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I am submitting herewith a dissertation written by Denise Karen Wood entitled "The Effect of Two Free Weight Training Programs on Selected Closed Motor Skills." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Physical Education.

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THE EFFECT OF TWO FREE WEIGHT TRAINING PROGRAMS ON SELECTED CLOSED MOTOR SKILLS

A Dissertation
Presented for the
Doctor of Education
Degree
The University of Tennessee, Knoxville

Denise Karen Wood

December 1984

To My Parents

Victor and Anna Wood

who have unselfishly guided and supported me
throughout my life and instilled in me
the qualities necessary to fulfill my goals.

ACKNOWLEDGMENTS

To Dr. Patricia Beitel, the chairperson of my committee, who has patiently guided and encouraged me throughout this study. I extend my sincerest appreciation to her for all of her efforts as an outstanding educator, as a willing subject, and as a wonderful friend.

Special thanks is extended to Dr. Craig Wrisberg, Dr. Jean Lewis, Dr. Edward Howley, and Dr. Schuyler Huck for their service as committee members. The combined knowledge and expertise of these dedicated scholars contributed greatly to the study and their interest and support is deeply appreciated.

ABSTRACT

The purpose of this study was to determine which of two types of strength training programs more positively affected the performances of untrained female subjects on selected closed motor skills with motor skill components of speed, strength, coordination, and agility. Two experimental groups trained for 8 weeks executing explosive (n = 10) and non-explosive (n = 9) training tasks with free weights. The groups were pretested and posttested on the: (a) vertical jump, (b) standing broad jump, (c) standing triple jump, (d) 20 yard dash, and (e) the obstacle run.

The Mann-Whitney U Test indicated that the explosive method of training produced significantly better performances on the change scores of the standing broad jump (p = .002) and less significant results on the change scores on the vertical jump (p = .08) and on the standing triple jump (p = .08). Change scores indicated that both groups improved almost equally on the 20 yard dash (p = .27). The explosive group did not improve to a significantly greater degree than the non-explosive group on the obstacle run (p = .14), but did improve somewhat more than the non-explosive group, although improvements were not produced to the extent to which they were on the jumping skills.

It was concluded that explosive weight training exercises with free weights improved performances in the jumping skills. Improvements could be attributed to the positive transfer of learning from performance of the explosive weight training tasks to the jumping tasks due to the nature of the similarity of the movement demands between the tasks.

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CHAPTER I

INTRODUCTION

A limited number of studies have dealt with learning and transfer of learning from strength training programs to motor skills comprised of specific types of movements. The results of several studies (Eliot, 1968; Henry & Whitley, 1958; Laycoe & Marteniuk, 1971) have supported the notion that strength gains involve a learning factor, and that neuromotor patterns are developed specifically according to the type of muscular contraction performed.

Motor learning studies involving task similarity and transfer have shown that the greater the similarity between two tasks in terms of both stimulus and response requirements, the greater the positive transfer between them (Ammons, Ammons, & Morgan, 1958; Gagne, Baker, & Foster, 1950; Leonard, Karnes, Oxendine, & Hesson, 1970). Osgood (1949) diagrammatically attempted to indicate the relationship of stimulus and response compatibility and type of transfer produced. Morgan and King (1966) summarized Osgood's (1949) work and the results of other studies concerning stimulus-response similarity and transfer, and determined that the amount of positive transfer is a function of task similarity. The greater the similarity between two tasks, the greater the amount of transfer. In a study relating strength training to motor skills performance, Garhammer (1979) has shown logically and experimentally that there is similarity between the pull phase of olympic lifts and the vertical jump, as well as between multi-joint extensions in these explosive lifts and the performance of other athletic skills.

Strength training is commonly employed by athletes participating in a variety of sports and activities. Strength training is particularly important in the performance of sports in which coordinated speed and strength are factors which affect the successful completion of tasks (Higgins, 1972). Strength programs used by athletes vary greatly depending upon the type of equipment available and the past experiences of learners/performers and teachers/coaches with particular training regimens (Wood, 1982).

Devising a weight training program to increase strength, speed, and skilled performance in a particular sport is a task for which there are many considerations. Coaches often advocate heavy, slow, purposeful lifting of weights (e.g., back squat, military press, dead lift) in many programs which are designed: (a) to improve speed and strength components; and (b) to apply speed and strength in coordinated movements (Garhammer, 1981; O'Shea, 1976; Riley, 1982). If the specificity of training principle (Osgood, 1949; Henry, 1958) and the transfer of training literature (Ammons, Ammons, & Morgan, 1958; Gagne, Baker,

& Foster, 1950) are correct, then it appears that optimal training with weights would involve a program which offers movement demands similar to the movement demands of a particular sport or training task.

The determination of an effective weight training program necessitates an integration of information concerning: (a) task demands, (b) past experience, and (c) transfer principles. According to the specificity of training principle, the greatest possible benefit (i.e., positive transfer) from a weight training program should be produced by exercises which have the same or similar movement demands (i.e., joint actions and type of action) as the movement demands of the sport activities which are expected to be positively affected by performance of the weight training program. Garhammer (1981) has shown that for athletic performance, free weight training exercises are superior to those exercises performed on machines. Most coaches advocate the use of free weights for strength gains in sports where strength is important in performance. In addition, task transfer specificity (Morgan & King, 1966) is projected to be important to change performance. The present study was designed to determine the relative importance/effect of two types of free weight training programs on the performance of motor skills which have motor skill components of speed, strength, power (i.e., speed and strength), coordination, and agility. If the principles of specificity of training and task transfer are true, then in order to attain the greatest possible benefit from a weight training program, the exercises must have the same or similar movement demands as the movement demands of the sport activities to which they are applied.

Statement of the Problem

This investigation was conducted to determine which of two types of strength training programs (explosive or nonexplosive) more positively affected the performances of untrained female subjects on selected closed motor skills which have movement demands of specified joint action and type of movement and which include the motor skill components of strength, speed, power (i.e., speed and strength), coordination, and/or agility. The selected skills referred to included: (a) standing broad jump, (b) vertical jump, (c) standing triple jump, (d) 20 yard dash, and (e) obstacle run.

Due to the similarity in task demands between the selected closed motor skills and the explosive training tasks, it was hypothesized that the increased motor skill performance of the explosive training group would be significantly greater than that of the non-explosive training group.

Scope of the Study

The data collection occurred from January, 1984, to March, 1984. The 20 subjects were female students and faculty members at the University of Tennessee. The subjects completed questionnaires concerning their participation on varsity sports and any prior weight training experience which they may have had in order to insure that none were specifically trained in any sport or activity (Appendix A). All of the subjects were then asked to sign a consent form indicating their understanding of all risks associated with participation in the study (Appendix B).

Assumptions

The following assumptions were made regarding this study:

1. The measures of motor skill (i.e., broad jump, vertical jump, triple jump, 20 yard dash, obstacle run) are reliable and valid (Scott & French, 1959).

2. The free weights used in the weight training programs were accurately marked.

3. Each person in each group consistently and accurately adhered to the prescribed program.

Limitations

The results of the study are applicable only to:

1. Untrained female subjects ranging from 19 to 45

years of age.

2. Programs employing free weights.

3. Activities in which the selected motor skills used in the study are employed to some extent.

4. The 8 week time period of the study at a frequency of 3 days per week.

5. The specific strength programs used in the study.

Definition of Terms

The following terms used in this study are identified in this section to clarify both the theoretical definition and the operational definition, where appropriate.

Conditioning Period

The conditioning period was the initial phase of the weight training program during which the subject learned the exercises and prepared for heavier training periods. The purpose of the conditioning period was to build some level of training safety into the program in order to prevent injury. Relatively high numbers of repetitions were executed per set, and the weight load was lower than in subsequent training periods. The conditioning period in this study was 3 weeks at 3 days per week with repetitions ranging from 5 to 10 depending upon the demands of the specific exercise upon the whole body (Appendix C).

Free Weights

The free weights were barbells, or olympic bars plus weights, which the performer was required to support and move without restriction or guidance of any apparatus or other person.

Intensive Training Period

The intensive training period in this study was the 3-week training period which followed the conditioning period and the session determining the performer's maximum lift for one repetition. During this period, the amount of weight was constant but greater for each lift, and the number of repetitions was lower for both groups than the number of repetitions executed during the conditioning period.

Motor Skills

A motor skill is a group of simple, natural movements combined in a new or unusual manner to achieve a predetermined objective (Gowitzke & Milner, 1981). The motor skills selected for this study were:

Obstacle run. In this study the obstacle run was taken from the Scott Motor Ability Test with performance time measured to the nearest .1 sec. This test is a well-known measure of speed, strength, coordination, and agility (Scott & French, 1959). The test was considered to require a great deal of coordination and was the only test to require agility on the part of the performer.

Standing broad jump. This motor skill was used to assess speed, strength, and coordination as measured by the performer's ability to project the body in a forward direction. In this study the performer's score was measured to the nearest lower inch (Scott & French, 1959).

Standing triple jump. This motor skill combined a hop, step, and a jump in a coordinated fashion and was used to assess speed, strength, and coordination. In this study, the distance covered was measured to the nearest inch.

Twenty yard dash. The 20 yard dash was a motor skill designed to assess speed, strength, and coordination. The subject was required to run as quickly as possible from one point to another separated by a distance of 20 yards. Measurement in this study was the best of two trials recorded to the nearest .001 sec.

Vertical Jump. This motor skill was used to assess speed, strength and coordination. Performance was measured as the distance to the nearest inch through which the performer displaced herself from a standing position to the maximal height which could be attained by jumping. In this study, the distance recorded was the best of three trials measured to the nearest inch.

Motor Skill Components

Motor skill components are qualities which a performer must possess in order to complete the task of performing a motor skill successfully. The following motor skill components are included in the motor skills used in this study:

Agility. Agility is the ability of the body or parts of the body to change direction rapidly and accurately (Barrow & McGee, 1973). In this study, agility was a component in the performance of the obstacle run.

Coordination. Coordination is the ability of an athlete to control the independent body parts involved in a complex movement pattern and to integrate those parts in a single, smooth, and successful effort at achieving some goal (Singer, 1980). In this study, coordination was a component in the performance of all of the motor skills.

Power. Power is defined as the performance of work per unit time involving the integration of speed and strength (Heusner & Van Huss, 1978). It includes the relative maximal load that can be moved at maximal speed for either low, medium, or high numbers of repetitions (Edington & Edgerton, 1976). In this study, power was required for execution of the explosive lifts (i.e., clean-and-jerk, snatch, speed squat) and for performance of all of the motor skills.

Speed. Speed is the rate at which a body moves from one location to another (Hay, 1978). In this study, speed of movement was a component of all of the motor skills.

Strength. Strength referred to in this study is the maximum load that can be moved throughout a total range of motion. In strength activities, the contractile force is applied to a resistance and maintained for a relatively short period of time (Edington & Edgerton, 1976). In this study, strength was a motor skill component of all of the training tasks and all of the motor skills.

Movement Demands

Movement demands are necessary factors imposed upon a performer in order to effectively execute a skill (Higgins, 1972). In this study, movement demands included: (a) the joint actions necessary to execute a particular training task or motor skill, (b) the type of joint action required for successful execution of a training task or motor skill, (c) the multi-joint actions executed in the proper sequence for performing a training task or motor skill, and (d) the motor skill components required for performance of a training task or motor skill.

Olympic Lifting

Olympic lifting is a competitive sport in which the two lifts executed are the clean-and-jerk and the snatch. Both olympic lifts involve the motor skill components of strength, speed, coordination, flexibility, agility, and a high degree of coordinated technique in order to be successfully and efficiently performed. Garhammer (1979) has shown that to be successful, these lifts require more power on the part of the performer than that required in many other sports. In this study, the olympic lifts were used by the explosive group as part of their lifting program. This required explosive execution of the training tasks with integrated speed and strength and coordinated sequencing of total body joint action.

Power Lifting

This is a competitive sport which involves the execution of the back squat, the dead lift, and the bench press. The lifts are performed slowly when maximum weights are being lifted. Strength is a major factor in the performance of these lifts and the whole body multijoint sequencing and coordination are not present to the extent that they are in olympic lifting. In this study, the back squat and the dead lift were the power lifts used by the non-explosive group.

Recovery

Recovery is a short, non-lifting period of time. During this time, the performer rests in preparation for the next activity. In this study, the performer was allowed the time needed for rotation of the lifters in the group (a minimum of 2 minutes) for recovery between sets and at least 48 hours of rest between training sessions.

Repetition

This is the execution of the entire movement of one exercise performed one time. In general, an exercise done with high repetitions is performed 5 to 12 times and with low repetitions, 1 to 3 times. In this study, high repetition sets were those in which the exercise was performed 10 times. However, as few as 5 repetitions were completed per set in some exercises which required the use of the whole body or which were particularly stressful on the low back. Low repetitions were performed during the sessions determining one repetition with a maximum weight (1RM). In this study, as is generally accepted, medium repetitions of 4 to 6 in number were used in the intensive training period (Stone, O'Bryant, & Garhammer, 1982).

Set

A set is the number of repetitions executed without rest. The number of sets per exercise in this study ranged from 3 to 6 depending upon the exercise and the training period (Appendix C).

Specificity of Training

This concept means that an individual must train in the same manner in which performance is desired. The concept is supported in neuromotor, physiological, and motor learning literature (Kroll, 1974; McCafferty & Horvath, 1979; Fischman, Christina & Vercruyssen, 1982). In this study, explosive lifting movement demands were assumed to be more similar to the movement demands of the selected motor skills in terms of explosiveness, multi-joint sequencing, and speed (Garhammer, 1979).

Strength Training Program

A strength training program is a regimen of training with resistance to provide an overload on the muscles of the body with the intent of gaining strength. In this study, the strength training program was performed using free weights. The two types of strength training programs used were: (a) explosive and (b) non-explosive (Appendix C).

Task Analysis

Task analysis is a procedure designed to determine the nature of underlying abilities important to task performance. The essential idea is to break down the task to consider: (a) what kinds of abilities might be involved

(Schmidt, 1982), and/or (b) the nature of the environmental and/or movement demands (Gentile et al., 1976; Higgins, 1972). For this study, task analysis was an important concept relating the movement demands of the weight training exercises to the movement demands and motor skill components of the selected motor skills. (Appendix D)

Training Tasks

The training tasks used in this study included explosive or non-explosive lifting exercises (Appendix C & D).

Explosive training exercises were performed by one of the experimental groups in this study. They involved the ballistic lifts in which the performer was required to accelerate the weights. The lifts executed by the group using explosive lifting were the clean-and-jerk, the snatch, and the speed squat.

The clean-and-jerk, an olympic lift, involved the execution of two major movements of the bar in an explosive and coordinated fashion until the bar was in an overhead position. The clean phase involved the lifting of the bar from the floor to a racked position upon the shoulders. This phase was executed through multi-joint movements in the proper sequence to bring the weight to the shoulders. The jerk phase of the lift was accomplished by executing a short, rapid knee flexion followed by a rapid splitting of the legs into a lunge or forward stride position. Simultaneous with the lunge, the arms explosively drive the weight into an overhead position. For the purposes of this study, the previous description was used only in determining one maximum repetition. During the conditioning and training periods of the study, one clean was followed by the number of jerks performed in fast repetition as designated by the specific training program (Appendix C & D).

The snatch involved the movement of the bar from the floor to an overhead position by the performer in one explosive, coordinated, continuous upward movement, followed by the lowering of the bar to the floor under control. The grip used for this lift was wider than that used for any other lift.

The speed squat was executed by placing the feet on the floor slightly wider than the width of the shoulders; the bar was supported on the shoulders as the performer slowly lowered the body into a squat position (as in the back squat) until the thighs were parallel to the floor. The performer executed the upward phase of the lift as explosively as possible until the body was fully extended with the body weight on the balls of the feet. This lift was included in the training regimen of the explosive group in order to simulate the back squat with an explosive quality (Appendix C & D).

The non-explosive training exercises included in this study were: (a) back squat, (b) dead lift, (c) military press, (d) lunges, and (e) heel raises. (Appendix C)

The back squat, a competitive power lift, was executed by supporting the weights on the shoulders, slowly flexing, primarily at the hip and knee joints, until the thighs were parallel to the ground, and then slowly extending at the hip and knee joints to return to the original standing position.

The dead lift, a competitive power lift, involved slow and steady lifting of the weight through leg extension from the floor to the height at which the bar rested on the thigh. This movement was performed with the arms continuously fully extended. The performer then extended at the knees and the hips until the body was fully upright. The bar was then lowered to the floor.

The heel raises involved slow and steady plantar flexion of the ankle joint and then a return to the starting position with the free weights supported upon the shoulders. In this study, the feet were on the flat surface of the floor in order to assure a range of motion similar to that performed during the execution of the explosive lifts.

The lunges were performed from an erect position with the bar on the shoulders supported by the hands. A step was taken forward onto one foot using a wide stride, and then the body was lowered slowly until the thigh was horizontal. The performer then returned to a standing position by pushing and stepping back with the forward foot. The next repetition was executed with the opposite leg. This exercise was used in the present study in order to simulate the same joint actions as the repetitive jerks in the clean and jerk but without the speed component (Appendix C & D).

The military press was executed by the subject by slowly moving the bar from the racked position at the shoulders to an overhead position with the arms fully extended, and then slowly returning the bar to the racked position. The lift was used in this study to simulate the arm action in the jerk movement of the clean-and-jerk (Appendix C & D).

Transfer

Transfer is the degree to which the learning or performance of one or more tasks has an influence, either negative or positive, on the learning or acquisition of one or more other tasks (Cratty, 1973). Transfer in this study was measured as the difference (if any) in performance on selected motor skills due to the performance of selected strength training exercises.

Weight Training Program

A weight training program is a regimen of exercises performed with the resistance of weights on the body. It is designed to increase various components of muscular fitness, particularly speed and strength. In this study, the weight training programs (Appendix C) were performed with free weights. This study dealt with explosiveness or non-explosiveness in the weight training movements.

Significance of the Problem

It is difficult for teachers/coaches to design strength training programs which will enhance the performance of specific sport skills. In order to devise a weight training program which can promote optimal results for the performer in a particular sport, information provided by studies concerning task specificity and transfer theory must be considered. The outcome of the present study is expected to provide practical information which could aid teacher/coaches and learner/performers in determining the type of weight training program which will bring optimal results for the performance of specific sports participants while saving time, effort and expense.

CHAPTER II

REVIEW OF LITERATURE

While many studies have focused upon strength training programs, few have dealt with: (a) learning factors involved in weight training or, (b) with influence that movements which are learned in weight training exercises might have on the acquisition/performance of motor skills. The present review of literature encompasses those parameters which deal with strength and the acquisition and performance of motor skills. Specific topics addressed include: (a) weight training and learning factors, (b) neuromuscular aspects of weight training, (c) biomechanical and physiological considerations in weight training, (d) specificity and variability of strength training, and (e) transfer of learning.

Weight Training and Learning Factors

Several studies involving the execution of weight training activities have shown that there is a learning factor in the acquisition of strength. Henry and Whitley (1960) performed experiments on two groups of college men (n = 35 and 30) in which a lateral arm movement of about 90 degrees where a rapid hand movement about 4 feet in length was involved. Movement time, effective arm mass, and the static dynamometric strength of the muscles were measured for each subject. There was no significant correlation between static strength and dynamic strength (the latter computed from arm mass and speed of movement). Henry and Whitley (1960) concluded that strength as ordinarily measured reflects neuromotor coordination rather than the ultimate physiological capacity of the muscle. Thus, it appears that the neuromotor pattern energizing the muscle is different during movement than during simple static tension. Henry and Whitley (1960) have also concluded that static strength and dynamic strength are developed independently of each other. They have asserted that the development of a neuromotor coordination pattern is an important factor to consider in determining the strength of a muscle and that the neuromotor pattern for static strength is different from that required for the development of dynamic strength.

Eliot (1968) supported the conclusions of Henry and Whitley (1960), as reported by Laycoe and Marteniuk (1971). Eliot (1968) found that there was substantial improvement in the performance of three strength tests over 36 trials which could not be accounted for by any factor other than learning. He added that performance on a complex task requiring strength could show considerable improvement from the learning which results from practice of that task.

Laycoe and Marteniuk (1971) concluded that the specificity of strength as found in their research involving static and eccentric strength could have been predicted from the specificity of learning principles of motor skills. They divided 45 subjects into 3 groups of equal numbers and trained the experimental groups three days per week for 6 weeks on either a static or eccentric leg training program. Results indicated that both static and eccentric strength groups produced significant gains in static strength when compared to the control group. The eccentric strength group increased significantly due to eccentric training, but this improvement was unrelated to static strength improvement scores. Other correlations indicated that eccentric and static strength were unrelated in terms of pretraining scores and posttraining scores. Laycoe and Marteniuk (1971) suggested that the "development of a complex neuromotor program is a significant part of task performance involving the application of tension" (p. 305). The development of strength might be considered to develop in a specific way just as motor skill patterns are developed specifically. Laycoe and Marteniuk (1971) concluded that there were at least two factors responsible for increases in strength: (a) the physiological change in the muscles occurring through the inducement of tension, and (b) the development of neuromotor patterns which enable the individual to coordinate the muscles effectively to exert maximum tension. Laycoe and

Marteniuk (1971) suggested that since the neuromotor patterns are specific to the type of contraction performed, it is expected that the ability to produce tension will be specific to the situation in which it is utilized.

Neuromotor Aspects of Weight Training

Kroll (1974) discussed coordination in relation to strength from a neuromotor aspect. He stated that:

> The coordination of agonistic-antagonistic firing sequences is of high importance....The force an agonist muscle group can effectively exert in action can be reduced if the antagonist muscle group fires. The antagonist muscle group can work in opposition to the action of the agonist muscles resulting in less actual force being produced. Strength in action rather than the maximum contractile capability of a single muscle group is determined in a large measure by the agonist-antagonist muscle firing pattern. Even further, the resultant force being produced can be influenced by such factors as the contraction state of the fixator and the synergistic muscles and the firing sequence of several different agonist muscle groups required in the performance (pp. 10-11).

Kroll (1974) then added that such coordination features could be described as "efficient nervous system control of muscular action in the performance of some volitional task. It could also be called skill. Such coordination--or skill--is involved in strength activities" (p. 10).

Kroll (1974) further discussed weightlifting as a skill involving strength and cited a study by Cerquiglini, Figura, Marchetti, and Salleo (1973) which demonstrated that the EMG firing pattern of champion weightlifters was distinctive when compared to that of untrained or less skilled lifters. They also found that the upward velocity of the barbell was very similar for the best lifters even though different forces were applied to the barbell at different joint angles. These findings are consistent with those of Zajaczowska (1962) who found that as skill in lifting a 10 kg weight developed, a shift occurred from a constant acceleration of the weight to a constant velocity. Velocity in the initial and final phases of the movement was gradually raised to match peak velocity. Based on these findings Kroll (1974) has suggested that changes in strength performance may be accomplished either wholly or in part by neuromotor mechanisms.

Kroll (1974) also has contended that synchronized EMG patterns are best suited for strength activities. Such a notion has received recent support from work by Stepanov and Burlakov (1961) who reported that trained weightlifters demonstrated synchronized EMG patterns even when lifting a load as light as 10% of maximum. Even at light loads, these weight trainers exhibited the type of EMG pattern most efficient for lifting heavy weights.

Biomechanical and Physiological Considerations in Weight Training

Garhammer (1981) has discussed the application of weight training to skilled performance in athletic events.

He has noted that the use of free weights requires the involvement of the whole body, the maintenance of balance, and the coordination of many major muscle groups during the execution of an exercise. The involvement of multiple joints and their controlling muscles during the weight training movements is similar to the control of the body during athletic events. Garhammer (1981) thus contends that free standing total body lifts result in the training of one's neuromuscular system and that such training transfers to the neuromuscular demands of athletic competition. For example, Garhammer's (1979) work in cinematographical and force plate techniques revealed great similarity between the "double knee bend pull" and the vertical jump. Garhammer (1979) therefore suggested that the clean should be used for the enhancement of shotputting and jump-related activities due to the respective similarities in training exercises and these movements.

Stone (1981) investigated the use of free weights, not only from the basis of neuromuscular development, but also from that of mechanical specificity. He contended that since many strength exercises are similar to athletic performances, motor unit firing patterns can be simulated closely, particularly with free weights. Possible reasons for such carryover of weight training to sport performance may be due to: (a) the pattern of firing being enhanced or stabilized, (b) the activation of more motor units, or (c) an increased firing rate of motor units.

Power output is another factor bearing on the relationship of weight training to athletic performance. Stone (1981) has cited a number of research studies which have shown that both high force and high speed exercises recruit fast twitch fibers (Burke & Edgerton, 1975; Edgerton, 1976; Edgerton, 1978; Komi, 1979; Maton, 1976; Prince, et al., 1976; Spectar, et al., 1980). He has also noted that some authors recommend purposeful slow movements (Allman, 1976; Darden 1975; Jesse, 1977; Nautilus Instruction Manual, 1980). Slow, purposeful movements reduce the intensity (power output) and the training effect (Edington & Edgerton, 1976; Stone & Garhammer, 1981). A reduced training effect due to slow lifting movements results from the reduced motor unit recruitment which is caused by a reduction in the number of active fast twitch motor units. The fast twitch motor units used for high level strength and power performance may therefore not be trained effectively by slow lifting. The lower force output may also reduce the need to increase the frequency of motor unit firing and possibly the synchronization of firing.

Stone (1981) suggested that while slow, purposeful lifting may positively affect power output, high power exercises will optimize and bring about peak high power performance. Garhammer (1980b), using high speed cinematography, filmed the maximum snatch and the maximum clean and jerk lifts of olympic lifters of national and international caliber for a period of years. He found that the greater power output by each lifter occurred when the heaviest weight was lifted. The time required by each lifter to complete these lifts was nearly identical regardless of the weightload lifted, suggesting that the primary differentiating factor between the clean and jerk and the snatch lifts and the power output was strength. Similar results were found for the maximum squat lifts of world caliber power lifters (Stone, 1981). Stone and Garhammer (1981) concluded that lifting a heavy weight as fast as possible produces a training effect of greater: (a) force, (b) power output, and (c) increased power for movement under heavier resistance. Garhammer (1980a, 1980b) added that olympic style lifters have been shown to produce the highest power output of any human performers measured to date.

Specificity and Variability of Strength Training

Physiologically, the concept of specificity has received considerable attention. According to Edington and Edgerton (1976) the specificity of training theory holds that training adaptations are specific to training methods. This suggests that an individual should train in the same manner as that required in the performance of a particular task. Edington and Edgerton (1976) added that the effects of training are specific to the type of overload which is placed upon the muscles during training.

McCafferty & Horvath (1979) also concluded that training effects are task specific, even at the subcellular level. They found that training for endurance and training for strength or power events resulted in different adaptations within the cells. The adaptations made by the body from high tension, low repetition activities such as weight lifting are apparently different from those resulting from low-tension, high-repetition activities. McCafferty and Horvath (1979) maintained that training must be specific to an event in order to stress the energy sources needed for that activity. They also contended that adaptation was dependent upon: (a) the type, (b) the intensity and duration, and (c) the recovery time of the exercise (McCafferty & Horvath, 1979).

Garhammer (1980a) agreed with the implications of the concept of specificity of training, but he contended that the notion of total specificity is pragmatically unacceptable due to the need for variability in an exercise program. Just as distance runners train at varying distances, weight lifters also train at varying weight loads, often between 75% and 85% of maximum in order to reach new maximum efforts. He projected that lack of variation would lead to stagnation, overtraining, and decreased performance. Garhammer (1981) stated that neuromuscular similarities between the major free weight training exercises and the neuromuscular demands of athletic movements allowed transfer of strength and permitted the use of a variety of exercises.

Transfer of Learning

The concept of transfer of learning has been mentioned previously in this review, but not from the perspective of motor behavior research. Transfer may be defined as the influence of previously acquired skills on the performance of new skills (Schmidt, 1975). In the case of strength training programs and their effect on motor skills, maximum positive transfer, or facilitation of performance on a selected motor skill, is the desired outcome.

An important consideration in the transfer of training is task similarity of the skills in question. Research has shown that the greater the similarity between two tasks in terms of both stimulus and response requirements, the greater the positive transfer.

Osgood (1949) has proposed a theoretical transfer surface indicating that the amount and direction of transfer depends upon the similarity of stimuli and/or responses in the learning and transfer tasks. Based upon research data, he suggested certain advantages: (a) the theoretical transfer surface may be applied in practice;

(b) an integration of problems encountered in the understanding of human learning is offered as far as the similarity variable is concerned, (c) the theory allows prediction of performance based on empirical evidence, and (d) the theory resolves the fundamental paradox that ordinary learning becomes theoretically feasible (Osgood, 1949).

Ammons, Ammons, and Morgan (1958) investigated the effects of differences in the speed requirements of two tasks on intertask transfer. Using 4 different speeds on the rotary pursuit task, 16 different combinations of speeds were presented under 3 different conditions of distribution of practice to 48 subgroups with 4 subjects in each subgroup. It was found that the greater the speed of the task, the poorer the performance. However, when movement rate of the final task was equal to or lower than that of the training tasks, transfer from the practice tasks to the final task was greater.

Gagne, Baker, and Foster (1959) examined the concept of task similarity as it applied to the transfer of training between two motor skills requiring the acquisition of two or more discriminative habits involving manual responses to the presentation of various light stimuli. They proposed that transfer between such tasks may be best understood in terms of the similarity among the stimuli and among the responses within each of the tasks to be learned, rather than between the elements of the first and second tasks. Four types of alterations were: (a) making the stimuli of the second task more alike than those of the first task, (b) making the stimuli of the second task less alike than those of the first, (c) displacing the stimuli of the second task, relative to those of the first task, in the same direction along a scale of similarity, and (d) reversing the stimulus-response relationships of the second task in relation to what they were in the first task. The results showed:

1. When the stimuli within tasks were more similar, positive transfer occurred and decreased with increased similarity among the stimuli within the second task.

2. Positive transfer occurred when stimuli of the second learning task were less similar to each other than those of the first task and transfer decreased as similarity among stimuli of the second task decreased.

3. Transfer decreased with increased displacement of stimuli to the second task from the first task. With the use of the concept of the gradient of generalization, conceived as applicable to both stimulus and response, the results of each of these alterations were related by hypotheses to positive and negative transfer effects (Gagne, Baker, & Foster, 1959). Taken together, the results suggest the importance of task similarity for positive transfer between tasks.

Leonard, Karnes, Oxendine, and Hesson (1970) studied the effects of five levels of training task difficulty on transfer performance using a pursuit-rotor tracking task. Five groups of 15 subjects practiced 45 30-sec. trials at each of the levels of difficulty and, 48 hrs. later, all practiced at 45 rpm. The results showed that the performance of the extreme transfer groups (those practicing at 30 and 60 rpm's) was significantly poorer than that of the central transfer groups (those practicing at 40, 45, and 50 rpm's) on the first five trials of the second session. However, after 9 blocks of 5 trials at 45 rpm, performance was not significantly different.

Morgan and King (1966) have summarized the major points concerning stimulus-response similarity and transfer. They suggested that: (a) learning to make identical responses to new stimuli results in positive transfer, (b) the amount of transfer is a function of stimulus similarity, and (c) amount of transfer (positive or negative) is largely dependent upon response similarity between training and transfer tasks.

Because of the similarities shown in cinematographic films by Garhammer (1979) between the pull phase of the olympic lifts and the vertical jump and between the multijoint extensions in these lifts and other athletic performances, the concept of task similarity and transfer for motor learning appear to hold.

Taken together, the research results reviewed in this chapter suggest that movements executed in performance of the explosive weight training tasks would be expected to transfer to similar movements of the motor skills. Theoretically, there is a strong rationale for the execution of explosive weight training movements for improvement of performance upon motor skills involving similar motor skill components and task demands.

CHAPTER III

PROCEDURES

The purpose of this study was to determine the relative effects of two types of free weight training programs on the performance of selected motor skills. The relative effect of the degree of explosiveness or non-explosiveness of training exercises on motor skill performance was investigated. Two experimental groups were formed. No control group was used, since the purpose of the study was to determine the relative effectiveness of weight training programs. Contrasts were made between the training effects of slow, purposeful, non-explosive lifting movements and explosive lifting movements. The conditions were as equal as possible in terms of the movements being executed in a practically implemented program, although the weights were moved at different speeds. It was necessary for the non-explosive group to execute more exercises because the group using the explosive exercises using more muscle groups per exercise. If the joint actions in both groups were to be similar, the addition of extra exercises with limited (i.e., non-explosive) movements was necessary.

The procedures followed in this research study included three major sections: (a) design of the study, (b) collection of the data, and (c) analysis of the data. Each section is presented separately in this chapter.

Design of the Study

The design of the study included: (a) selection of the sample, (b) controls, (c) schedule of the study, (d) rationale for the selection of the motor skills and training tasks, (e) identification and specification of the motor skills, (f) identification and specification of the training tasks, (g) procedures for the determination of one repetition maximum, (h) training the test administrators.

Selection of the Sample

The subjects were either female students or female faculty members at the University of Tennessee. The women had little or no weight training experience with free weights. They were neither athletes, persons specifically trained in any sport, nor current members of a varsity team. Random assignment with stratification by obstacle run skill assured that the groups were not different. Each subject was fully informed of the activities and nature of the study and a questionnaire (Appendix A) and consent form (Appendix B) were completed by each subject. Proper safety procedures were maintained and an explanation of any risks was presented to the subjects. Questionnaires were filled out by subjects to determine the nature and extent of their prior weight training experiences and whether any subject was unsuitable for the study.

The questionnaire provided information concerning any orthopedic problems which a subject may have had (Appendix A).

Controls

The following controls were used in the study in order to assure consistency in administration.

1. Each subject was given an individualized program to follow with the specific exercises, number of sets, number of repetitions, and amount of weight lifted.

2. All subjects recorded the date in the appropriate block allotted on the program which served as an attendance record.

3. Subjects were asked not to practice the motor skills during the study.

4. Subjects were asked not to practice any of the weight training exercises outside of the training sessions.

5. Subjects were asked not to discuss their specific programs with subjects not in their group.

6. Subjects were asked: (a) not to change any other activities in which they normally engaged, nor (b) add any activities which they did not participate in prior to the beginning of the study.

7. Subjects were monitored for accuracy of technique and corrected if necessary during the training sessions.

8. The data were collected by the test administrators and no performance feedback was presented to subjects before the posttest.

Schedule of the Study

The study was conducted over an 8-week period with 3 training days per week. The activities which occurred during the study are described in this section.

Warmup occurred prior to the actual testing period and prior to all of the training sessions. During the first session, each subject was tested on the five motor skills. After testing was completed, the subjects were assigned to one of the two experimental conditions with stratification by performance in the obstacle run and by age. The two fastest times were randomly assigned, one to each group. Similarly, one of each of the next two fastest times was assigned to each group, and so forth until all subjects were assigned to the groups. The groups were then tested for statistical differences on all dependent variables and on age and were found not to be different ($p \leq .05$).

Prior to a conditioning period, two sessions were conducted in order for the subjects to learn the proper lifting techniques and to become familiar with the exercise programs so that they could be performed with some level of proficiency during the conditioning period (Appendix C). Instruction continued throughout the study so that proper lifting technique and coordination could be maximized for each subject. Each subject was given a copy of the program she was to follow and each subject recorded the amount of weight she lifted for each exercise. Each subject was asked to meet at the designated training time assigned to her experimental group. Each session lasted for about one hour. The non-explosive group met for the first hour and the explosive group met for the second hour.

During the first three weeks of training the subjects trained according to the schedule of the conditioning program in order to learn the lifting exercises and to gain strength and avoid injury. The conditioning program involved a relatively high repetition phase with low weight loads. During this time, the subjects had to approximate the prescribed percentages of weight being lifted, since attempting one repetition maximum (1RM) was not feasible at this time.

When the conditioning program was completed, all of the subjects determined 1RM for the specified training exercises. Two class periods were allotted for this procedure. The non-explosive group determined 1RM for the back squat, the dead lift, and the military press. The explosive group determined 1RM for the clean and jerk the snatch and the back squat. The determination of 1RM allowed greater control and accuracy over the amount of weight being lifted, affording greater control over the intensity of the weight load being lifted by each subject during the intensive training program.

The next three week period consisted of the intensive training program which involved greater weight loads and lower repetitions in order to simulate a program which would be followed after an initial conditioning period used by athletes. This training program was expected to promote greater strength gains and improve performance of the lifting exercises. Following the three week intensive training program, the subjects again attempted 1RM for the same lifts as they did after the conditioning program.

The groups trained three days per week so that subjects had time to recover between training sessions. Recovery time between sets was allotted so that the subjects were rested before the execution of the next set of any exercise. Rotation of subjects at a station allowed recovery time between sets for each subject. During this rest time, subjects rotated use of the bar and changed the weights for each other.

The final session was used to administer the posttest on the selected motor skills. The same procedures that were followed in administering the pretest to the subjects were followed in administering the posttest.

Rationale for the Selection of the Motor Skills and Training Tasks

Motor skills. The motor skills were selected for this study because they were closed sport tasks which required the subject to demonstrate some degree of proficiency in one or more of the following motor skill components: (a) strength, (b) speed, (c) coordination, and/or (d) agility. Performance of the motor skills had: (a) similar explosive movement demands of the joints, (b) similar types of joint actions in the proper sequence, and (c) some similar and some different motor skill components (Appendix D). The broad jump and the vertical jump were considered to require less coordination than the other skills due to the limited time required for movement and to the symmetrical body actions. More coordination was required to perform the triple jump than to perform the broad jump and the vertical jump due to the sequencing of body movements over a longer period of time. However, all three tasks required speed and strength for performance. The 20 yard dash required speed of movement and strength with coordination within a short distance. The obstacle run required the greatest degree of coordination and agility as well as containing the components of speed and strength. For these reasons it was considered to be the most complex of the selected motor skills.

<u>Training tasks</u>. The explosive and non-explosive exercises were closed motor tasks, as were the selected motor skills. The non-explosive exercises involved the same joint movements of the lower body (i.e., ankle, knee, and hip joint movements) and of the upper body (i.e., the shoulder joint, shoulder girdle, elbow, and wrist joint movements) as the explosive exercises did; but they were executed more slowly. The explosive exercises included more joint movements in a coordinated sequence than did the non-explosive exercises (Appendix D).

The weight training exercises were chosen because the lower body joint movement demands were similar to those of the motor skills (Appendix D). The training tasks involved the same muscle groups used in many sport movements, particularly those for which leg speed, strength, agility, and coordination are factors. The weight training tasks also required patterns of joint movements similar to those involved in the execution of the motor skills.

The back squat, the dead lift, and the heel raise required the performer to execute joint actions of the hip, knee, and ankle joints similar to those required for execution of the broad jump and the vertical jump; although the explosive factor was not present in the training tasks (Appendix D). These lifts also required the same joint actions as those required for executing the triple jump, the 20 yard dash, and the obstacle run; the primary difference being that the motor skills required alternate leg action while the lifts demanded simultaneous leg action.

The lunge and repeated jerks offered similar joint actions and alternate leg action as that used in the triple jump, 20 yard dash, and obstacle run. In addition, the rapid alternating action of the legs during execution of the jerks further simulated the alternating action of the legs in the triple jump, the 20 yard dash, and the obstacle run and also required the coordination of the arm action in conjunction with the action of the legs. These training movements, however, were performed slowly rather than in the explosive fashion they would be performed in executing the motor skills.

The clean-and-jerk, the snatch, and the speed squats required the same joint actions of the hip, knee, and ankle joints as used in the performance of the motor skills. The coordinated explosiveness required for the successful performance of these three exercises was also important for the successful performance of the motor skills.

The exercises executed by each group in this study were designed to be as equal as possible in the number of joint movements so that the speed of sequencing of movements was the only difference between the training exercises for the non-explosive and explosive groups. The clean phase of the clean-and-jerk and the pull phase of the snatch executed by the explosive group were represented in the non-explosive group by the execution of the dead lift and the heel raise. The jerk phase of the clean-and-jerk executed by the explosive group was represented in the non-explosive group through performance of the military press and the lunge. The speed squats executed by the explosive group were simulated by the non-explosive group through the execution of the back squat and the heel raise. The explosive group performed fewer exercises than the non-explosive group because more joint actions were executed per exercise by the explosive group. Thus, if there were significant effects for the improvement upon the performance of the motor skills on the posttest, they could be attributed to the difference in the speed and sequencing of coordinated movements in the performance of the non-explosive and explosive training tasks and not to the number of exercises or to the amount of weight lifted.

Identification and Specification of the Motor Skills

An explanation and demonstration of each of the jumping skills (i.e., broad jump, vertical jump, and triple jump) were given to the subjects as a group. The subjects were then divided into three groups and assigned to a station where they practiced the jumping skill which was being administered at that site. Practice was designed to allow a specific warmup opportunity for each individual. The rationale for the practice of the skills was to allow each individual time to learn to perform each skill effectively before testing began. Subjects practiced the skills in an area near the testing station until each felt ready to perform each skill with a maximal effort for the test. After the first jumping skill was performed, each subject moved in the specified rotation until all of the subjects completed all of the jumping skills. The order in which they performed the skills was recorded on the score sheet which was carried by each subject as she rotated through the stations so that the same order was maintained during the posttest.

After all 3 of the jumping tests were completed, all subjects moved to the 20 yard dash station where the test was explained and demonstrated. Subjects practiced this test by performing short sprints until they felt ready to be tested but were not too fatigued to put forth a maximum effort. At least two minutes of rest was allowed between trials and the subjects were tested in the same order for each trial. Warmup between the trials was allowed if any subject felt it was necessary in order to make a maximal effort for the second trial.

After the 20 yard dash testing was completed, all of the subjects moved to the obstacle run. No warmup was allowed for any of the subjects so that it was a new task for all subjects. It was also assumed that subjects had warmed up by this point in the testing, and practice would have increased the time between tests. Fatigue could also have become a factor for some subjects if warmup were allowed. After completion of all of the tests, the subjects were asked to meet for the next class session and were assigned to groups to learn the weight training tasks.

The motor skills administered were:

1. Vertical jump. Each subject was allowed three trials. The subject stood next to a wall and touched the wall as high as possible without stretching or leaving the ground, leaving a chalk mark on the wall with the fingers. After re-chalking the fingers, the subject took three trial jumps touching the wall as high as possible on each trial. Each jump was measured to the nearest lower half-inch by the test administrator. As much rest as was desired by the subject was allowed between trials. The subject was not allowed any steps before taking the jump, and the take-off was from both feet simultaneously. Measurement was taken from the highest points of the chalk marks which the subject made from both the standing position and from the jump. The best score of the three trials was the dependent measure.

2. Standing broad jump. Each subject was allowed

three trials in succession with as much rest as was desired by the subject between trials. The toes had to be behind the designated starting point upon takeoff (which was performed from both feet simultaneously). Measurement was made with a tape measure to the nearest lower half-inch as taken from the back of the restraining line to the back of the closer heel in the landing area. The best of the three trials was the subject's score for this task (Scott & French, 1959).

3. Standing triple jump. The subject was allowed three trial jumps, the best of the three being used as the score. The subject stood with the preferred foot at the starting point with the other foot in a backward stride position a comfortable distance behind the forward foot. The subject was permitted to shift the body weight toward the back foot prior to takeoff provided the forward foot did not leave the initial position at the starting line. After takeoff, the subject projected herself forward as far as possible, landing on the same foot from which she took off at the starting point (hop). The next phase of the task required that the subject: (a) leave the same foot upon which she just had landed, and (b) project herself as far forward as possible, landing upon the opposite foot (step). From this foot she projected herself forward and landed on both feet (jump) to complete the task. The distance between the back point at which her feet landed

and the back of the restraining line was measured. The distance was measured to the nearest lower inch on the tape measure.

4. 20 yard dash. Two mats were placed 20 yards apart, each stimulated by pressure. Each subject was allowed two trials to run the 20 yards from a standing position (the first step taken was on the first mat which started the timing device). The subject ran as fast as possible to the second mat which was 20 yards away. An automatic performance analyzer was used to record time (between the first and second mat) to the nearest thousandth of a second. The faster time of the two trials was used to represent the 20 yard dash performance. Each subject rested as long as desired, understanding that she should be warmed up but not tired in order to attain a maximum performance.

5. Obstacle run. Each subject was allowed only one trial on the obstacle run. A stopwatch was used as the measuring instrument; the performance time was recorded to the nearest .1 sec. This test was identical to the first test item in the Scott Motor Ability Test (Scott & French, 1959) (Appendix F). The subject began by lying on her back with her heels touching the starting line. On the command "go", she rose to her feet and ran as rapidly as possible toward a pole 35 ft away while putting both feet in each of 3 squares 10 ft apart on the way. She then

circled the pole one complete time and proceeded to a crossbar, crawling under it. After getting to her feet from under the crossbar, she ran to a line on the floor and shuttled back and forth between that line and another line 15 ft away until the farther line from the crossbar was reached 3 times.

Identification and Specification the Training Tasks

During the first two sessions of the research study after the motor skill testing, subjects were taught how to execute the appropriate lifts to be performed throughout the training program. The non-explosive group was taught to perform the back squat, the dead lift, the military press, lunges, and heel raises. The explosive group was taught to perform the clean and jerk, the snatch, and the speed squat.

The non-explosive group performed the following 5 exercises.

1. Back squat. The weights were placed on the shoulders of the subject behind the neck and were supported by the hands. The subject's feet were placed slightly wider than the shoulders and pointed outward slightly. The subject looked straight ahead as she slowly and steadily bent the knees and flexed the hips until the thighs were parallel to the ground. She then extended at the knees and hips until she resumed a standing position. She was

instructed to move at a controlled speed without bouncing up from the lowest position. The subject had to experiment with the weight loads to find a weight which she could successfully squat ten times. It was suggested that she begin with just the bar and raise the weight until she felt that there was some resistance but that she could execute ten repetitions successfully. Other subjects at the station were present and ready to spot in case the performer lost her balance or the weight was too heavy. The expertise of the researcher was used to help each subject determine this weight.

2. Dead lift. Each subject was instructed to step close enough to the bar so that her feet were under it and it was next to her shins as she squatted down to pick it up. She was asked to squat down to reach the bar using an alternate grip (one hand pronated, the other supinated) with the arms outside the knees. It was emphasized that the back be very flat and that the subject look straight ahead. Keeping the bar very close to the body, the subject was instructed to stand up with the weight until she was in a fully upright standing position. She then lowered the weight to the floor in the same manner as she stood up with it, moving at a controlled pace. The subject was then told that she must be able to perform five repetitions in succession without stopping. The expertise of the researcher was used to help subjects determine this

weight. The number of required repetitions to be performed in the dead lift was less than in the other training tasks due to the stress which the task placed upon the body, particularly upon the lower back. Weight belts were utilized to aid in back support.

3. Military press. Each subject was instructed to use a pronated grip on the bar with the hands placed just outside the shoulders, the palms facing upward. The weights were slowly and steadily raised from the shoulders in front of the neck to an overhead position until the arms were completely extended. The weights were then returned slowly and steadily to the original position on the shoulders. Throughout the exercise, the weights were moved at a controlled rate. The subjects determined a weight which they could lift ten times, but which offered some resistance. The expertise of the researcher was used to help subjects determine this weight.

4. Lunges. Each subject was instructed to support the weights on the back of the shoulders with the hands on the bar. The subject took a step forward onto one leg in a wide stride position and lowered the body slowly and steadily until the forward thigh was parallel to the ground. After reaching this position, the bent leg was extended until the subject resumed a normal standing position. The upper body was held erect at all times. The movement was repeated with the opposite leg forward and

the exercise was continued until a total of eight repetitions were executed (four repetitions on each leg alternately). The weight was light enough for the subject to execute the movement successfully without great stress, but offered some resistance. The subjects were told that they must choose a weight with which they could successfully execute the exercise a total of ten times (five times on each leg alternately). The expertise of the researcher was used to help subjects determine this weight.

5. Heel raises. Subjects were instructed to support the bar on the shoulders with the additional support of the hands. The subject raised the heels as high as possible and then lowered them back to the floor at a controlled rate. No bouncing was permitted in this exercise. The weight offered resistance but not so much that the subject was fatigued. Subjects were asked to determine a weight which they could successfully lift ten times. The expertise of the researcher was used to help subjects determine this weight.

The explosive group performed the following 3 exercises.

1. Clean-and-jerk. The clean phase of this exercise was taught to the subject by first having the subject hold only the bar while standing in an upright position with the bar at arms length overhead using. A grip was used

which placed the hands at a distance slightly wider than the shoulders. The subject was asked to shrug the shoulders at the same time as she lifted her heels. This action promoted the movement of the entire body and prevented the use of the arms prematurely. When the desired position was observable, the bar was brought to a lower point on the legs nearer the knees, allowing a longer range of motion through which to move, and the subject continued to coordinate the shrug with the heel raise action while keeping the bar against the body. The bar was next lowered to the mid-shin area, allowing an even longer range of motion as well as the potential for more acceleration. At this point the subject again completed a coordinated shrug and heel raise with the bar remaining close to the body. After this movement was accomplished satisfactorily, the subject was asked to execute the movement with the addition of bringing the bar to the shoulders after the shrug was completed. The bar was then brought from the mid-shins to the shoulders in one coordinated movement.

After the clean was learned successfully, the jerk phase of the lift was presented to the subject. When the bar was on the shoulders, the subject was asked to move quickly into a forward stride position and simultaneously to quickly move the weights to an overhead position. The subject then assumed a lunge position under the weight and re-supported the bar overhead. After this position was attained with the majority of the body weight distributed toward the forward leg, the feet were brought back to the original standing position while the bar and weights were brought back to the shoulders. Timing was the primary consideration. Once the timing was executed correctly, the subject worked to attain that same coordination at a faster speed. The exercise was performed with one clean followed by six jerks in repetition. The expertise of the researcher was used to help subjects determine this weight.

2. Snatch. The subjects were taught to accomplish the pull phase and the full body extension of the snatch through the same procedure as they were taught these movements of the clean and jerk, although the bar ultimately reaches an overhead position in one continuous motion. Again, the bar was held at arms length against the body. The grip in this case, however, was much wider than the grip which was used in the clean. The grip was wide enough to firmly support the bar and also allow the shortest possible distance from the bar to the floor when the bar was supported in the overhead position. The most effective grip for each individual was determined by trial and error after several attempts at the whole exercise. The subject repeated the procedure used in learning the clean by progressively lowering the bar against the body

and raising it with the arms extended until coordinated movements were learned and proper technique was developed. The subject was then instructed to bring the bar from the mid-shin area to an overhead position after executing an accelerated full body extension. The bar was lowered from overhead by bringing it back to the hip area and then to the floor. Since beginners tend to pull with the arms prematurely, emphasis was placed upon body extension. The subjects were then asked to determine a weight which they could lift successfully for five repetitions. The expertise of the researcher was used to help subjects determine this weight.

3. Speed squat. The speed squat was taught in the same way as the back squat. The only difference was the rate at which the bar was raised as the subject moved from the lowest position to the original standing position. The grip, foot placement, and body actions were identical to those in the back squat. After the thighs were parallel to the floor, the subject accelerated the weight as rapidly as possible and continued the upward action through plantar flexion until the subject was well up on the balls of the feet. The subject was instructed not to leave the ground but to raise the heels as high and as explosively as possible. The weight load used for this exercise was intended to be lighter than the weight load used for the back squat. A weight load could not be accur-

ately determined for this lift until the first attempt at 1RM was made after the three week conditioning program. The subject was asked to determine a weight which she could successfully lift for 6 repetitions of this exercise. The expertise of the researcher was used to help determine this weight.

<u>Procedure for the Determination of One Repetition Maximum</u>

After the three week conditioning program was completed, the next two class sessions were used to determine the maximum weight subjects could lift for one repetition (1RM) so that more accurate weight loads could be lifted throughout the intensive training period to follow. (Appendix E)

The subjects were instructed to warm up with the weight loads which they used during the conditioning program. The objective for attaining the maximum weight was to be warmed up but not to be tired by the time a heavy weight load was introduced. A great deal of trial and error was expected for the first attempt at 1RM since the subjects had no idea what they could lift until they actually tried. If an attempt was successful and easy for the subject, the researcher suggested that the next weight attempted be a greater increase in weight than if the attempt was difficult. Each subject recorded the maximum weight load which they successfully executed for each of the designated lifts. Percentages of 1RM were calculated to determine the weight loads which subjects used during the intensive training period.

For the non-explosive group 1RM was determined for the back squat, the dead lift, and the military press. It was not practical to determine 1RM for the lunge or for the heel raises because it is difficult to define 1RM in terms of the range of motion involved. There was also a safety factor to consider in executing the lunge with a maximum load, since a heavy weight load could have caused the subjects to fall forward or lose balance. The subjects were asked to determine a new weight load for these training exercises by chosing a weight which they could successfully lift for the required number of repetitions but which offered them a good deal of resistance.

The explosive group attempted 1RM for the clean and jerk, the snatch, and the back squat. The subject executed one clean and one jerk only. This required that the subject remain in the split position when the jerk was executed and temporarily balance the weight overhead. After stability was attained, the subject pushed backward from the front leg and then forward from the back leg until both feet were together. The bar was then lowered to the shoulders, then to the hips, and then to the floor. The back squat was executed instead of the speed squat so that the maximum amount of weight which could be lifted by the subjects could be determined. A lower percentage of the maximum weight lifted was used for determining the new training weight for the speed squat than the percentage used for determining the new training weight used for the back squat. It should also be noted that as weight load increases in a speed squat, speed of execution slows down. Thus, defining a maximum repetition for the speed squat was not possible through the performance of the speed squat itself since actual speed could not be measured and a criterion could not be attained which would constitute one maximum repetition for that lift.

Training the Test Administrators

The data were collected by a team of 4 test administrators. The test administrators included the principal investigator and 3 trained female undergraduate students at the University of Tennessee who were members of the track and field team and who have had experience in measuring and recording identical and/or similar test items. Each of the student investigators was responsible for the administration of a jumping test and was supervised by the principal investigator. Each received an instruction sheet for her testing station (Appendix F) and had the opportunity to administer the test in practice before the actual testing of subjects began. The administrators also practiced as subjects for the tests they administered so that they understood: (a) what the subjects would experience, and (b) any problems which might arise.

In addition to the specific jump test for which each administrator was responsible, she also assisted the principal investigator in administering the 20 yard dash and the obstacle run. Each administrator aided the principal investigator in setting up the test stations prior to the testing and served as a practice subject to insure the efficient operation of the equipment (i.e., the Automatic Performance Analyzer, stopwatches, etc.), and the proper specifications for the placement of objects for the obstacle run. The principal investigator operated the timing devices during both of these tests, while an assistant recorded the scores of the trials. The test administrators were also available to assist subjects with questions about the testing and to bring any concerns to the attention of the principal investigator.

Collection of the Data

The data collected in this study were gathered by the principal investigator and three test administrators. The data consisted of the pretest and posttest scores on each of the five motor skill tests. Conditions during data collection were as controlled as possible (see p. 34) so that any extraneous variables were kept to a minimum.

Analysis of the Data

Subjects were assigned to groups through randomization with stratification based upon pretest performance on the obstacle run. MANOVA procedures applied to the pretest data determined that the groups were not significantly different ($\underline{p} \leq .05$) with regard to motor skill performance and age. Correlation coefficients were used to determine significant relationships among the dependent variables and between each dependent variable and age. Due to the small size of the sample, the Mann-Whitney $\underline{U}$ Test was used to analyze the change scores of the groups.

CHAPTER IV

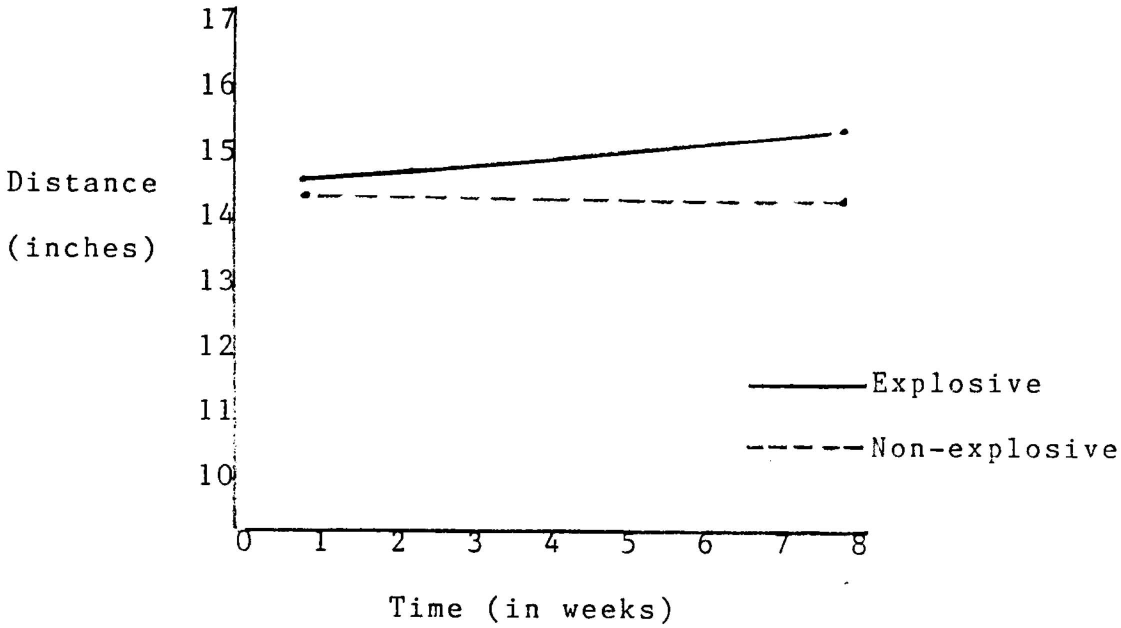
RESULTS

The purpose of this study was to determine the effects of explosive and non-explosive free weight training programs on selected motor skills (i.e., vertical jump, standing broad jump, standing triple jump, 20 yard dash, obstacle run). MANOVA applied to the pretest data indicated that there were no significant differences between the two groups based upon performances in the obstacle run ($\underline{F}_{1,18}$ = 0.03, $\underline{p}$ = 0.8951). The resultant univariate A N O V A's showed that the groups were not significantly different ($\underline{p} \leq .05$) on any of the other four dependent variables; nor for age (Appendix G). Pearson Product moment correlation procedures revealed that all variables were significantly related ($\underline{p} \leq .05$) and that all of the dependent variables were significantly related to age (Appendix H).

The Mann-Whitney $\underline{U}$ Test for small samples of 9 to 20 cases was used to assess the differences in the change scores of the explosive group (n = 10) and the non-explosive group (n = 9) on each of the motor skills.

Vertical Jump

The explosive group mean on the vertical jump pretest was 14.5 inches with a standard deviation of 1.72 (Fig. 1). The non-explosive group had a mean score of 14.4



	Pretest E	Pretest N	Posttest E	Posttest N
Mean	14.5	14.4	15.2	14.4
St. D	1.72	2.65	2.25	2.51

Change (E) .7

Change (N) 0

Figure 1. Vertical jump.

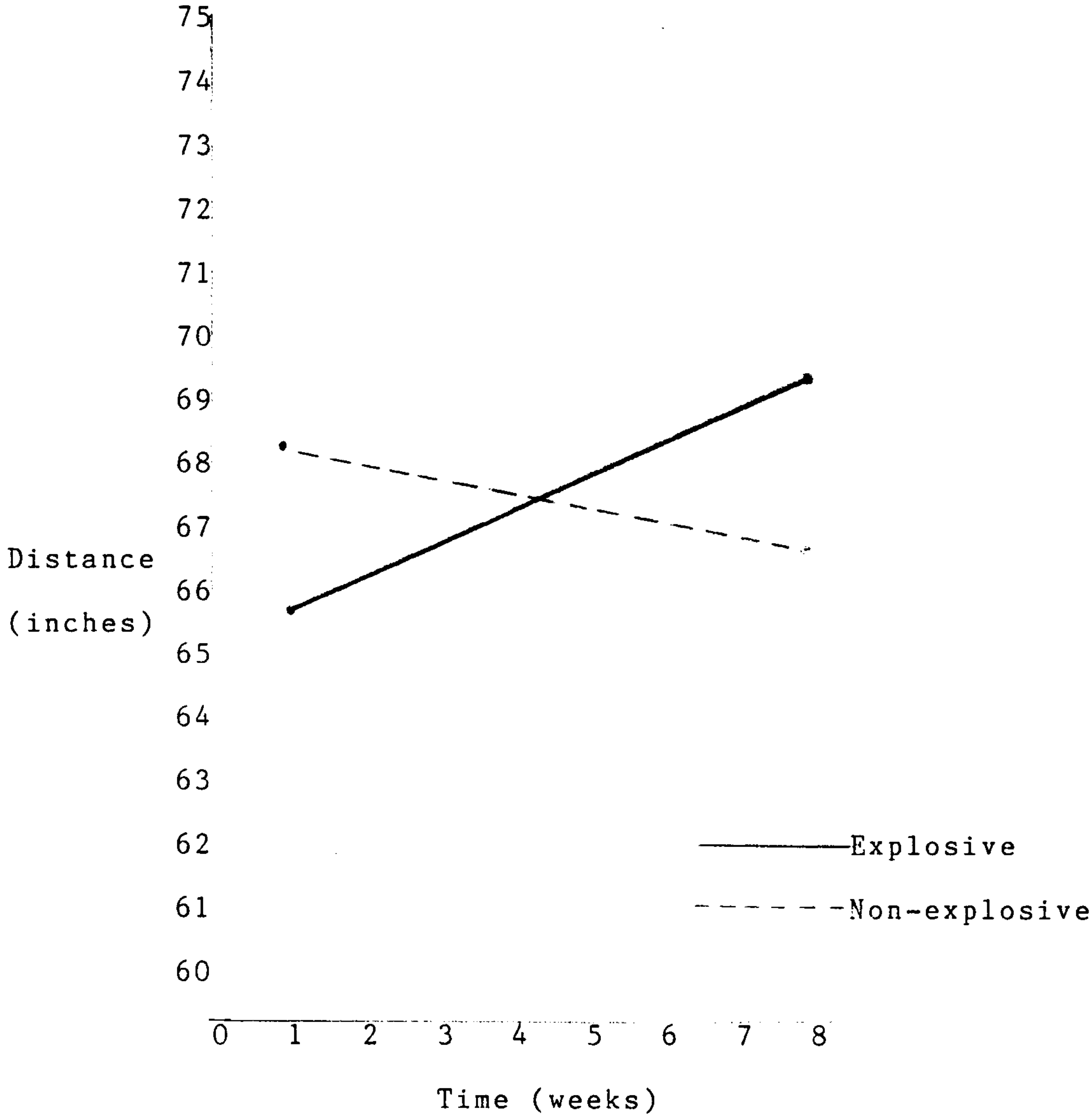
inches and a standard deviation of 2.65 on the pretest. On the posttest, the explosive group scored a mean of 15.2 inches with a standard deviation of 2.25 and the non-explosive group's mean was 14.4 inches with a standard deviation of 2.51. The change score between the pretest and posttest was .7 for the explosive group and 0 for the non-explosive group.

The Mann-Whitney U Test revealed a significant difference (p = .08) between the change scores of the non-explosive group and the explosive group on the vertical jump. The value of U obtained for the vertical jump was 72.5.

Standing Broad Jump

The explosive group produced a mean of 65.8 inches and a standard deviation of 8.3 inches on the pretest while the non-explosive group mean was 68.1 inches with a standard deviation of 9.29 inches (Fig. 2). On the posttest, the explosive group had a mean score of 69.4 inches and a standard deviation of 7.85. The non-explosive group showed a mean of 66.7 inches with a standard deviation of 10.26 inches on the posttest. The change scores were 3.6 inches for the explosive group and -1.45 inches for the non-explosive group.

The Mann-Whitney U Test revealed a significant dif-



	Pretest		Posttest	
	E	N	E	N
Mean	65.8	68.1	69.4	66.7
St. D	8.30	9.29	7.85	10.2

Change (E) 3.60

Change (N) -1.45

Figure 2. Standing broad jump.

ference between the change scores of the non-explosive and the explosive groups on the standing broad jump ($\underline{p}$ = .002). The value of $\underline{U}$ obtained for the standing broad jump was 56.

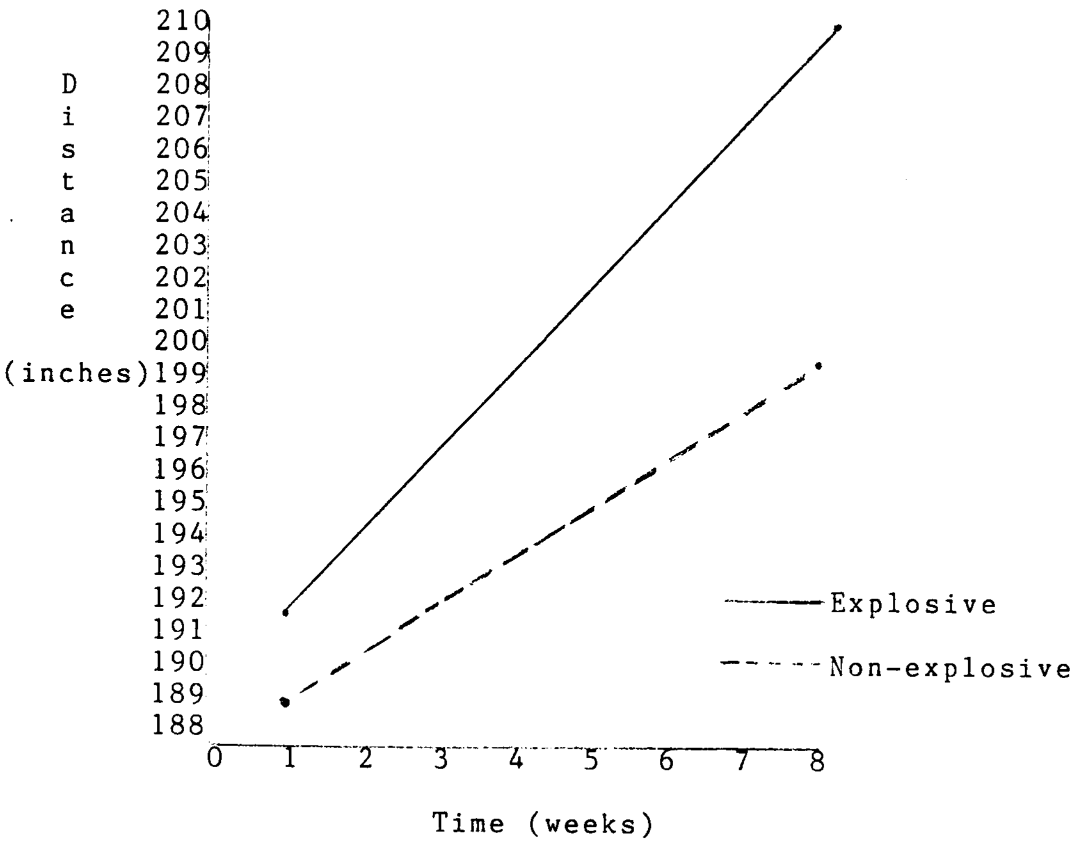
Standing Triple Jump

The explosive group mean on the standing triple jump pretest was 191.7 inches with a standard deviation of 23.36 (Fig. 3). The non-explosive group had a mean score of 188.9 inches and a standard deviation of 24.47 on the pretest. On the posttest, the explosive group scored a mean of 209.7 inches with a standard deviation of 16.68 and the non-explosive group's mean was 199.0 inches with a standard deviation of 25.15. The change scores were 18 inches for the explosive group and 10.11 inches for the non-explosive group.

The Mann-Whitney $\underline{U}$ Test revealed a significant difference between the change scores of the non-explosive and the explosive groups on the change scores for the standing triple jump ($\underline{p}$ = .08). The value of $\underline{U}$ obtained for the standing triple jump was 72.

20 Yard Dash

The explosive group mean for the 20 yard dash pretest was 3.481 seconds with a standard deviation of .232 (Fig. 4). The non-explosive group had a mean score of 3.526

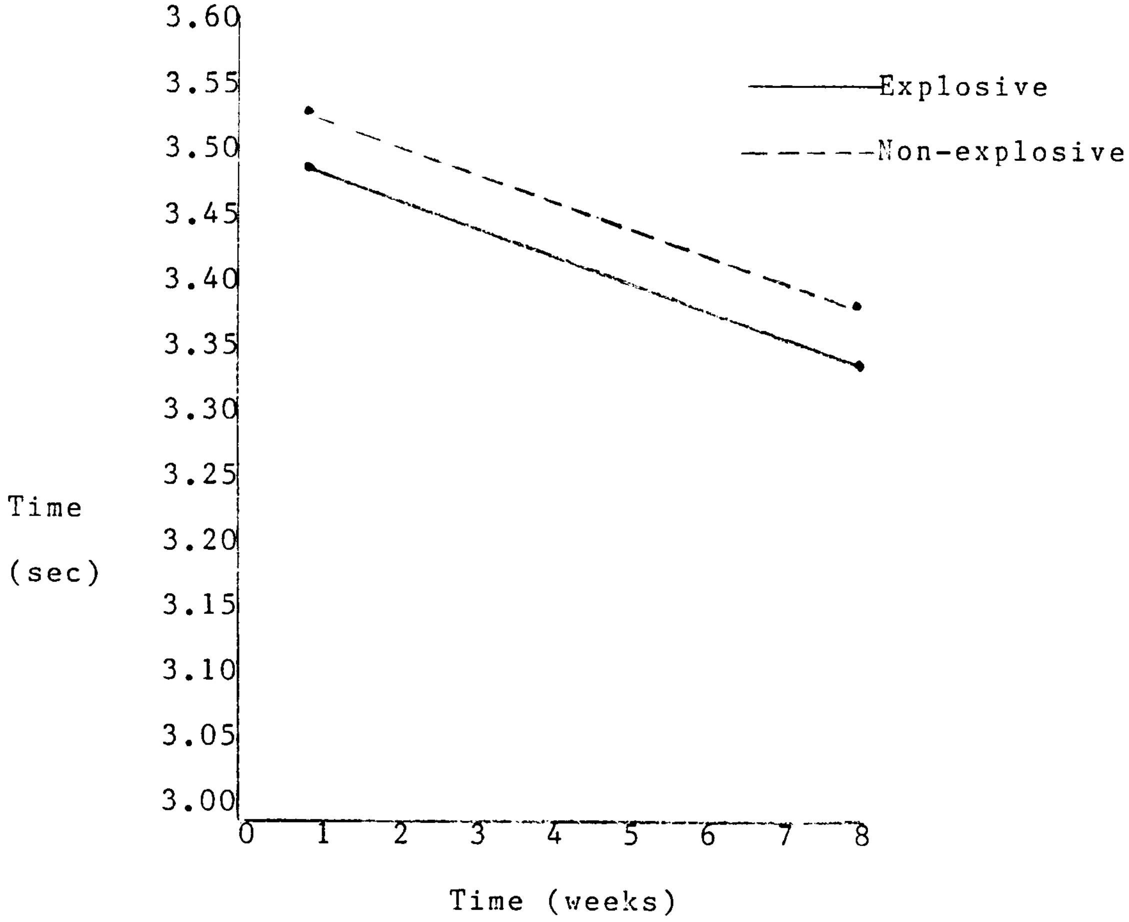


	Pretest		Posttest	
	E	N	E	N
Mean	191.7	188.9	209.7	199.0
St. D	23.36	24.47	16.68	25.15

Change (E) 18

Change (N) 10

Figure 3. Standing triple jump.



	Pretest		Posttest	
	E	N	E	N
Mean	3.481	3.526	3.335	3.380
St. D	.232	.357	.268	.306

Change (E) -.146

Change (N) -.145

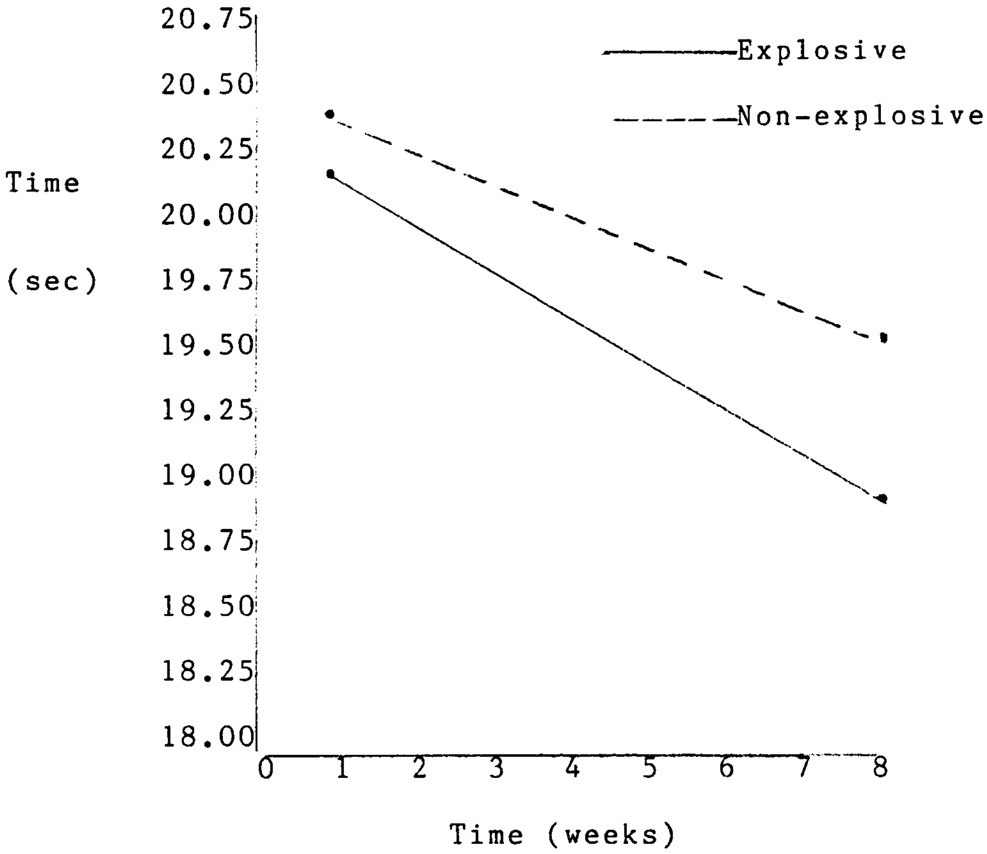
Figure 4. 20 yard dash.

seconds and a standard deviation of .357 on the pretest. On the posttest, the explosive group scored a mean of 3.335 seconds with standard deviation of .268 and the non-explosive group's mean was 3.380 seconds with a standard deviation of .306. The change scores between the pretest and the postest for the explosive group and the non-explosive group was -.146 seconds and -.145 seconds, respectively.

The Mann-Whitney *U* Test revealed no significant differences between the change scores of the explosive and the non-explosive groups on the 20 yard dash ($p = .27$). The value of *U* obtained for the 20 yard dash was 81.5.

Obstacle Run

The explosive group mean on the obstacle run was 20.19 seconds with a standard deviation of 2.63 (Fig. 5). The non-explosive group had a mean score of 20.42 seconds and a standard deviation of 2.73. On the posttest, the explosive group had a mean score of 18.98 seconds with a standard deviation of 1.98 and the non-explosive group's mean was 19.58 seconds with a standard deviation of 2.25. The change scores between the pretest and the posttest for the explosive group was -1.31 and -1.84 for the non-explosive group.



	Pretest		Posttest	
	E	N	E	N
Mean	20.19	20.42	18.88	19.58
St. D	2.633	2.730	1.980	2.250

Change (E) -1.31

Change (N) -1.84

Figure 5. Obstacle run.

The Mann-Whitney *U* Test revealed no significant differences between the change scores of the non-explosive and the explosive groups on the obstacle run ($p = .14$). The value of *U* obtained for the obstacle run was 76.

CHAPTER V

DISCUSSION

The Mann-Whitney U Test revealed that the explosive method of training was significantly more effective than the non-explosive method of training on the standing broad jump ($p = .002$), the vertical jump ($p = .08$), and the standing triple jump ($p = .08$). The explosive group showed greater improvement in the obstacle run than did the non-explosive group. Both groups improved equally in the 20-yard dash. The hypothesis that the explosive group would perform significantly better on the posttest, therefore, was accepted for the standing broad jump, the vertical jump, and the standing triple jump, and rejected for the obstacle run and the 20 yard dash. The statistical results may have been somewhat clouded by the within-group variability of performances. Analysis of the pretest data indicated that the groups themselves were not significantly different before the treatments were administered, but the wide range of performance within each group probably had some effect upon the results of the Mann-Whitney U Test. After the first week of training, one subject in the non-explosive group dropped out of the study, leaving only 9 subjects in that group. This could also have had some effect upon the statistical analysis of the change scores, particularly considering the small size of the total sample (N = 19).

The explosive group performed 3 exercises compared to the non-explosive group which performed 5 exercises. The non-explosive group executed more repetitions and also lifted more weight per session than did the explosive group. Since the explosive group improved significantly more than the non-explosive group on the jumping tasks (even though less weight was lifted per workout and fewer exercises were performed) the explosive method of training was more effective in improving the performance of subjects in the jumping skills than was the non-explosive method of training. Differences may be due to the explosive nature of the method of training and not due to the amount of weight lifted.

Although subjects in the explosive group improved more than subjects in the non-explosive group on performances in the obstacle run, improvement was significant only at $\underline{p} = .14$. Both groups improved almost equally in the 20 yard dash (Fig. 4), indicating that neither the explosive nor the non-explosive method of training was more effective in improving performance of that skill. This parallel improvement in 20 yard dash performance by both groups could be attributed to the fact that each training condition placed some overload on the subjects of both groups resulting in some increases in leg strength (which was evident in the final attempt at 1RM). The fact that the jumping skills appeared to have been more affected by the weight training methods than were the running skills could be explained by the nature of the degree of similarity between the explosive weight training exercises and the motor skills which involved jumping. The results of this study, therefore, support the results of other studies which have related task similarity to a positive transfer of training (Ammons, Ammons, & Morgan, 1958; Gagne, Baker, & Foster, 1959; Leonard, Karnes, Oxendine, & Hesson, 1970; Osgood, 1949).

In order to perform the standing broad jump and the vertical jump, the subject was required to perform simultaneous extensions of the legs in an explosive manner. Similar leg extensions performed alternately were executed explosively in the standing triple jump as well. Explosive leg movements very similar to those performed in the jumping skills were executed by the explosive group (i.e., the clean phase of the clean-and-jerk, the snatch, and the speed squat). The leg movements of the exercises which were performed by the non-explosive group (i.e., the back squat, the dead lift, and the heel raises) were similar to the leg movements performed in the jumping skills, but they were not executed explosively. The alternation of the legs required for the performance of the standing triple jump was also required for the performance of the clean-and-jerk (by the explosive group) and of the lunges (by the non-explosive group). The explosive group, therefore, performed training tasks in which the movements were more similar to the movements performed in the jumping skills than the non-explosive group. Since the explosive group performed significantly better than the non-explosive group in the jumping skills, the results indicate the importance of task similarity for a positive transfer of learning from the execution of weight training exercises to motor skill performance. The fact that the non-explosive group performed more exercises and lifted more weight than the explosive group further supports the notion that there was some positive transfer from the explosive training tasks to the jumping skills.

Stated in terms of the transfer of learning concept, the performance of the movements executed in the explosive method of training appears to have had a greater effect upon the learning of the jumping skills (i.e., standing broad jump, standing triple jump, and vertical jump) than did the performance of non-explosive movements. There was a greater transfer of learning from practice upon explosive lifting movements than there was from non-explosive lifting movements. Because of the greater similarity of the explosive weight training tasks to the selected motor skills involving speed and strength, the results of this research supports studies which have shown that greater transfer occurs between tasks which have similar elements. The greater the similarity between the tasks, the greater the positive transfer between them. In this case, the standing broad jump, standing triple jump, and vertical jump are more similar to the movements executed in the explosive method of lifting than they are to the more slowly executed movements performed in the non-explosive method of lifting. This study, therefore, supports the findings of other studies which have previously shown a greater positive transfer between tasks with similar elements (Ammons, Ammons, & Morgan, 1958; Gagne, Baker, & Foster, 1950; Leonard, Karnes, Oxendine, & Hesson, 1970; and Osgood, 1949).

This study also supports the conclusions of Henry and Whitley (1960) who stated that strength reflects neuromotor coordination rather than the ultimate physiological capacity of the muscle. In this study, if the ultimate physiological capacity of the muscle was the only factor necessary in developing functional strength, the non-explosive group (which lifted greater weight loads) would have performed better than the explosive group on the change scores. Since the explosive group improved more on the jumping skills than did the non-explosive group, the neuromotor coordination developed by the explosive group may have contributed to the increased performance.

This study also supports Stone's (1981) contention that since strength exercises are often similar to athletic performances, motor unit firing patterns can be closely simulated with free weight training activities. Kroll's (1974) comments relating to coordination and synchronized EMG firing patterns being involved in strength activities and skills are also applicable to the results of this study.

Garhammer's (1981) study contended that free standing total body lifts (i.e., the clean-and-jerk and the snatch) result in the training of the neuromuscular system and that such training transfers to the neuromuscular demands of athletic competition. Garhammer (1979) demonstrated that the double knee bend pull and the vertical jump were very similar and that the clean should be used for the enhancement of jump-related activities due to the respective similarities between the total body lifts and these movements. Garhammer's (1981, 1979) suggestions are supported in the present study, since there was significant improvement by the explosive group (which executed the "double knee bend pull" of the snatch and the clean phase of the clean-and-jerk) on the jumping skills.

It should be noted that although there was more significant improvement for the explosive training group on the standing broad jump performance ($\underline{p}$ = .002) than on the standing triple jump ($\underline{p}$ = .08) or on the vertical jump ($\underline{p}$ = .08) performance, that training explosively may produce greater results than non-explosive training when applied to activities which include jumping skills. This information may be useful, particularly when even small improvements can result in differences in the outcome of a sport performance. Although the obstacle run was significant only at $\underline{p}$ = .14 and cannot be considered strong evidence in favor of explosive lifting, the direction of the improvement may be helpful in making some improvements in sport performances. Implications made from the results of the present study suggest the utilization of explosive weight training exercises when training for sports or activities which involve jumping tasks.

CHAPTER VI

SUMMARY, CONCLUSIONS, IMPLICATIONS FOR FURTHER RESEARCH

Summary

The purpose of this study was to determine which of two types of strength training programs more positively affected the performances of untrained female subjects on selected closed motor skills which have movement demands similar to the movement demands inherent in many sports and activities. Two experimental groups trained for 8 weeks executing explosive ($n = 10$) and non-explosive ($n = 9$) training tasks with free weights. The groups were tested before and after the training programs on selected closed motor skills which possessed motor skill components of strength, speed, coordination, and/or agility (i.e., vertical jump, standing broad jump, standing triple jump, 20 yard dash, and obstacle run).

The Mann-Whitney _U_ Test indicated that the explosive method of training produced significant results on the change scores of the standing broad jump ($p = .002$) and on the change scores of both the vertical jump and the standing triple jump ($p = .08$). Change scores indicated that both groups improved almost equally on the 20 yard dash. The explosive group improved more than the non-explosive group did on the change scores in the obstacle run, but the improvement was not considered to be significant (p = .14).

Results indicated that the explosive method of training with free weights seemed to produce greater improvements on the performances of the selected closed motor skills than did the non-explosive method of training. Although only one test, the standing broad jump, showed strong statistical significance, significant improvements were made by the explosive group over the non-explosive group in the other two jumping skills. Both groups improved almost equally in the 20 yard dash. The explosive group improved slightly more on the obstacle run than did the nonexplosive group but the improvement was not significantly greater.

Conclusions

The purpose of this investigation was to determine whether an explosive or non-explosive weight training program would more greatly improve performance on selected closed motor skills which have similar movement demands to the movement demands inherent in many sports and in which speed, strength, coordination, and agility are motor skills components. It was concluded that the explosive method of training produced significantly greater improvements upon the performances of the jumping skills and that task similarity and movement demands of weight training tasks and motor skills should be as identical as possible for the greatest degree of positive transfer.

Implications for Further Research

1. Future studies should attempt to involve greater numbers of subjects in order to elicit a more accurate picture of the training effects of explosive vs. non-explosive lifting upon the performance of the selected motor tasks.

2. Within-group variability could be minimized if a a more homogeneous group of subjects were used.

3. Although the present results indicate that the explosive training method produced significant improvements on the standing broad jump performances and some improvement on the standing triple jump and vertical jump performances, exploring the possibility of a combined training program of both explosive and non-explosive training tasks could result in the development of practical weight training programs to better meet the movement demands of specific sports.

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APPENDICES

APPENDIX A

QUESTIONNAIRE

QUESTIONNAIRE

Name: Age: Height:

Weight:

1. Have you ever been a member of an athletic team?

If so, please list sports (s) and number of years of participation.

How long ago was your last active participation?

2. Are you presently training in any sport or activity?

If so, which sport(s) are you training for and how much time per day do you train?

3. Have you ever done any type of weight training?

If so, what type of equipment did you use? (Free weights, Universal, Nautilus)

When was the last time you trained with weights?

4. Do you have any orthopedic problems which could limit your performance or which should be brought to the attention of the researcher? If so, please describe them.

5. Do you have any medical problems or diseases which could affect your peformance and which should be considered (asthma, allergies, etc.)?

APPENDIX B

INFORMED CONSENT

INFORMED CONSENT

I,________________, hereby volunteer to participate in a research study designed to determine the effects of weight training on selected motor skills.

I realize I will be involved in a weight training program three days per week for one period of 50 minutes per day during the winter quarter of 1984. In addition, I am aware that I will be performing 5 selected motor skills prior to and following the completion of the weight training program to which I am assigned. I realize that the weight training program will be of moderate intensity and that free weights will be utilized.

I realize that if I successfully complete the course, that I will receive two hours of credit at the end of the winter quarter, 1984. I understand that improvement in weight training or in the performance of the motor skills will not be a factor in grading. I understand that I may withdraw my consent and discontinue participation in the research study at any time, but may continue in the class and receive credit. I realize that confidentiality will be maintained by the researcher for my skill test scores and the specifics of my weight training routine; and that only group data will be used in reporting the results and conclusions.

I have had the procedures and requirements explained to me and I understand my role in the research study. I confirm that my participation is entirely voluntary.

Signed:____________________

Date:______________________

Witness:___________________

Print Name:________________

Local Phone:_______________

Local Address:

Project Director: Denise Wood
Womens Athletics
Stokely Athletic Center
Phone: 974-4275

APPENDIX C

WEIGHT TRAINING PROGRAMS

CONDITIONING PROGRAM

Group I (NonExplosive)	Group II (Explosive)
Back squat 50%/10*3	Clean and jerk 50%/5*6
Dead lift 50%/5*6	Snatch 50%/5*6
Military press 50%/10*3	Speed squat 50%/5*6
Lunge 50%/5*6 (3@leg)	
Heel raise 50%/10*3	

INTENSIVE TRAINING PROGRAM

Back squats 75%/5*6	Clean and jerk 60%/4*6
Dead lift 60%/4*6	Snatch 70%/4*6
Military press 75%/4*6	Speed squat 60%/5*6
Lunge 70%/8*3	
Heel raise 70%/5*6	

APPENDIX D

TASK ANALYSIS

TASK ANALYSIS

	MOTOR SKILL COMPONENTS			
MOTOR SKILLS	Speed	Strength	Coordination	Agility
Vertical Jump	X	X	X	
Standing Broad Jump	X	X	X	
Standing Triple Jump	X	X	X	
20 Yard Dash	X	X	X	
Obstacle Run	X	X	X	X
EXPLOSIVE TRAINING TASKS				
Clean and Jerk	X	X	X	X
Snatch	X	X	X	
Speed Squat	X	X	X	
NON-EXPLOSIVE TRAINING TASKS				
Back Squat		X		
Dead Lift		X		
Military Press		X		
Lunges		X		
Heel Raises		X		

APPENDIX E

SCHEDULE OF THE STUDY

SCHEDULE OF THE STUDY

WEEK	DAY 1	DAY 2	DAY 3
1	MEET	PRETEST	TEACH
2	TEACH	CONDITION	CONDITION
3	CONDITION	CONDITION	CONDITION
4	CONDITION	CONDITION	CONDITION
5	CONDITION	1RM	1RM
6	INTENSIVE	INTENSIVE	INTENSIVE
7	INTENSIVE	INTENSIVE	INTENSIVE
8	INTENSIVE	INTENSIVE	INTENSIVE
9	1RM	POSTTEST	

APPENDIX F

MOTOR SKILL INSTRUCTIONS

MOTOR SKILL INSTRUCTIONS

Standing Broad Jump

You must take off from both feet simultaneously, jump as far forward as possible, and land on both feet. Try not to fall backward after the landing. You can jump farther by crouching before the jump and by swinging your arms. You will have three trials to reach your greatest distance.

Standing Vertical Jump

Stand next to the wall with both feet flat on the floor and touch the wall as high as possible after chalking your fingers. Rechalk your fingers and then jump as high as possible by swinging your arms and taking off from both feet simultaneously. You may not take any steps prior to the jump. You will have three trials to reach your greatest height.

Standing Triple Jump

You are to execute a sequence of a hop, step, and jump. You may stand in a stride position behind the starting line. You must take off from the foot that is forward, land on that same foot for the hop, then land on the opposite foot for the step, and then onto both feet for the jump. You will have three trials to jump as far as possible.

20 Yard Dash

You may stand in any desired position behind the plate. You must touch the plate on your first step and run as fast as possible until you step on the second plate. Slow down only after you step on the mat. You will be allowed two trials to get your fastest time.

Obstacle Run

You must lie on your back with your heels touching the starting line. On the signal "Go" you are to get to your feet as rapidly as possible and run to the jumping standard. On the way you must step on each square with both feet. You must then circle the jumping standard twice and proceed to the crossbar where you crawl under it. You rise and continue across the first line until you reach the second line on the floor. You touch this line and then return to the first line. You then shuttle between these lines until you reach the last line the third time. (Scott & French, 1959)

APPENDIX G

MANOVA DATA ON PRETEST SCORES

MANOVA DATA ON PRETEST SCORES

Source	df	Sum of squares	F	PR > F
Vertical jump	1	.05	.01	.9191
Standing broad jump	1	39.20	.53	.4761
Standing triple jump	1	8.45	.02	.9028
20 yard dash	1	.0058	.07	.7957
Obstacle run	1	.2205	.03	.8591
Age	1	57.80	.70	.4127
Error	108			

*$p \leq .05$

Wilk's Criterion: $F_{(5,14)} = 0.56$, Prob > F = 0.7323

APPENDIX H

CORRELATION COEFFICIENTS ON PRETEST DATA AND AGE

CORRELATION COEFFICIENTS ON PRETEST DATA AND AGE

	VJ	SBJ	TJ	DASH	OBS	AGE
VJ		0.74	0.73	-0.82	-0.75	-0.58
SBJ			0.82	-0.75	-0.76	-0.69
TJ				-0.70	-0.69	-0.69
DASH					0.92	0.65
OBS						0.72

* All variables were related at $\underline{p} \leq .05$

KEY: VJ = Vertical Jump
SBJ = Standing Broad Jump
TJ = Standing Triple Jump
DASH = 20 Yard Dash
OBS = Obstacle Run

VITA

Denise Karen Wood was born in Paterson, New Jersey, on June 24, 1950. She lived in Haledon, New Jersey, and graduated from Manchester Regional High School in June, 1968. Following graduation, Wood attended Montclair State College in Upper Montclair, New Jersey, where she played basketball and competed in track and field. During her college track and field career at Montclair State College, Wood was captain of the track and field team, was undefeated for four years in shotput, discus, and javelin during regular season competition, and won four national championships. She graduated in May of 1972 with a Bachelor of Arts degree in physical education and health. Following graduation, she taught physical education and health in Wanaque, New Jersey in grades K-8 from 1972 to 1980. During her teaching career, Wood was instrumental in initiating and conducting an annual gymnastics show, student-faculty games, adult physical education, adapted physical education, and interscholastic competitions. She was active in the Wanaque Borough Teachers Association, serving on the negotiations and grievance committees. During her teaching career, she voluntarily coached track and field at several high schools and colleges while training for national and international track and field competitions. Her knowledge and expertise in strength training was strongly influenced by a number of national and world class olympic lifters and coaches with whom she trained. In September of 1980, Wood accepted a graduate assistantship at The University of Tennessee, received a Master of Science degree in physical education in December of 1981, and began her doctoral studies at that time. While in graduate school, she coached the throwing events and supervised the strength training programs in women's athletics. The track and field team won the National Championship in 1981 and has been ranked as the top women's team in the United States since that time. As a member of the staff, Wood has coached several national champions and all-Americans and one olympian. During her own track and field career, Wood has won a number of national championships, has been a member of more than 20 National Track and Field Teams and has been elected team captain six times. She has represented the United States in the Soviet Union, China, New Zealand, and in a number of countries in Europe and Africa. Since entering The University of Tennessee, she has been awarded the Chancellor's Citation for Extraordinary Academic Achievement and has been named as an Outstanding Young Woman of America. She has also been inducted into the Hall of Fame at Montclair State College. She is a member of Pi Lambda Theta, National Honor Organization in Education, and is the National Chairperson of the Women's Advisory Committee of the National Strength and Conditioning Association. Wood is also a member of the Athletes' Advisory Committee, representing national track and field athletes to The Athletics Congress. She will graduate in December of 1984 with a Doctor of Education degree in physical education with specializations in motor behavior, social and psychological aspects of sport, and research design and statistical analysis.