	0.0084
Seated behind-the-neck press	B	23	-22.65	58.50	12.20	-1.86	0.077
No treatment	C	19	-18.68	40.84	9.37	-1.99	0.061

For the Cybex measure at 180 degrees-per-second peak torque at 15 degrees of abduction, experimental group A

(N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 2.77 foot-pounds with a standard deviation of 15.99 foot-pounds was realized. A t-value of 0.81 was recorded, indicating a probability of 0.43 (see Table 13).

For the Cybex measure at 180 degrees-per-second peak torque at 15 degrees of abduction, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 4.09 foot-pounds with a standard deviation of 9.46 foot-pounds was realized. A t-value of 2.07 was recorded, indicating a probability of 0.050 (see Table 13).

Table 13

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Peak Torque at 15 Degrees of Abduction for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	2.77	15.99	3.41	0.81	0.43
Seated behind-the-neck press	B	23	4.09	9.46	1.97	2.07	0.050
No treatment	C	19	-12.00	12.05	2.76	-4.34	0.0004

For the Cybex measure at 180 degrees-per-second peak torque at 15 degrees of abduction, control group C (N = 19), performing no treatment, realized a mean gain of -12.00 foot-pounds with a standard deviation of 12.05 foot-pounds. A t-value of -4.34 was recorded, indicating a probability of 0.0004 (see Table 13).

For the Cybex measure at 180 degrees-per-second peak torque at 80 degrees of abduction, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 2.91 foot-pounds with a standard deviation of 8.43 foot-pounds was realized. A t-value of 1.62 was recorded, indicating a probability of 0.12 (see Table 14).

For the Cybex measure at 180 degrees-per-second peak torque at 80 degrees of abduction, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 3.13 foot-pounds with a standard deviation of 9.49 foot-pounds was realized. A t-value of 1.58 was recorded, indicating a probability of 0.13 (see Table 14).

For the Cybex measure at 180 degrees-per-second peak torque at 80 degrees of abduction, control group C (N = 19), performing no treatment, realized a mean gain of 0.11 foot-pounds with a standard deviation of 8.60 foot-pounds. A t-value of 0.05 was recorded, indicating a probability of 0.96 (see Table 14).

Table 14

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Peak Torque at 80 Degrees of Abduction for all Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	2.91	8.43	1.80	1.62	0.12
Seated behind-the-neck press	B	23	3.13	9.49	1.98	1.58	0.13
No treatment	C	19	0.11	8.60	1.97	0.05	0.96

For the Cybex measure at 180 degrees-per-second torque acceleration energy, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 2.82 foot-pounds with a standard deviation of 2.46 foot-pounds was realized. A t-value of 5.37 was recorded, indicating a probability of 0.0000 (see Table 15).

For the Cybex measure at 180 degrees-per-second torque acceleration energy, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 1.78 foot-pounds with a standard deviation of 2.15 foot-pounds was realized. A t-value of 3.97 recorded. The probability of 0.0006 (see Table 15).

For the Cybex measure at 180 degrees-per-second torque acceleration energy, control group C (N = 19), performing no treatment, realized a mean gain of 0.63 foot-pounds with a standard deviation of 2.41 foot-pounds. A t-value of 1.14 was recorded, indicating a probability of 0.27 (see Table 15).

Table 15

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Torque Acceleration Energy for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	2.82	2.46	0.52	5.37	0.0000
Seated behind-the-neck press	B	23	1.78	2.15	0.45	3.97	0.0006
No treatment	C	19	0.63	2.41	0.55	1.14	0.27

For the Cybex measure at 180 degrees-per-second power, experimental group A (N = 22) performed the seated side-lateral raise with the dumbbell during the treatment period. A mean gain of 17.95 watts with a standard deviation of 27.54 watts was realized. A t-value of 3.06 was recorded, indicating a probability of 0.0060 (see Table 16).

For the Cybex measure at 180 degrees-per-second power, experimental group B (N = 23) performed the seated behind-the-neck press with the barbell during the treatment period. A mean gain of 14.65 watts with a standard deviation of 29.62 watts was realized. A t-value of 2.37 was recorded, indicating a probability of 0.027 (see Table 16).

For the Cybex measure at 180 degrees-per-second power, control group C (N = 19), performing no treatment, realized a mean gain of 0.63 watts with a standard deviation of 31.17 watts. A t-value of 0.09 was recorded, indicating a probability of 0.93 (see Table 16).

Table 16

Pretest to Posttest Results of Matched Pair T-Tests for the Cybex Measure at 180 Degrees-Per-Second Power for All Groups

Condition	Group	N	Mean	SD	SE mean	T	P
Seated side-lateral raise	A	22	17.95	27.54	5.87	3.06	0.0060
Seated behind-the-neck press	B	23	14.65	29.62	6.18	2.37	0.027
No treatment	C	19	0.63	31.17	7.15	0.09	0.93

Results of Analysis of Variance for Cybex Variables at 60 Degrees Per Second, Among the Three Groups

An analysis of variance was calculated among the three groups per variable. To determine statistical significance at the .05 level, the F-ratio critical value needed to be 3.1478 or higher.

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second peak torque showed an F-ratio of 1.62 with a probability of 0.2063, indicating there was no significant difference among the three groups (see Table 17).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second peak torque percentage of bodyweight revealed an F-ratio of 0.58 with a probability of .566, inferring there was no significant difference among the three groups (see Table 18).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second angle of peak torque revealed an F-ratio of 0.50 with a probability of .6090, inferring there was no significant difference among the three groups (see Table 19).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second peak torque at 15 degrees of abduction revealed an F-ratio of 3.06 with a probability of .0541, inferring there was no significant difference among the three groups (see Table 20).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second peak torque at 80 degrees of abduction revealed an F-ratio of 0.82 with a

Table 17

Analysis of Variance for the Cybex Variable
of 60 Degrees-Per-Second Peak Torque
for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	6.682	7.961
Seated behind-the-neck press	23	5.696	6.832
No treatment	19	2.316	9.440

Source	DF	SS	MS	F	P
Condition	2	210.2	105.1	1.62	0.2063
Error	61	3,961.7	64.9		
Total	63	4,171.9			

Table 18

Analysis of Variance for the Cybex Variable of 60 Degrees-Per-Second Peak Torque Percentage of Bodyweight for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	3.045	4.203
Seated behind-the-neck press	23	3.087	3.976
No treatment	19	1.737	5.445

Source	DF	SS	MS	F	P
Condition	2	23.6	11.8	0.58	.563
Error	61	1,252.5	20.5		
Total	63	1,276.1			

Table 19

Analysis of Variance for the Cybex Variable of 60 Degrees-Per-Second Angle of Peak Torque for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	- 1.05	98.32
Seated behind-the-neck press	23	-15.04	50.40
No treatment	19	-24.00	65.81

Source	DF	SS	MS	F	P
Condition	2	5,538	2,769	0.50	.6090
Error	61	336,830	5,522		
Total	63	342,368			

Table 20

Analysis of Variance for the Cybex Variable of
60 Degrees-Per-Second Peak Torque at
15 Degrees of Abduction
for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	8.455	8.325
Seated behind-the-neck press	23	9.000	8.350
No treatment	19	2.842	9.616

Source	DF	SS	MS	F	P
Condition	2	467.0	233.5	3.06	.0541
Error	61	4,654.0	76.3		
Total	63	5,121.0			

probability of .4452, inferring there was no significant difference among the three groups (see Table 21).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second torque acceleration energy revealed an F-ratio of 2.14 with a probability of .1254, inferring there was no significant difference among the three groups (see Table 22).

An analysis of variance for the three groups for the Cybex variable of 60 degrees-per-second power revealed an F-ratio of 2.96 with a probability of .0593, inferring there was no significant difference among the three groups (see Table 23).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second peak torque revealed an F-ratio of 5.72 with a probability of .0053, inferring there was significant difference among the three groups (see Table 24).

Tukey test results showed that experimental groups A and B were equal. Experimental groups A and B were both significantly greater than control group C at the .05 level. A critical difference of 1.42 was needed to show significance (see Table 24).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second peak torque percentage of bodyweight revealed an F-ratio of 3.12 with a

Table 21

Analysis of Variance for the Cybex Variable of
60 Degrees-Per-Second Peak Torque at
80 Degrees of Abduction
for all Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	4.000	9.160
Seated behind-the-neck press	23	3.739	9.827
No treatment	19	0.789	6.949

Source	DF	SS	MS	F	P
Condition	2	127.3	63.6	0.82	.4452
Error	61	4,755.6	78.0		
Total	63	4,882.9			

Table 22

Analysis of Variance for the Cybex Variable of
60 Degrees-Per-Second Torque Acceleration
Energy for all Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	0.8182	0.7327
Seated behind-the-neck press	23	0.7826	0.6713
No treatment	19	0.3684	0.8951

Source	DF	SS	MS	F	P
Condition	2	2.503	1.251	2.14	.1254
Error	61	35.607	0.584		
Total	63	38.109			

Table 23

Analysis of Variance for the Cybex Variable of
60 Degrees-Per-Second Power for all Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	6.545	9.816
Seated behind-the-neck press	23	6.304	9.383
No treatment	19	0.000	9.787

Source	DF	SS	MS	F	P
Condition	2	551.7	275.8	2.96	.0593
Error	61	5,684.3	93.2		
Total	63	6,236.0			

Table 24

Analysis of Variance for the Cybex Variable of
180 Degrees-Per-Second Peak Torque
for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	9.136	5.634
Seated behind-the-neck press	23	7.783	8.338
No treatment	19	1.579	8.349

Source	DF	SS	MS	F	P
Condition	2	650.3	325.2	5.72	.0053*
Error	61	3,469.1	56.9		
Total	63	4,119.4			

Tukey honest significant difference test

Seated side-lateral raise	Seated behind-the neck press	No treatment	CD	Difference among means
A	B	C		
9.14	7.78		1.42	1.36
9.14		1.58	1.42	7.56*
	7.78	1.58	1.42	6.2*

Conclusions:
A = B
B > C
A > C

*Significance at the .05 level.

probability of .0513, inferring there was no significant difference among the three groups (see Table 25).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second angle of peak torque revealed an F-ratio of 0.17 with a probability of 0.844100, inferring there was no significant difference among the three groups (see Table 26).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second peak torque at 15 degrees of abduction revealed an F-ratio of 9.83 with a probability of .0002, inferring there was significance among the three groups (see Table 27).

Tukey test results showed that experimental group B was significantly stronger than experimental group A and control group C. Experimental group A was significantly stronger than control group C at the .05 level (see Table 27).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second peak torque at 80 degrees of abduction revealed an F-ratio of 0.72 with a probability of 0.4908, inferring there was no significant difference among the three groups (see Table 28).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second torque acceleration energy revealed an F-ratio of 4.46 with a probability of 0.156, inferring there was significant difference among the three groups (see Table 29).

Table 25

Analysis of Variance for the Cybex Variable of 180 Degrees-Per-Second Peak Torque Percentage of Bodyweight for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	4.682	2.750
Seated behind-the-neck press	23	4.348	4.914
No treatment	19	1.579	4.970

Source	DF	SS	MS	F	P
Condition	2	116.1	58.1	3.12	.0513
Error	61	1,134.6	18.6		
Total	63	1,250.7			

Table 26

Analysis of Variance for the Cybex Variable of
180 Degrees-Per-Second Angle of Peak Torque
for all Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	-27.59	44.52
Seated behind-the-neck press	23	-22.65	58.50
No treatment	19	-18.68	40.84

Source	DF	SS	MS	F	P
Condition	2	818	409	0.17	0.844100
Error	61	146,933	2,409		
Total	63	147,751			

Table 27

Analysis of Variance for the Cybex Variable of
180 Degrees-Per-Second Peak Torque
at 15 Degrees of Abduction
for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	2.77	15.99
Seated behind-the-neck press	23	4.09	9.46
No treatment	19	-12.00	12.05

Source	DF	SS	MS	F	P
Condition	2	3,206	1,603	9.83	.0002*
Error	61	9,952	163		
Total	63	13,158			

Tukey honest significant difference test

Seated side-lateral raise	Seated behind-the neck press	No treatment	CD	Difference among means
A	B	C		
2.77	4.09		1.08	1.32*
2.77		-12.00	1.08	14.77*
	4.09	-12.00	1.08	16.09*

Conclusions:
A < B
A > C
B > C

*Significance at the .05 level.

Table 28

Analysis of Variance for the Cybex Variable of
180 Degrees-Per-Second Peak Torque at
80 Degrees of Abduction
for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	2.909	8.428
Seated behind-the-neck press	23	3.130	9.493
No treatment	19	0.105	8.602

Source	DF	SS	MS	F	P
Condition	2	114.2	57.1	0.72	0.4908
Error	61	4,806.2	78.8		
Total	63	4,920.4			

Table 29

Analysis of Variance for the Cybex Variable of 180 Degrees-Per-Second Torque Acceleration Energy for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	2.818	2.462
Seated behind-the-neck press	23	1.783	2.152
No treatment	19	0.632	2.409

Source	DF	SS	MS	F	P
Condition	2	48.75	24.38	4.46	.0156*
Error	61	333.61	5.47		
Total	63	382.36			

Tukey honest significant difference test

Seated side-lateral raise	Seated behind-the neck press	No treatment	CD	Difference among means
A	B	C		
2.818	1.783		1.61	1.035
2.818		0.632	1.61	2.186*
	1.783	0.632	1.61	1.151

Conclusions:
A = B
A > C
B = C

*Significance at the .05 level.

Tukey test results showed that experimental groups A and B were equal. Experimental group B and control group C were equal. Experimental group A was significantly greater than control group C at the .05 level (see Table 29).

An analysis of variance for the three groups for the Cybex variable of 180 degrees-per-second power showed an F-ratio of 1.96 with a probability of .1496, concluding there was no significant difference among the three groups (see Table 30).

Electromyography Analysis

The first subject used 100 pounds of weight to perform the seated behind-the-neck press and a 20-pound dumbbell to perform the seated side-lateral raise. The subject weighed 200 pounds and was 69 inches in height.

The anterior deltoid was the first muscle analyzed for subject 1. While performing the seated behind-the-neck press, the anterior deltoid produced peak microvolts recorded by the electromyography, as follows: 4,000 for the first repetition; 4,000 for the second repetition; and 4,500 for the third repetition. While performing the seated side-lateral raise, the anterior deltoid produced 1,500 peak microvolts for each of the three repetitions.

The second muscle for subject 1 analyzed was the middle deltoid. While performing the seated behind-the-neck press, the middle deltoid produced peak microvolts as follows: 9,000 for the first repetition; 8,000 for the second

Table 30

Analysis of Variance for the Cybex Variable of
180 Degrees-Per-Second Power for All Groups

Condition	N	Mean	SD
Seated side-lateral raise	22	17.95	27.54
Seated behind-the-neck press	23	14.65	29.62
No treatment	19	0.63	31.17

Source	DF	SS	MS	F	P
Condition	2	3,388	1,694	1.96	.1496
Error	61	52,719	864		
Total	63	56,107			

repetition; and 7,000 for the third repetition. While performing the seated side-lateral raise, the middle deltoid produced peak microvolts as follows: 6,500 for the first repetition; 8,500 for the second repetition; and 5,500 for the third repetition.

The posterior deltoid was the third muscle analyzed for subject 1. While performing the seated behind-the-neck press, the posterior deltoid produced peak microvolts as follows: 4,500 for the first repetition; 4,500 for the second repetition; and 6,000 for the third repetition. While performing the seated side-lateral raise, the posterior deltoid produced peak microvolts as follows: 9,000 for the first repetition; 8,000 for the second repetition; and 7,500 for the third repetition.

The fourth muscle analyzed for subject 1 was the triceps. While performing the seated behind-the-neck press, the triceps produced 10,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the triceps produced peak microvolts as follows: 1,000 for the first repetition; 1,000 for the second repetition; and 1,500 for the third repetition.

The supraspinatus was the fifth muscle analyzed for subject 1. While performing the seated behind-the-neck press, the supraspinatus produced peak microvolts as follows: 8,000 for the first repetition; 10,500 for the second repetition; and 9,000 for the third repetition.

While performing the seated side-lateral raise, the supraspinatus produced 11,000 peak microvolts for each of the three repetitions (see Figure 4.1. and Table 31).

The second subject used 80 pounds of weight for the seated behind-the-neck press and a 10-pound dumbbell for the seated side-lateral raise. The subject weighed 205 pounds and was 69 inches in height.

While performing the seated behind-the-neck press, the anterior deltoid produced 3,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the anterior deltoid produced peak microvolts as follows: 1,500 for the first repetition; 2,000 for the second repetition; and 2,500 for the third repetition.

While performing the seated behind-the-neck press, the middle deltoid produced peak microvolts as follows: 500 for the first repetition; 500 for the second repetition; and 1,000 for the third repetition. While performing the seated side-lateral raise, the middle deltoid produced peak microvolts of 1,000 for each of the three repetitions.

While performing the seated behind-the-neck press, the posterior deltoid produced peak microvolts as follows: 1,500 for the first repetition; 1,500 for the second repetition; and 1,000 for the third repetition. While performing the seated side-lateral raise, the posterior deltoid produced 7,500 peak microvolts for each of the three repetitions.

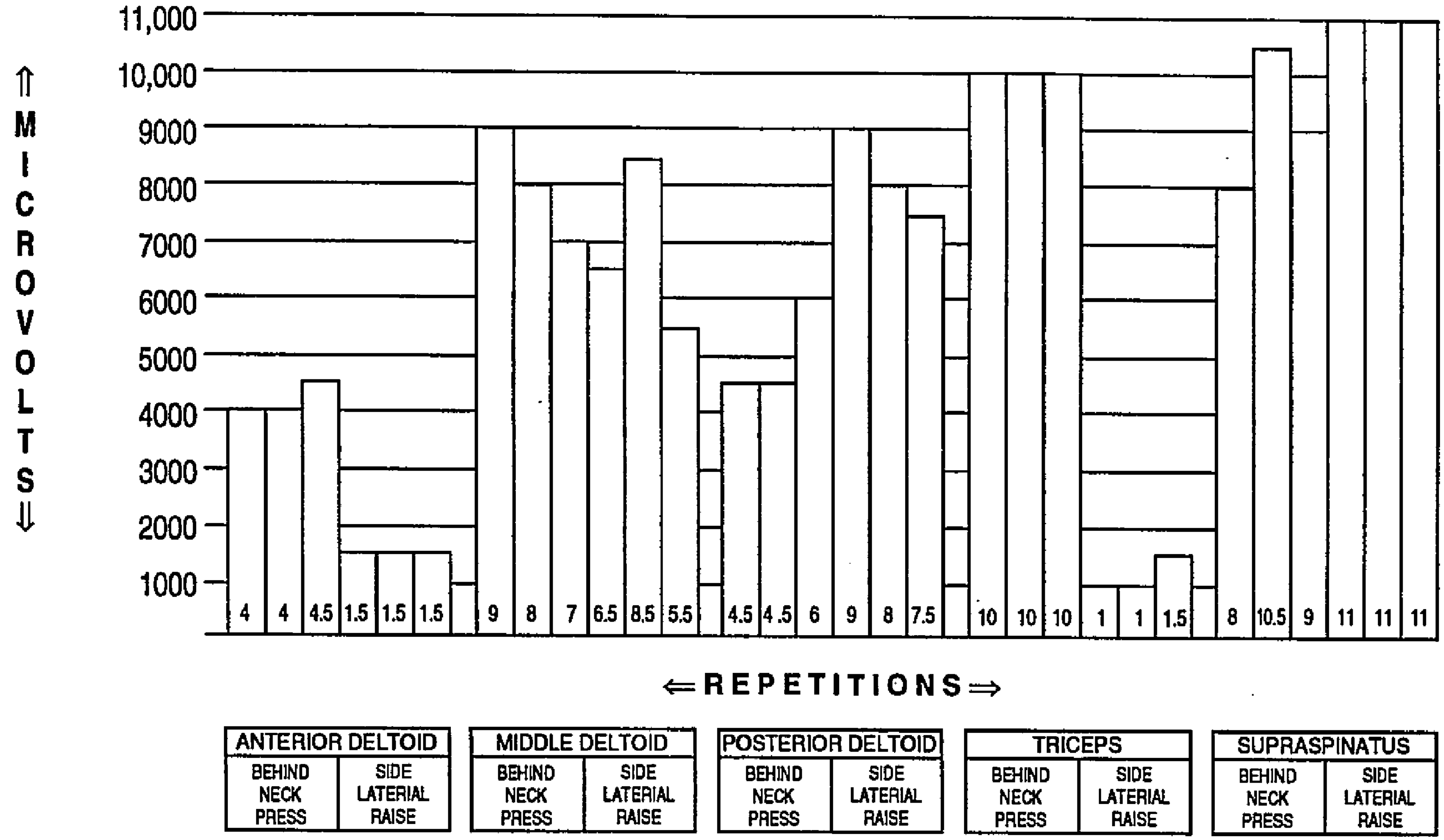


Figure 4.1. Peak Microvolts of Muscle Contraction for Subject 1, Performing the Seated Behind-the-Neck Press and the Seated Side-Lateral Raise

Table 31

Peak Microvolts Per Individual, Per Repetitions

Muscle	Reps	Subject 1		Subject 2		Subject 3		Subject 4		Subject 5	
		B	A	B	A	B	A	B	A	B	A
Anterior deltoid	1	4,000	1,500	3,000	1,500	10,500	9,000	5,000	6,000	5,500	4,000
	2	4,000	1,500	3,000	2,000	11,000	11,000	6,500	7,000	7,000	4,500
	3	4,500	1,500	3,000	2,500	11,000	11,000	6,500	7,000	6,000	4,500
Middle deltoid	1	9,000	6,500	500	1,000	5,000	9,500	11,000	10,000	4,000	4,000
	2	8,000	8,500	500	1,000	7,000	7,000	11,000	11,000	6,500	3,500
	3	7,000	5,500	1,000	1,000	4,500	9,000	11,000	11,000	6,000	5,000
Posterior deltoid	1	4,500	9,000	1,500	750	3,500	2,225	4,000	5,000	10,000	2,000
	2	4,500	8,000	1,500	750	3,000	2,000	4,000	5,000	8,500	2,500
	3	6,000	7,500	1,000	750	4,000	2,225	4,000	5,000	8,500	2,500
Triceps	1	10,000	1,000	10,000	2,500	6,000	2,000	8,000	2,500	11,000	9,000
	2	10,000	1,000	11,000	2,000	6,000	2,000	7,000	4,000	8,500	10,500
	3	10,000	1,500	11,000	2,225	6,000	2,000	6,000	4,000	11,000	11,000
Supraspinatus	1	8,000	11,000	10,000	3,225	11,000	11,000	11,000	11,000	11,000	11,000
	2	10,500	11,000	11,000	3,000	11,000	11,000	11,000	11,000	11,000	11,000
	3	9,000	11,000	11,000	3,000	11,000	11,000	11,000	11,000	11,000	11,000

Note: B = seated behind-the-neck press; A = seated side-lateral raise.

While performing the seated behind-the-neck press, the triceps produced peak microvolts as follows: 10,000 for the first repetition; 11,000 for the second repetition; and 11,000 for the third repetition. While performing the seated side-lateral raise, the triceps produced peak microvolts as follows: 2,500 for the first repetition; 2,000 for the second repetition; and 2,225 for the third repetition.

While performing the seated behind-the-neck press, the supraspinatus produced peak microvolts as follows: 10,000 for the first repetition; 11,000 for the second repetition; and 11,000 for the third repetition. The supraspinatus, while performing the seated side-lateral raise, produced peak microvolts as follows: 3,225 for the first repetition; 3,000 for the second repetition; and 3,000 for the third repetition (see Figure 4.2. and Table 31).

The third subject used 75 pounds for the seated behind-the-neck press and a 10-pound dumbbell for the seated side-lateral raise. The subject weighed 180 pounds and was 68 inches in height.

While performing the seated behind-the-neck press, the anterior deltoid produced peak microvolts as follows: 10,500 for the first repetition; 11,000 for the second repetition; and 11,000 for the third repetition. While performing the seated side-lateral raise, the anterior deltoid produced peak microvolts as follows: 9,000 for the

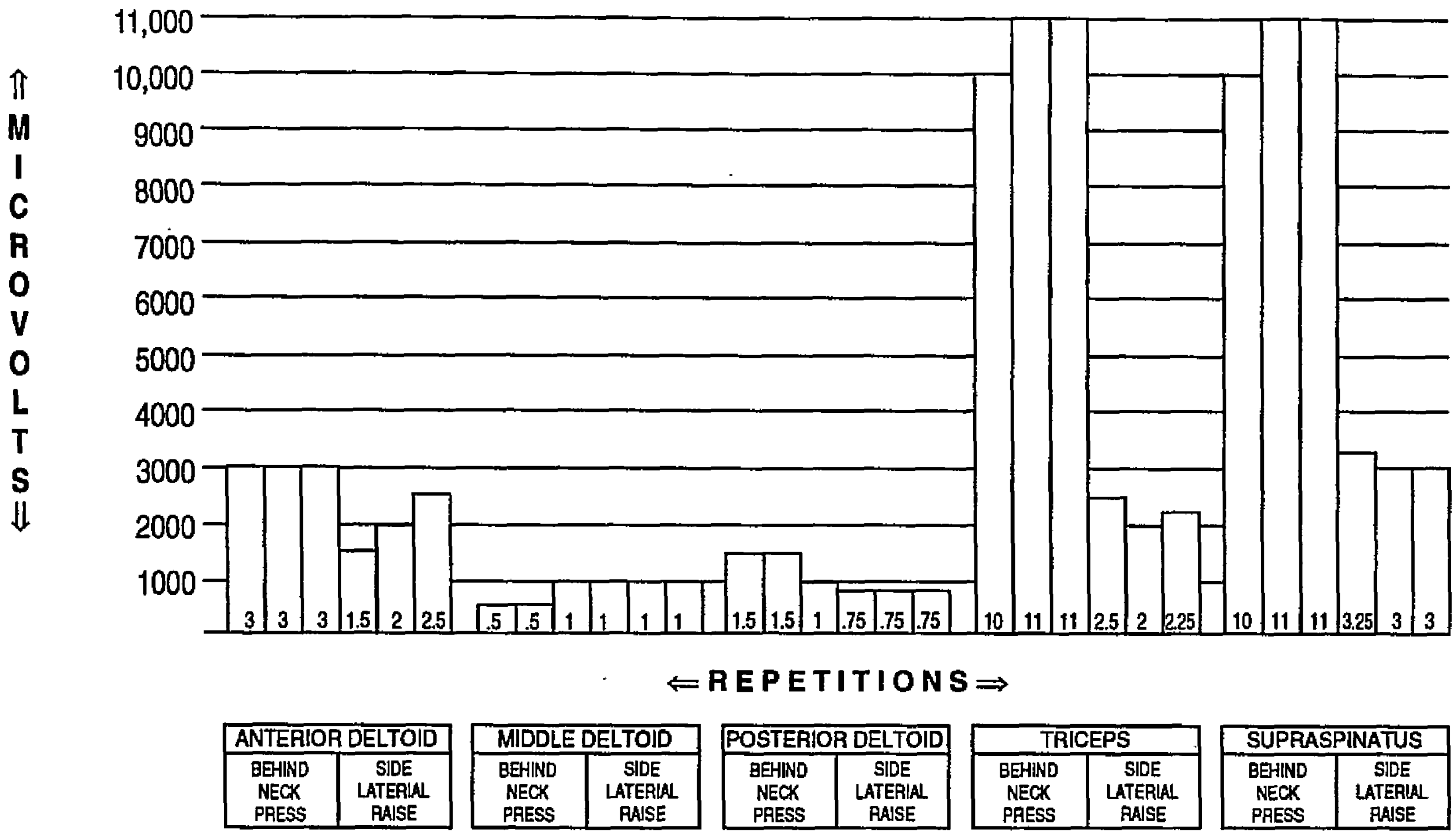


Figure 4.2. Peak Microvolts of Muscle Contraction for Subject 2, Performing the Seated Behind-the-Neck Press and the Seated Side-Lateral Raise

first repetition; 11,000 for the second repetition; and 11,000 for the third repetition.

While performing the seated behind-the-neck press, the middle deltoid produced peak microvolts as follows: 5,000 for the first repetition; 7,000 for the second repetition; and 4,500 for the third repetition. While performing the seated side-lateral raise, the middle deltoid produced peak microvolts as follows: 9,500 for the first repetition; 7,000 for the second repetition; and 9,000 for the third repetition.

While performing the seated behind-the-neck press, the posterior deltoid produced peak microvolts as follows: 3,500 for the first repetition; 3,000 for the second repetition; and 4,000 for the third repetition. While performing the seated side-lateral raise, the posterior deltoid produced peak microvolts as follows: 2,225 for the first repetition; 2,000 for the second repetition; and 2,225 for the third repetition.

While performing the seated behind-the-neck press, the triceps muscle produced 6,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the triceps produced 2,000 peak microvolts for each of the three repetitions.

While performing the seated behind-the-neck press, the supraspinatus produced 11,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the supraspinatus also produced 11,000 peak microvolts for each of the three repetitions (see and Figure 4.3. and Table 31).

The fourth subject used 70 pounds for the seated behind-the-neck press and a 10-pound dumbbell for the seated side-lateral raise. The subject weighed 155 pounds and was 70 inches in height.

While performing the seated behind-the-neck press, the anterior deltoid produced peak microvolts as follows: 5,000 for the first repetition; 6,500 for the second repetition; and 6,500 for the third repetition. While performing the seated side-lateral raise, the anterior deltoid produced peak microvolts as follows: 6,000 for the first repetition; 7,000 for the second repetition; and 7,000 for the third repetition.

While performing the seated behind-the-neck press, the middle deltoid produced 11,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the middle deltoid produced peak microvolts as follows: 10,000 for the first repetition; 11,000 for the second repetition; and 11,000 for the third repetition.

While performing the seated behind-the-neck press, the posterior deltoid produced 4,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the posterior deltoid produced 5,000 peak microvolts for each of the three repetitions.

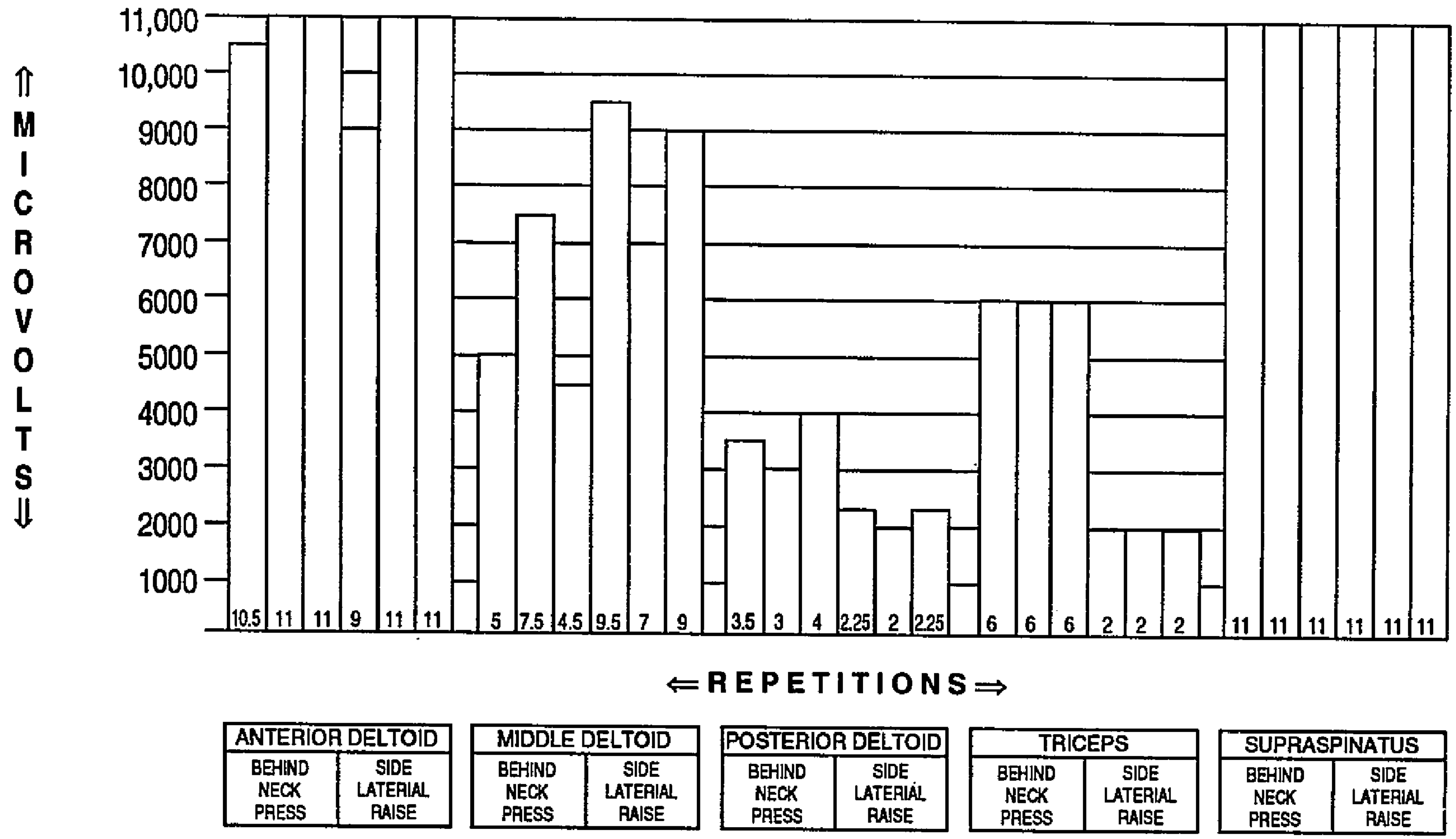


Figure 4.3. Peak Microvolts of Muscle Contraction for Subject 3, Performing the Seated Behind-the-Neck Press and the Seated Side-Lateral Raise

While performing the seated behind-the-neck press, the triceps produced peak microvolts as follows: 8,000 for the first repetition; 7,000 for the second repetition; and 6,000 for the third repetition. While performing the seated side-lateral raise, the triceps produced peak microvolts as follows: 2,500 for the first repetition; 4,000 for the second repetition; and 4,000 for the third repetition.

While performing the seated behind-the-neck press, the supraspinatus produced 11,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the supraspinatus also produced 11,000 peak microvolts for each of the three repetitions (see Figure 4.4. and Table 31).

The fifth subject used 70 pounds for the seated behind-the-neck press and a 10-pound dumbbell for the seated side-lateral raise. The subject weighed 195 pounds and was 71 inches in height.

While performing the seated behind-the-neck press, the anterior deltoid produced peak microvolts as follows: 5,500 for the first repetition; 7,000 for the second repetition; and 6,000 for the third repetition. While performing the seated side-lateral raise, the anterior deltoid produced peak microvolts as follows: 4,000 for the first repetition; 4,500 for the second repetition; and 4,500 for the third repetition.

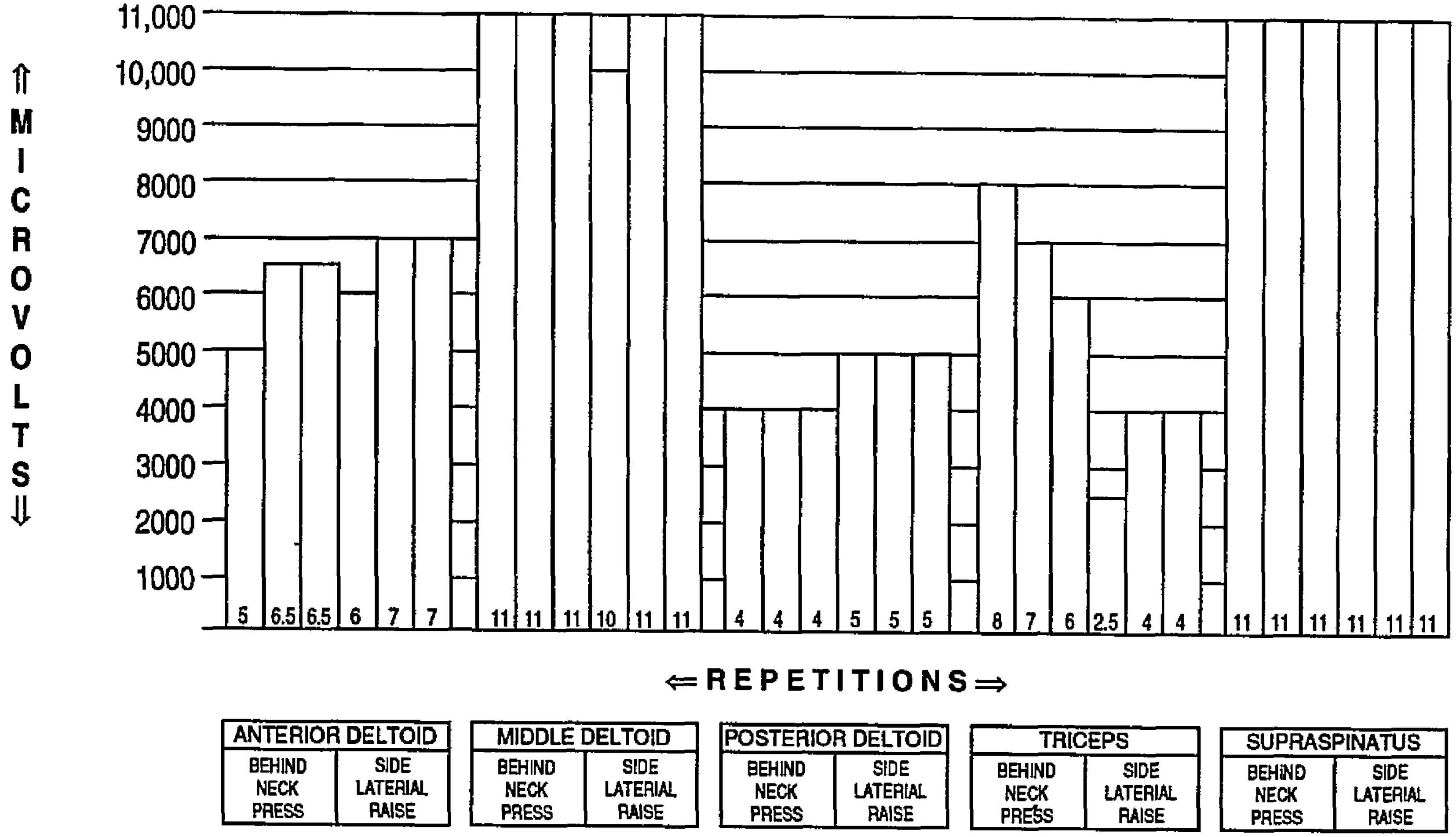


Figure 4.4. Peak Microvolts of Muscle Contraction for Subject 4, Performing the Seated Behind-the-Neck Press and the Seated Side-Lateral Raise

While performing the seated behind-the-neck press, the middle deltoid produced peak microvolts as follows: 4,000 for the first repetition; 6,500 for the second repetition; and 6,000 for the third repetition. While performing the seated side-lateral raise, the middle deltoid produced peak microvolts as follows: 4,000 for the first repetition, 3,500 for the second repetition, and 5,000 for the third repetition.

While performing the seated behind-the-neck press, the posterior deltoid produced peak microvolts as follows: 10,000 for the first repetition; 8,500 for the second repetition; and 8,500 for the third repetition. While performing the seated side-lateral raise, the posterior deltoid produced peak microvolts as follows: 2,000 for the first repetition; 2,500 second repetition; and 2,500 for the third repetition.

While performing the seated behind-the-neck press, the triceps muscle produced peak microvolts as follows: 11,000 for the first repetition; 8,500 for the second repetition; and 11,000 for the third repetition. While performing the seated side-lateral raise, the triceps muscle produced peak microvolts as follows: 9,000 for the first repetition; 10,500 for the second repetition; and 11,000 for the third repetition.

While performing the seated behind-the-neck press, the supraspinatus muscle produced 11,000 peak microvolts for each of the three repetitions. While performing the seated side-lateral raise, the supraspinatus muscle also produced 11,000 peak microvolts for each of the three repetitions (see Figure 4.5. and Table 31).

Mean of the Three Repetitions for the Seated Behind-the-Neck Press and Seated Side-Lateral Raise

The first subject had a recorded mean peak microvolts of the three repetitions for the seated behind-the-neck press as follows: anterior deltoid, 4,160; middle deltoid, 8,000; posterior deltoid, 5,000; triceps, 10,000; and supraspinatus, 9,160. For the seated side-lateral raise, the first subject had a recorded mean peak microvolts of the three repetitions as follows: anterior deltoid, 1,500; middle deltoid, 6,830; posterior deltoid, 8,160; triceps, 1,160; and supraspinatus, 11,000.

The second subject had a recorded mean peak microvolts of the three repetitions for the seated behind-the-neck press as follows: anterior deltoid, 3,000; middle deltoid, 660; posterior deltoid, 1,330; triceps, 10,660; and supraspinatus, 10,600. For the seated side-lateral raise, the second subject had a recorded mean peak microvolts of the three repetitions as follows: anterior deltoid, 2,080; middle deltoid, 1,000; posterior deltoid, 750; triceps, 2,250; and supraspinatus, 3,080.

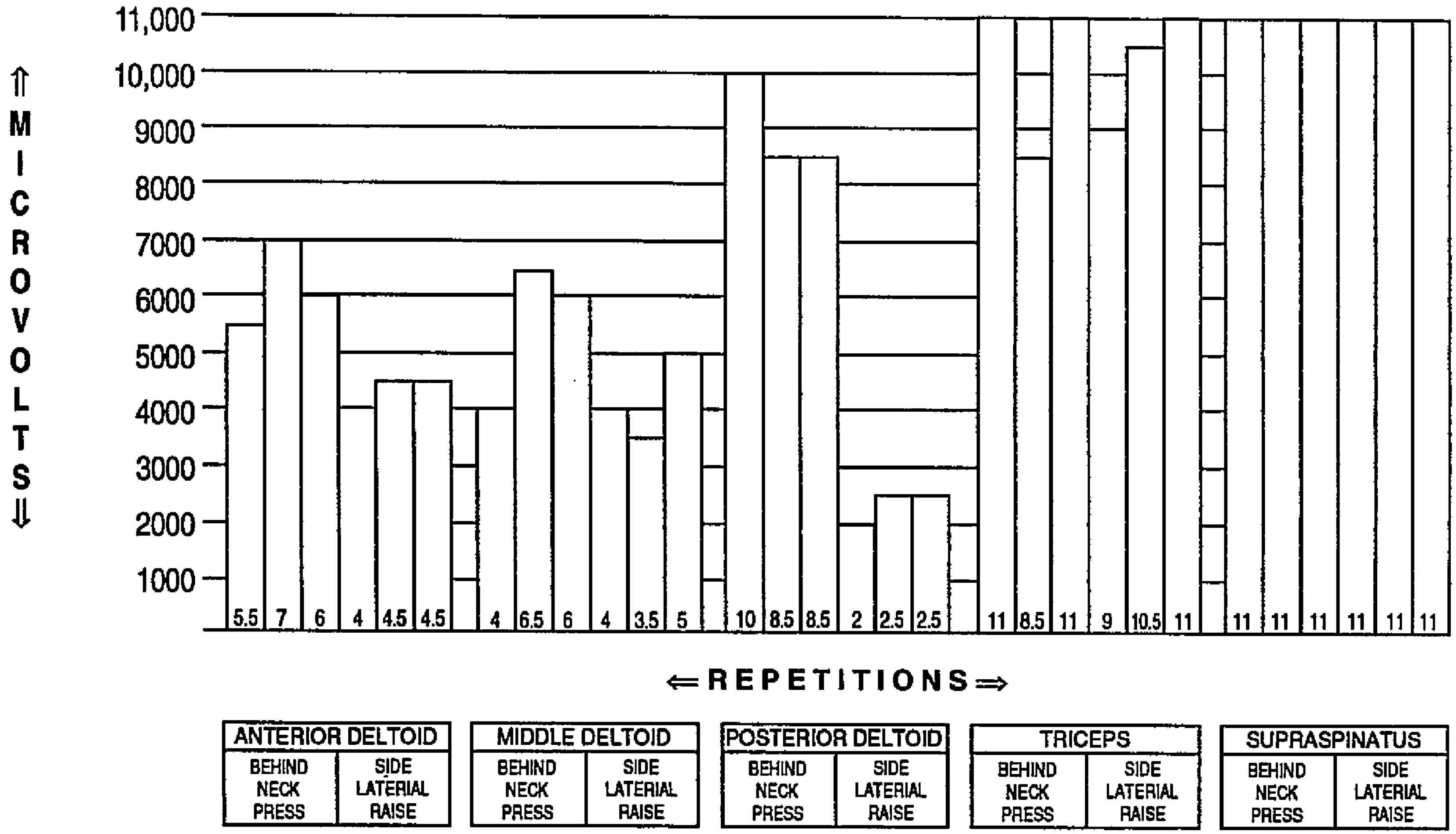


Figure 4.5. Peak Microvolts of Muscle Contraction for Subject 5, Performing the Seated Behind-the-Neck Press and the Seated Side-Lateral Raise

The third subject had a recorded mean peak microvolts of the three repetitions for the seated behind-the-neck press as follows: anterior deltoid, 10,830; middle deltoid, 5,500; posterior deltoid, 3,500; triceps, 6,000; and supraspinatus, 11,000. For the seated side-lateral raise, the third subject had a recorded mean peak microvolts of the three repetitions as follows: anterior deltoid, 10,330; middle deltoid, 8,500; posterior deltoid, 2,250; triceps, 2,000; and supraspinatus, 11,000.

The fourth subject had a recorded mean peak microvolts of the three repetitions for the seated behind-the-neck press as follows: anterior deltoid, 6,000; middle deltoid, 11,000; posterior deltoid, 4,000; triceps, 7,000; and supraspinatus, 11,000. For the seated side-lateral raise, the fourth subject had a recorded mean peak microvolts of the three repetitions as follows: anterior deltoid, 6,660; middle deltoid, 10,600; posterior deltoid, 5,000; triceps, 3,500; and supraspinatus, 11,000.

The fifth subject had a recorded mean peak microvolts of the three repetitions for the seated behind-the-neck press as follows: anterior deltoid, 6,160; middle deltoid, 5,500; posterior deltoid, 9,000; triceps, 10,160; and supraspinatus, 11,000. For the seated side-lateral raise, the fifth subject had a recorded mean peak microvolts of the three repetitions as follows: anterior deltoid, 4,300; middle deltoid, 4,160; posterior deltoid, 2,660; triceps, 10,160; and supraspinatus, 11,000 (see Figure 4.6., Figure 4.7., and Table 32).

Peak Microvolts Mean of Means Across All Subjects

The means for the seated behind-the-neck press included: anterior deltoid, 6,030; middle deltoid, 6,130; posterior deltoid, 4,560; triceps, 8,760; and supraspinatus, 10,550. The means of the seated side-lateral raise were as follows: anterior deltoid, 4,970; middle deltoid, 6,210; posterior deltoid, 3,760; triceps, 3,810; and supraspinatus, 9,400 (see Figure 4.8 and Table 33).

Ranking

Performing the seated behind-the-neck press, the first subject utilized the involvement of the five muscles in the following rank order: triceps, supraspinatus, middle deltoid, posterior deltoid, and the anterior deltoid. Rankings of the order of greatest involvement for the five muscles during the seated side-lateral raise revealed the following sequence: supraspinatus, triceps, anterior deltoid, middle deltoid, and posterior deltoid.

Performing the seated behind-the-neck press, the second subject utilized the involvement of the five muscles in the following rank order: triceps, supraspinatus, anterior deltoid, posterior deltoid, and middle deltoid. Rankings of involvement of the five muscles during the seated

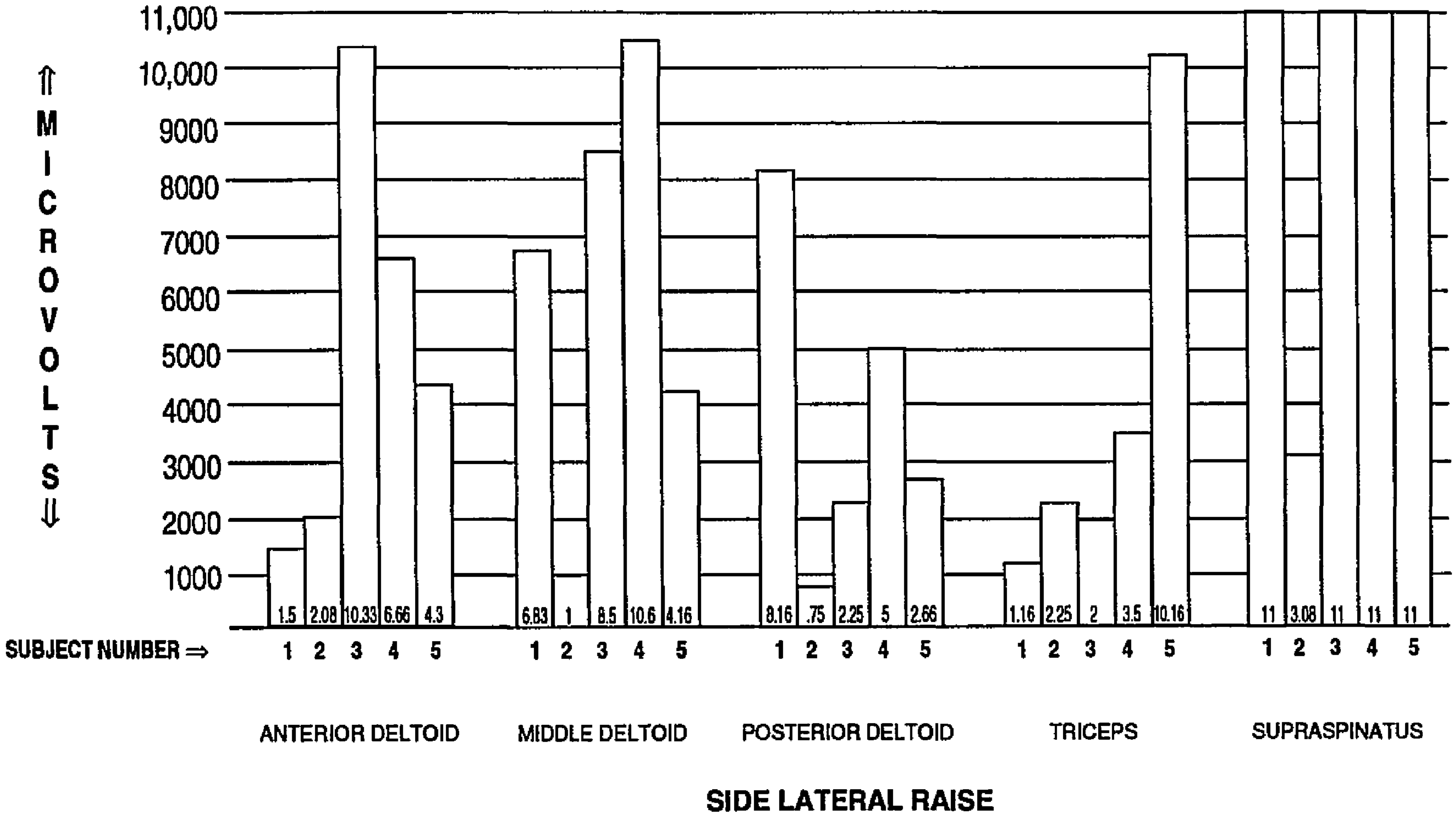


Figure 4.6. Means of the Three Repetitions for the Seated Side-Lateral Raise

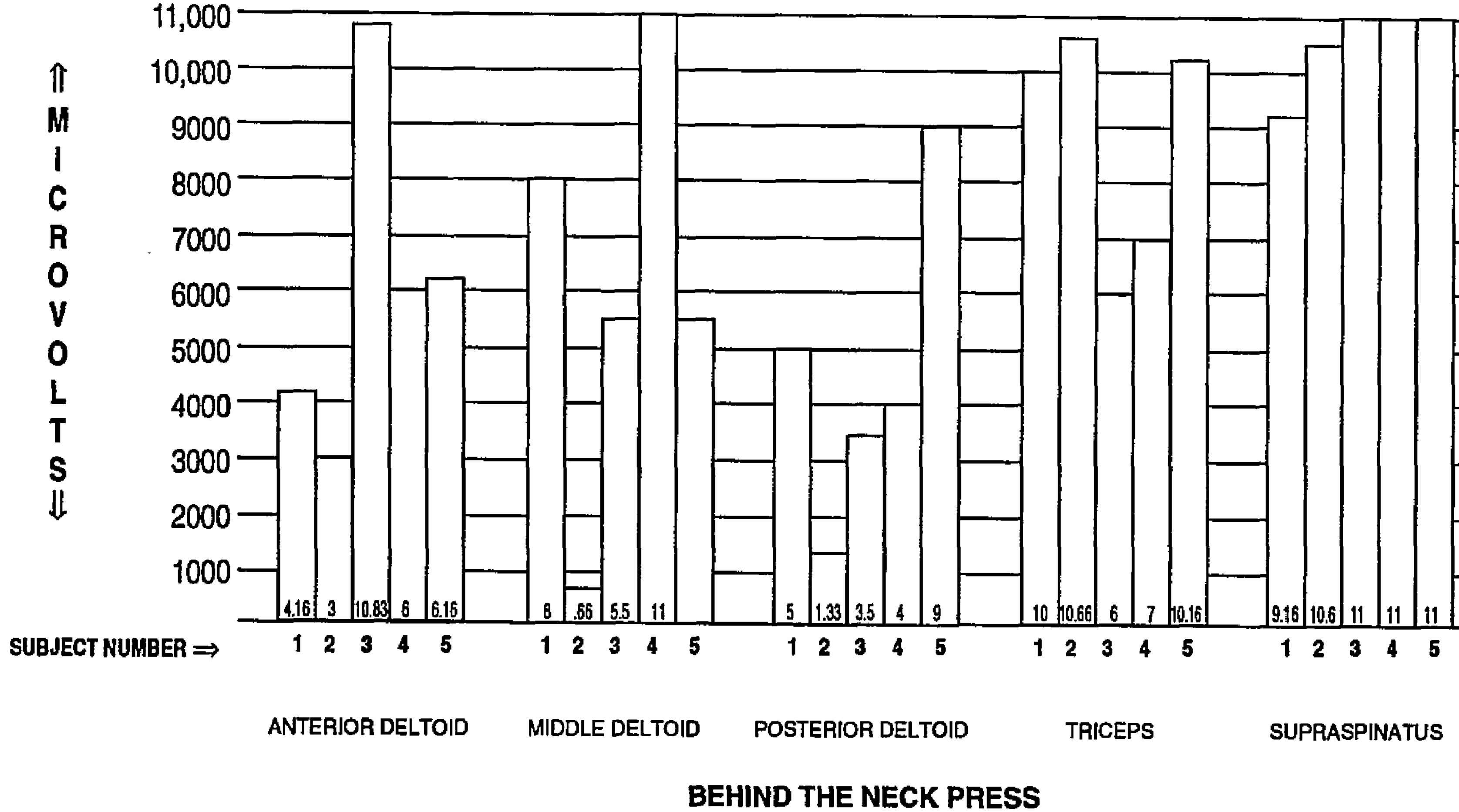


Figure 4.7. Means of the Three Repetitions for the Seated Behind-the-Neck Press

Table 32

Peak Microvolts Three-Repetition Mean of the Muscle, Per Indiviual

	Subject 1		Subject 2		Subject 3		Subject 4		Subject 5	
Muscle	B	A	B	A	B	A	B	A	B	A
Anterior deltoid	4,160	1,500	3,000	2,080	10,830	10,330	6,000	6,660	6,160	4,300
Middle deltoid	8,000	6,830	660	1,000	5,500	8,500	11,000	10,600	5,500	4,160
Posterior deltoid	5,000	8,160	1,330	750	3,500	2,225	4,000	5,000	9,000	2,660
Triceps	10,000	1,160	10,660	2,225	6,000	2,000	7,000	3,500	10,160	10,160
Supraspinatus	9,160	11,000	10,600	3,080	11,000	11,000	11,000	11,000	11,000	11,000

Note: B = seated behind-the-neck press; A = seated side-lateral raise.

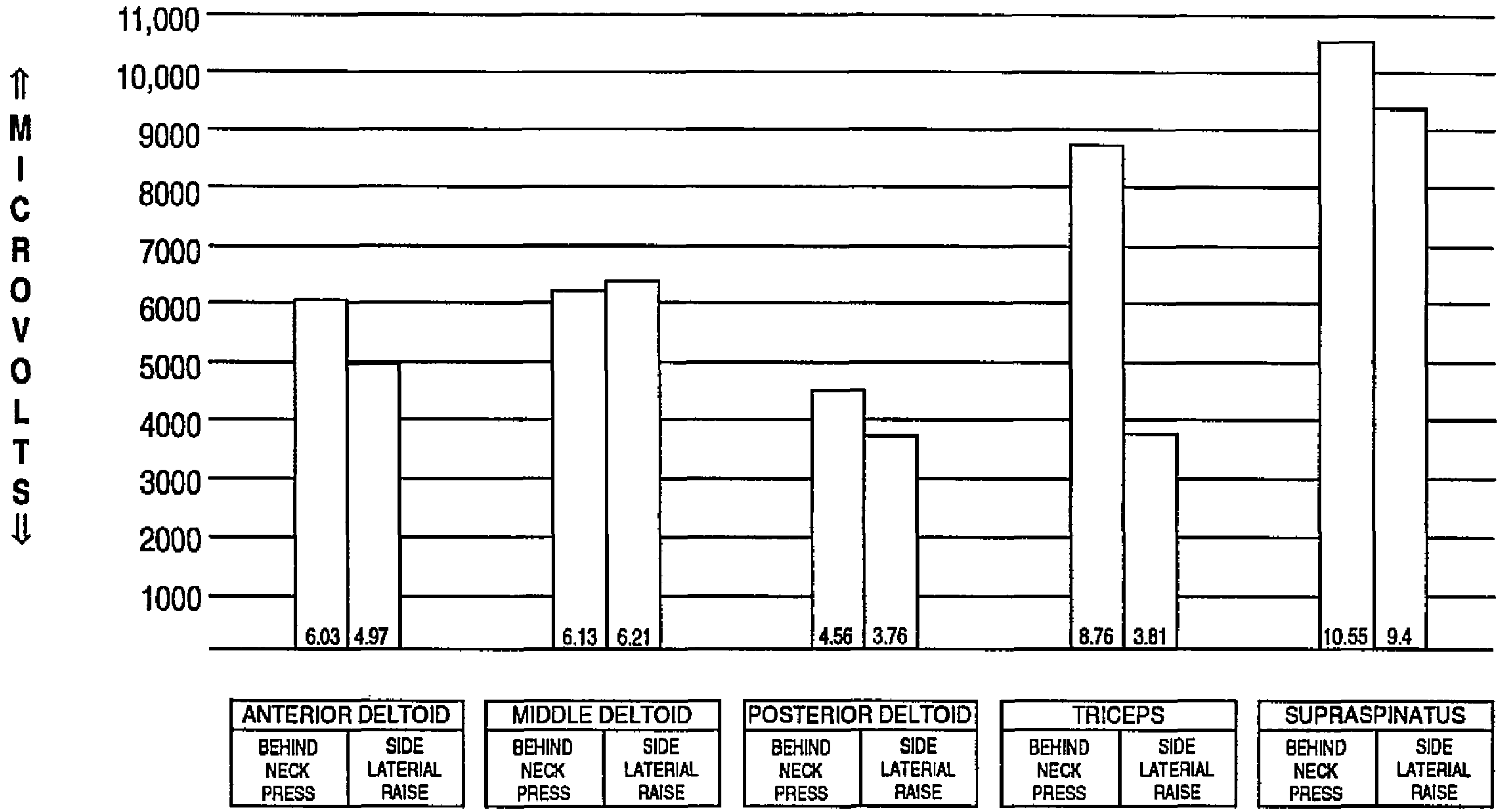


Figure 4.8. Peak Microvolts Mean of Means Across All Subjects

Table 33

Peak Microvolts Mean of Means Across All Subjects

	Seated behind-the-neck press	Seated side-lateral raise
Anterior deltoid	6,030	4,970
Middle deltoid	6,130	6,210
Posterior deltoid	4,560	3,760
Triceps	8,760	3,810
Supraspinatus	10,550	9,400

side-lateral raise were as follows: supraspinatus, triceps, anterior deltoid, middle deltoid, and posterior deltoid.

Performing the seated behind-the-neck press, the third subject utilized the involvement of the five muscles in the following rank order: supraspinatus, anterior deltoid, triceps, middle deltoid, and the posterior deltoid. Rankings of involvement of the five muscles during the seated side-lateral raise were as follows: supraspinatus, anterior deltoid, middle deltoid, posterior deltoid, and triceps.

Performing the seated behind-the-neck press, the fourth subject utilized the involvement of the five muscles in the following order: supraspinatus, middle deltoid, triceps, anterior deltoid, and the posterior deltoid. Rankings of involvement of the five muscles during the seated side-lateral raise were as follows: supraspinatus, middle deltoid, anterior deltoid, posterior deltoid, and triceps.

Performing the seated behind-the-neck press, the fifth subject utilized the involvement of the five muscles in the following order: supraspinatus, triceps, posterior deltoid, anterior deltoid, and the middle deltoid. Rankings of involvement of the five muscles during the seated side-lateral raise were as follows: supraspinatus, triceps, middle deltoid, anterior deltoid, and posterior deltoid (see Table 34).

Group rankings of muscle involvement of the five subjects for the seated behind-the-neck press were as follows: supraspinatus, triceps, middle deltoid, anterior deltoid, and the posterior deltoid. Group rankings of muscle involvement of the five subjects for the seated side-lateral raise were as follows: supraspinatus, middle deltoid, anterior deltoid, triceps, and posterior deltoid (see Table 35).

Table 34

Ranking of Most Involved Muscles for All Subjects

	Subject 1		Subject 2		Subject 3		Subject 4		Subject 5	
Muscle	A	B	A	B	A	B	A	B	A	B
Anterior deltoid	5	4	3	3	2	2	4	3	4	4
Middle deltoid	3	3	5	4	4	3	2	2	5	3
Posterior deltoid	4	2	4	5	5	4	5	4	3	5
Triceps	1	5	1	2	3	5	3	5	2	2
Supraspinatus	2	1	2	1	1	1	1	1	1	1

<u>Note</u>: A = seated behind-the-neck press; B = seated side-lateral raise. 1 = most involved; 5 = least involved.

Table 35

Mean Ranking of Most Involved Muscles for the Group

	Seated behind-the-neck press	Seated side-lateral raise
Anterior deltoid	4	3
Middle deltoid	3	2
Posterior deltoid	5	5
Triceps	2	4
Supraspinatus	1	1

CHAPTER 5

Summary and Conclusions

The purpose of this study was undertaken to compare the seated side-lateral raise to the seated behind-the-neck press for isotonic and isokinetic strength gains, as well as to analyze the muscles involved in the two lifts, using electromyography. The study was conducted at Middle Tennessee State University during the fall semester of 1992. Sixty-four male subjects participated in this study.

Prior to the research, each subject attended an orientation session concerning the procedures involved in the treatment and testing. Experimental group A, who performed the seated side-lateral raise, consisted of 22 subjects; experimental group B, who performed the seated behind-the-neck press, consisted of 23 subjects; and control group C, who performed neither of the lifts, consisted of 19 subjects. Experimental groups A and B were given a pretest and posttest isotonically performing a 10-repetition maximum with their assigned exercise. A 10-week period of treatment was conducted between the pretest and posttest. The treatment consisted of three sets of 10 repetitions with their assigned exercise. Subjects of all three groups were tested isokinetically at 60 degrees per second and at 180 degrees per second with the Cybex. Four repetitions were performed at 60 degrees per second, and 10 repetitions were performed at 180 degrees per second. Only the right arm was tested on the Cybex. The pretest was followed by a 10-week treatment period for experimental groups A and B. Control group C had no treatment for the 10-week period.

Five volunteers participated in the electromyography study in which surface electrodes were placed on the anterior, middle, and posterior deltoids, as well as the triceps. An intramuscular needle electrode was needed to analyze the supraspinatus muscle. Each subject performed three repetitions for the seated side-lateral raise and the seated behind-the-neck press. The electromyography recorded electrical impulses which indicated the extent of involvement for each muscle tested.

A matched-pair t-test was used to determine the differences between the isotonic pretest and posttest and the Cybex variables from pretest to posttest. An analysis of variance was used to determine differences among the groups. Where significant differences were found, a Tukey honest significant difference test was computed to show where the differences between the groups existed. Discussion of electromyography and other results follow.

Conclusions and Summary

Conclusions drawn for each of the eight hypotheses tested were as follows:

Hypothesis 1 stated there will be no significant difference between the pretest and posttest of experimental group A following 10 weeks of treatment using the seated side-lateral raise with the dumbbell. Since there was a significant difference indicated between the pretest and posttest ($p = 0.000$), Hypothesis 1 was rejected.

Hypothesis 2 stated there will be no significant difference between the pretest and the posttest of experimental group B after 10 weeks of treatment using the seated behind-the-neck press with the barbell. There was a significant difference found between the pretest and posttest ($p = 0.000$). Therefore, Hypothesis 2 was also rejected.

Hypothesis 3 stated there will be no significant difference between experimental A and B groups utilizing the Cybex isokinetic machine to analyze the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. No significant differences were found. Therefore, Hypothesis 3 was accepted.

Hypothesis 4 stated there will be no significant differences between experimental group A and control group C using the Cybex isokinetic machine to analyze the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at

80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. No significant differences were indicated. Therefore, Hypothesis 4 was accepted.

Hypothesis 5 stated there will be no significant differences between experimental group B and control group C using the Cybex isokinetic machine to analyze the following variables at 60 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. No significant differences were indicated. Therefore, Hypothesis 5 was accepted.

Hypothesis 6 stated there will be no significant differences between experimental groups A and B testing using the Cybex isokinetic machine to analyze the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. No significant differences were indicated. Therefore, Hypothesis 6 was accepted.

Hypothesis 7 stated there will be no significant differences between experimental group A and control group C using the Cybex isokinetic machine to analyze the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. There were statistically significant differences indicated in three of the variables: experimental group A showed a significantly greater increase at 180 degrees-per-second peak torque ($\underline{p}$ = 7.56), peak torque at 15 degrees of abduction ($\underline{p}$ = 14.71), and torque acceleration energy ($\underline{p}$ = 2.186). Therefore, those three interactions of Hypothesis 7 were rejected.

Hypothesis 8 stated there will be no significant differences between experimental group B and control group C using the Cybex isokinetic machine to analyze the following variables at 180 degrees per second: (1) peak torque, (2) peak torque percentage of bodyweight, (3) angle of peak torque, (4) torque at 15 degrees of abduction, (5) torque at 80 degrees of abduction, (6) torque acceleration energy, and (7) power after a 10-week period. There were significant differences found in two of the variables: experimental group B showed a significantly greater increase in 180 degrees-per-second peak torque ($\underline{p}$ = 6.2) and peak torque at 15 degrees of abduction ($\underline{p}$ = 16.09). Therefore, these variables for Hypothesis 8 were rejected.

Experimental Isotonic Gains

Experimental group A, who performed the seated side-lateral raise, showed a pretest mean of weight lifted as 71.95 pounds (see Appendix J). Experimental group B, who performed the seated behind-the-neck press, showed an average pretest mean of weight lifted as 34.09 pounds.

Both experimental groups A and B showed a significant increase in strength isotonically after the treatment period. Experimental group A, who performed the seated side-lateral raise, produced a mean gain of 31.818 pounds. Experimental group B, who performed the seated behind-the-neck press, produced a mean gain of 39.348 pounds (see Appendix J).

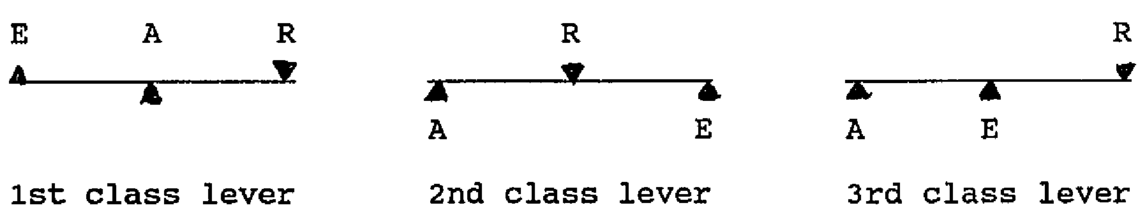
Experimental group A, who performed the seated side-lateral raise using the dumbbell, performed with lighter weights as shown by the pretest mean. Therefore, experimental group A has an advantage of increasing strength gains in percentages. Experimental group B, who performed the seated behind-the-neck press using the barbell, performed with heavier weights as shown by the pretest mean, therefore, giving experimental group B a disadvantage of gaining strength in percentages.

Experimental group A produced a 93.33 percent average gain in strength, while experimental group B produced a 54.7 percent average gain in strength (see Appendix I). A related study by Anderson and Kearney (1982) showed that in a nine-week study where subjects performed the bench press three times a week with three sets of six to eight repetitions, a 20 percent gain in average strength was realized as measured by a one-repetition maximum.

Experimental group B showed the largest gain in weight lifted, the reasons being the five muscles analyzed by the EMG showed greater involvement during the exercise (see Table 32). The lever system of the seated behind-the-neck press has an advantage over the lever system of the seated side-lateral raise when lifting weights.

Lever Comparison

The seated side-lateral raise is a third-class lever; the seated behind-the-neck press may not represent any of the three types of levers, but more closely resembles the second-class lever.



Key: E = effort
A = axis or fulcrum
R = resistance or weight

Figure 5.1. The Three Classifications of Levers

The seated side-lateral raise involves only a one-joint movement of the shoulder. The seated behind-the-neck press involves a two-joint movement of the shoulder and the elbow. Because the seated side-lateral raise utilizes a third-class lever system, it has the disadvantage of overcoming a great amount of weight.

The seated behind-the-neck press has a greater advantage as the weight is directly over the axis and involves a very powerful muscle, the triceps. The seated behind-the-neck press is partially an extension of the triceps.

Experimental Isokinetic Gains

Performing peak torque at 60 degrees per second, experimental group A produced a posttest average mean of 50.27 foot-pounds; experimental group B produced a posttest average mean of 48.13; and control group C produced a posttest average mean of 44.16 foot-pounds. The average norm for peak torque at 60 degrees per second is 44.6 ± 18.0 (Davies, 1987).

Performing peak torque percentage of bodyweight at 60 degrees per second, experimental group A produced a posttest average mean of 27.23; experimental group B produced a posttest average mean of 27.39; and control group C produced a posttest average mean of 24.47. The average norm for peak torque percentage of body weight at 60 degrees per second is 26.6 ± 9.4 (Davies, 1987).

Performing average power at 60 degrees per second, experimental group A produced a posttest average mean of

50.41 foot-pounds; experimental group B produced a posttest average mean of 48.95 foot-pounds; and control group C produced a posttest average mean of 41.47 foot-pounds. The average norm for average power at 60 degrees per second is 42.5 $\pm$ 21.4 (Davies, 1987).

Performing torque acceleration energy at 60 degrees per second, experimental group A produced a posttest mean of 3.59; experimental group B produced a posttest mean of 3.43; and control group C produced a posttest mean of 2.89. The average norm for torque acceleration energy at 60 degrees per second is 3.1 $\pm$ 1.3 (Davies, 1987).

Performing peak torque at 180 degrees per second, experimental group A produced a posttest mean of 46.36; experimental group B produced a posttest mean of 44.73; and Control group C produced a posttest mean of 40.21. The average norm for peak torque at 180 degrees per second is 32 $\pm$ 15 (Davies, 1987).

Performing peak torque percentage of bodyweight at 180 degrees per second, experimental group A produced a posttest mean of 25.13; experimental group B produced a posttest mean of 25.56; and control group C produced a posttest mean of 22.79. The average norm for peak torque percentage of bodyweight is 19 $\pm$ 8 (Davies, 1987).

Performing average power at 180 degrees per second, experimental group A produced a posttest mean of 116.95; Experimental group B produced a posttest mean of 111.38; and

Control group C produced a posttest mean of 41.47. The average norm for average power at 180 degrees per second is 80 $\pm$ 40 (Davies, 1987).

Performing torque acceleration energy at 180 degrees per second, experimental group A produced a posttest mean of 11.50; experimental group B produced a posttest mean of 10.38; and control group C produced a posttest mean of 9.78. The average norm for torque acceleration energy at 180 degrees per second is 9 $\pm$ 3 (Davies, 1987).

The peak torque at 15 degrees of abduction is believed to be the initiation of the movement, caused by the supraspinatus (Basmajian, 1979). The peak torque at 80 degrees of abduction is caused by the supraspinatus and deltoids. If the angle of the peak torque is from 0 to 15 degrees, then the supraspinatus is involved; if the angle of the peak torque is from 0 to 90 degrees, a combination of deltoids and supraspinatus is involved; and if the angle of the peak torque is from 90 to 180 degrees, the deltoids are involved (Luttgens & Wells, 1982). Experimental groups A and B indicated significant strength gains at 180 degrees per second peak torque at 15 degrees per second. Control group C did not show a significant gain, therefore concluding both exercises strengthen the supraspinatus significantly.

Electromyographic Analyses

The electromyographic analyses indicate that the major difference between the two exercises is the involvement of the triceps muscle (see Tables 31 and 33). The seated behind-the-neck press exercise allows the individual exercising to perform with heavier weights, thus creating more resistance to the muscle, stimulating growth.

Further research is suggested to determine why subjects, while performing similar exercises, seem to develop and utilize different muscles and muscle groups at varying degrees of intensity. For example, two subjects may be equally strong in the seated side-lateral raise, yet one subject may utilize most the middle deltoid, while the other may utilize most the anterior deltoid.

APPENDICES

APPENDIX A

LETTERS OF PERMISSION

APPENDIX A

LETTERS OF PERMISSION

August 24, 1992

To Whom It May Concern:

My name is David Durbin. I am a doctoral student in the field of physical education at Middle Tennessee State University. Currently, I am working on my dissertation, comparing muscle involvement of two weight-training exercises called the seated side-lateral raise and the seated behind-the-neck press.

In order to measure muscle involvement of these two exercises, the use of an electromyography machine is needed. Therefore, I am requesting the use of the EMG machine at the Veterans Administration Hospital in Murfreesboro, Tennessee.

I will be working under the direction and guidance of Paisal Jirut, M.D., an employee of the hospital. I am willing to follow the rules for the use of this machine, and at the conclusion of my study, I will gladly share the results with the hospital.

Sincerely,

David Durbin

DEPARTMENT OF VETERANS AFFAIRS
Alvin C. York Medical Center
3400 Lebanon Road
Murfreesboro TN 37130

October 14, 1992

In Reply Refer To:

Mr. David Durbin
Physical Education Department
Middle Tennessee State University
Murfreesboro, TN 37130

Dear Mr. Durbin:

This letter is to indicate your authorization to use the EMG machine in the Rehabilitation Medicine Service, Alvin C. York VA Medical Center, Murfreesboro, TN for the purpose of measuring degree of muscle involvement in certain exercises. Use of this machine will be under my direction.

Sincerely yours,

Paisal Jirut, M.D.
Chief, Rehabilitation Medicine Service

APPENDIX B

MIDDLE TENNESSEE STATE UNIVERSITY RESEARCH

ETHICS COMMITTEE APPROVAL LETTERS

APPENDIX B

MIDDLE TENNESSEE STATE UNIVERSITY RESEARCH

ETHICS COMMITTEE APPROVAL LETTERS

To: Mr. David Durbin
HYPERS

From: Peter Heller PH
Chair, MTSU Research Ethics Committee

RE: Review: Use of Human Subjects

Date: August 31, 1992

The purpose of this memo is to inform you that the MTSU Research Ethics Committee has favorably evaluated your research proposal entitled, "Comparison of Two Isotonic Weight Training Exercises" in terms of its ethical utlization of human subjects. Best of luck on the successful completion of your project.

TO: Mr. David Durbin
HYPERS

FROM: Peter Heller ph
Chair, MTSU Research Ethics Committee

RE: Review: Use of Human Subjects

Date: August 31, 1992

The purpose of this memo is to inform you that the MTSU Research Ethics Committee has favorably evaluated your research proposal entitled "Electromyographnic Analysis of Two Weight Training Exercises for the Shoulder" in terms of its ethical utlization of human subjects. Best of luck on the successful completion of your project.

APPENDIX C

STUDENT INFORMATION SHEET

APPENDIX C

STUDENT INFORMATION SHEET

NAME____

HOME PHONE______________________________________

SCHOOL PHONE____________________________________

WORK PHONE______________________________________

MAJOR____

CLASSIFICATION__________________________________

AGE____

ANY HEALTH PROBLEMS_____________________________

____

____

____

HEIGHT____

WEIGHT____

HAVE NEVER LIFTED WEIGHTS BEFORE	______YES	______NO
HAVE LIFTED WEIGHTS AT HOME	______YES	______NO
HAVE LIFTED WEIGHTS AT SCHOOL	______YES	______NO
HAVE BELONGED TO A GYM OR SPA	______YES	______NO

APPENDIX D

WAIVER FORM

APPENDIX D

WAIVER FORM

Health, Physical Education, and Recreation Department,

Middle Tennessee State University

I, ____ have voluntarily selected to participate in this activity ____ offered by the Health, Physical Education, and Recreation Department at Middle Tennessee State University.

I hereby release and discharge the instructor ____, the Department, Middle Tennessee State University, the Board of Regents, State of Tennessee, and each and all their agents and employees from any liability whatever to the undersigned resulting from, or in any manner arising out of, injury or damage which may be sustained by me, ________________________ on account of participation in this activity ________________ or in the transportation in connection therewith.

Signed this ______ day of ____________________, 19___.

____
Student

____

____
Address

APPENDIX E

INFORMED CONSENT FORMS

APPENDIX E

INFORMED CONSENT FORMS

Cybex Informed Consent Form

Explanation of Testing Procedures

The purpose of testing is to determine strength and endurance of the shoulder region during side abduction and adduction. The test you will be participating in will consist of two sets. The first set will include four repetitions performed at 60 degrees per second, and the second set will include 10 repetitions at 180 degrees per second. Between the sets there will be a 30-second rest period. The test will be performed on the Cybex 340 isokinetic dynamometer located in the Human Performance Laboratory at Middle Tennessee State University. Each subject will be tested twice. One test will serve as a pretest, and the other will serve as a posttest.

Discomforts

The individual being tested should experience no pain or discomfort. If at any time pain or discomfort occurs, the test will be terminated.

Freedom of Consent

Your participation in this experiment is voluntary. You are free to terminate participation in this experiment now and at any time during the testing, if you wish.

Consent to Participate

I hereby acknowledge that I have read this form in its entirety and that I understand the conditions of the experiment and the conditions of my voluntary participation. I consent to participate in the testing.

Signature ______________________ Date ____________

The Electromyography Informed Consent Form

The consent of the ELECTROMYOGRAPHY testing is to determine the amount of muscle involvement of certain muscles during two shoulder exercises.

Surface electrodes will be placed on the anterior, middle, and posterior deltoids and the triceps. A needle will be inserted into the supraspinatus muscle. The subject will perform three repetitions of each exercise.

Discomforts

The individual being tested should experience no pain or discomfort. If at any time pain or discomfort occurs, the test will be terminated.

Freedom of Consent

Your participation in this experiment is voluntary. You are free to terminate participation in this experiment now and at any time during testing, if you wish.

Consent to Participate

I hereby acknowledge that I have read this form in its entirety and that I understand the conditions of the experiment and my voluntary participation. I consent to participate in the testing.

Signature ______________________ Date ______________

APPENDIX F

RECORD CHART

NAME________________________________

EXERCISES	SETS	REPS	7	9	11	14	16	18	21	23	25	28	30	2	5	7
GROUP A	3	10														
GROUP B	3	10														
BENCH PRESS	2	10														
PULLUPS	2	10														
PULLDOWN	2	10														
CURL	2	10														
LEG PRESS	2	10														
DIPS	2	10														
SIT UPS	2	12														

GROUP A SEATED SIDE LATERALS
GROUP B SEATED BEHIND THE NECK PRESS

APPENDIX G

PHYSICAL CHARACTERISTICS OF SUBJECTS

APPENDIX G

PHYSICAL CHARACTERISTICS OF SUBJECTS

Seated Side-Lateral Raise Group (N = 22)

Subject number	Age	Height	Bodyweight before	Bodyweight after	Difference	Arm length
2	19	72	141	147	+ 6	27
5	25	69	146	145	− 1	25
7	24	67	150	150	0	23
9	19	67	175	178	+ 3	25
15	22	71	145	147	+ 2	28
20	20	72	214	218	+ 4	27
21	20	68	151	152	+ 1	25
24	18	71	164	163	− 1	27
27	25	72	248	250	+ 2	26
32	23	68	203	205	+ 2	27
33	19	70	227	225	− 2	27
36	18	72	167	169	+ 2	27
40	20	67	130	136	+ 6	25
41	19	69	117	121	+ 4	25
42	18	70	170	160	−10	26
49	20	73	220	223	+ 1	27
55	20	73	179	174	− 5	28
57	20	65	142	143	+ 1	26
59	19	69	243	240	− 3	25
60	22	72	235	252	+17	26
61	25	72	163	158	− 5	26
62	20	70	255	258	+ 3	27

Means: Age = 20.68; height = 69.952; bodyweight before = 181.13; bodyweight after = 182.45; difference = 1.22; arm length = 26.13.

Seated Behind-the-Neck Press Group (N = 23)

Subject number	Age	Height	Bodyweight before	Bodyweight after	Difference	Arm length
1	18	72	182	176	- 6	27
3	18	69	149	154	+ 5	26
4	25	68	204	194	-10	26
6	21	74	168	165	- 3	28
8	19	72	146	152	+ 6	27
10	18	72	200	208	+ 8	25
12	21	69	158	160	+ 2	26
13	19	65	176	170	- 6	22
14	25	70	142	142	0	28
18	24	74	222	225	+ 3	28
26	22	69	180	182	+ 2	27
28	18	72	177	180	+ 3	26
29	18	68	156	160	+ 4	26
34	19	72	175	168	- 7	25
35	18	75	230	226	- 4	29
37	18	68	164	164	0	26
38	19	71	155	152	- 3	27
39	19	71	165	168	+ 3	27
43	20	72	175	184	+ 9	26
44	18	67	158	161	+ 3	27
54	22	69	152	151	- 1	25
62	22	69	180	182	+ 2	27
63	18	61	136	148	+12	25

Means: Age = 19.956; height = 69.956; bodyweight before = 171.739; bodyweight after = 172.695; difference = .956; arm length = 26.347.

No Treatment Group (N = 19)

Subject number	Age	Height	Bodyweight before	Bodyweight after	Difference	Arm length
11	25	73	243	240	- 3	27
16	18	73	216	216	0	26
17	21	71	202	207	+ 5	26
19	19	72	167	167	0	26
22	25	67	166	166	0	25
23	25	69	190	190	0	25
25	18	68	159	155	- 4	25
30	19	73	156	156	0	26
31	21	68	218	218	0	26
45	25	68	144	145	+ 1	25
46	18	68	136	138	+ 2	23
47	25	70	154	154	0	25
48	20	70	204	204	0	24
50	19	73	163	155	- 8	27
51	22	70	169	156	-13	24
52	20	75	218	218	0	29
53	24	66	126	123	- 3	24
56	20	73	208	205	- 3	20
58	22	70	164	168	+ 4	24

Means: Age = 21.368; height = 70.368; bodyweight before = 179.105; bodyweight after = 177.631; difference = -1.157; arm length = 25.105.

APPENDIX H

PRETEST TO POSTTEST DIFFERENCE OF CYBEX VARIABLES

APPENDIX H

PRETEST TO POSTTEST DIFFERENCE OF CYBEX VARIABLES

Experimental Group A (Seated Side-Lateral Raise)

No. of Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	3	153	24	14	1	15	20	9	- 3	8	9	4	44
2	9	4	- 94	7	8	2	12	14	6	- 96	- 5	- 4	4	- 4
3	1	0	-137	6	4	1	1	5	2	2	-13	0	1	13
4	8	5	- 71	9	3	1	8	12	8	- 84	- 1	4	4	17
5	- 5	- 3	- 18	- 2	-10	0	-15	1	1	- 74	- 8	-11	1	-38
6	10	6	- 35	7	3	1	2	9	6	8	- 5	- 5	1	1
7	7	3	- 14	9	6	1	10	5	2	1	- 7	3	12	18
8	7	5	4	6	0	1	2	8	5	- 96	-10	- 6	2	-18
9	20	8	- 11	11	0	1	8	18	7	5	-12	2	3	43
10	11	4	132	9	8	1	19	15	6	- 1	8	11	3	48
11	- 1	2	-158	24	- 3	0	- 6	8	7	- 2	5	5	3	11
12	- 4	- 3	130	- 1	-12	0	- 4	3	2	1	0	- 7	1	-23
13	10	5	- 13	19	21	2	16	12	7	-111	9	17	4	35
14	12	3	- 3	1	9	1	11	11	2	- 6	52	9	5	24
15	13	5	89	9	9	1	15	3	1	0	12	17	2	78
16	15	7	146	2	9	0	17	11	5	9	15	11	1	44
17	15	10	154	1	- 6	0	5	0	0	9	-20	- 5	1	14
18	- 2	- 2	-127	- 6	- 2	-1	- 1	8	5	3	0	- 6	0	-15
19	- 2	- 1	-121	10	- 2	1	- 1	5	4	- 73	1	- 4	2	14
20	- 7	- 6	- 28	8	- 1	1	- 2	8	4	- 97	2	11	4	26

<u>Experimental Group A (Seated Side-Lateral Raise)</u>

No. of Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14
21	3	2	- 24	8	3	1	4	6	4	3	-	- 1	2	14
22	21	10	23	25	27	2	28	19	10	- 5	35	14	2	49

<u>Key</u>:

60 degrees per second

1 = peak torque
2 = peak torque percentage of bodyweight
3 = angle of peak torque
4 = peak torque at 15 degrees of abduction
5 = peak torque at 80 degrees of abduction
6 = torque acceleration energy
7 = power

180 degrees per second

8 = peak torque
9 = peak torque percentage of bodyweight
10 = angle of peak torque
11 = peak torque at 15 degrees of abduction
12 = peak torque at 80 degrees of abduction
13 = torque acceleration energy
14 = power

Experimental Group B (Seated Behind-the-Neck Press)

No. of Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	6	4	1	- 1	-11	0	- 8	- 2	- 1	2	- 2	-10	-1	-22
2	3	2	65	- 1	19	0	15	3	2	5	- 4	30	-3	33
3	- 5	- 3	-104	8	-16	1	-14	2	2	- 84	-15	-11	1	-32
4	- 5	- 3	- 3	9	1	1	3	- 1	0	-106	4	- 6	2	-18
5	8	3	7	20	11	2	5	7	3	- 1	3	9	1	2
6	13	9	- 8	19	10	1	15	16	10	0	12	0	2	26
7	9	4	6	17	16	1	21	10	5	- 1	11	13	3	72
8	0	1	- 5	- 4	3	0	0	1	1	5	-11	5	-2	10
9	0	- 1	12	0	- 3	0	2	8	4	- 81	11	2	2	-36
10	- 1	- 1	- 2	5	1	0	- 1	8	5	- 1	11	3	1	9
11	10	6	1	0	6	1	6	20	12	1	- 4	7	5	16
12	11	6	0	7	13	1	15	18	11	1	11	19	4	42
13	14	8	- 99	21	1	2	2	22	13	- 66	11	- 1	5	17
14	5	3	- 4	5	- 2	1	1	6	3	- 81	1	- 6	1	-11
15	18	10	41	18	21	1	26	7	3	94	8	11	1	56
16	5	3	- 8	13	4	0	10	7	4	90	10	3	2	46
17	10	4	-101	26	- 2	1	4	21	10	2	- 1	8	5	59
18	13	8	27	9	0	1	12	4	2	5	5	4	3	24
19	8	4	3	10	9	1	12	20	12	- 94	1	2	5	30
20	- 1	- 1	-103	3	- 1	1	4	- 2	- 2	- 93	-12	0	1	9
21	- 3	- 1	32	2	- 9	0	1	- 8	- 5	- 2	18	-10	1	-24
22	- 2	- 2	- 5	5	- 4	0	- 3	11	6	13	3	- 1	0	26
23	15	8	-105	16	19	2	17	1	0	-129	23	1	2	3

Key: (on next page)

Experimental Group B (Seated Behind-the-Neck Press)

Key:

60 degrees per second

1 = peak torque
2 = peak torque percentage of bodyweight
3 = angle of peak torque
4 = peak torque at 15 degrees of abduction
5 = peak torque at 80 degrees of abduction
6 = torque acceleration energy
7 = power

180 degrees per second

8 = peak torque
9 = peak torque percentage of bodyweight
10 = angle of peak torque
11 = peak torque at 15 degrees of abduction
12 = peak torque at 80 degrees of abduction
13 = torque acceleration energy
14 = power

Control Group C (No Treatment)

No. of Subjects	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	4	2	7	8	- 2	1	4	1	1	0	4	- 5	0	16
2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
3	2	0	- 13	- 2	- 8	1	-14	0	0	5	-38	-15	-2	-39
4	- 1	1	-101	- 1	- 8	0	-15	- 5	- 2	- 91	-30	-15	-1	-61
5	3	2	1	-13	2	0	- 1	- 5	- 3	7	-13	- 2	0	- 3
6	-28	-14	92	-26	- 9	-2	-20	-20	-10	2	-25	2	-5	29
7	5	5	-156	12	- 3	1	- 6	7	7	2	1	- 4	1	-11
8	13	10	8	7	9	0	14	9	8	4	-15	12	2	45
9	5	2	-145	8	3	1	5	7	3	-107	- 5	5	2	-14
10	0	0	- 18	9	- 4	1	- 1	1	1	9	-18	0	0	-19
11	13	9	10	13	18	1	19	14	9	7	-11	18	5	79
12	10	7	6	3	5	-1	- 1	17	11	6	- 3	8	5	26
13	1	1	- 1	10	- 1	0	1	- 2	0	- 85	0	- 4	1	-29
14	16	8	- 4	11	9	2	7	10	6	0	-10	6	2	1
15	2	1	3	- 2	3	0	4	- 3	- 2	7	-26	11	2	20
16	- 5	- 3	-155	- 1	- 4	1	- 4	6	3	6	-23	- 5	-1	-10
17	0	0	0	3	2	0	2	- 1	0	- 40	2	2	3	-11
18	- 6	- 4	9	3	- 5	0	- 6	0	0	- 88	- 6	- 7	0	- 8
19	9	6	1	12	8	1	12	- 6	- 2	1	-12	- 5	-2	1

Key: (on next page)

Control Group C (No Treatment)

Key:

60 degrees per second

1 = peak torque
2 = peak torque percentage of bodyweight
3 = angle of peak torque
4 = peak torque at 15 degrees of abduction
5 = peak torque at 80 degrees of abduction
6 = torque acceleration energy
7 = power

180 degrees per second

8 = peak torque
9 = peak torque percentage of bodyweight
10 = angle of peak torque
11 = peak torque at 15 degrees of abduction
12 = peak torque at 80 degrees of abduction
13 = torque acceleration energy
14 = power

APPENDIX I

PERCENT GAIN IN AVERAGE STRENGTH

APPENDIX I

PERCENT GAIN IN AVERAGE STRENGTH

Isotonics			Percent
Seated behind-the-neck press with barbell			54.7
Seated side-lateral raise with dumbbell			93.3
Cybex Variables	**Group A %**	**Group B %**	**Group C %**
60 degrees per second			
1 peak torque	15.3	13.4	5.6
2 percentage of bodyweight	12.6	12.7	7.6
3 angle of peak torque	- 1.2	-19.5	-34.4
4 peak torque at 15 degrees of abduction	27.2	29.7	8.7
5 peak torque at 80 degrees of abduction	12.0	11.2	2.4
6 torque acceleration energy	29.5	29.4	14.6
7 power	14.9	14.8	0.0
180 degrees per second			
1 peak torque	24.5	21.0	4.0
2 percentage of bodyweight	22.9	20.5	7.4
3 angle of peak torque	-48.7	-35.5	-40.9
4 peak torque at 15 degrees of abduction	18.4	35.6	-45.0
5 peak torque at 80 degrees of abduction	11.4	11.6	.4
6 torque acceleration energy	32.5	20.7	6.9
7 power	18.1	15.1	2.6

Note: Group A = seated side-lateral raise; Group B = seated behind-the-neck press; Group C = no treatment.

APPENDIX J

ISOTONIC MEANS

APPENDIX J

ISOTONIC MEANS

	Pre-mean	Post mean	Average mean gain
Seated side-lateral raise	34.09	65.90	31.81
Seated behind-the-neck press	71.95	111.29	39.34

APPENDIX K

CYBEX VARIABLE MEANS

APPENDIX K

CYBEX VARIABLE MEANS

	Pre mean	Post mean	Average mean gain
Group A (seated side-lateral raise)			
60 degrees per second			
Peak torque	43.59	50.27	6.68
Peak torque percentage of bodyweight	24.18	27.23	3.05
Angle of peak torque	85.86	84.86	- 1.00
Peak torque at 15 degrees of abduction	31.04	39.49	8.45
Peak torque at 80 degrees of abduction	33.31	37.31	4.00
Torque acceleration energy	2.77	3.59	.82
Power	43.86	50.41	6.55
Group A (seated side-lateral raise)			
180 degrees per second			
Peak torque	37.22	46.36	9.14
Peak torque percentage of bodyweight	20.45	25.13	4.68
Angle of peak torque	56.63	29.04	-27.59
Peak torque at 15 degrees of abduction	15.00	17.77	2.77
Peak torque at 80 degrees of abduction	25.54	28.45	2.91
Torque acceleration energy	8.68	11.50	2.82
Power	99.00	116.95	17.95

Group B (seated behind-the-neck press)

60 degrees per second

Peak torque	42.43	48.13	5.70
Peak torque percentage of bodyweight	24.30	27.39	3.09
Angle of peak torque	76.95	61.95	-15.00
Peak torque at 15 degrees of abduction	30.30	39.30	9.00
Peak torque at 80 degrees of abduction	33.30	37.04	3.74
Torque acceleration energy	2.65	3.43	.78
Power	42.65	48.95	6.30

Group B (seated behind-the-neck press)

180 degrees per second

Peak torque	36.95	44.73	7.78
Peak torque percentage of bodyweight	21.21	25.56	4.35
Angle of peak torque	63.78	41.13	-22.65
Peak torque at 15 degrees of abduction	11.47	15.56	4.09
Peak torque at 80 degrees of abduction	27.04	30.17	3.13
Torque acceleration energy	8.60	10.38	1.78
Power	96.73	111.38	14.65

Group C (no treatment)

60 degrees per second

Peak torque	41.84	44.16	2.32
Peak torque percentage of bodyweight	22.73	24.47	1.74
Angle of peak torque	69.78	45.78	-24.00
Peak torque at 15 degrees of abduction	32.63	35.47	2.84
Peak torque at 80 degrees of abduction	32.21	33.00	.79
Torque acceleration energy	2.52	2.89	.37
Power	41.47	41.47	.00

Group C (no treatment)

180 degrees per second

Peak torque	38.63	40.21	1.58
Peak torque percentage of bodyweight	21.21	22.79	1.58
Angle of peak torque	45.57	26.89	-18.68
Peak torque at 15 degrees of abduction	26.63	14.63	-12.00
Peak torque at 80 degrees of abduction	25.84	25.95	.11
Torque acceleration energy	9.15	9.78	.63
Power	96.47	97.10	.63

APPENDIX L

COMPARING ISOTONIC WEIGHT-LIFTING GAINS USING A HISTOGRAM

APPENDIX L

COMPARING ISOTONIC WEIGHT-LIFTING GAINS USING A HISTOGRAM

Weight (pounds)	Subjects
Histogram of dumbgain, N = 21	
20	6 ******
25	0
30	9 *********
35	0
40	4 ****
45	0
50	1 *
55	0
60	1 *
Histogram of barbgain, N = 23	
20	4 ****
25	0
30	3 ***
35	4 ****
40	2 **
45	1 *
50	8 ********
55	0
60	0
65	0
70	1 *

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