THE EFFECT OF TWO TYPES OF ISOTONIC RESISTANCE TRAINING ON STRENGTH, MOVEMENT TIME, AND REACTION TIME IN THE KNEE EXTENSOR MUSCLES

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CHAPTER I

INTRODUCTION

The quest to enhance physical performance has led to very specific and multifaceted modes of training. Many old training programs have given way to new and sophisticated techniques. Researchers and coaches are in constant search for new and proven methods or systems to improve the level of fitness and athletic prowess (1, 2). Polhemus (3) contends that coaches are incessantly seeking validity of information pertaining to the improvement of athletic ability. Unfortunately, strength and muscular development techniques, unlike cardiovascular development, has not shared the same specificity and is subjected to many untested and unproven whims of fancy.

For years physiologists have known that appropriate training of speed, strength, muscular endurance, balance, flexibility, and cardiovascular-respiratory endurance ultimately serves to increase the subject's level of physical fitness and his/her proficiency in all physical activities. Coaches generally feel that most athletic endeavors and physical activities utilize all of these physiological variables to some degree and that if any physical variable, alone or in combination, can be improved, then the ultimate performance potential also improves. However, coaches do not always regard strength gains in relationship to speed with the same favor. A popular opinion among coaches is that training with weights slows the athlete down or impairs quickness in such sports as baseball or basketball.

Obviously, all the variables involved in physical fitness contribute to the subject's physical development, but physical educators frequently acknowledge that muscular strength is the most important factor in the performance of physical skills (4, 5). The importance placed on physical strength in relationship to physical fitness is illustrated in a statement by Bjornaraa (6):

> The growing popularity of weight training as a conditioning basis for track and field, football, gymnastics, swimming, hockey, and many other sports indicate its value for sports that require great mobility, flexibility, agility, and speed. A sensible, systematic weight training program is the best means of improving all these attributes so necessary in the sport (p. 62).

Jensen, Schultz, and Bangerter (7, p. 154), in support of this view, claim that strength "may be the most important single factor in performance," and that increased strength will often contribute to better performance. In addition, Gettman (8) feels that strength will enable people to peform daily tasks and pursue recreational activities more efficiently.

In most cases, the amount of strength necessary to meet normal daily tasks is minimal compared to the strength needed to compete in highly competitive and specialized sports. Obviously, the sport in which an athlete is involved determines which of the physical components should be stressed. For example, a distance runner would need greater emphasis on cardiovascular endurance training than would a shot putter. The shot putter, in turn, would need to concentrate on muscular strength and quickness. Team sports such as football, wrestling, and basketball would require training in all of the physical components to some degree. With athletic competition in mind, Mathews (9) indicated that persons possessing satisfactory muscular strength have a better than average proficiency in sports. Rasch and Pierson (10) asserted that muscular strength is perhaps the most important of all factors in athletic performance. Dauer (11) also recognized strength as the most important quality in the performance of physical skills.

However, only recently has considerable effort been devoted to increasing athletic performance through direct, time-devoted emphasis on weight training. With regard to athletic weight training, Karpovich (12, p. 53) wrote: "There has been a radical change in the attitude toward weight lifting. Coaches and athletes are now using weight lifting as a training adjunct."

Presently, virtually every major college, professional, and even high school athletic organization devotes some of its preparation time to weight training.

Indeed, most major colleges and professional teams now employ professional full-time strength and conditioning coaches.

Furthermore, literature proclaiming the success of individual and team efforts has become extremely abundant. Authors such as Reynolds (13), Clarke (14), and DeVries (15) all added to the credibility of strength development by contending that strength training will consistently give an athlete a winning edge, and programs that include strength training are ultimately more successful.

An almost equally esteemed physical attribute is the ability to move quickly or run fast. Concerning speed, Johnson and Nelson (16) declared:

> Speed of movement and quick reactions are prized qualities in athletics. Coaches are frequently heard to praise certain players or an entire team for their quickness. In football, a player who is extremely fast poses a constant threat to break away for the long run; in baseball, the fast runner causes hurried throws and adjustments in pitching and defensive strategy; the full-court press is a potent weapon in basketball if a team has the speed to make it effective; and, of course, in track, speed is the essence of the sport (p. 83).

Previously, weight training to increase muscular strength was not favorably associated with speed of movement. Even today, the term "muscle-bound" is frequently heard among coaches. However, "muscle-boundness" refers to a limitation in the range of joint motion or to an individual's lack of flexibility. This condition has erroneously been linked to large and restrictive muscle mass. Inevitably, muscle hypertrophy accompanies gains in muscular strength. Although considerable evidence supports the claim that weight lifting will produce maximum hypertrophy as well as significant gains in strength (17, 18, 19, 20, 21, 22, 23), George and Evans (24) found evidence that weight training cannot be blamed for lack of range of motion. Leighton (25, 26) also found that lifting weights did not adversely affect flexibility; indeed, he discovered that weight training had no adverse effect on range of motion, and actually improved flexibility and range of motion.

Before this discussion can continue, certain technical terms need definition and clarification.

Terms

Contraction occurs when tension develops within a muscle. It does not necessarily imply that any visible shortening of the muscle takes place (27).

Contractions With Relationship to Length and Tension

1. Concentric contractions shorten the muscle while developing sufficient tension to overcome the resistance.

2. Eccentric contractions lengthen the muscle while it develops tension and the external resistance overcomes the active muscle.

Contractions With Relationship to Joint Movement

1. Isometric contractions create no movement in the joint.

2. Isotonic contractions occur throughout the range of movement in both eccentric and concentric contractions.

3. Isokinetic contractions are variations on the isotonic contraction which employ an apparatus to control the speed of muscular performance while allowing full muscular force throughout the range of motion (27).

Flexion refers to the movement of a body part which causes a decrease in the joint angle.

Extension refers to the movement of a body part which causes an increase in the joint angle.

Progressive Resistance Training progressively increases the load (amount of weight) the subject is training with as he becomes stronger. The subject remains within his prescribed percentage of training load.

1MR (one maximum repetition) is the greatest load with which a subject can correctly perform an exercise for one single sequence.

Repetition refers to one complete cycle of an exercise from the starting position, through the sequence of movements, and back to the initial position.

Set is the total number of repetitions executed each time the exercise is performed.

Hypertrophy refers to the increase in skeletal muscle size due to strength training viewed as a fundamental adaptation to an increased work load.

Reaction Time is the interval of time that elapses from the instant a stimulus is presented until the instant any measurable amount of movement occurs in response to the stimulus (28).

Movement Time is the interval of time from the initial movement in response to a stimulus until the completion of the specified movement. Reaction time ends at the onset of movement time (28).

Muscle Fatigue is the exhaustion of muscle fibers brought about by utilizing the overload principle during training.

The Quadricep Muscle Group includes the Vastus Medialis, Vastus Lateralis, Vastus Intermedius, and the Rectus Femoris, all of which are responsible for knee extension.

Strength gains nornmally occur through inducement of tension on the skeletal muscle. This inducement of tension must be greater than the normal daily-incurred stress in order to increase strength (29). This higher level of stress is commonly referred to as the "overload principle," and is the universally accepted method for muscle strength development (30, 31, 32).

The overload principle may take the form of any of the following applications: isometric, isotonic, or isokenetic. All of these modes have been proven to increase strength, but the most popular method, due to its versatility and high rate of strength increases in trainees, is the isotonic mode of training (33). Therefore, this investigation only involved isotonic weight training, since a vast amount of available research supported the fact that isotonic resistance exercises significantly increased muscular strength more than would the other forms of training (34, 35, 36).

In this study, the author has chosen two forms of progressive isotonic resistance training techniques. One commonly employed and proven method incorporates three sets of six repetitions at load increments of 80% 1MR. According to Berger (37, 38, 39), this specific amount of sets, repetitions, and percentage will significantly increase strength. The other method, called "manual resistance" (MR), employs a single set of 8 to 12 repetitions to near complete failure in both the concentric and eccentric phase of the exercise (40). If shown to significantly increase muscle strength, the latter of these two methods, which requires less than half the time of the first system, would be extremely advantageous to the time-conscious coach or athlete.

The manual resistance technique has only been in use for a few years. Riley (41) introduced the system as an extended phase of weight training for the athletes at Pennsylvania State University in the seventies. However, the MR system has yet to be tested and compared to the multiple set progressive isotonic resistance (MSPIR) technique which is commonly used. Unlike that of the MSPIR, MR uses a partner to supply added force to the weight by pushing on the bar, or weight training apparatus, during the eccentric phase of the exercise. At the completion of the eccentric phase of the exercise, the partner releases the existing weight (normally about 65% 1MR) so that the subject moves the weight independently during the concentric phase. An important criterion of the MR technique is that concentric muscle failure must occur between the subject's sixth and eighth repetition and eccentric muscle failure must occur between the eighth and twelfth repetition. Once the subject has reached concentric muscle failure (failure to lift the weight), the partner must assist the subject with the remaining concentric phases of the exercise until eccentric muscle failure (failure in resisting the weight) occurs. Thus, MR differs from the MSPIR technique in that it demands failure in both concentric and eccentric phases of the exercise; whereas, with the MSPIR technique, subjects may only reach failure in the concentric phase, and then only in the last one or two sets of the exercise.

The theory behind the MR technique is that by continuing the exercise past the level of concentric muscle failure and through eccentric muscle failure, the subject recruits and exhausts a greater number of muscle fibers. Since, according to Riley's muscle fiber recruitment theory, greater stress placed on muscles demands the use of a greater percentage of muscle fibers; that is, adaptation to the stress is proportional to the number of muscle fibers recruited to fatigue: this process therefore maximizes strength gains. Riley (42) also suggested that the MR technique be executed for only a single set to complete muscle failure in each exercise.

Several studies have addressed the controversial question of the effects of weight training on speed of movement. Generally, researchers agree that weight training will not retard speed, but there is a great deal of controversy as to whether or not weight training will increase speed of movement.

Most of the studies dealing with the effect of weight training on speed of movement have used weight lifting exercises that do not directly pertain to the corresponding joint action that was tested for speed of movement (43). Furthermore, many of the related studies were made without the use of modern weight-training methods. These researchers used either isometric exercises or isotonic resistance, deemed too light to cause significant strength gains by presently accepted standards (44). Most present day weight programs use Berger's standards for the number of sets, repetitions, and frequency of training (39, 45, 46, 47).

This study explored two methods of strengthening one specific muscle group, the knee extensors (Quadricep muscle) group, and examined speed of movement in the corresponding joint. Unlike preceding researchers, this author trained the knee extensor muscle group and examined the corresponding joint for speed of movement.

Additional knowledge of different weight training techniques and their effect on strength and speed of movement could be of great value. Not only could such information be helpful to exercise physiologists, athletes, and coaches, but if the same beneficial results in strength can be attained in half the time of the usually employed method, the trainee would have additional time for other activities.

Purpose of Investigation

The primary purpose of this investigation was to determine whether the strength increases of two types of progressive isotonic resistance training techniques affected speed of movement. More specifically, the purpose was to determine whether either of the two different methods of training would produce significant improvements in strength and whether these changes in strength significantly affected the reaction time and movement time in a corresponding joint action.

A secondary purpose was to compare the post-test means of strength gain of the MR group and the MSPIR group and to determine if there was a significant differnece between the two groups.

Hypotheses

The hypotheses for this study were as follows:

1. Manual resdistance training will not significantly affect reaction time.

2. Multiple set progressive isotonic resistance training (MSPIR) will not significantly affect reaction time.

3. Manual resistance training will not significantly affect movement time.

4. Multiple set progressive isotonic resistance training will not significantly affect movement time.

5. The mean strength gain of the three groups will not differ significantly.

6. The mean reaction time of the three groups will not differ significantly after treatment.

7. The mean movement time of the three groups will not differ significantly after treatment.

8. There will be no significant relationship between strength and movement time before or after treatment.

9. There will be no significant relationship between strength and reaction time before or after treatment.

10. There will be no significant relationship between movement time and reaction time before or after treatment.

Limitations

The limitations for this study were as follows:

1. No effort was made to control the diet of the subjects during the testing period.

2. No attempt was made to control the amount of rest the subjects were obtaining.

Delimitations

The delimitations for this study were as follows:

1. This study was limited to 45 Oklahoma State University spring semester, 1983, students between the ages of 18 and 22.

2. This study was limited to three 50 minute training periods per week for 10 weeks.

Assumptions

The following assumptions were made for this study:

1. The subjects would exert maximum effort on all tests.

2. The subjects would exert maximum effort during all training sessions.

3. The subjects would maintain sufficient motivation to attempt to improve their strength during the testing period.

4. The subjects agreed not to engage in any intramural or varsity sports activities.

5. The subjects agreed not to engage in any extra weight lifting during the testing period.

Description of Instruments

The following is a description of instruments utilized in this study:

Automatic Performance Analyzer. An instrument designed to measure movement and/or reaction time intervals (Model 741; Decan Automatic Performance Analyzer; Time-1/1000 second; Glen Ellyn, Illinois).

Nautilus Leg Extension Machine. A weight training apparatus designed for exercising the muscles responsible for knee extension.

Cable Tensiometer. An instrument that assesses human strength by the application of a force upon a cable, thus causing the gauge to register. Only isometric strength may be measured by this instrument (Type no. T5-6007-114-00; Tension Pounds--0 to 100; Pacific Scientific Co., Anaheim, California).

Reaction Seat. An apparatus constructed by the researcher designed to test the reaction and movement time of the knee extensor muscles with the aid of the APA.

<u>Goniometer</u>. A device that measures joint angle. The goniometer consists of a fixed arm along a zero degree line and a moveable arm which can be adjusted from 0 to 360 degrees.

CHAPTER II

RELATED LITERATURE

Certainly, the primary reason for the emphasis placed on muscular strength is the belief that stronger individuals possess the potential to exert more force, thus enabling those individuals to apply more power. Yessis (48) contended that power, which is a combination of strength and speed, increased after strength had been increased.

A review of the literature indicated that relatively few researchers have conducted experiments that correlate the use of modern techniques of strength development for specific muscle groups with its effect on the subject's movement and reaction time for the corresponding joint action. Most of the researchers in the available reports utilized exercises that indirectly involved the muscles tested for movement and reaction time. Several studies dealt with speed of movement under certain conditions, with the relationship between movement time and reaction time, or with the relationship between strength and speed of movement. However, these studies were so contradictory in nature that they led to a great deal of confusion.

For convenience, the literature has been subdivided into four major categories: (1) literature pertaining to speed of movement, (2) literature pertaining to the relationship between movement time and reaction time, (3) literature pertaining to the relationship between strength and speed of movement, and (4) literature pertaining to the effect of strength increases by weight training on speed of movement.

Speed of Movement

A number of variables affect the measurements of reaction time and movement time. Some of the more prominent ones are age, sex, race, athletic involvement, stress, and fatigue.

The research of Atwell and Elbel (49) found that hand response and body reaction time in adolescent boys improved with age, although the differences in improvement between the age groups were not significant. However, a group of university students demonstrated a significantly shorter hand response time than that of any of the four teenage groups.

Spirduso (50) studied the effect of age and physical activity level on reaction and movement time. The subjects included 60 male volunteers categorized according to age and sport involvement. The younger group included men who ranged from 20 to 30 years of age, while the older group ranged from 50 to 70 years of age. The sport group included men who played squash, racketball, or handball a minimum of three times per week. The non-sport group included men who did not and who never had participated in sports of any type on a regular basis. Spirduso's findings indicated that older non-active males provided the slowest times. The order of the speed of the groups, from fastest to slowest, were as follows: (1) young active, (2) old active, (3) young inactive, and (4) old inactive.

In an earlier study, Miles (51) determined the effects of aging on reaction time. He tested a group of 100 subjects with a mean age of 49 years. Generally, these adults experienced a gradual loss of hand and foot coordination as they grew older; however, 25% of the oldest subjects were as fast as the group average or faster. This indicated a wide individual difference among the aged in both movements. Miles concluded that as adults grow older there is a greater loss in foot coordination than in control of hand movement.

According to Woodsworth (52), the optimum reaction time is 20 years of age. There are however, additional factors involved. Patrick (53, p. 68) stated that "Experience and maturity have a direct effect on reaction time." He also found that reaction time could be improved with practice. Likewise, Griffith (54), Garrett (55), Woodsworth (52), and Forbes (56) disagreed in that they concluded practice has little or no effect on reaction time.

In a study involving the effect of proprioceptive facilitation patterning on reaction and movement time, Surburg (57) used 15 women and 27 men, all of whom were university students. The groups were randomly assigned to one of the following training groups: (1) training with weights, (2) target throwing, and (3) proprioceptive facilitation patterning. The subjects engaged in three training sessions per week for six weeks. The testing procedure for movement time included flexion, adduction, external rotation at the shoulder, and elbow extension. Analysis of the data revealed significant improvement for the proprioceptive facilitation patterning group in movement time and reaction time.

In dealing with reaction and movement time by sex, Ferguson (28) tested a total of 120 college students. They included a random selection of 30 white males, 30 black males, 30 white females, and 30 black females. Reaction time measurements included two separate tests: pressing a button with the index finger and jumping from a switch mat placed on the floor. Ferguson recorded the subject's movement time by placing a switch mat one foot away from the subject and having him/her jump onto it. All experiments for movement time and reaction time testing used a buzzer as the stimulus. Results indicated that black males produced a reaction time mean superior to those of the other groups. Ferguson found that black females had a significantly faster mean time than white females for both movement and reaction time measurements, and white males produced a significantly faster movement time and reaction time than white females and black females.

However, the results of Hipple's (58) study on the influence of motivation on muscular tension, reaction time, and speed of movement for black and white males seem somewhat contrary to those of Ferguson. Hipple used 60 subjects ranging in age from 12 to 14. With regard to reaction time, he concluded that there was no significant difference between the races during the portion of the study in which the subjects had no motivation; however, when motivation was present the white group produced a significantly faster reaction time.

Harsch's (59) study involving reaction time of college-aged black and white athletes supports Hipple's findings. He tested 27 black males and 43 white males, all of whom were involved in athletics. Harsch concluded that black athletes do not react more rapidly than white athletes.

Patrick (53) measured the reaction time of a group of basketball players using a visual stimulus in the form of a red light. On the basis of the data he concluded that:

1. Boys with the best reaction time were the best basketball players.

2. Potential basketball players have quicker reaction time to a visual stimuli.

3. Experience and maturity have a direct effect upon the reaction time.

4. Reaction time improves with practice and experience.

Keller (60) studied the reaction time of 359 college-aged athletes and 275 non-athletes with respect to whole body movements made in response to a light stimulus. The results indicated that athletes respond faster than non-athletes. Baseball, basketball, football, and track athletes had significantly faster reaction times than did gymnasts, swimmers, and wrestlers; however, no significant difference was found between the sports within each group. Keller concluded that there is a positive relationship between the ability to move the entire body quickly and the success in athletic activities.

Burley (61) examined the reaction time of 77 male university students ranging in age from 18 to 23. The subjects were divided into six groups designated as: (1) non-letter winners, (2) high school letter winners, (3) football linemen, (4) football backs, (5) baseball players, and (6) swimmers. In testing simple reaction time with a visual stimulus, the baseball players recorded a significantly faster time than did football linemen, football backs, and high school letter winners. High school letter winners were significantly faster than swimmers and non-letter winners. However, there was no specific distinction between the groups. There existed the possibility of overlap in the categories.

In a study dealing with the physical fitness of champion athletes, Cureton (62) included members of the United States' men's swimming and diving team, the United States' track and field athletes, and the Danish gymnastic team. The experiment compared the world-class athletes with 80 non-athletes in a test of vertical jump reaction time. The conclusions suggested that athletes have faster reaction times than non-athletes. Cureton also found that reaction time was not dependent on strength.

Westerlund and Tuttle (63) compared the relationship between reaction time and running events in track. The study involved champion sprinters, average sprinters, middle distance runners, and distance runners. The authors found that the champion sprinters recorded the shortest reaction time, and as the running distances increased, the reaction time for the runners also increased. However, they admitted that these results could be attributed to innate ability rather than training, or a combination of both.

In a study by Burpee and Stroll (64), reaction time was tested in subjects that participated in athletics under four conditions: (1) full participation, (2) irregular participation, (3) high success, and (4) average success. The results indicated that men who participated successfully in athletics possessed a shorter reaction time (140 milliseconds) than those who participated in athletics with average success (163 milliseconds). Those who participated with average success also had a shorter reaction time than those who participated irregularly.

The effects of stress or fatigue seem to directly relate to reaction time and/or movement time. It is possible that the anticipation of the testing procedures in the discussed studies led to undue stress in the participants, thus affecting the recorded data. Elbel (65) suggested that emotional factors may shorten the athlete's reaction time before competitive activities.

Jackson (66) investigated the effects of emotion on specific muscular tasks of beginners and experts in gymnastics. A movement analyzer recorded their performance of a specific muscular skill for the gymnastic events. Jackson used a subjective questionnaire to evaluate the emotional attitudes of the subjects. He observed that the beginners exhibited lack of coordination, and that all individuals, when in fear of the situation, performed like beginners.

In a similar study, Johnson (67) measured the physical indicators of emotion--heart rate, blood pressure, and blood sugar levels--of 5 wrestlers and 15 football players at varying intervals (a few days, a few hours, and immediately) before their corresponding athletic contests, and correlated these measurements with the athlete's response to a subjective questionnaire administered at each testing session. No significant changes occurred in the measurements of the football players; however, the changes in the measurements of the wrestlers indicated a marked increase in emotion. The weakness of this study was that Johnson assumed he was measuring emotion when in fact he was only measuring physical signs of emotion. Furthermore, it would seem that the test for blood sugar levels is anxiety-producing in itself since this requires the use of a syringe.

Ash (69) studied the relationship between fatigue and reaction time, using industrial workers as subjects. He concluded that:

> The principle of fatigue is loss of efficiency, a lessening of capacity to do work, or to sustain activity, together with a lowering of sensitivity so that a given stimulus calls forth a response of less magnitude and intensity after exertion, than before (p. 21).

Griffith (54) claimed that fatigue slows the reaction time of the subjects; however, Garrett (55) concluded that fatigue significantly affected movement time, but only moderately affected reaction time.

Buck (70) investigated the effects of sleep loss on movement time and reaction time. On two separate weekends, 20 male subjects between the ages of 28 and 20 were tested three times every four hours under two regimes: one in which they slept for six and one-half hours at night, and one in which the subjects stayed awake. Twelve subjects were tested for two days under each condition, and eight subjects for three days. Buck's conclusions suggested that reaction time increased following sleep loss. However, movement time increased to a greater extent. Buck further felt that movement time is a more sensitive index of performance deterioration due to sleep loss, and that movement time and reaction time represented two separate processes.

Relationship Between Reaction Time and Movement Time

Research regarding the relationship between reaction time and movement time was found to be extremely contradictory. Inomata (71, p. 63) agreed by stating "It appears that there are still some unanswered questions as to the correlation of movement time and reaction time."

According to Pierson (72), most research that has found no correlation to exist between reaction time and movement time was conducted on college aged male students. He indicated that such results may be caused by the specificity of this age group and maturity level, since studies involving different age groups and utilizing both sexes have produced contradictory results.

Pierson (72) investigated response time and movement time in 400 male subjects between 8 and 83 years of age. He concluded that older men show a statistically significant correlation between movement time and reaction time (r = .56). He, therefore, suggested that the relationship between reaction time and movement time may be a result of maturity.

In a study involving arm movement, Youngen (73) compared 112 college aged female subjects. Seventy-five of the subjects were grouped as non-athletes and 47 as athletes. She found a statistically significant correlation between reaction time and movement time for both groups. However, athletes were significantly faster than non-athletes in both reaction time and movement time.

Westerlund and Tuttle (63), in a study previously mentioned, tested 22 college aged sprinters, middle distance runners, and distance runners, and found a relationship between reaction time and movement time. Analysis of the data of reaction time and movement time (75 yard full sprint) revealed a positive correlation of r = .86.

A study by Magill and Powell (74) involved the testing of 18 male and 18 female undergraduate majors and minors in physical education at Florida State University. The researchers used a visual stimulus presented at varying intervals to initiate the reaction and movement time for a lateral hand and arm movement. Results indicated significant relationships between movement time and reaction time for the 18 males (r = .482-.544), but not for the females (r = .341-379).

Although many studies such as the ones reported have presented significant positive correlations between movement time and reaction time, a corresponding amount of research has reported no significant levels of correlation to exist between the two variables.

Lotter (75) tested 105 college aged men for interrelationships among reaction times and the speed of movement in different limbs. A light served as the visual stimulus to elicit a movement response from the subjects. Reaction time and movement time was tested by the removal of the subject's hand or foot from a key switch to the touching of a string device placed 28 inches away from the key switch. Lotter found no correlation between reaction time and movement time in either the arm or the leg action. Hodgkins (76) reported similar results in a study involving both sexes of various age groups in a corresponding test to that of Lotter. She concluded that reaction and quickness of movement involved independent functions.

Groves (77) researched the independence of reaction time and movement time in a gross motor skill among 16 members of the University of Missouri swim team, who averaged 20 years of age. To test the racing start of swimming, he used a Cline-Kodak 16mm camera, calibrated at 69 frames per second, as the reaction/movement time measuring device. By using the Pearson product-moment coefficient, Groves found the relationship between reaction time and movement time to be $-.293$ ($p > .05$). He concluded that reaction time and movement time are largely independent factors.

Mendryk (78) compared the reaction times and movement times of 12, 22, and 48 year old subjects. In testing speed of movement involving arm motion, he found that none of the groups produced significantly high correlations between reaction time and movement time, and the combined correlation for the groups was only $r = .12$.

In another study, Henry (79) compared reaction time and movement time of 60 male college students. At the presentation of the stimulus, a flash of light, the subject released a treadle press key and grabbed a tennis ball which was suspended on a string 12 inches above the press key. As the subject grabbed the ball, the timer connected to the ball stopped the timing mechanism. Henry calculated reaction time between the exitation of the stimulus and the subject's release of the press key; calculating movement time as the time between the release of the press key and the grabbing of the ball. Results indicated that reaction time and movement time are independent and uncorrelated ($r = .15$).

Henry (80) conducted another similar study using a 90 degree arm movement. He used 120 college undergraduate students only to conclude, again, that individual differences in reaction time and movement time are unrelated.

Relationship Between Strength and Speed of Movement

An area which has attracted the attention of researchers is Henry's (80) theory that motor specificity is the relationship between strength and speed of movement. Furthermore, some researchers feel that the speed with which a limb can be moved is highly dependent upon the strength of the muscles which are used in the movement. However, according to Macintosh (81), a great preponderance of studies which have investigated the relationship between strength and the speed of limb movement indicate that differences in strength are not dependent upon differences in the speed with which the limb can be moved. Macintosh further contends that more research is needed to establish any relationship between strength and limb movement.

Clarke (82) investigated the correlation between the strength/mass ratio and the speed of an arm movement. The subjects consisted of 48 male university students. The testing procedures for speed of limb movement involved horizontal adduction of the shoulder joint as the subject stood erect. The subject's hand rested on a double-action microswitch and at the onset of an auditory stimulus, swung his arm leftward in a horizontal plane at maximal speed for a distance of 117 centimeters to strike a string. Strength measurements were taken with the subject in a supine position on a table. The arm being tested was extended laterally at shoulder height, and on command, the subject applied a maximum upward pull against a 90 centimeter wooden arm support. At the end of the support was attached a spring balance, which in turn was securely anchored to the floor at right angles to the direction of pull. All measurements were recorded from a cable tensiometer. Clarke found that the correlation between the movement time and strength/mass was not significant ($r = -.277$).

A similar study by Henry (83) involved 36 men and 36 women. Henry's testing methods for strength and speed of movement closely corresponded to those of Clarke; however, Henry timed the horizontal arm swing at seven equidistant points on an arc of 120 degrees. The correlations between strength and speed of movement were found to be almost zero, except in the middle phase of the action, where the relationship was .29 for men and .27 for women. Henry suggested that these low correlations supported the hypothesis of neuromuscular specificity.

Henry and Whitley (84) performed two separate experiments to establish the relationship between individual differences in strength, speed, and mass in an arm movement. In the first experiment there were 35 male subjects, heterogeneous in age (M = 29.17 years), and physically activity in their living habits. The second experiment included 30 male students (M = 19.7 years) who were volunteers from activity classes at a university. Both groups were tested similarly for strength and speed of movement. The speed measurements were conducted as the subject stood erect with his back to the wall, and the hand of his laterally extended arm resting on a microswitch. Movement time was tested in a horizontal adductive arm swing. Strength tests were conducted similarly to the method used by Clarke (82) in a previously mentioned study. Henry and Whitley found no correlation between strength and speed of movement, and agreed with the concept that strength is determined by a neuromotor coordination pattern that is different from the pattern used during movement.

Henry et al. (85) tested 80 college males for individual differences in two separate movements and 70 college males for individual differences in limb speed, reaction time, and strength. The test required the subject to swing his dominant arm at full extension through a 31.5 inch, 70 degree, horizontal arc. The subject also made a 27.5 inch, 42 degree, stiff-legged kick with the dominant leg. Strength in the corresponding arm and leg action was measured by a cable tensiometer. After collecting and analyzing the data, the experimenters suggested that the factor of strength is unrelated to limb speed.

In studying the specificity of individual differences for the relationshp between forearm strengths and speed of forearm flexion, Smith (86) tested 65 college men at the University of Iowa. The speed of forearm flexion was measured through an arc of 85 degrees. Strength was measured with a cable tensiometer as the subject placed his elbow on a padded cushion fastened to the top of a table. The subjects were tested at a 90 degree angle of elbow flexion. Results indicated that the range of correlation between speed of movement and static strength was extremely low: -.06 to -.14. Smith concluded that "The relationship between arm strength and speed of movement is not significantly altered as a result of employing a different arm movement" (p. 10). That is, the relationship between strength and speed of movement is predominantly independent.

Those studies that have yielded strong correlations between strength and speed of movement are not quite as abundant as those that support the theory that strength and speed of movement are independent factors. However, the research that does exist in substantiating a high correlation between the two variables make an equally strong contention.

Lotter (75, 87), in two separate studies--one involving 105 subjects and another involving 80 college men--suggested that individual differences in speed of movement are highly specific to the particular motor task, rather than existing as speed components that can be measured in a motor ability task.

Nelson and Fahrney (88) found, by correlation analysis of speed and strength, a statistically significant coefficient. The authors also acknowledged that their results were in disagreement with previous studies. They felt that their results contradicted those of previous studies because strength and speed tests were performed on the same day and because other studies recorded movement time to the nearest .01 second. Nelson and Fahrney tested their subjects for strength and speed of movement on separate days and recorded the time interval to the nearest .0001 second.

In most of the aforementioned studies, strength tests were conducted by means of static tension or isometric contraction. Generally, an accurate measurement of strength must include the movement of the joint through its full range of motion, since the specific angle of the joint determines the amount of torque that the muscle can exert.

Effect of Strength Increase on Speed of Movement

In regard to the lack of available information concerning the effect of weight training on speed of movement, the American Association for Health, Physical Education, and Recreation (AAHPER) (89, p. 289) stated: "There seems to be an absence of controlled experiments on the possible effects of heavy muscular work on quickness of movement." This statement brought about several studies; however, Macintosh (90) feels that:

> Such studies which have investigated the effect of strength training programs on relevant limb movement, involving simple speed movement under controlled laboratory situations, have yielded confusing results (p. 169).

As early as 1951, Zorbas and Karpovich (91) investigated whether weight lifters, when compared to non-weight lifters, would be significantly less efficient in speed of movement. The test included the movement of a single arm crank to be turned circularly in a frontal plane. A cross sectional group of 300 weight lifters were compared to 300 non-lifters. The authors found that weight lifters were faster in the speed of rotary arm motion than the non-lifters. However, Zorbas and Karpovich did not claim that the faster movement time was a result of weight lifting. Also, the study was limited by the fact that the weight lifters were a select group as they were chosen from an entirely different population than was the control group.

Clarke and Henry (92) tested arm strength, effective arm mass, and speed of a lateral adductive arm movement using 62 college men for a 10 week training period. Half of the subjects were given weight training exercises that did not involve the tested movement, while the other half served as a control group. Results of the investigation revealed that in the arm movement, individual differences in the amount of change in the strength and arm mass had a low but significant correlation with individual change in maximal speed of movement.

Anderson (93) tested 14 men enrolled in a weight lifting course at the University of Illinois. The study attempted to compare the effects of weight training and physical fitness training on total body reaction time. Anderson found that the reaction time of weight lifters improved significantly in their response to both a visual and an auditory stimuli. He also found that the fitness group improved significantly in reaction time and that there was no significant difference between the improvements of the two groups. However, Anderson failed to mention the training system used by either of the groups, nor did he include a detailed report on the amount of weight, number of repetitions, or number of sets employed by the weight-training group.

Masley, Hairabedian, and Donaldson (94) sought to determine whether increased strength gained through weight training is accompanied by an increase in speed of movement. Speed of movement was defined for this study as the rapidity with which a subject could complete 24 revolutions of the arm in the frontal plane. Sixty-nine subjects were selected in the following manner: (1) students enrolled in a weight-training class, (2) students enrolled in a beginning volleyball class, and (3) students enrolled in a sports lecture class. Weight-training was designed to develop the arms and shoulder girdle by using moderate weight and encouraging the subjects to increase the number of repetitions each week. The load (weight) for the exercises remained constant throughout the eight week training period. There was no mention of the specific type of exercises executed by the training group or the amount of weight used by the subjects. At the end of the training period, the authors concluded that weight training did result in significant increases in strength which was accompanied by an increase in the speed of the tested movement.

In a study to determine the effects of two types of training on reflex time and reaction time, Gottshall (95) compared sprint starts to a series of specific exercises. The exercises included side-straddle hops, push-ups, sit-ups, chins, and vertical jumps. Twenty-four inmates at a county jail in Massachusetts were randomly divided into two groups for the eight week study. The test for reaction time included a knee extension that was to be executed at the onset of an auditory stimulus. Gottshall concluded that spring start training and a general exercise program may both significantly shorten reaction time. Gottshall further reported that although the subjects were enthusiastic at the onset of the experiment, they seemed to lose a great deal of their enthusiasm about half way through the experiment.

Berger (96) sought to determine the effects of dynamic and static strength improvements on vertical jumping ability. Eighty-nine male college students participated in four separate training programs. Group I (N = 29) trained by performing one set of 10 repetitions of their 10 MR in the squat exercise; Group II (N = 20) trained with 50% to 60% of their 10 MR for 10 repetitions; Group III (N = 21) trained statically; and Group IV (N = 19) trained by jumping vertically. Training sessions were held three times weekly for seven weeks. Berger discovered that the groups that trained dynamically (Groups I and II) improved significantly in the vertical jump over the groups that trained statically or by strictly jumping vertically (Groups III and IV).

Tweit, Gollnick, and Hearn (97) reported statistically significant improvements in a series of reaction time and movement time measurements after a six week period of "vigorous training." Tests included 20 total body reaction time measurements involving the subjects' hands and feet. However, the authors did not mention how the subjects were trained other than stating, ". . . a battery of vigorous exercises designed to develop the large muscle groups of the body" (p. 508).

Smith (98) studied the effect of a 12 week strength program on speed of arm movement in horizontal adduction. His subjects were 26 male university students that volunteered for the study. The subjects trained with standard weight lifting exercises two times per week. The weight lifting exercises included the military press, bench press, arm curl, and reverse arm curl. Smith used no control group because he felt that other studies had consistently demonstrated that a control group does not significantly increase in strength and that this particular study was concerned only with the effect of an increase in strength on speed of movement. Smith found that an increase in strength favorably corresponded with an increase in the speed of a standardized limb movement.

Colgate (99) investigated whether the strengthening of the arm-shoulder muscles is accompanied by a decrease in the movement time of the arm. The author solicited 49 male students from the University of Iowa, all of whom were right-handed. Movement time tests included the action of horizontal adduction, horizontal abduction, and flexion of the shoulder. Strength measurements corresponded to the movement time actions and were measured with a cable tensiometer. The subjects were assigned randomly to four groups: (1) adduction-flexion, (2) abduction-flexion, (3) four-exercise group, and (4) control group. The findings of the study revealed a significant increase in the mean strength of the arm-shoulder muscles accompanied by a significant increase in mean arm speed in the measured positions. However, the relationship of arm-shoulder strength to arm speed was not always found to be significant or positive.

Chui (100) compared the effect of isometric and dynamic weight-training exercises on strength and speed of movement. In his study, 72 male subjects were divided into three groups: Group A, isometric contraction; Group B, rapid dynamic contraction; and Group C, slow dynamic contraction. Twenty-four male subjects served as a control group. The experimental groups performed six exercises three days a week for nine weeks. Weight exercises were: the two-hand military press, the stiff-leg dead-lift, the two-hand curl, and the squat. Group A trained with a load equal to their 10-execution maximum for each exercise. The midpoint in the normal range of movement for each exercise was held as the static position for the isometric contraction for a duration of six seconds. Each exercise was performed in three bouts, with a 30 second rest between bouts. Group B trained with their respective 10-execution maximum for each exercise. The subjects performed each exercise in three sets with the same load. If the subjects succeeded in performing the first two sets in 10 executions, they increased the load used at the succeeding training period. Group C trained with a load that was equal to their 10-execution maximum for each exercise; however, the subjects performed each exercise at a rate of speed of two seconds for the movement phase and two seconds for the recovery phase. Group C also performed each exercise in three sets. The six movements related to the training program were tested separately for speed. A cable tensiometer was used to obtain the various strength measurements. Chui found that the subjects in all three treatment groups showed significant gains in each speed-of-movement test ($p = .05$, t's ≥ 2.06). He further concluded that gains in strength are accompanied by gains in the speed of execution of the same movement.

Whitley and Smith (101) designed an experiment to compare the effects of: isometric-isotonic, (2) dynamic overload, and (3) free swing exercise programs on the speed and strength of a lateral arm movement. The study involved 26 college men in each group: three experimental groups and one control group. Each group was tested in the horizontal adductive arm swing which, according to previous studies, would yield reliable results in measurements of strength and speed. Strength was tested in the same movement (lateral adduction) with a cable tensiometer.

The isometric-isotonic group performed six, equidistant-angle, isometric pulls for six seconds in the lateral adductive arm swing along with dynamic weight training exercises designed to strengthen the general musculature. The dynamic overload group performed the horizontal adductive movement with a weighted box (19.5 kg). Subjects in the free-arm swing group moved their arms six times through the prescribed movement at maximum speed. Each group exercised twice per week for a 10 week period. Whitley and Smith (101) found significant increases in both strength and speed in the isometric-isotonic and the dynamic overload groups. However, no significant speed or strength gains were registered by either the free swing or the control group.

One of the first studies to suggest that strength training does not improve speed of movement was conducted by Wilkin (102). He attempted to determine whether training with heavy weights had impaired speed of movement in a selected group of subjects. The study involved three groups: (1) students with no previous weight lifting experience, (20 members of the weight lifting team at the University of California, and (3) members of an elementary swimming and golf class. The speed of movement test involved turning a bicycle crank with the hands for a 15 second period. Wilkin reported that although heavy weight training did not improve speed of arm movement, it did not impair speed of arm movement.

Swegan's (44) findings may be the most controversial of all the research involving the effects of weight training on speed of movement. He compared the effects that static contraction and standard weight lifting had on movement speed. The subjects consisted of 60 freshman males divided into two groups. One group trained by standard weight training procedures (1 set of 10 repetitions), and the other group trained by static (isometric) contraction at one specific angle of the joint. The subjects trained three days per week for a 10 week period. Following the study, Swegan postulated that both types of training slowed the speed of movement

Nelson and Nofsinger (103) explored the effect of overload on speed of elbow flexion. The investigation involved 23 male students enrolled in a mandatory physical education class at the University of Maryland. The subjects, randomly assigned to four groups, trained under four different conditions. Amounts of overload in increments of 15%, 30%, and 45% of maximal static strength were assigned to three groups. The fourth group served as a control group for the experiment. Strength tests were conducted by attaching a cable tensiometer to the same apparatus used for speed of movement tests and for strength training. Results of the experiment indicated that overload has no effect on the speed of movement. However, one criticism of the research is that strength was measured by isometric contraction while the training mode required isotonic exercises.

McKethan and Mayhew (104) included 24 male students in a study to determine the effects of isometric exercise, isotonic exercise, and a combination of isometric and isotonic exercise on quadricep strength and speed of a vertical jump. The subjects were divided into four groups according to type of exercise performed: (1) isometric (N = 7), (2) isotonic (N = 5), (3) isometric-isotonic (N = 6), and (4) no exercise (control group, (N = 4). Measurements of the subject's quadricep strength were determined through the use of a cable tensiometer. Training for the isotonic group included three sets of six repetitions, two times per week, for a nine week period. The isometric group executed six second static leg extensions at 90, 110, and 130 degrees of extension for the corresponding duration of the experiment. The combination group trained by using both methods for the entire testing period. Following the study, the authors found significant increases in quadricep strength for the isotonic group, while the isometric and the combination group demonstrated no significant strength increases over the control group. In addition, increases in strength were not equated by increases in vertical jump performance.

Payne (105) conducted a study to determine the relationship between static strength and speed of movement.

The subjects included 72 eighth grade girls who were divided into three groups according to the exercises performed: (1) isotonic weight lifting, (2) isometric weight exercises, and (3) no exercise, as a control. The two treatment groups performed arm and shoulder exercises for 20 minutes, 3 days per week, for 5 weeks. All girls were tested before and after training for movement speed of three arm movements. Payne found virtually no significant relationships between strength and speed of movement following the training program. She also found that there was a significant relationship between static strength and speed of a dominant arm prior to training. Furthermore, she recommended that similar studies be conducted using college women as subjects, and that weight training be used as the strength training program since Payne's study only utilized non-weighted, arm-shoulder exercises and lead-up games or relays.

Macintosh (106) investigated the relationship between strength and speed of forearm flexion, and compared the effects of three methods of training on the speed of forearm flexion. Ninety-one university freshmen were tested for maximum static strength and for speed of forearm flexion. The men were assigned to four groups: (1) no exercise (control), (2) speed of movement without resistance, (3) isometric exercises, and (4) isotonic exercises. The subjects were examined before and after an eight week period of training. Results revealed a significant relationship at the .05 level between static strength and speed of forearm flexion. However, low correlations existed beween static strength and the mass moved during the movement. Furthermore, correlations between strength/mass and speed were not significant. The result of both correlational computations indicated that increasing the strength of the muscles which move a limb does not result in a corresponding increase in the speed with which the limb moves.

Surburg (57) initiated a study utilizing 15 women and 35 men between the ages of 20 and 23 years. The groups were randomly divided and classified as: (1) weight training without resistance, and (2) weight training with maximum resistance. Reaction time and movement time was measured by having the subject perform a horizontal extension swing with the arm. The weight training exercises consisted of arm curls performed three times per week for six weeks. Surburg designated a specific and constant amount of weight for the subjects to train with throughout the six week period. Surburg concluded that there was no improvement in reaction time or movement time in any of the groups from pre-test to post-test. However, the muscle group that Surburg sought to strengthen in the subjects was not directly involved in the movement that he measured in the speed of movement tests. Moreover, the amount of resistance was not gauged to accommodate each individual's specific need.

Summary

None of the studies regarding the effect of strength training on speed of movement adhered to modern techniques of strength development; in fact, most of the research involved isometric exercises. As evidenced throughout the preceeding literature, isometric weight training has not been advocated in the field of strength development for several years. In addition, those studies that employed isotonic weight training treatments demanded a lighter weight load than is now commonly accepted for optimum strength development. Furthermore, many authors failed to test the corresponding joint action for both strength and speed of movement. In light of the controversy in the research dealing with the relationship of strength and speed of movement, the effect of weight training on speed of movement, and the outdated methods used to measure strength and to train the subjects with weights, this researcher sought to determine the effects of modern strength training techniques on speed of movement in the corresponding joint action.

CHAPTER III

PROCEDURE

To properly investigate the effects of two types of isotonic progressive weight training, the researcher designed an experiment which required him to select subjects, to construct and/or operate measuring devices, to test subjects, to establish a training program, and to prepare a statistical analysis of resultant data.

Selection of Subjects

The experiment was conducted during the spring semester of the 1982-83 school year. The subjects for the experiment were randomly selected from the freshman, sophomore, and junior caucasian male students enrolled in a weight training course at Oklahoma State University. The subjects, ranging from 18 to 20 years of age, were enrolled in the weight training course for the entire semester and volunteered to be part of the 10 week experiment. At the onset of the spring semester, the researcher solicited 30 subjects from two different classes who had little or no previous weight training experience who were willing to abide by the provisions of the experiment. Those provisions were that they: (1) must remain in the experiment the full 10 weeks, (2) must not participate in intercollegiate or intramural sports competition, (3) must attend training sessions regularly, (4) must not train with weights or practice the experimental procedures outside designated sessions, (5) must abide by the training techniques of the specific group, and (6) must cooperate by exerting maximum effort at all times in both training and test sessions. Since intramural activities would not continue throughout the testing period, it was thought best not to have the subjects either begin or end some type of physical activity during the testing session. However, if the student had previously engaged in a regular activity such as jogging prior to the experiment, he was encouraged to continue this activity on the same level of intensity and frequency throughout the 10 week testing period. After enlisting the subjects, the experimenter allotted the first three class meetings of the study for familiarizing the subjects with the weight room, the types of training methods commonly used, and the testing procedure.

A group of 15 volunteers from an anatomy/kinesiology class comprised the control group. These subjects were chosen at random from a selection of 25 caucasian males within the same age group as the subjects used for the experiment. The members of the control group were not weight lifters and agreed not to engage in weight lifting or sport activities during the 10 week testing session.

Pre-test and post-tests provided the only measurements of the control group.

Measurement Devices

Reaction times and movement times were recorded with a Dekan Automatic Performance Analyzer (APA), Model 741 (Figure 1), which includes a digital read-out mechanism capable of split-mode timing. Thus, the device can record two separate time intervals in a single trial. For this experiment, the researcher used the APA to assess the subject's movement time and reaction time in a single trial.

The APA is equipped with both a visual stimulus in the form of a flashing light and an auditory stimulus in the form of a loud buzzer, but this experiment used only the visual stimulus during the testing sessions. The APA also has a delay signal as an additional feature. This delay interval ranges from one to three seconds from the press of the switch to the exitation of the stimulus. The delay signal assures the researcher that the subject cannot anticipate the stimulus and invalidate the results.

In order to conduct this study, the experimenter designed and constructed a reaction/movement time apparatus (reaction seat, Figure 2) consisting of a 2" steel pipe, rectangular frame containing a padded seat, leg rest platform, and leg reaction frame. The apparatus includes two timer switches: (1) a reaction time switch

Figure 1. Dekan Automatic Performance Analyzer

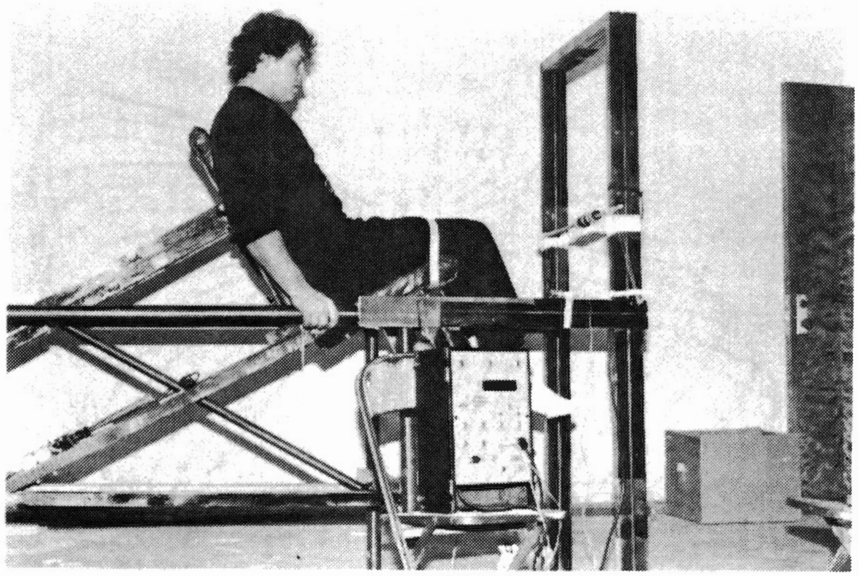

Figure 2a. Reaction Seat With Subject in Starting Position

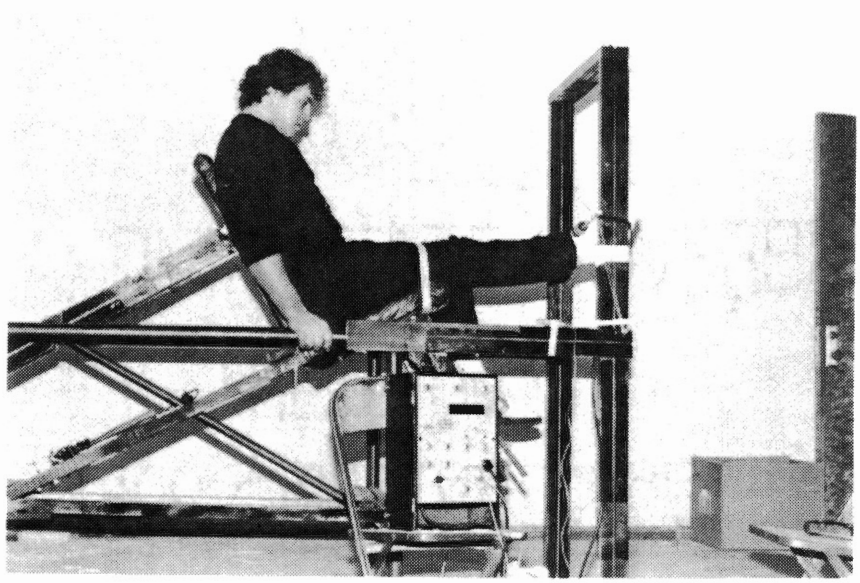

Figure 2b. Reaction Seat With Subject in Mid-Point Position

located at the heel position on the leg rest platform of the reaction seat (Figure 3) and designated to break electrical contact the instant the subject removes his heel from it, and (2) a movement time switch located on the leg reaction frame and depressed by a horizontal kick-bar (Figure 4), so designed to break electrical contact the moment the leg is fully extended and the ankle contacts the horizontal kick-bar. A strap was used to secure each subject's thigh to the seat of the reaction/movement time apparatus. This strap prevented unwanted leg movement during the testing session.

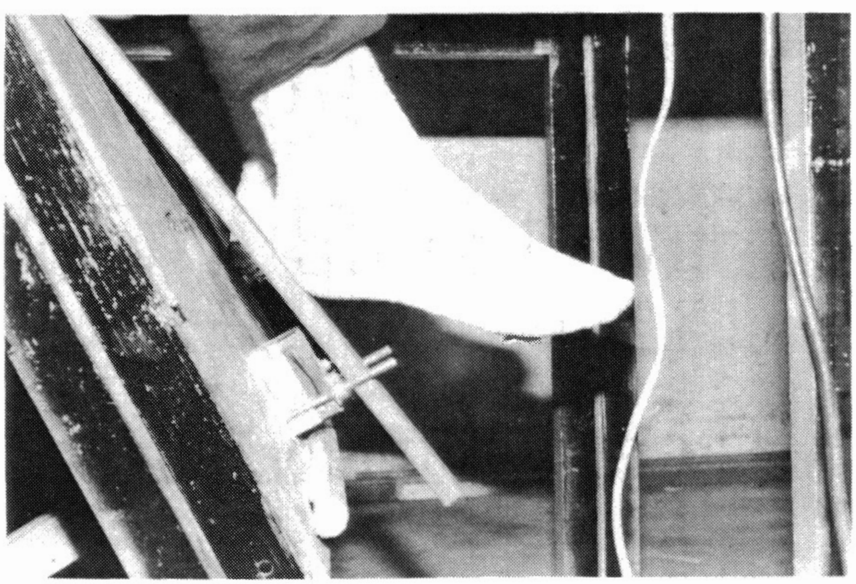

Figure 3. Reaction Time Switch

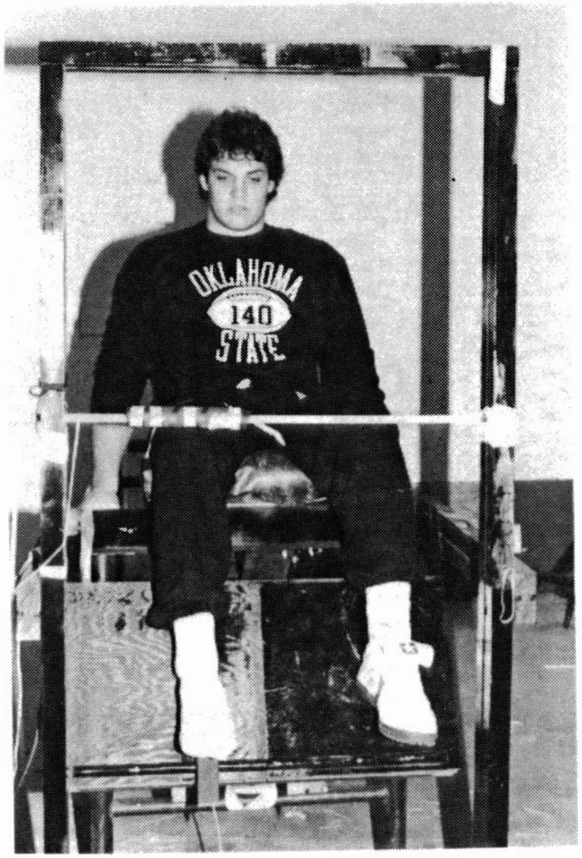

Figure 4a. MT Kick-Bar Placed

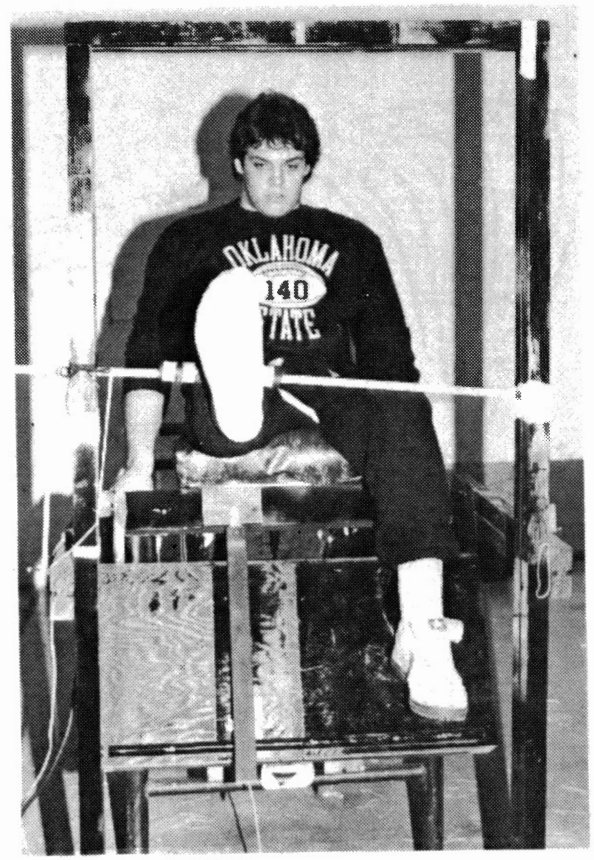

Figure 4b. MT Kick-Bar Displaced

During testing, the heel switch records the time interval from the visual stimulus--a flashing light located on the reaction frame directly in front of the subject--to the moment the leg is fully extended and the horizontal kick-bar is displaced. Movement time is then the difference between the reaction time and the total time interval from the stimulus to the displacement of the horizontal kick-bar. Therefore, to find the subject's movement time, the experimenter simply subtracts the initial reaction time from the read-out time on the APA.

Strength was measured by two devices: a cable tensiometer and a Nautilus Leg Extension machine. The cable tensiometer measures isometric strength with a joint at a specific predetermined angle. For this experiment, the knee of each subject was positioned at a 45 degree angle. Using a goniometer to assure testing consistency, the experimenter checked each subject's knee prior to each trial (Figure 5). A gauge on the tensiometer registered the subject's maximum applied force (Figure 6).

A Nautilus Leg Extension machine was used to measure the subject's leg strength (Figure 7). Maximum isotonic strength measurements required several trials to find each subject's 1MR. Smaller weights, other than those already present on the machine, were used during the trial so that additional weight could be added in

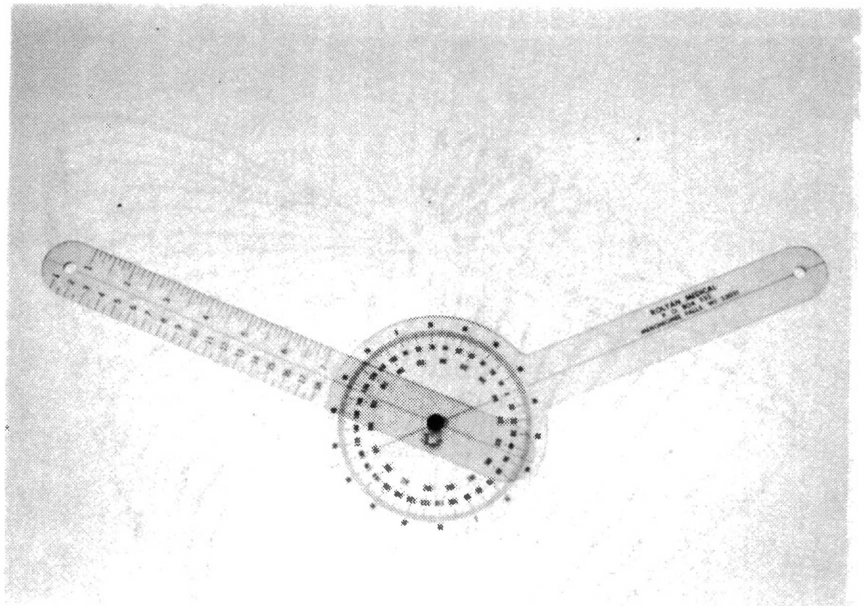

Figure 5. Goniometer

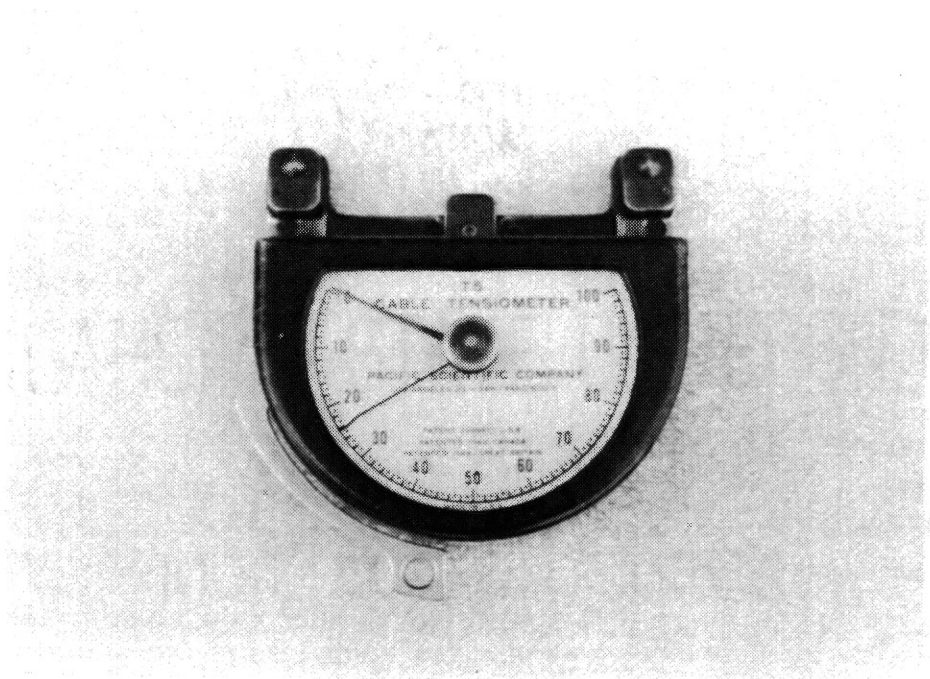

Figure 6. Cable Tensiometer

Figure 7a. Nautilus Leg Extension Machine With Subject in Starting Position

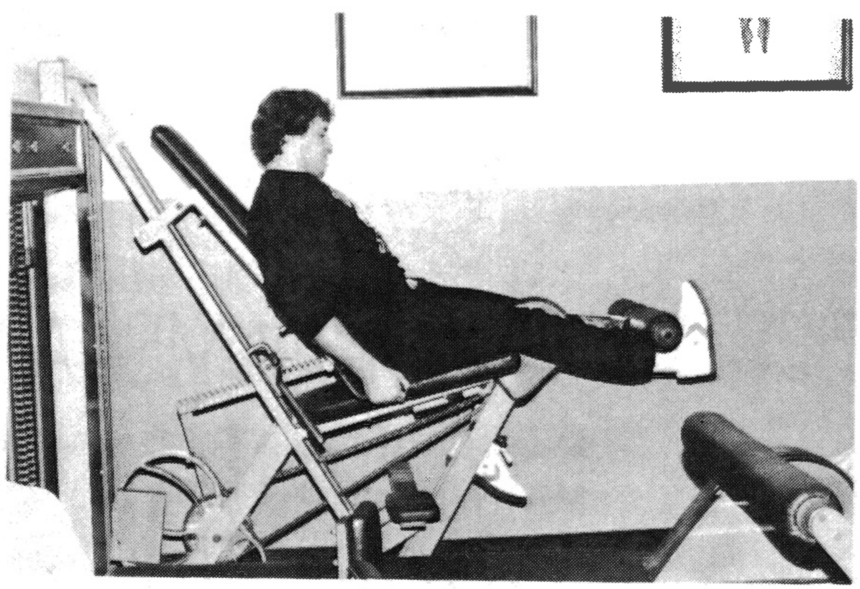

Figure 7b. Nautilus Leg Extension Machine With Subject in Mid-Point Position

increments of 2.5 pounds, thus enabling a closer estimate of the subject's 1MR.

Tests

All tests were recorded on a pre-test and a post-test format at a 10 week training period interval. The subjects were also tested at two week intervals for maximum isotonic strength gains, so that the subjects could establish new 1MR levels in order to exercise within their specific percentages.

Reaction Time and Movement Time

The subject removed his right shoe and seated himself comfortably in the reaction seat. So that the hip flexor muscles would not interfere in the knee extension movement, the subject's right thigh was securely strapped to the seat portion of the apparatus. The subject was further told to adjust his right leg so that, in the relaxed position, the heel of his right leg depressed the timer switch on the leg rest platform.

To prepare for testing, the subject was advised to hold onto the bars on the side of the reaction seat apparatus, and also told to focus his attention on a small light bulb located immediately in front of him. Additional preparatory instructions included the cue words "get ready," spoken by the researcher. The cue words alerted the subjected that at varying intervals of one to three seconds, the light would produce a bright flash. The flash of light, in turn, served as the stimulus to which the subject responded by extending his leg and displacing the horizontal kick-bar.

Movement time was recorded during the corresponding reaction time trials. The split timer feature on the Dekan Performance Analyzer made it possible to obtain both measurements in a single trial. In the movement time procedure, the subject was instructed to kick the horizontal kick-bar on the reaction leg frame as quickly as possible after receiving the stimulus. As the subject displaced the kick-bar, he tripped the switch and stopped the timing mechanism. The reading on the APA represents the time interval from the stimulus to the displacement of the horizontal kick-bar. The difference between the total time interval and the reaction time interval yields the subject's movement time.

Prior to each trial, the experimenter altered the stimulus delay switch to eliminate any anticipated reaction by the subject. The experimenter also continually checked the leg strap securing the subject's thigh to assure that it had not loosened, lest the hip flexor muscles interfere with the motion. In addition, testing for reaction and movement time occurred in a totally empty room to alleviate any extraneous visual or auditory distractions. A 30 second intermission elapsed between each trial. After two practice trials, 10 reaction times were recorded.

Strength (Tensiometer)

The subject assumed a comfortable position in the Nautilus Leg Extension machine and adjusted the backrest so that his knee joint advanced to a predetermined location on the testing apparatus. To insure consistency, each subject gripped the handles on either side of the leg extension apparatus during all testing and training sessions. Prior to testing the subjects, one end of a cable was attached to the front support of the Nautilus Leg Extension machine. After looping the canvas strap on the other end of the cable around the subject's ankle, the experimenter adjusted the cable so that each subject's knee reached a 45 degree angle for the static strength tests. The experimenter measured static strength at a 45 degree angle because this angle was the midrange angle between full knee extension and the angle of the knee at the starting point on the Nautilus Leg Extension machine. By determining the angle of each subject's knee with a goniometer, a 45 degree angle could be maintained consistently throughout each trial.

To measure the subject's strength, a cable tensiometer gauge was attached to the cable midway between the base attachment and the canvas loop. After the cable had been secured to the subject's ankle and drawn taut, the researcher gave the signal to begin. This signal served as the cue for the subject to extend his knee with maximum effort. The cable tensiometer registered the amount of force exerted on the cable by each subject. All subjects completed three trials, with 90 second rest periods between each trial. The resultant data on the cable tensiometer gauge was read and recorded after each trial. If at any time the subject's buttocks left the seat of the leg extension machine during a test trial, the results were voided and the subject was permitted a retest.

Strength (Nautilus Leg Extension Machine)

After a short warm-up period, the subject, with the aid of the researcher, assumed the proper position on the Nautilus Leg Extension machine. The researcher adjusted the backrest for each subject so that the knee joint reached a specific location on the testing apparatus. The backrest position was recorded for each subject so that the corresponding position could be used for all testing and training sessions. The researcher further suggested that all subjects grip the handles on each side of the Nautilus machine. All subjects were also securely fastened to the apparatus by a canvas belt during testing.

By following the directions of McArdle, Katch, and Katch (107), the subject's single maximum isotonic (1MR) was established. A suitable starting weight, close to but below the subject's estimated maximum lifting capacity, was selected. If one repetition was completed, the experimenter added weight to the apparatus until the subject reached his maximum capacity.

The subjects were given two class periods to find their 1MR so that undue fatigue through multiple trials would not interfere with the accuracy of the results. The criterion for a successful attempt was that the subject fully extend his knee. If the subject did not reach full extension during a trial, the attempt was voided, and the researcher permitted the subject a five minute rest before retesting him. Moreover, if the subject's buttocks left the seat on the apparatus, the results were voided.

Training Program

Orientation of Subjects

The following explanations were given to students of two weight training classes on the first class day:

1. Only those male students in the class who had little or no previous weight training experience are eligible for the study.

2. Subjects will be divided into two randomly selected groups.

3. Subjects are to be chosen on a voluntary basis.

4. Subjects are asked to strictly adhere to the established provisions.

5. Compliance with the provisions of the study will result in an A grade for the course.

6. All subjects are encouraged to continue their normal daily routine.

7. Subjects are instructed on importance of regular class attendance.

8. Missed classes must be made up at a prescribed time.

9. If a subject fails to attend at least three classes in any two week period, he will be eliminated from the study.

The following weekly schedule was presented and posted for the subjects:

Week 1 - Orientation of subjects and explanation of the study.

Week 2 - Instruction of weight training equipment and warm-up procedures.

Week 3 - Movement tests and reaction tests administered. Strength tests administered. Subjects divided randomly into two different training groups.

Week 4 - Specified training program begins.

Week 6 - Strength test for new 1MR.

Week 8 - Strength test for new 1MR.

Week 10 - Strength test for new 1MR.

Week 12 - Strength test for new 1MR.

Week 14 - Movement and reaction time post-test.
Strength test (tensiometer) post-test.

Week 15 - Strength test (Nautilus) post-test.

Treatment Procedures

After the subjects had been oriented in the weight room and instructed in the proper weight training techniques, they were randomly divided into two equal groups. The subjects drew lots from a basket which contained an equal amount of tags, numbered one or two. The experimenter assigned all subjects with a number one tag number to the MR group and those subjects with a number two tag to the MSPIR group. The MR group was to train using the manual resistance technique, and the MSPIR group was to train with three sets of six repetitions.

The training period lasted 10 weeks, with training sessions scheduled three times per week for 40 minutes each. The subjects trained on Mondays, Wednesdays, and Fridays. In case of a missed class period, the subject reported on the following Tuesday at a specified time to complete the missed training session. All other training sessions were conducted at regularly scheduled class times. Except for each group's specifically designed "training routine," both groups executed identical training routines for the upper torso muscle groups. Since the experiment only called for results in the leg extension movement, it was felt that upper torso weight training would not affect the outcome of the study.

Manual Resistance Training Program

The group of subjects labeled "MR" were to execute the manual resistance training program. Their training design employed a Nautilus Leg Extension machine for the right and left knee extension exercise. Following the suggested MR training criteria, the subjects performed only one set of the exercise. Each subject utilized a 60% to 65% weight load based on his specific 1MR. Each subject then adjusted his percentage load every two weeks after he and the researcher determined a new 1MR. As the subjects progressively increased their maximum strength loads, the training loads also increased to maintain their 60% to 65% training load during all workout sessions. Each subject was also trained in the technique of applying resistance to the individual executing the leg extension exercise. Furthermore, all subjects were encouraged to keep the same partner throughout this experiment. All training sessions were supervised by the researcher or an assistant to insure proper execution of the manual resistance training method.

Multiple Set Progressive Isotonic Resistance Training

The MSPIR group performed three sets of six repetitions on the Nautilus Leg Extension machine. Each of the subjects calculated his workload of 80% to 85% of his 1MR prior to the initial training session. In order to perform the MSPIR training technique correctly, each subject had to be able to execute a minimum of two sets for the required six repetitions. The experimenter suggested that the subject reach concentric muscle failure on the fourth, fifth, or sixth repetition. If the subject did not fail within the specified number of repetitions on the third set, then he was to increase his training load. Moreover, if the subject reached concentric muscle failure prior to the third set, he needed to reduce his work load. All subjects executed all three sets of the prescribed exercise with a 90 second interval between sets. A large clock mounted on the wall served as a timer for the subject's reference. The subjects were encouraged not to leave the exercise area until all three sets were completed. All training sessions were supervised by the experimenter or an assistant. The control group engaged in no training during the entire 10 week experimental period.

Statistical Analysis

To efficiently compare the measured results of the three groups and the three variables, the analysis included a measure of central tendency and dispersion for all pre- and post-test data. Central tendency included the calculated pre-test mean, post-test mean, and total change in means. The measure of central tendency included standard deviation and range. Furthermore, each two-phase permutation on the three variables was graphed according to the following format: pre- and post-test isotonic strength, pre- and post-test tensiometer strength, pre- and post-test reaction time, and pre- and post-test movement time. Each graph represents the pre- and post-test means for each variable.

Each hypothesis was statistically treated in the following manner:

1. Hypothesis one was tested by t-ratio, comparing pre- and post-test results of reaction time means within the manual resistance group.

2. Hypothesis two was tested by t-ratio, comparing pre- and post-test results of reaction time within the MSPIR group.

3. Hypothesis three was tested by t-ratio, comparing pre- and post-test movement time means within the manual resistance group.

4. Hypothesis four was tested by t-ratio, comparing pre- and post-test movement time means within the MSPIR group.

5. Hypothesis five was tested by analysis of covariance, comparing post-test means of the manual resistance, MSPIR, and control groups on quadricep strength.

6. Hypothesis six was tested by analysis of covariance, comparing post-test means of the manual resistance, MSPIR, and control groups on reaction time.

7. Hypothesis seven was tested by analysis of covariance, comparing post-test means of the manual resistance, MSPIR, and control groups on movement time.

8. Hypothesis eight was tested by a product-moment correlation between strength and movement time before and after treatment in each group.

9. Hypothesis nine was tested by a product-moment correlation between strength and reaction time before and after treatment in each group.

10. Hypothesis ten was tested by a product-moment correlation between movement time and reaction time before and after treatment in each group.

All t-tests and analysis of covariance were tested at the .05 level of confidence.

CHAPTER IV

RESULTS AND DISCUSSION

Forty-five white, college-aged males participated in the study and were assigned to three groups. Each group consisted of 15 subjects and was randomly chosen for one of the following treatments:

Group I - Manual Resistance (MR)

Group II - Multiple Set Progressive Isotonic Resistance (MSPIR)

Group III - Control (C)

A total of four variables were measured prior to and after treatment with a pre-test and a post-test for each variable. The following abbreviations were used in this chapter:

RT - Reaction Time

MT - Isotonic Strength

TEN - Tensiometer Strength

PreRT - Pre-Test Measurement of Reaction Time

PreMT - Pre-Test Measurement of Movement Time

PreISOT - Pre-Test Measurement of Isotonic Strength

PreTEN - Pre-Test Measurement of Tensiometer Strength

PostRT - Post-Test Measurement of Reaction Time

PostMT - Post-Test Measurement of Movement Time

PostISOT - Post-Test Measurement of Isotonic Strength

PostTEN - Post-Test Measurement of Tensiometer Strength

Paired t-tests, analyses of covariance, and correlation coefficients were calculated on all four variables for each of the three groups. RT was measured in milliseconds, MT in milliseconds, ISOT in pounds, and TEN in force units. The .05 level of significance was chosen as the standard of confidence. All statistical procedures were performed by the experimenter using the SPSS Batch computer system. In addition, a scattergram was constructed on all correlation coefficients to provide the experimenter with a graphic representation of the correlation coefficient results.

Means, standard deviation, and maximum and minimum scores for each group's pre- and post-test on each variable are displayed in Table I. Tables II through V presents pre- and post-test means for each variable (RT, MT, ISOT, TEN), as well as the differences between pre- and post-tests for each group.

Table II includes the pre- and post-test data for reaction time (RT). The pre-test results were extremely similar (MR- .2148 second, MSPIR-.2125 second, and C- .2117 second) with a range of only .0034 second. Post-test results indicated a mean change of -.00583 second in the performance of the two treatment groups and only a

TABLE I

TOTAL GROUP RESPONSES: PRE- AND POST-TEST

Variable	N	X	S.D.	Min.	Max.
Pre RT	45	.213	.017	.178	.272
Post RT (Sec.)	45	.209	.016	.178	.254
Pre MT	45	.153	.014	.125	.189
Post MT (Sec.)	45	.145	.013	.118	.170
Pre ISOT	45	61.01	14.39	35.00	95.00
Post ISOT (Lbs.)	45	75.83	18.66	37.00	120.00
Pre TEN	45	67.31	9.77	50.00	91.00
Post TEN (F.U.)	45	70.88	9.90	52.00	92.00

TABLE II

MEANS FOR RT TEST BY GROUPS (SEC.)

Group	N	Pre	Post	Change
MR	15	.2148	.2085	-.0063
MSPIR	15	.2125	.2071	-.0054
C	15	.2117	.2102	-.0015

TABLE III

MEANS FOR MT TEST BY GROUPS (SEC.)

Group	N	Pre	Post	Change
MR	15	.1529	.1414	-.0115
MSPIR	15	.1552	.1448	-.0104
C	15	.1513	.1489	-.002

TABLE IV

MEANS FOR ISOT STRENGTH TEST BY GROUPS (LBS.)

Group	N	Pre	Post	Change
MR	15	61.17	80.67	19.50
MSPIR	15	61.67	85.83	24.16
C	15	61.53	61.00	- .53

TABLE V

MEANS FOR TEN STRENGTH TEST BY GROUPS (F.U.)

Group	N	Pre	Post	Change
MR	15	67.60	72.73	5.13
MSPIR	15	67.07	72.20	5.13
C	15	67.27	67.73	.46

-.0015 second difference in that of the control group. Figures 8 and 9 illustrate the differences between pre- and post-test results for each group.

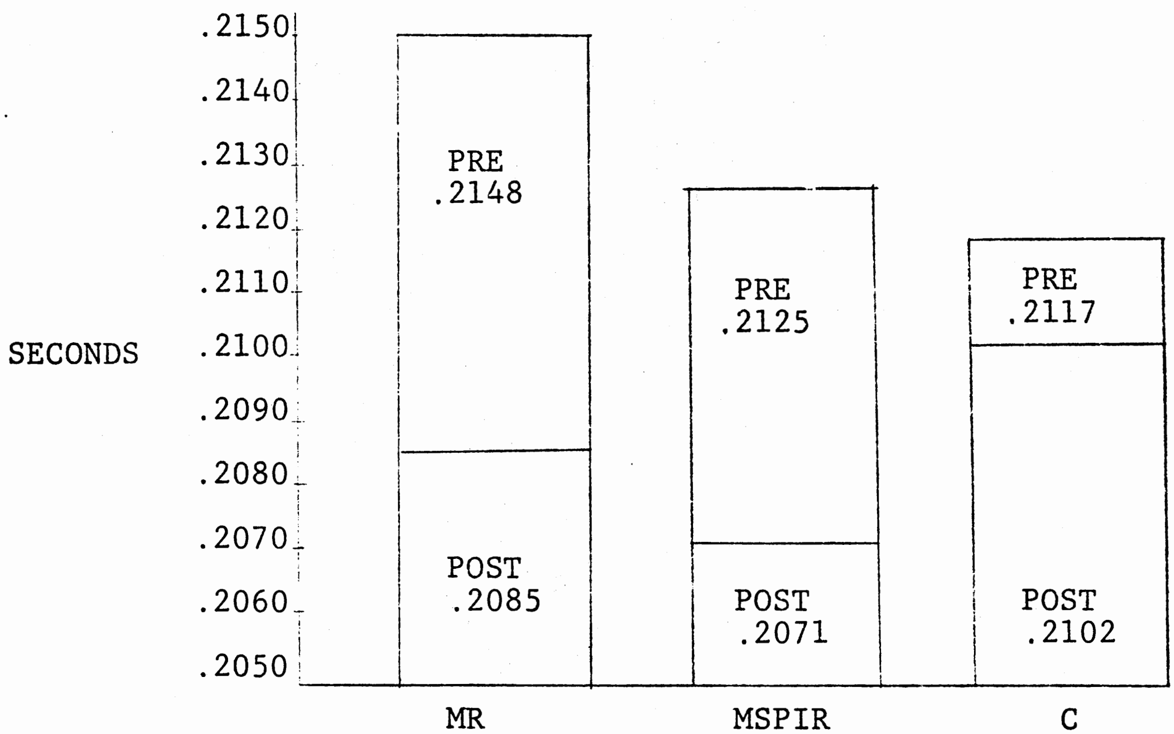

Figure 8. Pre- and Post-Test Means for RT Test

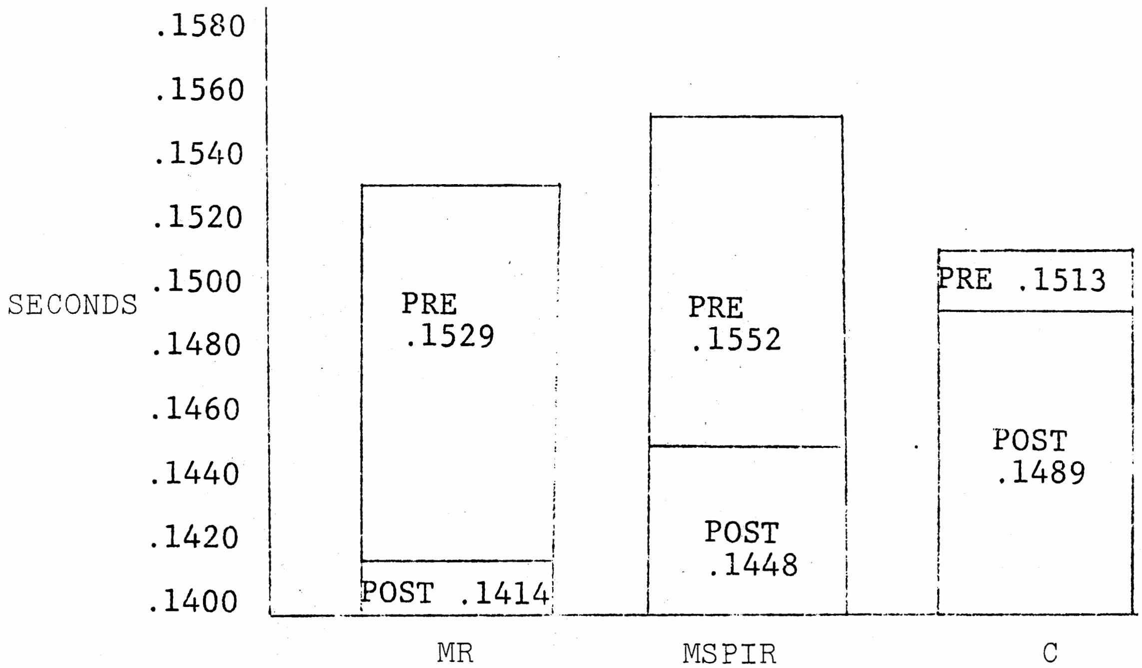

Figure 9. Pre- and Post-Test Means for MT Test

Table III presents the pre- and post-test results for movement time. Again, the pre-test means of all three groups were similar (MR- .1529 second, MSPIR-.1552 second, and C-.1513 second), with a range of only .0036 second. However, the difference from pre-test to post-test was much greater in the two treatment groups than in the control group. The mean change of the MR and MSPIR groups was -.01095 second as compared to the change of -.002 second of the control group. Results recorded in both Tables II and III indicated a negative change from pre-test to post-test, which suggests that the subject's reaction time and movement time decreased following the 10 week study. Quicker reaction and movement time were considered a favorable outcome.

Table IV displays the pre- and post-test means for the isotonic strength test conducted on the Nautilus Leg Extension machine. Although the pre-test means for all three groups were strikingly similar (MR- 61.17 lbs., MSPIR- 61.17 lbs., and C- 61.53 lbs.), a substantial gain occurred in the strengths of the MR (19.50 lbs.) and MSPIR (24.16 lbs.) groups. Furthermore, the control group experienced a very slight drop in strength (-.53 lb.). Figure 10 vividly illustrates the marked increases of the MR and MSPIR groups from pre-test to post-test, as well as the decrease registered by the control group.

Table V represents the pre- and post-test means for the tensiometer strength test. As in the isotonic pre-test, the tensiometer pre-test also indicated a similar mean response between the groups (MR- 67.60 F.U., MSPIR- 67.07 F.U., and C- 67.27 F.U.). Both treatment groups experienced a 5.13 F.U. difference, while the control group only registered a slight gain of .46 F.U. Figure 11 further represents the change. A superficial scan of the pre- and post-test means of each test reveal a much larger change in the MR and MSPIR groups than in the control group.

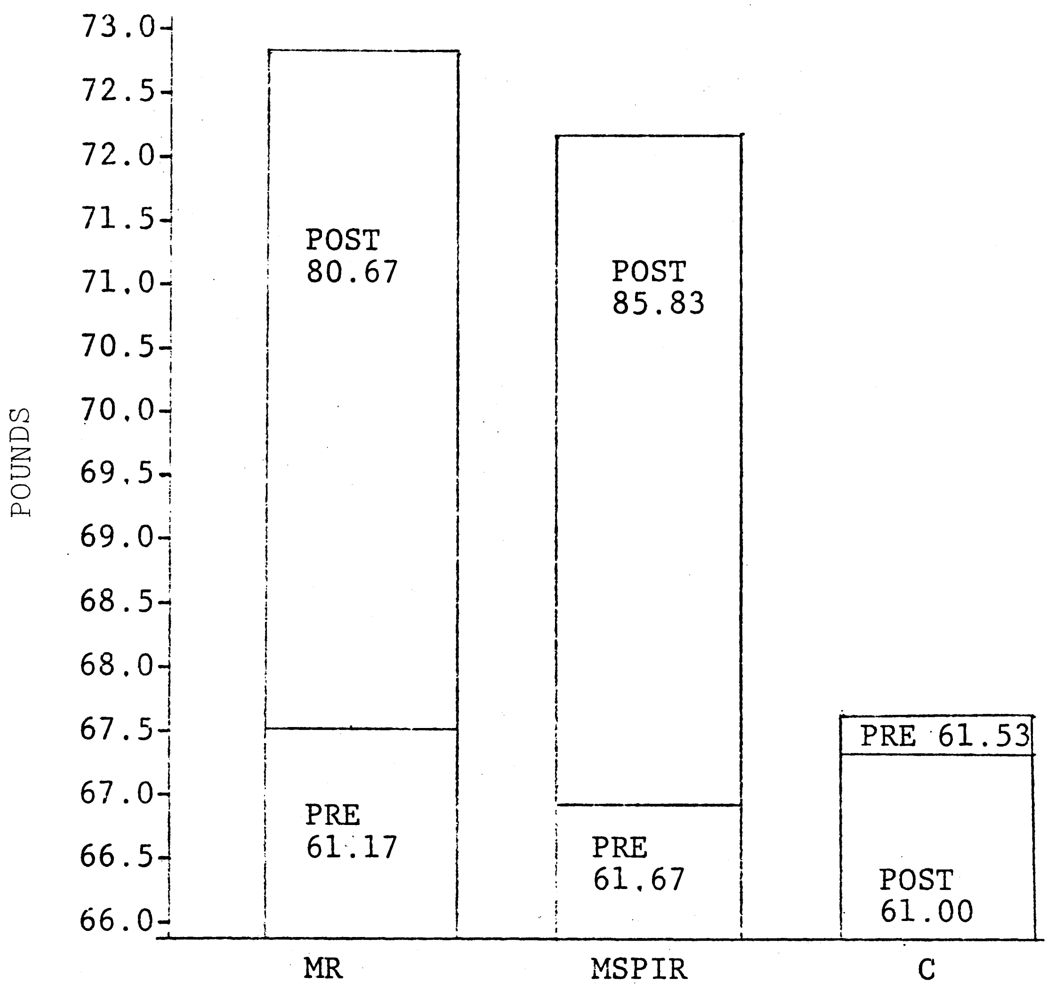

Figure 10. Pre- and Post-Test Means for ISOT Test

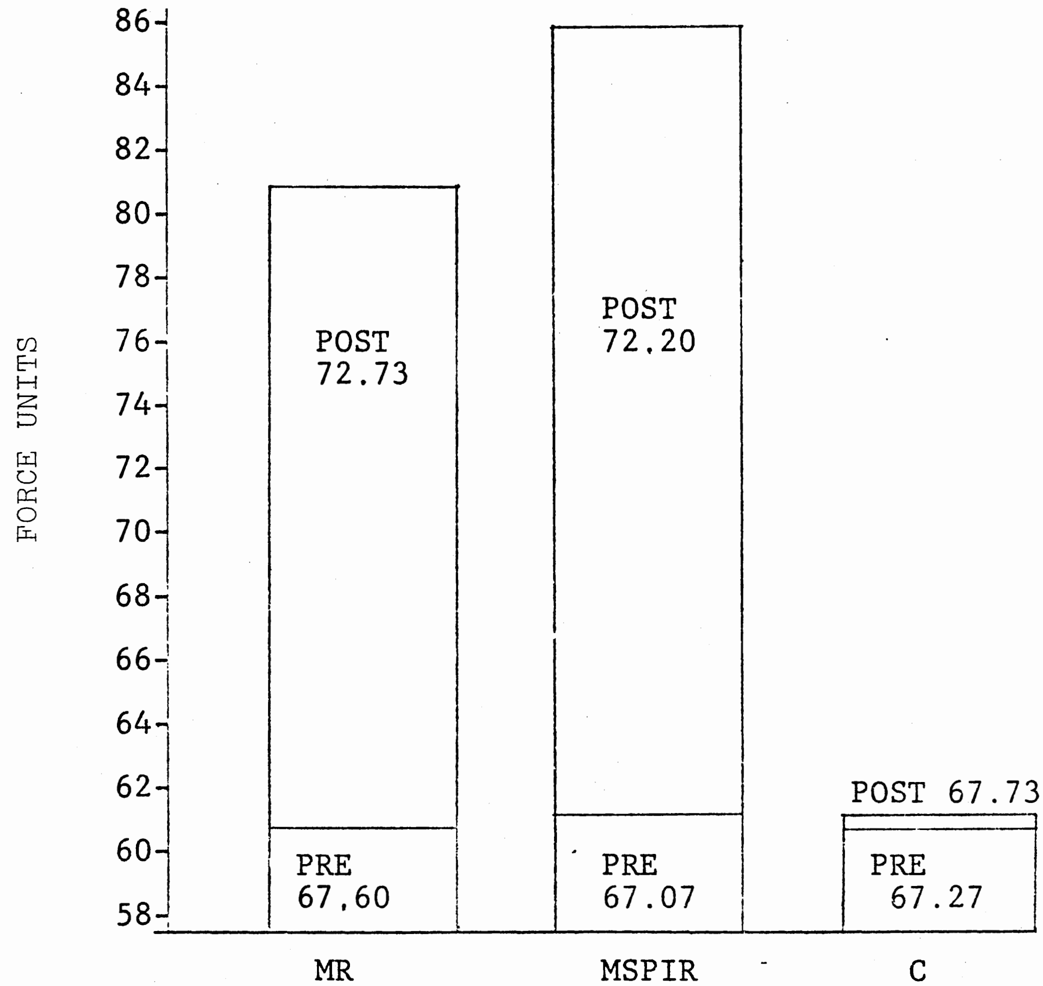

Figure 11. Pre- and Post-Test Means for TENS Test

Significant Differences

Hypotheses one through four were treated by means of a two-tailed t-test to establish if, in fact, MR or MSPIR would have a significant effect on movement time and reaction time.

Hypothesis One

Hypothesis one stated that manual resistance training would not significantly affect reaction time. The pre- and post-test reaction time means for the MR group listed in Table II were .2148 second and .2085 second, respectively. Table VI presents a mean difference in reaction time of .0063 second, with a standard deviation of .006 and a standard error of .001. Reaction time for the MR group yielded a t-value of 2.98, which was significant at the .05 level ($p = > .01$). This indicates that MR training significantly decreased reaction time.

Hypothesis Two

Hypothesis two stated that multiple set progressive isotonic resistance training will not significantly affect reaction time. Table II shows a pre-test mean for the MSPIR group of .2125 second and a post-test mean of .2071 second, with a standard deviation of .007 and a standard error of .002. Table VII further presents a t-value of 2.88, which proves to be significant at the .05

TABLE VI

T-TEST FOR MR GROUP BY VARIABLE

Variable	N	Mean Difference	S.D.	S.E.	T-Value	Prob.
RT (Sec.)	15	.0063	.008	.002	2.98	.010*
MT (Sec.)	15	.0115	.010	.003	4.45	.001*
ISOT (lbs.)	15	-19.500	8.567	2.212	-8.82	.000*
TEN (F.U.)	15	-5.133	3.378	.872	-5.89	.000*

*Significant at the .05 level.

TABLE VII

T-TEST FOR MSPIR GROUP BY VARIABLE

Variable	N	Mean Difference	S.D.	S.E.	T-Value	Prob.
RT (Sec.)	15	.0054	.007	.002	2.88	.012*
MT (Sec.)	15	.0104	.008	.002	5.32	.000*
ISOT (lbs.)	15	-24.1667	8.327	2.150	-11.24	.000*
TEN (F.U.)	15	-5.1333	4.033	1.041	-4.93	.000*

*Significant at the .05 level.

level ($p > .012$). The results of this t-test would thereby imply that MSPIR training significantly decreased reaction time.

Hypothesis Three

Hypothesis three stated that manual resistance training will not significantly affect movement time. A pre-test mean of .1529 second and a post-test mean of .1414 second for the MSPIR group is shown in Table III. A difference of .0115 second from pre-test to post-test is indicated by the results shown in Table VI, along with a standard deviation of .010 and a standard error of .003. The t-value for the MR group was found to be 4.45, which proved to be significant at the .05 level of confidence ($p > 0.000$). These results substantiate a significant reduction in movement time for the MR group after treatment.

Hypothesis Four

Hypothesis four stated that multiple set progressive isotonic resistance training will not significantly affect movement time. Table III elucidates the fact that the MSPIR group had a difference of -.0104 second from pre-test mean (.1552 second) to post-test mean (.1448 second). Table VII shows a standard deviation of .007 and a standard error of .002. The same table also shows the t-value of 5.32 as the result of a t-test conducted between the pre- and post-test mean. The t-value denotes that MSPIR training significantly decreased movement time at the .05 level ($p > 0.00$). It should be reemphasized that an improvement in reaction time and movement time is indicated by a decrease in the score. The lower the score in RT and MT, the faster the subject executed the prescribed action.

As a means of comparison, a t-test was also conducted on the control group for each variable. Table VIII represents the variable, mean difference, standard deviation, standard error, t-value, and probability results for the control group. In the reaction time test the control group marked a pre-test score of .2101 second and a post-test score of .2101 second, indicating a difference of -.0015 second. Table VIII points out the standard deviation of .006, standard error of .001, and a t-value of 1.03. Therefore, the control group showed no reaction time ($p > .319$). Furthermore, in calculating movement time, the control group demonstrated a pre-test mean of.1513 second and a post-test mean of .1489 second, eliciting a difference of -.002 second. Table VIII indicates a standard deviation of .005 and a standard error of .001, with a t-value of 2.02. Hence, the control group did not significantly increase in movement time ($p > .063$).

TABLE VIII

T-TEST FOR CONTROL GROUP BY VARIABLE

Variable	N	Mean Difference	S.D.	S.E.	T-Value	Prob.
RT (Sec.)	15	.0015	.006	.001	1.03	.319
MT (Sec.)	15	.0024	.005	.001	2.02	.063
ISOT (lbs.)	15	.5333	2.532	.654	.82	.424
TEN (F.U.)	15	-.4667	2.031	.524	-.89	.388

Hypothesis Five

Hypothesis five stated that the mean strength gain of the three groups would not differ significantly. Table IV and Figure 10 clearly show a much greater isotonic strength change in the MR and the MSPIR groups over that of the control group. The MR group responded with a pre-test mean of 61.17 pounds and a post-test mean of 80.67 pounds, noting a difference of 19.50 pounds. Concurrently, the MSPIR group demonstrated a pre-test mean of 61.67 pounds, and a post-test mean of 85.83 pounds, with a change of 24.16 pounds. According to the t-test (Tables VI and VII), both groups (MR and MSPIR) significantly increased in isotonic strength after the 10 week treatment, scoring a t-value of 8.82 and 11.24, respectively. Table VII indicates the results recorded by the control group in the ISOT test when subjected to a t-test. The control group registered a pre-test mean of 61.63 pounds and a post-test mean of 61.00 pounds, pointing out a difference of -.53 pound (Table IV). The control group further displayed a standard deviation of 2.523 and a standard error of .654, with a t-value of .82. These results imply that the control group did not significantly improve isotonic strength ($p > .424$). A similar illustration may be seen in Figure 10.

In the tensiometer test, the MR group scored a pre-test mean of 67.60 F.U., and a post-test mean of 72.73

F.U., with a difference of 5.13 F.U. (Table V and Figure 11). The standard deviation was 3.378, the standard error .872, and the t-value was -5.89 (Table VI). The MSPIR group revealed a pre-test mean of 67.07 F.U. and a post-test mean of 72.20 F.U., also resulting in a difference of 5.13 F.U. The MSPIR further noted a standard deviation of 4.033, a standard error of 1.041, and a t-value of 4.93 (Table VI). According to the t-test (Tables VI and VII), both the MR and the MSPIR group recorded a significant difference in strength gains following the 10 week treatment period. However, the control group denoted a pre-test mean of 67.27 F.U. and a post-test mean of 67.73 F.U., representing a difference of only .46 F.U. Figure 11 further illustrates the comparative gains of the MR, MSPIR, and C groups. Table VIII shows the results of a t-test conducted on the control group by revealing a standard deviation of 2.031, a standard error of .524, and a t-value of -.89. As demonstrated by the t-test, the control group did not significantly increase in tensiometer strength ($p > .388$).

To alleviate any pre-test discrepancies between the two groups, Hypothesis five was treated by an analysis of covariance. Table IX details the results of the postISOT test by each group (MR- 80.67 lbs., MSPIR- 85.83 lbs., C- 61.00 lbs.), with each preISOT mean as the covariate. Table IX points out the results of postISOT strength (MR- 80.67, MSPIR- 85.83, and 61.00) poundage by each group

TABLE IX

ANALYSIS OF COVARIANCE BY GROUP POST-TEST

Variable	Sum of Squares	DF	Mean Square	F-Value	Sig. of F
POST-RT	.000	2	.000	1.846	.171
POST-MT	.001	2	.000	6.455	.004*
POST-ISOT	5165.039	2	2582.520	51.425	.000*
POST-TEN	218.198	2	109.099	10.482	.000*

*Significant at the .05 level.

with preISOT means as the covariate. The ANCOVA for ISOT training resulted in a sum of squares value of 5165.039, a mean square of 5282.520, and an F-value of 51.425. This result indicated that there was a significant post-test difference in the three groups (significance of F = .000). However, the analysis of covariance technique did not yield a breakdown of where the significant existed; therefore, a post-hoc t-test was conducted to identify where the discrepancies occurred. Table X presents the results of an augmented t-test analysis in the form of a probability matrix. The results indicated that there was no significant difference between the isotonic strength gains of the MR group to those of the MSPIR group (p = .0770). However, there was a significant difference in the isotonic strength gains between the MR group and the control group (p = .001), and also a significant difference between the MSPIR group and the control group (p = .001).

An additional analysis of covariance was conducted on the tensiometer strength results using the pre-test as a covariate. Table IX points out the results of the ANCOVA by showing a sum of squares of 218.198, a mean square of 109.099, and an F-value of 10.482. The results of the ANCOVA disclosed a significant difference between the tensiometer strength gains of the three groups (significance of F = .000). Since a difference existed, the results were subjected to post-hoc t-analysis to determine which groups were significantly different. Table XI illustrates the results in probability matrix form. It was concluded that manual resistance training did not produce a significant difference from the MSPIR group in tensiometer strength gains (p = .9762); in fact, they were extremely similar. However, both the manual resistance group and the MSPIR group differed from the control group in tensiometer strength gains, scoring p = .0003 and p = .0003, respectively.

TABLE X

MATRIX T-ANALYSIS FOR POST-TEST ISOT

	MR	MSPIR	C
MR		p = .00770	p = .0001*
MSPIR	p = .0770		p = .0001*
C	p = .0001*	p = .0001*	

*Significant at the .05 level.

Hypothesis Six

Hypothesis six stated that the mean reaction time of the three groups would not differ significantly after treatment. An analysis of covariance was used to analyze the differences of post-reaction time between the three groups using the pre-test means as the covariate. Table IX shows the results of the ANCOVA with a sum of squares of .000, mean square of .000, and an F-value of 1.846. According to the results, there were no significant differences in reaction time after treatment by any combination of the groups (significance of F = .171). As a means of checking the group differences, an extensive t-analysis was executed. Table XII displays the results of the post-hoc t-test by showing no significant difference between reaction time in the MR and MSPIR groups (p = .8394) or between the MSPIR group and the control group (p = .1276). However, although there was no significant difference between the MR group and the control group at the .05 level, the results demonstrated a closer relationship between the two than between any other two groups (p = .0868). This relationship, although closer in nature, was not considered significant.

Hypothesis Seven

Hypothesis seven stated that the mean movement time of the three groups would not differ significantly after treatment. An analysis of covariance was used to determine if, in fact, any difference existed between the post reaction time test of the three groups, applying their pre-test results as the covariate. The results of the ANCOVA are displayed in Table IX, identifying the sum of squares as .000, the mean square as .000, and the F-value as 6.455. These results indicated that a significant difference in movement time developed between two or more groups after the 10 week study (p = .004). A post-hoc t-analysis was carried out in order to find exactly where the difference occurred. Table XIII charts a two-place comparative permutation on the three groups, displaying no significant difference between the manual resistance and the MSPIR groups in post-test movement time (p = .5361). However, a significant difference occurred between movement times of the MR group and the control group (p = .0061) and of the MSPIR group and the control group (p = .0090).

TABLE XI

MATRIX T-ANALYSIS FOR POST-TEST TEN

	MR	MSPIR	C
MR		p = .9762	p = .0003*
MSPIR	p = .9762		p = .0003*
C	p = .0003*	p = .0003*	

*Significant at the .05 level.

TABLE XII

MATRIX T-ANALYSIS FOR POST-TEST RT

	MR	MSPRI	C
MR		p = .8394	p = .0868
MSPIR	p = .8394		p = .1276
C	p = .0868	p = .1276	

TABLE XIII

MATRIX T-ANALYSIS FOR POST-TEST MT

	MR	MSPIR	C
MR		p = .5361	p = .0061*
MSPIR	p = .5361		p = .0090*
C	p = .0061*	p = .0090*	

*Significant at the .05 level.

Hypothesis Eight

Hypothesis eight stated that there would not be a significant relationship between strength and movement time before or after treatment. Table XIV represents the

TABLE XIV

CORRELATION COEFFICIENT MATRIX BY
PRE-TEST FOR MR GROUP

	PRE-RT	PRE-MT	PRE-ISOT	PRE-TEN
PRE-RT (Sec.)		.3232 p=.120	.0167 p=.476	-.1377 p=.312
PRE-MT (Sec.)	.3232 p=.120		.0860 p=.380	.0229 p=.468
PRE-ISOT (lbs.)	.0167 p=.476	.0860 p=.380		.7236 p=.001*
PRE-TEN (F.U.)	-.1377 p=.312	-.0229 p=.468	.7236 p=.001*	

*Significant at the .05 level.

results of each pre-test variable correlated with all other pre-test variables in a Pearson Product Moment correlation matrix for the MR group. In the pre-test correlation matrix, the correlation coefficient indicating the relationship between isotonic strength and movement time for the MR group was .086 ($p = .384$), which was not significant at the .05 level. Therefore, it is extremely doubtful that any significant relationship exists between pre-test isotonic strength and movement time in the MR group. In addition, the correlation coefficient between MR tensiometer strength and movement time for pre-tests yielded a value of .0229. This too indicated that no significant relationship existed between pre-test tensiometer strength and movement time for the MR group ($p = .468$).

The relationship between pre-test isotonic strength and movement time for the MSPIR group was found to be -.1124 (Table XV). This result suggests not only that the relationship between isotonic strength and movement time for the MSPIR group was not significant, but also that a slight inverse relationship existed ($p = .345$). Furthermore, the correlation between pre-test tensiometer strength and movement time in the MSPIR group was -.3354, further indicating an insignificant relationship between pre-test tensiometer strength and movement time ($p = .111$).

Results of the correlation between post-test strength and movement time for the MR group are cited in

TABLE XV

CORRELATION COEFFICIENT MATRIX BY
PRE-TEST FOR MSPIR GROUP

	PRE-RT	PRE-MT	PRE-ISOT	PRE-TEN
PRE-RT (Sec.)		.4957 p=.030*	-.0024 p=.497	-.1124 p=.345
PRE-MT (Sec.)	.4957 p=.030*		-.1124 p=.345	-.3354 p=.111
PRE-ISOT (lbs.)	-.0024 p=.497	-.1124 p=.345		.8012 p=.000*
PRE-TEN (F.U.)	-.1124 p=.345	-.3354 p=.111	.8012 p=.000*	

*Significant at the .05 level.

Table XVI. By the product moment correlation, the relationship between isotonic post-test strength and movement time produced a value of .3492 for the MR group and a probability of .185, which indicated no significant relationship between movement time and isometric strength after the manual resistance training. In addition, the correlation coefficient result between post-test movement time and tensiometer strength for the MR group yielded only .1931, which was statistically insignificant (p = .245).

The MSPIR group demonstrated a correlation coefficient of -.2557 between post-test movement time and isotonic strength (Table XVII), which indicated that no significant relationship existed (p = .209). Similarly, the result of the correlation coefficient procedure between post-test movement time and tensiometer strength for the MSPIR group indicated an outcome of -.2750, which proved to be insignificant (p = .161).

Hypothesis Nine

Hypothesis nine stated that there would not be a significant relationship between strength and reaction time before or after treatment. Table XIV represents the pre-test MR group strength correlated with reaction time. Results of the correlation test produced a value of .0167 for the MR group for isotonic strength and reaction time relationship. This result indicated a non-significant

TABLE XVI

CORRELATION COEFFICIENT MATRIX BY POST-TEST FOR MR GROUP

	POST-RT	POST-MT	POST-ISOT	POST-TEN
POST-RT (Sec.)		.3305 p=.114	.1495 p=.297	-.2842 p=.152
POST-MT (Sec.)	.3305 p=.114		.2492 p=.185	.1931 p=.245
POST-ISOT (lbs.)	.1495 p=.297	.2492 p=.185		.7212 p=.001*
POST-TEN (F.U.)	-.2842 p=.152	.1931 p=.245	.7212 p=.001*	

*Significant at the .05 level.

TABLE XVII

CORRELATION COEFFICIENT MATRIX BY
POST-TEST FOR MSPIR GROUP

	POST-RT	POST-MT	POST-ISOT	POST-TEN
POST-RT (Sec.)		.3038 p=.135	.0996 p=.362	-.1963 p=.242
POST-MT (Sec.)	.3038 p=.135		-.2257 p=.209	-.2750 p=.161
POST-ISOT (lbs.)	.0996 p=.362	.2257 p=.209		.8956 p=.000*
POST-TEN (F.U.)	.1963 p=.242	-.2750 p=.161	.8956 p=.000*	

*Significant at the .05 level.

relationship between isotonic strength and reaction time. In the tensiometer pre-test, strength and reaction time correlated -.1377, indicating not only an insignificant relationship between reaction time and strength (p = .312), but also an inverse relationship.

The MSPIR group indicated a pre-test correlation of -.0020 between isotonic strength and reaction time. This inverse relationship did not produce a significant relationship (p = .497). Furthermore, the MSPIR group also scored an inverse relationship between pre-test tensiometer strength and reaction time (-.1124), thus indicating an insignificant relationship between tensiometer strength and reaction time (p = .345).

In the post-test, the MR group's relationship between isotonic strength and reaction time resulted in a value of .1495, which produced an insignificant relationship of p = .297. The results of post-test tensiometer strength in relationship to reaction time created a value of -2842, which also indicated an insignificant inverse relationship (p = .242).

The MSPIR group generated a value of .0996 in the correlation of isotonic post-test strength and reaction time (Table XVII). This substantiated the fact that there was no significant relationship between MSPIR group isotonic post-test strength and reaction time (p = .362). In addition, the MSPIR group produced a -.1963 value in the relationship between tensiometer strength and reaction time. The result related the fact that there was an insignificant inverse relationship between MSPIR group post-test tensiometer strength and reaction time (p = .242).

Hypothesis Ten

Hypothesis ten stated that there would be no significant relationship between movement time and reaction time before or after treatment. Table XIV illustrates the results of a correlation coefficient between the MR group's pre-test movement and reaction time. The results yielded a value of .3232, implying that there was no significant relationship between MR group pre-test reaction time and movement time (p = .120). However, the MSPIR group scored a low, but significant relationship between pre-test reaction time and movement time by exhibiting a value of .4957. This proved to be a significant relationship with a probability of p = .030.

Table XVI indicates the results of a correlation coefficient procedure between post-test movement time and reaction time. Statistically, the correlation between post-test movement time and reaction time resulted in a value of .3305, indicating an insignificant relationship between MR group movement time and reaction time (p = .114). The MSPIR group (Table XVII) correlation value was only .3038, thereby indicating that post-test movement time and reaction time were not significant related (p = .135).

Summary of Results

The primary purpose of this investigation was to determine whether the strength increases of two types of progressive isotonic resistance training techniques would affect the speed of movement. The secondary purpose was to compare the post-test means of strength gains of the two training groups to determine the relative effectiveness of the training methods.

Both treatment groups (MR, MSPIR) underwent much greater value changes, from pre-test to post-test in all test variables (RT, MT, ISOT, TEN), than did the control group. The MR group displayed significant differences between the pre- and post-test in all variables tested. According to the t-test results for the MR group, reaction time decreased significantly after training (p = .010), movement time decreased significantly after training (p = .000), isotonic strength increased significantly after training (.000), and tensiometer strength increased significantly after training (.000).

The MSPIR group demonstrated results similar to those of the MR group in all variables tested. The t-test indicated a significant decrease in reaction time after training (.012), a significant decrease in movement time after training (.000), a significant increase in isotonic strength after training (.000), a significant increase in isotonic strength after training (.000), and a significant increase in tensiometer strength after training (.000). The control group, on the other hand, did not produce any significant changes from pre-test to post-test in any of the variables.

These results indicated that both manual resistance and MSPIR training were equally effective means of increasing strength and decreasing speed of movement after a 10 week period.

The ANCOVA analysis on each variable indicated no significant post-test reaction time changes between any of the groups (significance of F = .171). However, it was found that a significant difference existed in post-test movement time between the MR group and the control group (p = .006) and the MSPIR group and the control group (p = .009). There was no significant difference between the two training groups (p = .5361). Furthermore, significant differences occurred between the MR group and the control group in post-test isotonic strength (p = .0001) and post-test tensiometer strength (p = .0003). Likewise, a significant difference was found between the MSPIR group and the control group in post-test isotonic strength (p = .0001) and post-test tensiometer strength (p = .0003). There was no significant difference between the MR group and the MSPIR group in either post-test isotonic strength (p = .0770) or post-test tensiometer strength ($p = .9763$). These results support the fact that manual resistance training was as beneficial as MSPIR training in its effects on speed of movement and strength. However, according to the ANCOVA results, there was no significant change between any of the groups in post-test reaction time. Thus, resistance training in either of the two forms tested will not produce significantly faster reaction times.

Concerning the relationshp between pre-test reaction time and strength, neither manual resistance or MSPIR training resulted in a significant correlation between pre-test isotonic strength or pre-test tensiometer strength and reaction time. Furthermore, there existed no significant relationship between pre-test isotonic strength or pre-test tensiometer strength and movement time for either the MR group or the MSPIR group. These results point out that, in untrained college-aged men, there is no significant relationship between strength and reaction time, or strength and movement time.

Correlations between post-test strength and reaction time produced an insignificant relationship between the MR group isotonic strength and reaction time ($p = .297$) and tensiometer strength and reaction time ($p = .152$). Correspondingly, the MSPIR group produced insignificant relationships between post-test isotonic strength and reaction time (p = .362) and post-test tensiometer strength and reaction time (p = .242).

The correlation between post-test isotonic strength and post-test tensiometer strength to movement time also indicated no significant relationship for either the MR group or the MSPIR group. Therefore, no significant relationship existed between strength gained through training by MR or MSPIR and reaction time or movement time.

The pre-test correlation between reaction time and movement time indicated no significant relationship for the MR group (p = .120) and a low, but significant, relationship for the MSPIR group (p = .030). However, interestingly enough, the significant correlation of the MSPIR group vanished after the 10 week training period. Post-test correlation coefficients resulted in insignificant values for both the MR group (p = .114) and the MSPIR group (p = .135). In light of these results, it was concluded that added strength through manual resistance training does not affect the initial relationship between reaction time and movement time. Furthermore, because only the MSPIR group registered a significant pre-test correlation between reaction time and movement time, it was concluded that this occurrence may have been due to chance.

Discussion

To simplify the discussion of the obtained results in relationship to preceding findings in related areas, the following divisions of subheadings were formulated:

1. Relationship between reaction time and movement time.

2. Relationship between strength and movement speed.

3. Effect of strength training on speed of movement.

Relationship Between Reaction Time and Movement Time

This study found a significant correlation between reaction time and movement time in the pre-test results of the MSPIR group ($p = .030$), but not in the MR group ($p = .120$). Concurrently, there were no significant correlations in the post-test results by either group (MR, $p = .114$; MSPIR, $p = .135$). Only the MSPIR pre-test result agrees with the findings of Youngen (73), Westerlund and Tuttle (63), and Magill and Powell (74) that a significant correlation exists between reaction time and movement time. However, Lotter (75), Hodgkins (76), Groves (77), Mendryk (78), and Henry (79, 80) also studied the relationship between reaction time and movement time and found no significant relationship to exist between the two. The MR pre-test and both groups' post-test correlation coefficients results in this study support the conclusions of the latter group of authors. Such contradictory data indicate, as Inomata (71) noted, that some unanswered questions definitely remain in this area.

Relationship Between Strength and Movement Speed

With regard to the relationship between strength and speed of movement, this study produced results similar to the majority of previous studies such as those of Cureton (62), Clarke (82), Henry (83), and Henry and Whitley (84) in that there is no significant relationship between strength and speed of movement in untrained subjects. However, some studies such as those by Lotter (75, 87) and Nelson and Fahrney (88) contradict this conclusion; in fact, their research supports a significant correlation coefficient in the relationship between strength and speed of movement.

Macintosh (81) felt that more research was needed to establish the relationship between strength and limb movement under laboratory conditions. This study added evidence to suggest that there is no significant relationship between strength and movement speed in untrained subjects.

Effect of Strength Training on Speed of Movement

The results of this study indicated that as a consequence of a 10 week weight-training period, the subjects revealed a significantly faster movement time (MR, $p > .0016$; MSPIR, $p > .0090$) but not a significantly faster reaction time (MR, $p > .0868$; MSPIR, $p > .1276$). The results of this study coincide with those of Clarke and Henry (92), Masley, Jairabedian, and Donaldson (94), Smith (98), Colgate (99), Surburg (57), and Chui (100), who also found a significant improvement in speed of a limb movement after strength development by weight training. However, the results of an ANCOVA statistical procedure on the two treatment groups in this study conflict with the findings of Anderson (93), Gottshall (95), and Tweit, Gollnick, and Hearn (97), who claim that reaction time is significantly improved as a result of weight training. Furthermore, Swegan (44) actually professes that weight training slows the subjects' movement speed, but is the only author found who supports this theory.

Macintosh (90) reported that studies dealing with the effect of strength training through the use of weights on speed of movement have yielded confusing results. This study lends credence to the belief that as a result of weight-training, movement time significantly improves, but reaction time does not. It should be further noted that reaction time was not adversely affected after weight training by either group in this study.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Although weight training has become a popular method of increasing the potential for physical performance, two types of fear have deterred the full-scale adoption of weight training programs as an integral part of sport training: (1) a fear that increased strength through weight training may impair the individual's ability to move quickly, and (2) a fear that the amount of time necessary to maintain or increase skeletal muscle strength is not readily available or may detract from other equally important areas at which the time could be spent.

The following is a list of the hypotheses as they appeared in Chapter III. Each hypothesis is followed by the term "rejected" or "accepted," according to the end result of each experiment after statistical treatment.

Hypothesis one: manual resistance training will not significantly affect reaction time. Rejected--significance was calculated at $p > .01$ using the t-test.

Hypothesis two: MSPIR training will not significantly affect reaction time. Rejected--significance was calculated at $p > .012$ using the t-test.

Hypothesis three: manual resistance training will not significantly affect movement time. Rejected--significance was calculated at $p > .000$ using the t-test.

Hypothesis four: MSPIR training will not significantly affect movement time. Rejected--significance was calculated as $p > .000$ using the t-test.

Hypothesis five: the mean strength gain of the three groups will not differ significantly. Rejected--both the MR and the MSPIR groups differed significantly from the control group. However, there was no significant difference between the two treatment groups.

Hypothesis six: the mean reaction time of the three groups will not differ significantly. Accepted for all combinations.

Hypothesis seven: the mean movement time of the three groups will not differ significantly after treatment. Rejected--movement time in both the MR and the MSPIR groups differed significantly from that of the control group. There was no significant difference between the two treatment groups.

Hypothesis eight: there will be no significant relationship between strength and movement time before or after treatment. Accepted for all combinations.

Hypothesis nine: there will be no significant relationship between strength and reaction time before or after treatment. Accepted for all combinations.

Hypothesis ten: there will be no significant relationship between movement time and reaction time before or after treatment. Accepted for pre-test results in the MR group. Rejected for pre-test results in the MSPIR group. Accepted for post-test results in both MR and MSPIR groups.

The results of this 10 week study indicated that although reaction time did not decrease after weight training, no detrimental effect due to the training was observed. Moreover, it was found that movement time significantly decreased after training by both MR and MSPIR training methods. This dispelled the theory that weight training may impede an individual's speed of movement. The fact that speed of movement and strength are not significantly related has already been thoroughly researched. However, this study found that strength increased through weight training can decrease simple movement time if the strength training exercises are closely related and coordinated with the movement desired. Therefore, emphasis should be placed on analyzing the physical activity to be performed by the individual prior to recommending weight training exercises for the enhancement of performance. Many sports and activities utilize different movements by different muscle groups. A strict movement analysis should therefore be the first step in implementing a weight program.

A vast amount of research has been conducted on the effect of weight training on strength. Researchers unanimously agree that virtually any type of resistance training will in some way increase muscle strength. Recent studies involving isotonic weight training exercises in comparison to isometric resistance exercises have revealed significant strength increases in individuals training by isotonic exercises over those training isometrically. However, traditionally all isotonic exercises have employed multiple sets as the training mode. The disadvantage of this training mode is that it is extremely time consuming in the event several muscle groups are to be exercised. Manual resistance, which utilizes a single set for each exercise, can be performed in half the time of the traditional multiple-set exercise. The results of this study indicated that manual resistance training produced nearly identical results as the MSPIR training. This implies that strength gains through manual resistance training can increased at the same rate as mutliple set training, but in a fraction of the time. This discovery could be beneficial to those individuals involved in organized sports, who have but a short period of time to train. Coaches and trainers could greatly benefit from utilizing manual resistance training during the regular season to save time that can be of further use in the meeting rooms or on the practice field. One problem, however, that may occur is the participant's motivation to train at his highest level of intensity. Manual resistance training is extremely strenuous and intense exercise; therefore, the participant must be willing to cope with this intensity during each training bout.

Further studies are needed to determine the effect of manual resistance training on trained athletes. This study used untrained men with no previous weight lifting experience. Therefore, a study is needed to determine whether experienced lifters could equally benefit from manual resistance training.

In addition, it is also recommended that a similar study be conducted using various muscle groups and various exercises to determine if related results apply to all skeletal muscle. It is also recommended that the study span a longer period of time--optimally one year. Not only would this allow for greater changes to take place as a result of the exercise program, but it would also indicate whether any variation or adaptation by the trainees wold occur.

Unfortunately, this study did little to settle the dilemma of reaction time-movement time relationship. Although no significant relationship was found in the pre-test results in the MR group ($p = .120$), the MSPIR group indicated a low but significant relationship between reaction time and movement time ($p = .030$). Moreover, no significant relationship existed in either group after treatment. This only served to add to the current confusion. It is recommended that further studies be performed on various simple movement and reaction time actions on larger groups to ascertain an answer to this problem.

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APPENDIXES

APPENDIX A

SUBJECT PRE- AND POST-TEST

RESULTS BY GROUP

RESULTS FOR C GROUP

SUBJECT	TEST	RT	MT	ISOT	TENS
1 C	PRE	.204	.169	73	70
	POST	.200	.163	72	71
2 C	PRE	.221	.138	90	88
	POST	.217	.141	95	85
3 C	PRE	.206	.171	60	68
	POST	.211	.170	62.5	65
4 C	PRE	.204	.149	70	68
	POST	.202	.150	75	69
5 C	PRE	.225	.146	40	55
	POST	.223	.143	42.5	57
6 C	PRE	.204	.139	77.5	82
	POST	.206	.143	75	83
7 C	PRE	.233	.161	42.5	54
	POST	.230	.150	40	55
8 C	PRE	.215	.164	57.5	57
	POST	.211	.159	60	57
9 C	PRE	.210	.139	75	78
	POST	.104	.137	77.5	79
10 C	PRE	.190	.150	65	70
	POST	.187	.148	65	73
11 C	PRE	.221	.150	67.5	82
	POST	.220	.153	70	85
12 C	PRE	.221	.160	50	61
	POST	.223	.152	50	59
13 C	PRE	.184	.143	55	61
	POST	.193	.136	50	63
14 C	PRE	.220	.127	37.5	50
	POST	.204	.130	40	52
15 C	PRE	.218	.163	62.5	65
	POST	.222	.158	65	63
PRE E			2269	923	980
POST E		30680	2193	949.5	990
PRE $\overline{X}$		.20540	.14860	61.53	65.33
POST $\overline{X}$		.20453	.14620	63.30	66.00

RESULTS FOR MR GROUP

SUBJECT	TEST	RT	MT	ISOT	TENS
1 MR	PRE POST	.210 .217	.170 .145	80 87.5	68 71
2 MR	PRE POST	.211 .207	.152 .123	95 120	91 92
3 MR	PRE POST	.206 .204	.141 .136	62.5 85	76 75
4 MR	PRE POST	.196 .194	.132 .127	75 95	73 78
5 MR	PRE POST	.226 .229	.189 .164	37.5 60	54 59
6 MR	PRE POST	.204 .189	.148 .141	40 52.5	55 62
7 MR	PRE POST	.231 .219	.153 .148	55 90	64 71
8 MR	PRE POST	.207 .196	.131 .129	55 85	73 78
9 MR	PRE POST	.235 .215	.165 .160	65 72.5	67 72
10 MR	PRE POST	.189 .190	.142 .130	35 55	56 62
11 MR	PRE POST	.202 .205	.136 .118	65 72.5	70 73
12 MR	PRE POST	.272 .254	.160 .135	60 77.5	59 64
13 MR	PRE POST	.189 .178	.152 .148	65 77.5	63 77
14 MR	PRE POST	.221 .213	.152 .149	67.5 95	81 85
15 MR	PRE POST	.223 .218	.170 .168	60 85	67 75
PRE Σ		3222	2293	897.5	1023
POST Σ		3128	2121	1195	1083
PRE $\overline{X}$		.21480	.15286	59.83	67.4
POST $\overline{X}$		.20853	.14140	79.33	72.2

RESULTS FOR MSPIR GROUP

SUBJECT	TEST	RT	MT	ISOT	TENS
1 MSPIR	PRE	.216	.166	60	61
	POST	.217	.140	80	62
2 MSPIR	PRE	.213	.151	75	73
	POST	.205	.132	87.5	75
3 MSPIR	PRE	.194	.155	40	56
	POST	.198	.148	62.5	58
4 MSPIR	PRE	.217	.161	65	71
	POST	.198	.155	85	80
5 MSPIR	PRE	.178	.150	77.5	80
	POST	.179	.144	100	91
6 MSPIR	PRE	.226	.164	52.5	57
	POST	.220	.137	80	62
7 MSPIR	PRE	.236	.174	67.5	63
	POST	.239	.166	105	72
8 MSPIR	PRE	.215	.140	50	60
	POST	.208	.135	80	63
9 MSPIR	PRE	.234	.147	52.5	67
	POST	.216	.141	80	75
10 MSPIR	PRE	.206	.171	62.5	78
	POST	.203	.159	100	85
11 MSPIR	PRE	.235	.174	85	77
	POST	.235	.163	105	78
12 MSPIR	PRE	.211	.162	37.5	60
	POST	.207	.155	60	62
13 MSPIR	PRE	.198	.148	70	60
	POST	.185	.145	80	73
14 MSPIR	PRE	.223	.125	65	72
	POST	.212	.120	82.5	73
15 MSPIR	PRE	.184	.140	65	71
	POST	.184	.132	100	74
PRE Σ		3186	2328	965	1026
POST Σ		3106	2172	1327.5	1103
PRE $\bar{X}$		.21240	.15520	64.3	68.4
POST $\bar{X}$		.20706	.14480	88.5	73.53

APPENDIX B

SUBJECT EVALUATION FORM

SUBJECT PRE- AND POST-TEST EVALUATION FORM

NAME: ____________________

GROUP: ____________________

PRERT	POSTRT	PREMT	POSTMT
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
______	______	______	______
Avg. ______	Avg. ______	Avg. ______	Avg. ______

PREISOT	POSTISOT	PRETEN	POSTTEN
______	______	______	______
______	______	______	______
______*	______*	______*	______*

ABSENCES: 1. ______ 2. ______ 3. ______

MAKE-UP: 1. ______ 2. ______ 3. ______

2

VITA

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Doctor of Education

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