# AN ABSTRACT OF THE THESIS OF

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The purpose of this study was to examine the relative effectiveness of functional isometric squats on the development of dynamic strength, static strength and power of college males. Ten college males volunteered for the study. The subjects trained two days per week for a total of eight weeks which consisted of a two week pre-conditioning period followed by a six week functional isometric squat training period. The test data were statistically treated using a paired t-test and one-way analysis of covariance. The .05 level of significance was selected for accepting or rejecting the null hypotheses. The results of the imposed training program revealed a significant increase in dynamic strength. There were no significant increases in power between groups; however, a significant increase in power was found within the functional isometric and dynamic squat training groups. The results of this study have several implications towards strength training of athletes and students enrolled in a physical education weight training activity class.

# FUNCTIONAL ISOMETRIC WEIGHT TRAINING: ITS EFFECTS ON DYNAMIC AND STATIC LEG STRENGTH

By

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# Functional Isometric Weight Training: Its Effects on Dynamic and Static Leg Strength

## I. INTRODUCTION

### Introduction

Ever since the beginning of organized sports in the late 1800's, physical educators, coaches, and athletes have sought various methods and techniques for improving athletic performance. The four basic components used to enhance performance through training are strength, endurance, flexibility, and coordination. The most frequently used component is strength and the traditional method of developing strength is through dynamic weight training.

Expressed biomechanically, strength is the effective force output of the muscular system. When speaking of athletic conditioning strength can be generally categorized as dynamic base strength, power, and strength endurance. Dynamic base strength is represented by the maximum contraction of a muscle or a group of muscles, such as a one repetition maximum (1-RM) in the squat or power clean. This type of strength is the foundation upon which the other forms of strength or power are developed. Power is the combination of strength and speed through a full-range of multiple body joint movements (e.g. power clean and snatch) and is the best expression of athletic type strength. Strength endurance is the ability of muscles to exert tension for a length of time or a number of repetitions.

Frequently the terms of strength and power are thought of as synonymous, but they are not. Power is the amount of work that can be accomplished in a unit of time and is expressed as:

$$\text{Power} = \text{Force} \times \text{Velocity}$$

In the case of throwing, for example, one can view power as the muscular strength generated by the body's so-called "power zone" (i.e. the strength generated by the thighs, hips, buttocks, abdominals, and lower back) plus the upper torso multiplied by the speed of the limbs as they move through the full-range of the throwing movement.

The coach or physical educator who wants to develop high velocity power needs to emphasize both strength and speed development in training. Athletic strength training programs are generally based upon the periodization concept in which the training emphasis is divided into five phases (44). These are 1) conditioning phase, 2) base strength phase, 3) strength and power phase, 4) competitive phase, and 5) active rest phase. Considered to be the most scientific approach to athletic training and conditioning, periodization provides continuous long-term progress while avoiding the pitfalls of a hit-and-miss program (44, 41).

Athletic strength and conditioning coaches consider the parallel squat to be the "king" of all strength training exercises due to its intrinsic ability to stimulate optimal physical growth and development (42, 43). The strength developed through the squat has great carry-over to sports requiring dynamic strength, speed, and power (42, 43).

The execution of the parallel squat increases the ability of the muscles to develop stored kinetic energy through eccentric contraction of the hip and quadriceps extensors. Kinetic energy provides the necessary muscular force for running, jumping, throwing, blocking, and tackling. Thus, the parallel squat can bring about optimal development of the power zone. The power generated from this zone radiates out to the upper body and limbs and greatly enhances overall physical performance (Figure 1).

To supplement the squat and to facilitate the development of the power zone, the concept of functional isometric squat training was proposed by Hoffman (28). O'Shea (44) described functional isometrics as an advance training concept which would push the athlete toward his upper physical and psychological strength limits. Its main purpose is to place maximum stress on the muscles and ligaments and maximize the utilization of stored kinetic energy in generating a powerful ballistic movement throughout the large muscle groups of the power zone. Functional isometric squatting in theory is capable of

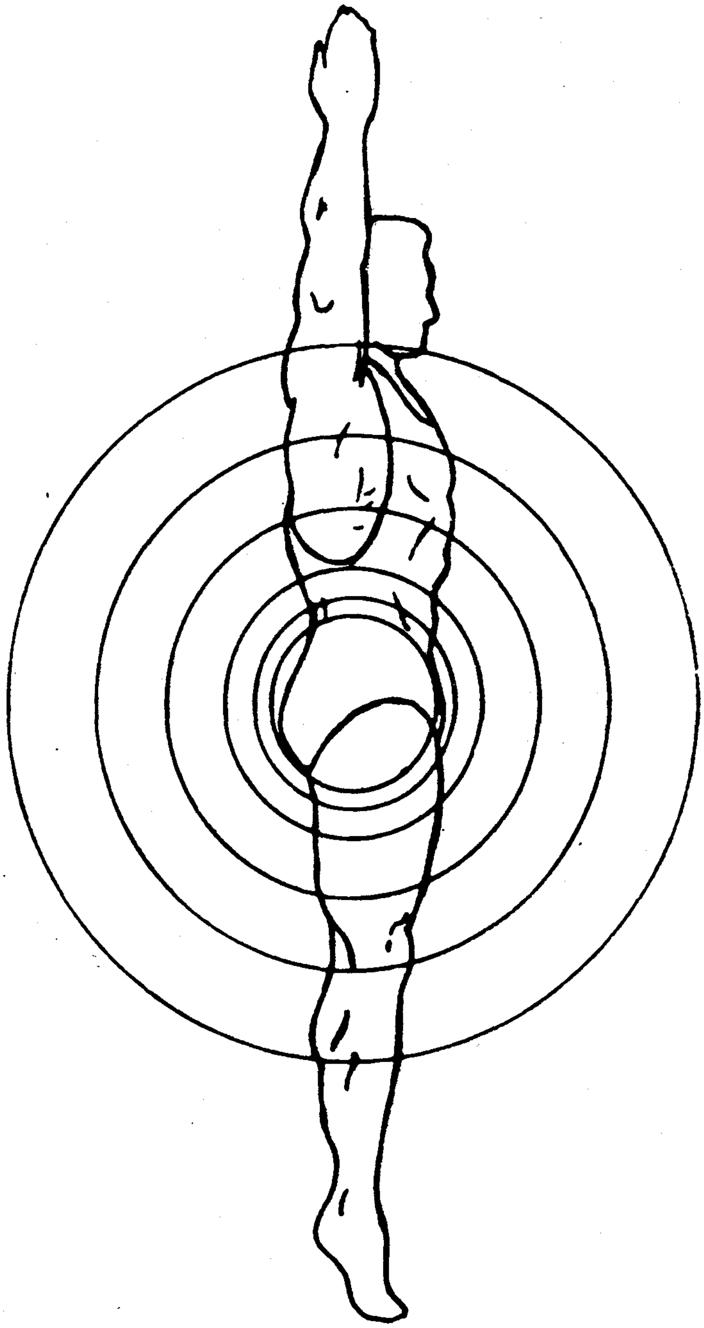

Figure 1. The "Power Zone".

accomplishing this through maximum stress it places on both static and dynamic muscle contraction.

The execution of a functional isometric squat involves both dynamic and static muscle contraction. The barbell rests upon a power rack with the pins placed two inches above the supports. After assuming a starting squat position (leg angle approximately 60-75 degrees), the athlete drives the barbell up to the pins (dynamic phase), then holds it there (static phase) for three to five second count. Through the use of functional isometric squats the weak leverage positions can be worked and trained.

Today, functional isometric training is reported to be used with good success by world class athletes such as shot putters, discus and hammer throwers, and Olympic style lifters (44). However, a search of the published research literature revealed one functional isometric study. More research is necessary to determine its effectiveness as a means of developing a high level of dynamic strength.

## Purpose of the Study

The purpose of this study was to examine the relative effectiveness of functional isometric squats on the development of dynamic and static leg strength and power.

## Need for this Study

Physical educators and coaches are often faced with the problem of developing dynamic strength and power in students and athletes. In recent years, various strength training programs have been used for this purpose. However, physical education textbooks are not in agreement as to the most effective method for developing strength. While conventional dynamic weight training is generally used for developing strength and power, functional isometrics may prove to be more or as effective. If so, physical educators and coaches would have an alternative training method to use in their teaching or coaching.

## Null Hypothesis

The general hypothesis tested in this study was that six weeks of functional isometric squat training would result in no significant statistical improvement in dynamic strength, static strength and power in college males.

## Sub-Hypothesis

The following sub-hypotheses were proposed for this study. As a result of the experiment, the following sub-hypotheses should be retained or rejected:

1. There will be no significant difference in the pre-test and the six week post-test means

for dynamic strength within the functional isometric and dynamic squat training group.

2. If There will be no significant difference in the six week adjusted mean scores for dynamic strength between the functional isometric group and dynamic squat training group.
3. There will be no significant difference in the pre-test and six week post-test means for static strength within the functional isometric group and the dynamic squat training group.
4. There will be no significant difference in the six week adjusted mean scores for static strength between the functional isometric group and the dynamic squat training group.
5. There will be no significant difference in the pre-test and six week post-test means for power within the functional isometric group and dynamic squat training group.
6. There will be no significant difference in the six week adjusted mean scores for power between the functional isometric group and the dynamic squat training group.

## Definitions

Functional Isometric Squat: The bar is positioned two inches below the top of the shoulders with the feet placed slightly wider than shoulder width at a 30 degree angle. In the ready position the muscles of the quadriceps and torso are isometrically contracted. Then with one explosive dynamic muscle contraction the bar is driven four inches and isometrically held against pins for two to three seconds.

<u>Isometric Contraction</u>: A muscle contraction in which the load is greater than the force generated by the muscle. The fibers contract but do not change in length, therefore, no external work is done and the energy is dissipated as heat. The tension developed by an isometric contraction is measured by a cable tensiometer.

<u>Isotonic Contraction</u>: A muscle contraction against a load in which the contractile force of the muscle is greater than the load. The muscle either lengthens or shortens and work is performed.

<u>Parallel Squat</u>: The bar is positioned about two inches below the shoulders and the feet are shoulder width apart with a 30 degree angle. With a strong eccentric contraction of the hip and quadricep extensors, the lifter descends to a position where the top of the thighs are just below parallel. The ascent begins with a powerful hip and torso rotational force to drive out of the parallel position to an erect position.

<u>Power</u>: The product of force and speed (i.e. Power =

Force x Velocity or Force x Distance/Time).

Repetition: The number of times a dynamic or static contraction is repeated in a given exercise set. One repetition maximum (1-RM) is the maximum load a muscle can contract against for one repetition. Thus, 2-RM is the maximum load a muscle can contract against for two repetitions, etc.

Set: One series of repetitions without a rest for a given exercise. A set may be repeated for any predetermined number of times.

Strength: The ability of a muscle or muscle group to produce force.

## Assumptions

1. Dynamic strength is represented by parallel squat strength.
2. Static strength is represented by knee extension strength.
3. Kinetic power is represented by the vertical jump.

## Delimitations

1. The number of subjects for this study is small.
2. The subjects are male college students enrolled in a physical education weight training class.

3. Strength was assessed using dynamic and static strength measurements.
4. The training period was limited to eight weeks, two weeks pre-conditioning and six weeks strength training.
5. Studies that compare dynamic and functional strength are rare.

# II. REVIEW OF LITERATURE

## Introduction

A review of literature was made concerning the relationship of the neuromuscular system and dynamic and static strength training. The published research related to functional isometric training was so limited that only one published study could be found. Due to the nature of functional isometric lifting it was appropriate to review studies relative to the basic physiology and concepts of neuromuscular strength development, all of which have a direct relationship to the study.

## Muscle Structure and Function

The skeletal muscle is composed of long, multinucleated cylindrical fibers of varying length. The muscle cell is composed of the myofibril which distinguishes it from other cells because it contains two basic protein filaments (myosin and actin). The smallest functional unit of the myofibril is the sarcomere which is defined as the distance between two Z-lines and when stimulated the unit will contract. Finally, each myofibril is surrounded by a thin sheath called endomyosium. The largest subunit of a muscle is referred to as the bundle of fasciculus which is surrounded by the connective tissue called perimyium. The individual muscle cells are also surrounded by the endomysium connective tissue. (17)

The muscle spindle provides sensory information to the higher brain centers, concerning changes in the muscle tension and length, velocity of the stretch, and pressure. The muscle spindle is located parallel to the extra fusal fiber and within the spindle are specially adapted muscles called intrafusal fibers. The central portions of the intrafusal fibers have lost their ability to contract, containing neither of the contractile proteins, actin and myosin, whereas, the end portions still contain actin and myosin and the ability to contract (45).

The muscle spindle is capable of emitting static and dynamic responses. The static response occurs when the intrafusal fibers in the skeletal muscles are slowly stretched and the dynamic response occurs when the primary receptor is activated by a rapid change in length of the intrafusal fibers. The dynamic response ceases almost as quickly as it is initiated, after which the muscle spindle returns to the static state.

The main function of the muscle spindle is to elicit the stretch response to a stimulus (11). The stretch reflex consists of three main components (35):

a) the muscle spindle,
b) an afferent nerve fiber that carries the sensory impulses from the spindle to the spinal cord, and

c) an efferent motor neuron in the spinal cord that signals the muscle to contract.

The stretch reflex is the neuromuscular function generally considered to typify the action of the squatting movement.

Another component of the stretch reflex is the Golgi tendon organs located in the ligaments of joints and responsible for detecting differences in muscle tension. The tendon organ responds maximally to sudden increases in tension and transmits a lower, more continuous level of impulse when tension is decreased. The Golgi tendon organs are thought to be a protective device preventing tearing of the muscle or tendon under extreme conditions.

The "sliding filament" theory is the most widely accepted explanation for skeletal muscle contraction (20). This occurs when a muscle develops tension and the actin filaments slide over the myosin filaments toward the center of the sarcomere. At rest, the myosin cross-bridges extend towards the actin filaments and the actin and myosin are in an uncoupled position. When the muscle is stimulated, calcium is released and the actin and myosin join together to form actomyosin. During the contraction, the cross-bridges collapse, actin slides over myosin, tension is developed and ATP (adenosin triphosphate) is formed (17). After the contraction, the muscle relaxes again with the removal of calcium ions.

There are four types of muscular contractions which are used at various times during athletic performance (44).

1. Isometric (static) - The muscle develops tension but does not change in length. When tension develops heat is produced but no mechanical work is performed.
2. Isotonic (dynamic) - The muscle either shortens or lengthens and work is performed. Both eccentric and concentric contractions are isotonic.
3. Eccentric - The muscle lengthens as tension is developed.
4. Isokinetic - The muscle is at a maximal contraction at constant speed over the full-range of motion.

## Motor Units

A muscle consists of three major types of fibers, which differ histochemically, biochemically, and metabolically. The three fiber types are identified as slow twitch (ST), fast twitch (FT), and fast twitch oxidative (FOG).

The ST fibers have a high oxidative, low glycolytic capacity and are recruited for low intensity, endurance activity. The ST fibers are well-suited for endurance activities because of the high concentration of mitochondrial enzymes.

The FT fibers have a low oxidative, high glycolytic capacity and are recruited for high intensity, short duration anaerobic type activities. The FT fibers are generally activated in short-term sprint activities that depend almost entirely on anaerobic metabolism for energy. The metabolic and contractile capabilities of these fibers are also important in the stop-and-go or change-of-pace sports, such as baseball or soccer, which at times require rapid energy that only the anaerobic pathways supply (35). As muscular effort is increased in force and speed, the relative importance of the FT fibers become increasingly greater because of the motor unit recruitment (45): where ST fibers are recruited first, the FOG fibers and then the FT fibers follow. The FT fiber's main responsibility is the great production of speed, strength, and power.

## Effects of Weight Training on Physiological Functions

Through scientific strength training specific changes occur in skeletal muscle as follows (27): 1) increases in the thickness and density of the bones at the sites of muscle origins and insertions, 2) increases in the amount of connective tissue within the muscle, 3) changes at subcellular level in the muscle fibers which enhance anaerobic production and/or the actual contractile properties of actin and myosin, and 4) hypertrophy of the muscle fibers.

The main physiological changes that occur with weight training affect the anaerobic capacity of an individual (2), because weight training is a high intensity, short duration activity that involves the FT fibers. In studies (54) of previous non-strength training individuals it has been shown that the rate of strength improvement is greatest in individuals having a high FT fiber percentage.

The hypertrophy of a muscle fiber is due to the: 1) increased diameter of existing fibers (due to greater number of myofibrilis per fiber), 2) more total protein, 3) increased size and number of mitrochondria, and 4) increased amount of sarcoplasm (55). But hypertrophy does not always occur with an increase in strength as noted by Brouha (9), who found a three-fold increase in muscular strength without a proportional increase in muscle size. Although it is thought by many researchers that weight training results in hypertrophy (increase in number of muscle cells) of the muscle fiber. The increase in muscle size associated with muscular strength depends on the duration, intensity, frequency, and type of exercises used in the training program.

The anaerobic and aerobic changes that occur at the subcellular level due to training are (20):

<u>Anaerobic</u>

1. Increased capacity of the ATP-CP system.
2. Increased muscular levels of ATP, PC, and creatine kinase.

### Aerobic

1. Increased myoglobin content.
2. Increased oxidation of glycogen.
3. Increased numbers and size of the mitrochondria in the skeletal muscle fibers.
4. Increased amounts of glycogen stored in the muscle.
5. Increased activity of glycogen synthesis.
6. Increased oxidation of fat which reduces lactic acid accumulation, resulting in less fatigue.

## Neuromuscular Function

The term "neuromuscular" refers to both the nervous system and the muscular system. There are two basic types of nerves - sensory (afferent) and motor (efferent). The sensory nerves transport information from the periphery to the central nervous system (brain and spinal cord). The motor nerves carry information from the central nervous system to the muscles.

The basic unit of the nervous system is the neuron which consists of the cell body, dendrites and axon. The dendrites transmit nerve impulses toward the cell body and the axon transmits them away. The axon can either be covered or uncovered by a fatty sheath called the myelin sheath. Along this sheath, located every 0.5 mm are the Nodes of Ranvier where impulses are conducted from node to node. The axons terminate in the neuromuscular junction.

The point of contact of a motor neuron and the muscle fiber it inervates is called the neuromuscular junction. The neuromuscular junction is also specialized in regard to muscle-fiber type, because during muscle hypertrophy or atrophy, the size of the neuromuscular junction changes in proportion to muscle-fiber size (18). The subneural post-synaptic folds are one structure that separates the muscle-fiber types. They are more complex and the vesicles are more concentrated in the neuromuscular junction of the slow-twitch than the fast-twitch muscle fibers. However, more transmitter is released for each action potential reaching the neuromuscular junction in the larger fast-twitch fibers.

When a nerve or muscle is stimulated above the threshold, the passage of an impulse causes a change in the electrical potential long the cell membrane and this potential change is called the action potential. The stimulus can be chemical, hormonal, mechanical, thermal, or electromagnetic. A subthreshold stimulus is one that is too small to cause an action potential, but two or more subthreshold stimuli can cause an action potential called summation (37).

When a group of motor neurons is facilitated because of emotional excitement (arousal), greater muscular tension is more easily attained. Arousal produces a high level of electrical activity in the CNS, which means more motor neurons are nearer their threshold for activation (18, 37). Therefore, a neural signal from the CNS is more likely to activate a large number of motor neurons and yields greater muscular tension. Also affected by facilitation is the preciseness of motor control, because movement requires a narrow range of tension for optimal performance (18). In all activities, the normal voluntary motor neuron recruitment must be modified to compensate for greater resting facilitation caused by emotional excitement. If the modification was not present, the force produced will likely over compensate the requirement for that movement.

O'Shea (41) summarized the effects of quality strength training on the neuromuscular system. As a result of isotonic, full range, multiple-joint strength training, there occurs in the neuromuscular system:

1. An increase in the nerve fiber diameters.
2. An increase in the length of the motor neuron, providing greater synaptic area for the effective release of the neurotransmitter.
3. An increase in the size of the neuromuscular junction in proportion to muscle-fiber type.
4. An increase in the motor end plate area (synaptic control area of the muscle fiber)

which expands in proportion to the increase in axon length in the hypertrophied muscle.

5. An increase in the number of functional synapes, which allow the athlete to utilize a greater percent of the motor units in a group of synergistic muscles at any one time; by performing a dynamic strength movement over and over for a prolonged period of time, correct patterns of "nerve-reflexes" are developed in which the synapse blocks weak signals while allowing the strong ones to pass, channeling the signal in the proper direction.

## Concepts of Strength Training Programs

The main purpose of a strength training program is to utilize a combination of intensity, load, volume and frequency to stimulate and develop the greatest amount of dynamic strength. A major difference in strength training programs involves the type of muscular contraction, dynamic and static, used in the training program. The dynamic contraction is where a muscle contracts against a load in which the force is greater than the load and work is performed. The static contraction is where the load is greater than the force generated by the muscle and no work is performed. Therefore, dynamic strength is defined as the maximum load that can be moved through a full-range of motion and static strength is the maximum amount of tension developed against a resistance.

Both dynamic and static strength training have been found to increase muscular strength, but there exists discrepancies as to which method is best for developing strength. Chui (12) found no significant difference in strength development between dynamic and static strength training. Berger (3), Rasch (47), and Darcus (15) found dynamic strength developed faster than static strength and Whitely and Smith (52) found static strength training better than dynamic strength training.

In a study comparing the increases in dynamic and static strength with dynamic and static strength training programs, Berger (3) found that dynamic strength increases to a greater degree than static strength when the training program involves dynamic contraction and vice versa for static strength. In 1953 Hettinger and Mueller (26) presented the first study in isometric training for strength development and had significant gains in strength. Ten years later Mueller and Rohmert (36) determined that six maximal voluntary contraction performed five to ten times a day produced the greatest amount of isometric strength. O'Shea (44) introduced the concept of functional isometrics which combined isotonic and isometric muscular contractions in one smooth movement. Functional isometric training requires an athlete to drive the barbell against the pins (isotonic contraction), then hold it there (isometric contraction) for a three to five second count. In a research study on the use of functional isometrics, in an isotonic strength training program, Jackson, et. al. (30) found a significant increase in strength. This study used a Universal Gym bench press and the isotonic program consisted of three sets of six to eight repetitions at maximum work loads. The functional isometric group performed either two sets of three maximal contractions or three sets of two maximal contractions held for six seconds with a 30 second rest between contractions.

The intensity of a strength training program determines the rate and level of strength increase. The intensity is based upon the number of repetitions, sets, and the load used for each exercise. The progressive overload was first introduced by DeLorme (16), which increases the load as the muscle becomes stronger. DeLorme suggested that one to three repetitions for three to four sets with a maximum load was the best for developing strength. Berger (4) conducted several studies to determine the optimal training program to develop strength. In his studies he varied sets and repetitions and found the best combination to produce the greatest amount of strength was three sets of six repetitions three times per week.

In a study conducted by O'Shea (38), subjects trained three times per week for six weeks using a 1-RM in the squat and a leg dynamometer for knee flexion. The subjects were divided into three groups, one performing three sets of ten repetitions, one group performing three sets of five repetitions, and one group performing three sets of two repetitions. All groups made a significant gain in static and dynamic strength, but no difference was found between the three groups.

In summarizing the research in strength training, O'Shea (41) indicates three different training programs are used to enhance the development of muscular strength and endurance as shown in Table 1. The three programs are: 1) three sets of one to three repetitions at 90% of 1-RM for maximum strength development, 2) four to five sets of four to ten repetitions at 75-85% of 1-RM for strength and muscular endurance development and 3) five to seven sets for eight to twelve repetitions of 1-RM at 60-75% for muscular endurance development.

Table 1. Weight Training Intensity

| Training Phase | Work Load % of 1-RM | Reps | Sets |
|---|---|---|---|
| 1. Maximum strength | 90% | 1-3 | 3 |
| 2. Strength/endurance | 75-85% | 4-10 | 4-5 |
| 3. Muscular endurance | 60-75% | 8-12 | 5-7 |

Stone, et. al. (50) analyzed eleven studies and presented a theoretical model for strength and power training

(Table 2). The four phases of the model include hypertrophy, basic strength, strength and power, and peaking or maintenance. The recommended training intensities are low intensity, high volume for hypertrophy; high intensity, moderate to high volume for basic strength; high intensity, low volume for strength and power; and for peaking very high to low intensity and very low volume. This theoretical model is similar to the cyclic weight training program designed by O'Shea (Table 3) (40) and suggests the cyclic program for dynamic strength development. The program is divided into three weekly periods of heavy, medium, and light weeks with varying percentages of the 1-RM for a given number of sets and repetitions. A typical cycle might go as follows: 1) four to five sets of one to three repetitions at 85-100% for heavy training, 2) three to four sets for ten to twelve repetitions at 60-75% for light training, and 3) four to five sets of four to five repetitions at 70-85% for medium training.

The frequency and duration of a training program will vary depending on the athlete's sport and how long the physiological adaptations take to occur. Studies (25, 50) indicate that a minimum of five weeks is required for the physiological adaptations to occur.

## Power Development

DeLorm (16) defines power as the whole potential strength of a muscle used over a short period of time as

Table 2. A Hypothetical Model of Strength Training

| Preparation | Transition 1 | Competition | Transition 2 | |
|---|---|---|---|---|
| Phase | Hypertrophy | Basic Strength | Strength & Power | Peaking* or Maintenance |
| Sets+ | 3-5 | 3-5 | 3-5 | 1-3 |
| Reps | 8-20 | 2-6 | 2-3 | 1-3 |
| Days/Week | 3-4 | 3-5 | 4-6 | 1-5 |
| Times/Day | 1-3 | 1-3 | 1-2 | 1 |
| Intensity Cycle (week)** | 2-3/1 | 2-4/1 | 2-3/1 | - |
| Intensity | low | high | high | very high |
| Volume | high | moderate to high | low | very low |

* Peaking for sports with a definite climax or maintenance for sports with a long season such as football.

** Intensity Cycle -- ratio of the number of heavy training weeks to light training weeks.

\+ Does not include warmup sets.

Table 3. The Cycle Program

| Training Week | Work Load % of 1-RM | Reps | Sets |
|---|---|---|---|
| Heavy | 85-100+ | 1-3 | 4-5 |
| Light | 60-75 | 10-12 | 3-4 |
| Medium | 70-85 | 4-5 | 4-5 |

in weight training. Power can also be described as the amount of work which can be performed per unit of time and can be stated as:

Power = Force x Speed or Force x Distance/Time

In athletic type activities, power can be thought of as the muscular strength a limb can generate in a given movement times the limb velocity during the movement (35).

Power = Muscular strength x Limb velocity

O'Shea (41) states that power combines the concepts of strength and power and to develop high velocity power the athlete needs to emphasize strength and speed in the training program.

Grahammer (21) explained the relationship between force and velocity on training as pictures in Figures 2, 3, and 4. In Figure 1, force and velocity are inversely related in a hyperbolic manner. While this relationship was originally found in isolated muscle, it is also true for intact single joint movements (46) and recently has been shown to be the same for multi-segment movements (22, 33). In Figure 2, it is shown that strength training can shift the curve to the right in beginners. Because Power = Force x Velocity, this clearly entails an increase in power at all points on the curve. As an individual continues with heavy resistance training, it is likely that the curve will lower but continue to the right as in Figure 3. Komi (33) also observed that specific types of

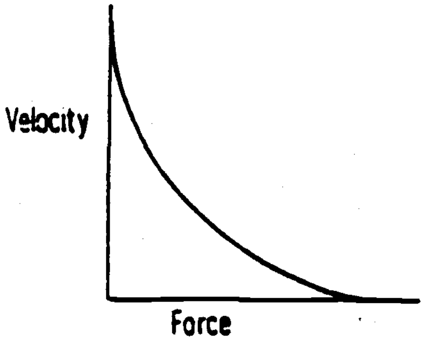

Figure 2. Force-velocity curve

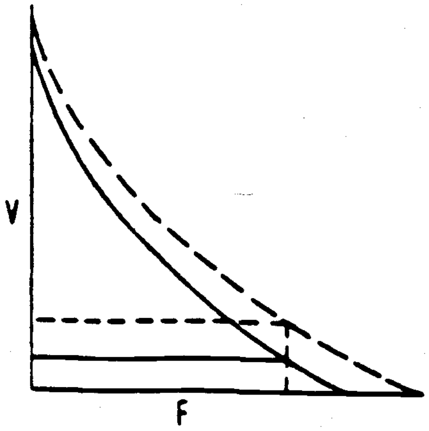

Figure 3. Force-velocity curve (training effects)

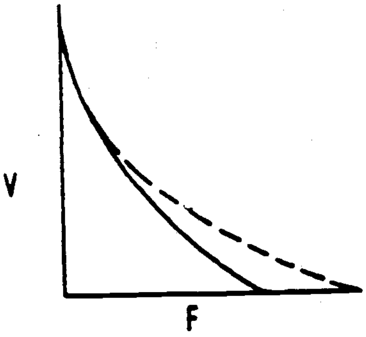

Figure 4. Changes in the force-velocity curve with advanced training

high speed, high power training may positively enhance the higher velocity of the curve.

Garhammer (24) has filmed the maximum snatch and clean and jerk of numerous weight lifters at national and international contests over several years. He concluded that for any given lifter the higher power output occurred when the heaviest weight was lifted.

According to O'Shea (41) when the skills of a sport involve running, jumping, lifting, throwing, blocking or tackling, strong rotary hip action is required. Thus, the athlete utilizing these skills needs a strong "power zone" to execute these effectively and safely. The muscles of the body's power zone are the abdominals, obliques, lower back, hip extensors and flexors, thighs and other smaller stabilizing muscles of the knee and hip joints. To maximize development of these muscles requires working and training them as one unit through a full-range of forceful joint movements with speed using a fairly heavy resistance of 25-30 percent of maximum speed (41).

In studies conducted to determine the effect of weight training on power development, Chui (12) found that after three months of training, the weight training group gained substantially in power while the control group did not. In a similar study, Capen (10) also reported significant development in power for the experimental group.

In a comparison study of dynamic and static weight training programs, Berger (8) found that those who trained dynamically improved significantly in the vertical jump compared to those who trained statically. Flood (19) researched the effects of power training on the development of power with the vertical jump as the criterion measure. The conventional weight training group executed two sets of six to eight repetitions for five selected exercises and two sets of fifteen repetitions for two exercises. The power training group executed a single one-minute bout of the seven required exercises during each training session with a two minute recovery period between each exercise. The groups trained two times per week for ten weeks and Flood concluded that both groups' power output increased significantly.

In summarizing this review of literature pertaining to scientific strength training, there exists an abundance of published material on the subject. However, only one published study was found relating to functional isometric training. With this in mind, the present study was proposed and conducted.

# III. RESEARCH DESIGN

## Introduction

The present study was conducted at Oregon State University, Corvallis, Oregon during the Winter Term, 1987. The testing of the subjects was conducted in the Exercise Physiology Laboratory and the weight room of the Department of Physical Education. The weight room was also the site of the training portion of the study. The purpose of the study was to assess the effectiveness of two techniques of the squat - dynamic low bar squat and functional isometric squat - on the development of dynamic and static leg strength and kinetic power output.

## Subjects

Ten healthy college male students of Oregon State University volunteered as subjects for the study. The population pool from which the subjects were taken consisted of male students enrolled either in intermediate or advance weightlifting physical education classes at Oregon State University, Winter Term 1987. Individuals from the weightlifting classes interested in participating in the study volunteered as subjects. All the males that volunteered were used as subjects. Of the ten subjects, two were Oregon State University athletes (wrestling and crew) with some weight training experience. The remaining subjects were non-athletes with at least one term (10 weeks) of weight training experience, either in physical education class or as part of a previous athletic training program. The subjects' ages ranged from 18 to 22 years of age, with the mean age 20.3.

The use of subjects for this study was approved by the Human Subjects Committee at Oregon State University. All subjects received the informed consent form and signed it for participation in the study. For the study, the subjects were equally divided and randomly assigned to either the experimental group (functional isometric squat group) or the control (dynamic squat group).

## Pre-Conditioning Training Procedures

A two week pre-conditioning period proceeded the six-week experimental period. During this period the subjects performed general strength conditioning exercises and were instructed in the technique of functional isometrics and the training procedures. For the experimental period, each subject was required to use only the prescribed training routines and to avoid any vigorous activities involving use of the legs, such as basketball or running, for the duration of the study. All training sessions were closely supervised and monitored. The training intensity in terms of load volume was similar for both the experimental and control groups. For the six week experimental training period, both groups trained Tuesday (heavy) and

Friday (light) afternoons for approximately 60 minutes. The training days were divided into heavy and light workouts to provide sufficient time for physiological recovery and to prevent overtraining.

## Functional Isometric Squat Procedures (FIS)

The functional isometric squat group (FIS) trained according to the method outlined by O'Shea (44). The FIS training required the use of a power rack with pins placed two inches above the support on which the barbell was resting. After assuming a starting squat position the subject drove the barbell up to the pins (isotonic phase), then held there (isometric phase) for a three second count. Close attention was given to having the barbell pressing only against the pins and not cornered between the pins and the upright supports of the power rack.

The subjects trained in two squat positions: 1) a low position in which the angle of the knee was 90 degrees and 2) a high position having a knee angle of 110 degrees (Figures 5 and 6). Each FIS workout was preceded by a ten minute warm-up routine consisting of static stretching of the lower back and thighs, followed by two sets of light weight dynamic full-range squats (see Table 4 - workout protocol). This warm-up was crucial to avoid injury and to provide some skill practice in executing the full-range squat.

## Table 4. Functional Isometrics Squat Program

### Workout Schedule - 6 weeks

Warm-up

A. Stretching - back and legs, 5 minutes
B. Full squat 1 x 10 at 135 pounds
C. Full squat 1 x 10 at 185 pounds

Functional Isometric Squat

A. Low position 3/4 squat position

135 x 5 (2 second hold)
185 x 5 (2 second hold)

Week 1 and 2

| | |
|---|---|
| 60-65% of full squat 1-RM | 2 x 3 (3 sec. hold) |

Week 3 and 4

| | |
|---|---|
| 70-75% of full squat 1-RM | 2 x 3 (3 sec. hold) |

Week 5 and 6

| | |
|---|---|
| 80-85% of full squat 1-RM | 2 x 3 (3 sec. hold) |

B. High position 1/2 squat position

225 x 3 (2 second hold)

Week 1 and 2

| | |
|---|---|
| 120-125% of full squat 1-RM | 2 x 3 (3 sec. hold) |
| 110-115% of full squat 1-RM | 2 x 3 (3 sec. hold)<br>FRIDAY |

Week 3 and 4

| | |
|---|---|
| 135-140% of full squat 1-RM | 2 x 3 (3 sec. hold) |
| 125-130% of full squat 1-RM | 2 x 3 (3 sec. hold)<br>FRIDAY |

Week 5 and 6

| | |
|---|---|
| 150-155% of full squat 1-RM | 2 x 3 (3 sec. hold) |
| 140-145% of full squat 1-RM | 2 x 3 (3 sec. hold)<br>FRIDAY |

Table 4. (Continued)

| | |
|---|---|
| C. <u>Warm down</u> | Take three equal jumps to reach required weight. |
| 1. Full squat 1 x 10 | |
| 2. Stretching - 5 min. | |
| 3. Ride stationary bide - 5 minutes | |

<u>SAMPLE WORKOUT</u>

1. 225 x 2
2. 265 x 2
3. 295 x 1
   315 x 3
   315 x 3

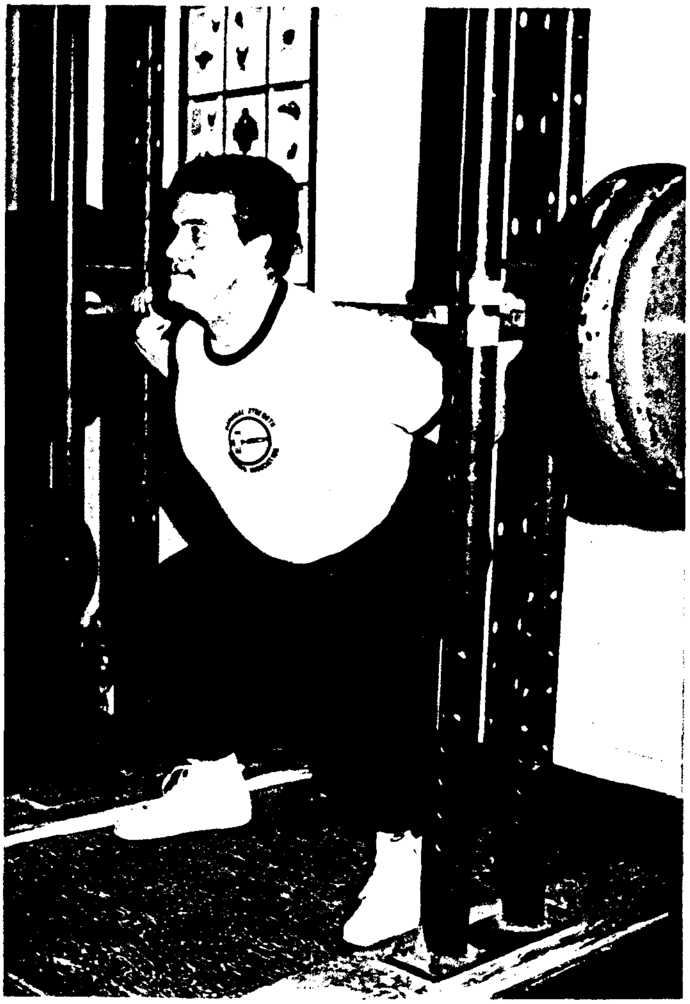

Figure 5. FI low squat position

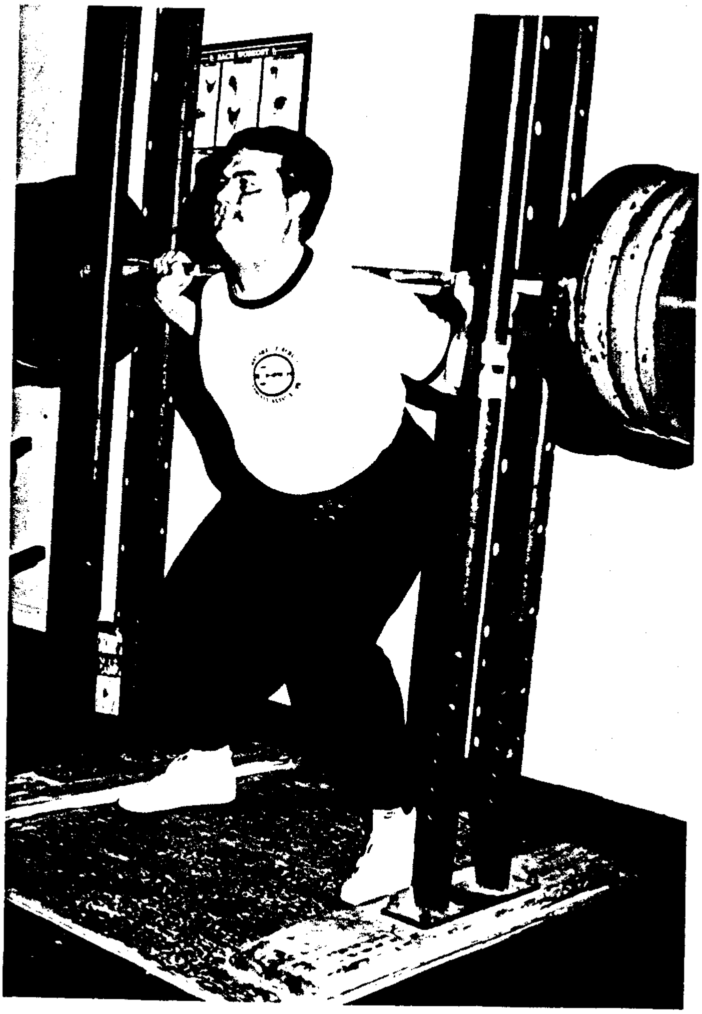

Figure 6. FI high squat position

Each FIS workout started with low angle squat position followed by the high angle position. At the low angle position, subjects performed two sets of three repetitions with a three second hold at a set percentage of the 1-RM squat. At the high angle squat position, 2-3 warm-up sets of equal jumps in weight were completed to prepare for the heavy loads. The subjects performed two sets of 2-3 repetitions with a three second hold at a set percentage of the 1-RM squat. Due to the extremely heavy loads, the subjects stood erect 5-10 seconds to recover sufficiently for the next repetition. A five minute rest was taken between sets.

The six week experimental FIS training program protocol utilized the progressive overload principle and was divided into three, two week phases (Table 4). For each phase a set percent of each subject's 1-RM was used to determine the maximum training load used in each of the two lifting positions. At the start of phase two and three the training loads were increased by 10 percent in the low position and 15 percent in the high. Training sessions were twice a week following a heavy-light workout schedule. Tuesday was the heavy day, with Friday the light active recovery day in which the training loads were reduced by 20-25 percent. This reduction provided for optimal neurophysiological recovery from the previous heavy workout.

## Dynamic Squat Training Procedures

The dynamic full squat group followed a conventional power oriented training program for the six-week experimental period (Table 5). They trained simultaneously with the FIS group and were supervised and monitored at every workout.

The six-week experimental training period consisted of three two week phases and incorporated the progressive overload principle. Training intensity was based on the one repetition maximum (1-RM) in the full squat with a given number of sets and repetitions performed (Table 5). In the first phase (base strength cycle) the subjects performed three sets of ten repetitions to build muscular endurance. During the second phase (strength/power cycle) three sets of 5-6 repetitions were required to incorporate both muscular strength and endurance. In the last phase (peaking cycle) three sets of 2-3 repetitions were performed to stimulated maximum muscular strength.

## Biomechanics of the Parallel Squat

The mechanics of the parallel squat involve the ready position, descent, and ascent (Figure 7). In the ready position, the bar is positioned on the back 1-2 inches below the shoulders with the hands in as close as possible. The feet are placed flat on the floor and spaced slightly wider than shoulder width, with the toes

## Table 5. Dynamic Squat Group

### Workout Schedule - 6 Weeks

**Warm-up**

A. Stretching - back and legs, 5 minutes
B. Full squat - light weight 10 repetitions

**Weeks 1 and 2**

70-75% of 1-RM

| Weight | Repetition | Sets |
|---|---|---|
| 115 or 135 | 10 | 1 |
| 70% | 10 | 1 |
| 70% | 10 | 1 |
| 70% | 10 | 1 |
| 115 or 135 | 10 | 1 |

**Weeks 3 and 4**

80-85% of 1-RM

| Weight | Repetition | Sets |
|---|---|---|
| 115 or 135 | 10 | 1 |
| 80% | 5 | 1 |
| 80% | 5 | 1 |
| 80% | 5 | 1 |
| 115 or 135 | 10 | 1 |

**Weeks 5 and 6**

90-95% of 1-RM

| Weight | Repetition | Sets |
|---|---|---|
| 115 or 135 | 10 | 1 |
| 155 or 175 | 5 | 1 |
| 95% | 2 | 1 |
| 95% | 2 | 1 |
| 95% | 2 | 1 |
| 155 or 175 | 10 | 1 |

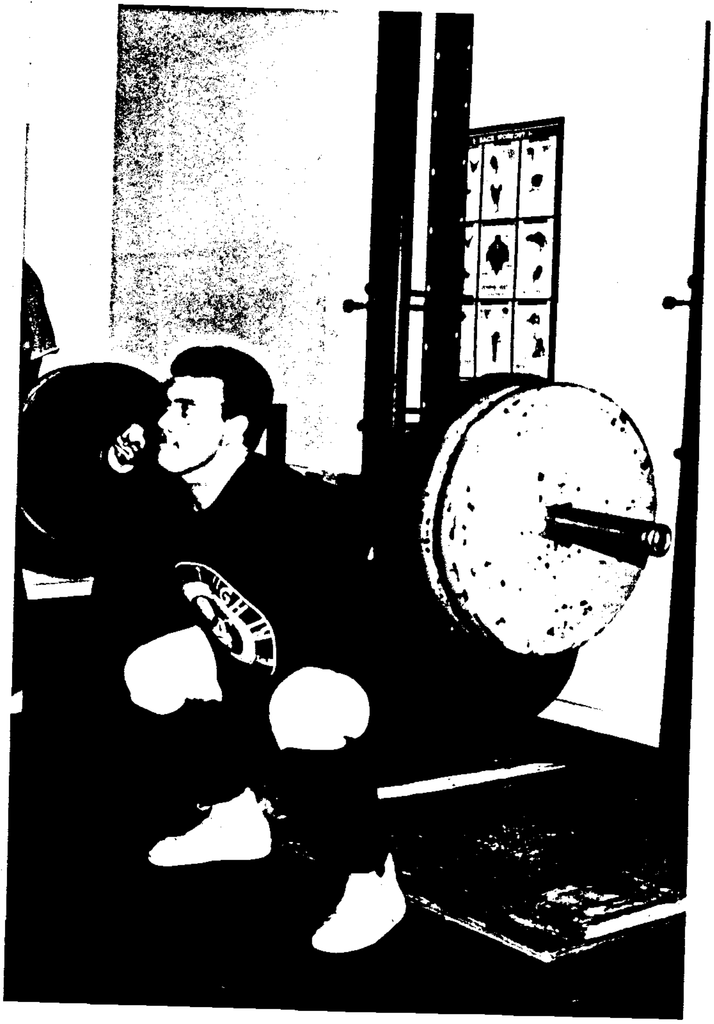

Figure 7. Dynamic squat - bottom position

turned out approximately 30 degrees. To begin the descent, inhale deeply and squat down in a slow, controlled manner (approximately 45 degrees per second), to the point where the top of the thighs are slightly lower than parallel. The ascent begins with a strong drive out of the parallel position with an explosive accelerated upward movement utilizing quadricep and hip extensor strength.

## Safety Precautions

Both the FIS and the dynamic squat training programs placed high stress on the legs and back. To reduce the possibility of injury the following safety measures were followed:

1. All training sessions were closely supervised.
2. Correct lifting technique was utilized at all times.
3. Spotters were used during both testing and training sessions.
4. Every workout started and finished with static stretching of the lower back and legs.
5. All subjects were required to wear a 10 cm. wide leather power-lifting belt which provided support to the lower back and abdominal muscles.

There were no injuries during the experimental training period of the study.

## Testing Procedures

Testing was conducted on a pre- and post-test basis. Pre-testing was conducted the week prior to the start of the six-week experimental period and the post-testing the week immediately following. Due to possible diurnal variations in strength, all of the tests were conducted at the same time of the day (53).

### Isometric Leg Strength

Static leg strength was assessed through the use of the knee extension cable tensiometer strength test described by Clarke and Clarke (13). The test was selected as it was relative to the major muscle groups utilized in executing the squat.

The starting position for the knee extension has the subject sitting in a backward-leaning position; arms extended to the rear, hands grasping sides of table. The right knee was positioned at 115 degrees extension. The subject slowly put tension on the strap and then made an explosive contraction of the quadricep muscle. The subject was not allowed to lift the buttocks off the table and flex the arms (Figure 8).

### Power

The vertical jump test was used to measure explosive

Figure 8. Static leg strength - knee extension

leg power. In executing the vertical jump test, the subject first stood flat footed with the right side against the board and the arm stretched as high as possible overhead to measure the reach. After chalking the fingers of the right hand, the subject assumed a squat position with a knee angle approximately 115 degrees and the feet spread 13 cm to 25 cm laterally and about 13 cm anteriorly-posteriorly (Figure 9). The subject held the squat position for approximately two seconds and then jumped as high as possible. As he reached the peak of his jump, the subject touched the boards with the chalked fingers while thrusting downward with the opposite arm. The score for each trial was the number of centimeters from the bottom of the board to the point touched during the jump, minus the standing score. The measurement was to the nearest half-centimeter. Three consecutive trials were given. The highest score was used as the power score. The vertical jump test is reported to give an accurate assessment of power.

### Dynamic Leg Strength

Assessment of dynamic strength was determined by a 1-RM in the parallel squat utilizing the technique previously described. Reliability of this 1-RM assessment has been verified by Jackson (31). The criteria for judging the success of the squat is outlined in the

Figure 9.  Power - Vertical jump

official rules of The International Power Lifting Federation (29).

The mechanics of executing the parallel squat are as follows (Figure 7): From a standing position with the barbell resting across the upper back just below the top of the shoulders, the subject squats down to a position where the top of the thighs are parallel to the floor. From this position the subject, with a vigorous extension of the thighs and hips returns to the standing position.

## Statistical Null Hypothesis

The general hypothesis was that six-weeks of training would produce no significant statistical improvement in static or dynamic strength between the functional isometric group or the dynamic squat group. The specific sub-hypotheses which were tested are as follows:

1. There will be no significant difference in the pre-test and six-week post-test means for dynamic strength within the functional isometric group and the dynamic squat training group.
2. There will be no significant difference in the six-week adjusted mean scores for dynamic strength between the functional isometric group and the dynamic squat training group.

3. There will be no significant difference in the pre-test and six-week post-test means for static strength within the functional isometric group and the dynamic squat training group.
4. There will be no significant difference in the six-week adjusted mean scores for static strength between the functional isometric group and the dynamic squat training group.
5. There will be no significant difference in pre-test and six-week post-test means for power within the functional isometric group and the dynamic squat training group.
6. There will be no significant difference in the six-week adjusted scores for power between the functional isometric group and the dynamic strength training group.

## Treatment of the Data

Statistical analysis of the data was carried out on the physical characteristics of the subjects and on static strength, dynamic strength, and power tests.

1. The methods used to analyze data from physical characteristics test involved determination of the means, standard

variables.

2. The t-test was computed on each dependent variable within each group to determine whether the changes which took place in each group were significant. Dependent variables present in this study were dynamic strength, dynamic strength, and power.
3. The one-way analysis of co-variance was used to determine differences in the means of the test scores in static strength, dynamic strength and power between the functional isometric group and the dynamic squat training group. The pre-test values were used as the covariates and the post-test values were used as dependent variables.
4. The .05 level of significance was selected for all statistical conclusions.
5. Graphical analysis was used to demonstrate the relationship in a given set of test scores.

# IV. RESULTS AND DISCUSSION

## Introduction

The effects of a functional isometric squat training program on developing dynamic strength, static strength, and power in college males was investigated and statistically analyzed using the paired t-test and one-way analysis of covariance (ANCOVA). The subjects were measured in a 1-RM dynamic squat, static strength, and power prior to and at the conclusion of the six week experimental period.

The null hypotheses of primary interest was that six weeks of functional isometric squat training would result in no modification of dynamic strength, static strength and power and that no difference would exist between the two groups in developing greater strength and power.

Paired t-tests were used within the FIS group and the dynamic squat group on each of the variables. One-way analysis of covariance was used to determine the significant difference between the two training programs with the pre-test mean score as the covariate and the post-test mean score as the dependent variable (14). This chapter will present and discuss the information and results obtained.

## Results

### Dynamic Squat Strength

A one-way analysis of covariance, at the .05 level of significance was used to determine the statistical difference between the FIS training group and the dynamic squat training group after the six week training period (Table 6). Calculation of the F-value was made after treatment of the data by a one-way analysis of covariance. The calculated variance showed that after the six week experimental training period, the FIS training group made a greater improvement statistically at the .05 (.024) level than the dynamic squat training group. It's important to note that the training programs for both groups were closely matched in terms of training intensity (loads and volume of the workouts).

The means, standard deviation, difference in means, and the t-test value were computed for the dynamic squat (Table 7). For the FIS training group the mean increased from 255 pounds in the pre-test to 325 pounds in the post-test with an average increase of 70 pounds. The dynamic squat training group had a significant lower increase from 278 pounds in the pre-test to 307 pounds in the post-test with an average increase of 29 pounds. Using the t-test analysis, both training groups demonstrated a significant improvement at the .01 level (Treatment -.0030, Control -.0068).

## Static Strength

A one-way analysis of covariance was calculated to determine if there was a significant difference between

Table 6. Analysis of Covariance Between Fl Training and Dynamic Training on Dynamic Strength

| Source of Variation | MS | df | F |
|---|---|---|---|
| Between | 3195.03 | 1 | 8.11* |
| Within | 2759.31 | 7 | |
| Total | 5954.34 | 8 | |

Decision: Null hypothesis was rejected.*

*Significant at the .05 level.

Table 7. T-test Values for Pre-test and Post-test Dynamic Strength

| Pre-test | Mean | S.D. | Difference in Means | t-value |
|---|---|---|---|---|
| FIS group | 255 | 13.69 | 70 | |
| Dynamic group | 278 | 47.78 | 29 | |
| **Post-test** | | | | |
| FIS group | 325 | 12.75 | | 6.60* |
| Dynamic group | 307 | 49.02 | | 5.01* |

Decision: Null hypothesis was rejected.*

*Significant at the .01 level.

Table 8. Analysis of Covariance Between Fl Training and Dynamic Training on Static Strength

| Source of Variation | MS | df | F |
|---|---|---|---|
| Between | 0.50 | 1 | 0.07 |
| Within | 2.40 | 7 | |
| Total | 52.90 | 8 | |

Decision: Null hypothesis was retained.

Table 9. T-test Values for Pre-test and Post-test Static Strength

| Pre-test | Mean | S.D. | Difference in Means | t-value |
|---|---|---|---|---|
| FIS group | 40.60 | 0.89 | -1.00 | |
| Dynamic group | 38.80 | 1.30 | -1.00 | |
| **Post-test** | | | | |
| FIS group | 39.60 | 1.67 | | -1.12 |
| Dynamic group | 38.80 | 4.09 | | -0.71 |

Decision: Null hypothesis was retained.

the FIS training group and the dynamic squat training group at the end of the training period. The obtained F-value indicated there was no statistically significant difference at the .05 (.798) level for either training group (Table 8).

The means, standard deviation, difference in means, and t-test values were calculated for static strength (knee extension) in Table 9. Static strength decreased for both the FIS and dynamic squat training groups with scores of 40.60 to 39.60 pounds and 39.80 to 38.80 pounds, respectively. Analysis of the t-test determined no statistically significant improvement at the .01 (Treatment - .173, Control - .266) level for both training groups.

### Power

Calculation of the one-way analysis of covariance and the obtained F-value determined there was no statistically significant improvement between the training groups at the .05 (.369) level (Table 10).

The t-test values, including the means, standard deviation, and difference in means were calculated for vertical jump (Table 11). For the FIS training group the mean increased from 50.20-53.60 cm and the dynamic squat training group increased from 55.20-58.18 cm. Using the t-test analysis the FIS training group had a statistically significant improvement at the .05 (.048) level,

Table 10. Analysis of Covariance Between F1 Training and Dynamic Training on Power

| Source of Variation | MS | df | F |
|---|---|---|---|
| Between | 9.31 | 1 | 0.98 |
| Within | 66.32 | 7 | |
| Total | 75.63 | 8 | |

Decision: Null hypothesis was retained.

Table 11. T-test Values for Pre-test and Post-test Power

| Pre-test | Mean | S.D. | Difference in Means | t-value |
|---|---|---|---|---|
| FIS group | 50.20 | 3.49 | 3.40 | |
| Dynamic group | 55.20 | 6.61 | 2.98 | |
| Post-test | | | | |
| FIS group | 53.60 | 6.01 | | 2.38* |
| Dynamic group | 58.18 | 9.09 | | 1.82** |

Decision: Null hypothesis was retained.

*Significant at the .05 level.

**Significant at the .01 level.

while the dynamic squat training group did at the .01 level (.083).

## Discussion

Several factors may be identified that account for the significant improvement in dynamic squat strength by the experimental group when compared as an individual group and compared to the control group. These factors are the biochemical and the neuropsychological aspects of FI lifting.

The biochemical demands of FI lifting places a tremendous overload upon the muscles which greatly increase their capacity to generate optimal muscular tension. This muscular tension is required in all physical activities and sports involving explosive-reactive-ballistic movements. Also, by lifting through a limited range of movement, FI permits one to selectively train and isolate positions that have weak mechanical leverage. Isolating and training weak leverage positions with heavy loads is not possible with dynamic weightlifting movements. Therefore, this has always been one of the limiting factors of dynamic lifting.

One of the primary conclusions that may be reached from this study is that the combination of FI training in weak leverage positions while using heavy loads greatly contributes to significant improvement in dynamic leg strength. This statement is supported by the fact that the experimental group improved significantly in power compared to the control group.

The neuropsychological factors of FI training in all probability played a key role in the dynamic strength improvement of the experimental group. These factors embrace both the physiological and psychological aspects of strength performance. In studying the effects of a 1-RM on the quadriceps, Rose (48) concluded that the persistence of strength as a learned act certainly does not appear to be an "impossible concept". Based upon Rose's observation one may reason that the psychological factors - motivation, body image, and consciousness - are a crucial consideration in neuropsychological function, and ultimately in the expression of strength.

The intrinsic nature of FI training (high intensity lifting utilizing maximal loads) challenges the higher brain centers involved in the voluntary recruitment of fast twitch Alpha motor units. These motor units are recognized for their high activation threshold and ability to generate peak muscle tension. Thus, the lifter must generate as strong an impulse as possible to recruit them.

In the performance of a maximum strength task such as a FI squat, which demands a strong ballistic impulse and peak muscle tension, optimal arousal is required (1, 32, 34, 49). Arousal being the act of "psyching up". Arousal involves mental imagery in which the athlete visualizes and feels the tremendous ballistic impulse he must generate at the moment of execution, and followed immediately by the all-out static strength effort required in holding the bar solid against the pins for a 3-second count.

Mental imagery stimulates the cerebral cortex into activating the arousal system (which includes the hypothalamus and adrenal medulla), bringing about greater motor unit recruitment through facilitation and spatial summation (1, 49). Spatial summation (multiple fiber summation) is the means by which signals of increasing strength are transmitted in the nervous system by the utilization of greater number of nerve fibers (16, 18). The stimulus becomes more intense as the number of nerve fibers stimulated increases.

In accounting for the greater increase in dynamic strength by the experimental group, it may be concluded that the intrinsic value of FI training provides an optimal level of self-generating stimulus-specific arousal. To achieve this state, FI lifting challenges and facilitates voluntary cortical function. FI training leads to enhanced cortical transmission enabling the neuromuscular system to respond selectively to one set of stimuli. This maximizes the motor response (generation of a strong ballistic impulse) required to execute a specific dynamic strength task (i.e. 1-RM FI squat). So in the process of arousal and mental imagery there exists a neuropsychological factor that FI lifting can effectively train and develop.

Several important questions which pertain to this discussion, remain unanswered. The questions are: when considering the significant increase in dynamic leg strength by both training groups why wasn't there a corresponding improvement in static strength? One would expect an increase but none occurred. The research literature is silent on this topic. Also, why didn't the control group improve in vertical jump power to match their gains in dynamic leg strength? Analyzing the formula for power, Power = Force x Velocity, the application of greater force should have resulted in an increase in power. Why this did not happen is difficult to say. Perhaps the controls were in a slight stage of fatigue? Whatever the reason both problems require further investigation.

## Application

Based upon the results of this study, FI lifting can play a major role in the overall strength training program of most athletes. FI assist athletes, especially those participating in sports requiring explosive-reactive-ballistic movements, develop an optimal relationship between strength and power. This increase in power production is highly transferable to other sports. The degree of transfer however, will be related to the athletes' skill level. Athletes possessing good technical skill stand to gain the most from FI training.

Within the yearly training cycle, FI can be most effectively used as the primary training mode during the last six weeks of a ten week strength cycle. During the strength and power cycle FI can be applied as an alternate workout schedule along with regular dynamic lifting. During the competitive cycle, field event athletes and football players will find FI beneficial in helping to maintain a high strength level with minimum workout time.

The scientific training concepts that govern dynamic strength training apply equally to FI training. By following them as they relate to training load, volume, intensity and frequency of workouts there should be no major problems in establishing a quality, result producing FI strength program.

For the school physical educator, FI can add a new dimension to a strength and conditioning unit. Through the use of FI, students can be exposed to a more advance method of strength training which will stimulate greater physical growth and development. Caution must be taken however, not to expose high school students to intense FI training as this may be dangerous, resulting in injuries to the knee joints or the lower back.

# V. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

## Summary

The purpose of this study was to examine the relative effectiveness of functional isometric squats on the development of dynamic strength, static strength, and power. The subjects for the study were ten male college students at Oregon State University, ranging in age from 18 to 22 years that were enrolled in an advanced weightlifting class.

Prior to the beginning of the experimental period, the 1-RM dynamic squat, static strength, and power of all subjects were tested. The FIS training group was engaged in an intense FI training program, while the dynamic squat training group trained using the traditional method for 60 minutes each, two days per week for the six week period. Following the training period, a post-test was given to determine the effects of FIS training on dynamic strength, static strength, and power.

The results were analyzed using the paired t-test to determine if there were statistically significant differences within the pre-test and post-test mean scores for both training groups. Comparisons of the results of the two training programs were made by using a one-way analysis of covariance.

There were statistical differences in the dynamic squat values at the .05 level of significance. Furthermore, there were no statistical differences in the static strength and power value at the .01 and .05 level of significance with the exception of the vertical jump within the FIS training group.

## Conclusion

The following conclusions have been formulated from the data presented in this study:

1. A six week FIS training program did significantly increase the dynamic strength of college males.
2. A six week FIS training program did not significantly increase static strength.
3. A six week FIS training program did not significantly increase power.

## Recommendations

The results of this study and the lack of research in the area of FI training are the basis for the following recommendations:

1. Further research should be conducted with a larger male subject population on the long term effects of FI training.
2. Further research should be conducted to compare the changes in strength and power between highly trained males and females on similar FI training programs.
3. Further research should be conducted to compare the changes in strength and power between trained and untrained individuals to a similar FI training program.
4. Further research should be conducted to

compare the effects of strength and power on male/female athletes using FI training programs.

5. Further research should be conducted using dynamic squats combined with jump drills (plyometrics) to see if there is an increase in leg power by the addition of vertical jumping.
6. Further research should be conducted to determine the relationship between FI and static leg strength.
7. Further research needs to be conducted to determine the physical rehabilitative value of FI.

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# APPENDICES

# APPENDIX A

## SAMPLE WORKOUT - FIS GROUP

### FUNCTIONAL GROUP

| NAME | SQUAT | WEEK | % | LOW | % | HIGH |
|---|---|---|---|---|---|---|
| JB | 265 | 1,2 | 60 | 160 | 120 | 315 |
| | | | 65 | 175 | 125 | 330 |
| | | 3,4 | 70 | 185 | 135 | 355 |
| | | | 75 | 200 | 140 | 370 |
| | | 5,6 | 80 | 210 | 150 | 395 |
| | | | 85 | 225 | 155 | 410 |
| DF | 270 | 1,2 | 60 | 160 | 120 | 325 |
| | | | 65 | 175 | 125 | 340 |
| | | 3,4 | 70 | 190 | 135 | 365 |
| | | | 75 | 205 | 140 | 380 |
| | | 5,6 | 80 | 215 | 150 | 405 |
| | | | 85 | 230 | 155 | 420 |
| SG | 255 | 1,2 | 60 | 155 | 120 | 305 |
| | | | 65 | 165 | 125 | 320 |
| | | 3,4 | 70 | 180 | 135 | 345 |
| | | | 75 | 190 | 140 | 360 |
| | | 5,6 | 80 | 205 | 150 | 380 |
| | | | 85 | 215 | 155 | 395 |
| HH | 235 | 1,2 | 60 | 140 | 120 | 280 |
| | | | 65 | 155 | 125 | 295 |
| | | 3,4 | 70 | 165 | 135 | 320 |
| | | | 75 | 175 | 140 | 330 |
| | | 5,6 | 80 | 190 | 150 | 355 |
| | | | 85 | 200 | 155 | 365 |
| CW | 250 | 1,2 | 60 | 150 | 120 | 300 |
| | | | 65 | 165 | 125 | 315 |
| | | | 70 | 175 | 135 | 340 |
| | | | 75 | 190 | 140 | 350 |
| | | | 80 | 200 | 150 | 375 |
| | | | 85 | 215 | 155 | 390 |

# APPENDIX B

## SAMPLE WORKOUT - DYNAMIC GROUP

### DYNAMIC GROUP

| NAME | SQUAT | WEEK | 70% | 75% | 80% | 85% | 90% | 95% |
|---|---|---|---|---|---|---|---|---|
| EA | 235 | 1,2 | 165 | 175 | | | | |
| | | 3,4 | | | 190 | 200 | | |
| | | 5,6 | | | | | 210 | 225 |
| GB | 265 | 1,2 | 185 | 200 | | | | |
| | | 3,4 | | | 210 | 225 | | |
| | | 5,6 | | | | | 240 | 250 |
| RK | 270 | 1,2 | 190 | 205 | | | | |
| | | 3,4 | | | 215 | 230 | | |
| | | 5,6 | | | | | 245 | 255 |
| RL | 250 | 1,2 | 175 | 190 | | | | |
| | | 3,4 | | | 200 | 215 | | |
| | | 5,6 | | | | | 225 | 240 |
| D | 360 | 1,2 | 250 | 270 | | | | |
| | | 3,4 | | | 290 | 305 | | |
| | | 5,6 | | | | | 325 | 340 |

## SAMPLE WORKOUT - TUESDAY

| Week 1 and 2 | Week 3 and 4 | Week 5 and 6 |
|---|---|---|
| 135 x 10 | 135 x 10 | 135 x 10 |
| 155 x 5 | 175 x 5 | 175 x 5 |
| *175 x 10 | *200 x 5 | 205 x 2 |
| 175 x 10 | 200 x 5 | *225 x 2 |
| 175 x 10 | 200 x 5 | 225 x 2 |
| 135 x 10 (pause) | 135 x 10 (pause) | 135 x 10 (pause) |

*FRIDAY use 20 pounds less

# APPENDIX C

## INDIVIDUAL DEMOGRAPHIC DATA

| Subject | | | Squat | | | Knee Extension | | | Vertical Jump | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Name | Age | BW | Pre | Post | Change | Pre | Post | Change | Pre | Post | Change |
| JB | | 200 | 265 | 335 | 70 | 40 | 42 | 2 | 48 | 50.5 | 2.5 |
| DF | | 150 | 270 | 310 | 40 | 42 | 40 | -2 | 50 | 57.0 | 7.0 |
| SG | | 135 | 255 | 315 | 60 | 40 | 38 | -2 | 52 | 57.0 | 5.0 |
| HH | | 167 | 235 | 340 | 105 | 40 | 40 | 0 | 55 | 59.0 | 4.0 |
| CW | | 182 | 250 | 325 | 75 | 41 | 38 | -3 | 46 | 44.5 | -1.5 |
| ER | | 164 | 235 | 250 | 15 | 38 | 32 | -4 | 54 | 53.0 | -1.0 |
| GB | | 170 | 265 | 305 | 45 | 40 | 40 | 0 | 64 | 68.9 | 4.9 |
| RK | | 155 | 270 | 290 | 20 | 41 | 43 | 2 | 61 | 67.0 | 4.0 |
| RL | | 162 | 260 | 305 | 45 | 39 | 40 | 1 | 50 | 49.0 | -1.0 |
| D | | 217 | 360 | 385 | 25 | 41 | 39 | -2 | 48 | 53.0 | 5.0 |

# APPENDIX D

## INFORMED CONSENT RELEASE

In consideration of the benefits to be derived and the data to be generated, the undersigned, a student of Oregon State University, agrees to participate in the research project, "A Comparison of Two Methods of Squat Training - Full Squat and Functional Isometric Squat - on Static and Dynamic Strength and Kinetic Power Output." The undersigned states that he or she has read an outline of the proposed study, including the possible risks and benefits, and is participating voluntarily and consents to following the testing and training program outlined. The undersigned also agrees to the use of the data generated as the above agencies may desire.

At any time during the study, if circumstances should arise and the undersigned cannot complete the study, he or she if free to discontinue.

______________________________
Participant

______________________________
Date

# APPENDIX E

# HUMAN SUBJECTS APPROVAL

**OREGON STATE UNIVERSITY**

**Committee for the Protection of Human Subjects**

**Chairman's Summary of Review**

**Title:** A comparison of two methods of squating on dynamic and static strength and kinetic power.

**Program Director:** Patrick O'Shea, Ed.D.

**Recommendation:**

XX **Approval***

____ **Provisional Approval**

____ **Disapproval**

____ **No action**

***The informed consent forms obtained from each subject need to be retained for the long term. Archives Division of the OSU Department of Budgets and Personnel Service is willing to receive and archive these on microfilm. At present at least, this can be done without charge to the research project. Please have the forms retained in archives as well as in your files.**

**Remarks:** It is not clear (#3 of "Subjects Informed Consent") whether training sessions will be on Tuesdays and Fridays of each week during the 6-week experimental training period or just one Tuesday and one Friday. Additionally, are training sessions a total of one hour or does each last one hour? This needs to be clarified.

Training sessions are on Tuesday + Friday for approximately 90 minutes

**Date:** January 6, 1987 **Signature**

**If the recommendation of the committee is for provisional approval or disapproval, the program director should resubmit the application with the necessary corrections within one month.**