Vertical jump training : the Kor trainer vs. conventional training
by Minde Rae Erickson

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Health and Human Development
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Abstract:
Vertical jump, or the maximum height an individual can reach when jumping in the vertical direction, has become a crucial measure of athletic success. Although most strength and conditioning professionals have adopted programs they consider efficient and effective, the desire to improve vertical jump training programs is being studied continually. The purpose of this study was to determine the effectiveness and efficiency of the KOR TRAINER, as compared to the widely used conventional method of back squats and plyometrics, in improving vertical jumping ability of athletes.

Twenty female collegiate level cheer and dance squad members volunteered to participate in the study. The subjects were assigned to either the Conventional Group (n = 10) or the KOR TRAINER Group (n = 10). The two groups participated in a seven week study in which the first week consisted of two familiarization session and the gathering of pre-training anthropometric data, and vertical jump and three-repetition maximum (3RM) values. The next six weeks consisted of a training program in which the subjects met twice a week to complete their assigned groups training protocol. The Conventional Group performed back squats on a squat rack and plyometric box jumps. The KOR TRAINER Group performed back squats and jump squats both on the KOR TRAINER. Vertical jump and 3RM were measured pre-training, at the mid-point of the training period, and at the conclusion of the six-week training period.

The results of the study noted no changes in vertical jumping ability in either of the two groups. Both groups made significant increases in strength as was measured by a three-repetition maximum. No changes were detected in thigh circumference that would indicate muscle hypertrophy, and calf circumference was found to decrease but a toning effect or systematic measurement error may have been a factor.

In conclusion, given the population of subjects used in this study, no difference in vertical jump was found for either the Conventional Group or the KOR TRAINER Group, however, strength increased equally for both groups. The KOR TRAINER Group completed each workout in roughly half the time of the Conventional Group.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

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CHAPTER 1

INTRODUCTION

Development of Problem

From the competitive athlete, who has made a career out of training, to the little old lady who has to jump to gain that extra inch needed to reach the desired item off of the shelf at the grocery store, jumping has become an important movement for humans as they attempt to keep up with today's fast-paced lifestyle.

Although jumping is important in our everyday behavior, to an athlete, the ability to jump as high as possible is a crucial determinant for athletic success (Ugarkovic, Matavulj, Kukolj, & Jaric, 2002). Strength and conditioning professionals are searching continually for the optimal way to improve the vertical jump and help athletes gain the extra edge in competition.

Jumping is a movement that requires the action of many joints and is dependent upon how much force and power those joints and surrounding muscles can produce (Fatouros, et. al., 2000). Numerous training methods and equipment designs have been developed over the years with the intent of increasing vertical jump (Kraemer, Ratamess, Volek, Mazzetti, & Gomez, 2000).

Background

Current training approaches include plyometric training, squats that vary the range of motion or the velocity of the movement, open vs. closed kinetic chain exercises, lifting techniques such as Olympic lifts, or a combination of training methods.

Regardless of the training approach applied, the concept of specificity should be considered (Weiss, Fry, Wood, Relyea, & Melton, 2000). The greatest increases in vertical jump are observed when movements that resemble the motion of a vertical jump are performed (Baker, 1996).

Training Approaches

Closed- Vs. Open-Kinetic Chain Exercises

Open-kinetic chain exercises are those exercises in which the end segment of the involved body segment is free to move, as in an isokinetic knee extension where the feet move up and down while the muscles of the quadriceps contract and relax. In contrast to open-kinetic chain exercises, closed-kinetic chain exercises are those exercises in which the end segment is fixed. An example of a closed-kinetic chain exercise is the barbell squat where the feet of the athlete are fixed to the ground.

In a program enhancement study comparing open-kinetic chain (isokinetic knee-extension) to closed-kinetic chain (barbell squat) exercises, the closed-kinetic chain training program improved vertical jump by five centimeters whereas no significant improvement was detected with open-kinetic chain exercises (Augustsson, Esko, Thomee, & Svantesson, 1998).

Deep vs. Shallow Squat

After a nine-week training program comparing the effects of deep and shallow machine based squats on vertical jump, Weiss, Fry, Wood, Relyea, and Melton (2000) found that the depth at which a squat is performed does not affect the amount in which vertical jump is enhanced (Weiss, Fry, Wood, Relyea, & Melton, 2000).

Olympic Lifting

In a study comparing power lifters, Olympic lifters, and sprinters, McBride, Triplett-McBride, Davie, and Newton (1999) found that Olympic lifters are more forceful and powerful due to their training philosophy. Olympic lifters combine heavy lifting at slow velocities with explosive movement, thus increasing both peak power and peak force which in turn leads to enhancements in vertical jump (McBride, Triplett-McBride, Davie, & Newton, 1999).

Slow vs. Fast Squat

In a study investigating the differences in vertical jumps after training with either slow or fast barbell squats, Morissey, Harman, Frykman, and Han (1998) discovered that the effects of training at either of the velocities was joint-specific. They found that fast training resulted in greater improvements in the variables associated with the hip and ankle whereas slow training led to gains in the knee variables. Although both training programs produced improvements in performance, the faster training resulted in greater magnitude and quantity of training effects than did the slow training. It was concluded that when implementing a training program, the velocity of the exercises comprising the training program should complement those of the target activity (Morrissey, Harman, Frykman, & Han, 1998).

Plyometric vs. Squat vs. Squat-Plyometric Training

After observing the improvements made in vertical jump from participation in either a plyometric training program, a squat training program, or a routine combining both plyometrics and squats, Adams, O'Shea, O'Shea, and Climstein (1992) concluded that by incorporating both plyometrics and parallel squats into a training regimen, the power produced by the hip and thigh is increased significantly more than either training program would elicit when performed solo. The Plyometric group increased vertical jump by an average of 3.81 cm, the squat group by an average of 3.30 cm and the group training with both squat and plyometrics increased their vertical jump by an average of 10.67 cm (Adams, O'Shea, O'Shea, & Climstein, 1992).

The KOR TRAINER

Recently, a new piece of equipment has been designed with the intent of improving athletic skills such as the vertical jump. The KOR TRAINER (Deden Technologies, Missoula, MT) (Appendix A) was developed in an attempt to provide an effective and efficient way of maximizing human ground-based movement by preserving the user's natural proprioception model (what the user would experience if performing the same movement while in a free-body state). Human ground-based movements are the ballistic athletic movements considered necessary to perform such skills as tackling, blocking, running, and jumping. Developers of the KOR TRAINER try to accomplish this through the application of a resistance tracking system that is believed to obey the natural principles of physics associated with accelerating ones own center of gravity (http://www.deden.com).

The KOR TRAINER claims to adhere to the concept of specificity of training, a crucial element in maximizing athletic potential. While performing ground-based movements, the user's paths of motion and speed of movement control the opposing resistance system, thus allowing users to efficiently improve sport-specific functional athletic strength, speed and skill.

The KOR TRAINER weighs 681 kg (1500 lbs) and can be adjusted, via its weight stack, to apply resistance up to 368 kg (810 lbs) in 20 kg (45 lb) increments. This adjustability allows users to train at a variety of resistances from very light to very heavy.

This study aims to examine the effectiveness of the KOR TRAINER in improving vertical jump by comparing a training program composed of exercises completed using the KOR TRAINER with a more conventional training program of back squats on a squat rack and plyometric box jumps.

Mike Deden, developer of the KOR TRAINER, believes that the unique design of the KOR TRAINER and its numerous applications to sport-specific training make it superior to the more conventional method of back squats and plyometric box jumps in improving vertical jump. This is just a speculation, however, as there is no research as of yet to confirm this belief (M. Deden, personal communication, September 23, 2002).

Statement of Purpose

The purpose of this study is to determine whether the KOR TRANER is a more effective method for increasing an athlete's vertical jump given a six-week training period when compared to the more conventional method of bar squats and plyometric box jumps.

Hypothesis

In light of the training advantages described, it is hypothesized that the group of subjects who perform the training program on the KOR TRAINER will have a greater change in vertical jump as compared to the change experienced by the subjects in the conventional group. However, there is no research to support the effectiveness of the KOR TRAINER, thus it is possible that it may be less effective than conventional training.

$$H_o: \mu_1 = \mu_2$$
$$H_{a1}: \mu_1 \neq \mu_2$$

The notations of μ_1 and μ_2 are the mean population values for the appearance of an increase in vertical jump in the KOR TRAINER and Conventional groups, respectively.

Assumptions

It is assumed that all subjects will adhere to the guidelines of the study and will comply with the protocols set by the researcher. It is also assumed that the activities performed outside of the experiment will not influence vertical jump.

Limitations

The level of prior conditioning and training is expected to vary within the subjects. Pre-vertical jump measurements will not be identical and therefore training may benefit those with lower pre-vertical assessments. Training induced relative strength gains are determined in large part by the pretraining strength level of the athlete. Hakkinen et al. (1987) found that athletes who trained in a weight training program for the first time experienced double the increase in relative strength in half the amount of time than those athletes with previous weight training experience (Kraemer, Deschenes, & Fleck, 1988).

Delimitations

Initially, female dancers and cheerleaders of college-age will be studied. This method of acquiring subjects does not result in a true random sample as it draws upon those cheerleaders and dancers who volunteer from Montana State University in Bozeman, Montana.

Operational Definitions

Before proceeding, several key terms should be defined.

Amortization Phase: the conversion from eccentric (negative) work to concentric (positive) work. The time the athlete's feet are in contact with the ground.

Center of Gravity: the point of balance of the body; an imaginary point through which the resultant force of gravity acts on an object (McGinnis, 1999).

Closed-kinetic chain: a system of joints in which the terminal joint segment is stationary (i.e. backsquat) (Baechle and Earle, 2000).

Concentric: a muscular activity that occurs when a muscle develops tension and its points of attachment move closer together (shortened).

Coordination: timing of segmental movement. Considered to be one of the most important factors in proficient performance.

Eccentric: a muscular activity that occurs when a muscle develops tension and its points of attachment move farther apart (stretched).

Extension: a straightening movement where the relative angle between two adjacent segments increases as the joint returns back to the zero, anatomical position.

Flexion: a bending movement where the relative angle between two adjacent segments decreases (moves away from anatomical position)

Hyperextension: an extension movement of a limb that continues past the original zero (anatomical) position.

Hypertrophy: an enlargement of muscle fibers but no increase in fiber number.

Kinematics: the branch of dynamics concerned with the description of motion.

Olympic lifting: a type of lifting that produces high power outputs through the combination of both heavy load, slow velocity training and explosive lifting.

Open-kinetic chain: a system of joints in which the terminal joint segment is free to move (i.e. leg-extension) (Baechle et al., 2000).

Plyometrics: a type of training which trains the neuromuscular system to move quickly between eccentric contractions and concentric contractions.

Proprioception: joint awareness and movement awareness, or how in tune a joint is as to where it is in space.

Reaction Force: an external contact force resulting from one object touching another (McGinnis, 1999).

RM: the mass that allows only a certain number of repetitions of an exercise to be performed to failure.

Vertical jump: a test in which an athlete makes a maximal attempt to jump as high as possible: a measure of hip and thigh power production.

CHAPTER 2

LITERATURE REVIEW

Introduction

The ability to jump is of utmost importance in the field of athletics today. As athletics has evolved over time, the vertical jump has become one indicator of an athlete's potential success in a given sport (McLaughlin, 2001). An athlete's vertical jump can be increased through the application of a variety of different training strategies. Strength and conditioning coaches have applied methods such as plyometrics, Olympic lifting techniques, closed- vs. open-kinetic chain exercises, slow vs. fast lower body exercises, or a combination of these methods in order to find the optimal technique in which to train their athletes. Although most coaches have adopted programs that they consider efficient and effective, the desire to improve vertical jump training programs is continually being studied.

It is hypothesized that through the use of the KOR TRAINER, an athlete will be able to make greater gains in his/her vertical jump in a shorter time period than an athlete participating in a more conventional method of vertical jump training. The rationale for this hypothesis is detailed in the following review of the literature.

Vertical Jump Description

Strength and conditioning professionals often use the vertical jump as a means of accruing baseline data on their athletes (Chu, 1998). The vertical jump is a measure of power wherein the athlete must exert a ground reaction force (GRF) in order to vertically accelerate the body's mass while it is still in contact with the ground. This acceleration propels the athlete and is crucial to the height in which the athlete can jump (Kreighbaum & Barthels, 1990). Although an important component in the majority of sports, successful vertical jumping ability is not something an athlete is born with but is a skill in which an athlete must be trained (Chu, 1998).

Before designing training programs intended to improve vertical jump, one must have an understanding of the kinematics of a vertical jump during the two phases in which the body is in contact with the ground. By breaking down the vertical jump into its most elementary parts, one can see that the joints involved in correctly completing a vertical jump are the ankle, knee, hip, shoulder, and to some extent the elbow (McGinnis, 1999). Hubley and Wells (1983) predicted that the ankle, knee, and hip extensors are responsible for 23%, 49%, and 28% of the work done in a countermovement jump respectively (Hubley and Wells, 1983). During the countermovement, or preparatory phase where the athlete's center of gravity (COG) descends quickly, the ankles dorsiflex, the knees and hips both flex, and the shoulders hyperextend (McGinnis, 1999). The arms move to a point behind the midline of the body while the trunk leans slightly forward. With the shoulders now in hyperextension and the arms as straight as possible, the athlete is prepared to swing the arms through (this happens in the propulsive phase) which results in the production of force to be directed downward into the ground (Chu, 1998). The ankle plantar flexors and the hip and knee extensors all contract eccentrically during the countermovement while the shoulder extensors contract concentrically (McGinnis, 1999).

The actions at each joint are reversed during the propulsive phase. The ankles plantarflex, the knees and hips extend, and the shoulders flex. During the propulsive phase all involved muscles contract concentrically (McGinnis, 1999). The force produced by the arms and legs is a major contributor to the quick extension of the ankles, knees, and hips. Once beyond the midline of the body, however, the swinging of the arms allows the body to take-off but contributes nothing more to the ground reaction force (Chu, 1998).

The importance of vertically accelerating the body as quickly as possible at the end of the preparatory phase and beginning of the propulsive phase indicates the need for strength in the ankle plantar flexors, knee extensors, hip extensors, and shoulder flexors (McGinnis, 1999). The force developed by the ankle, knee, and hip, the power produced by the muscles surrounding these joints, and the nervous systems ability to coordinate the necessary actions occurring at each joint have been established as being crucial factors in successful vertical jumping ability (Fatouros, Jamurtas, Leontsini, Taxildaris, Aggelousis, Kostopoulos, & Buckenmeyer, 2000). Also, Harman et al. (1991) found that the arms contribute as much as 21% to the overall height of the vertical jump (Chu, 1998). It is suggested that exercises used to improve strength and power in the muscles involved in vertical jumping be incorporated into an athlete's training program (McGinnis, 1999).

Everett Harman, PhD, et al. (1991) showed that as much as six percent of the overall height attained when performing a vertical jump comes from the completion of a successful countermovement. Because of the minimal contribution of the countermovement on total height achieved, Harman suggested that if an athletes sport does not require the ability to vertically jump maximally, a more effective approach would be using no countermovement when training (Chu, 1998).

Developing the Exercise Prescription

The type of training program employed significantly influences the physiological adaptations that occur during resistance training. In order to maximize training results, great detail must be taken when developing exercise prescriptions intended to increase the potential for athletic success (Kraemer, Deschenes, & Fleck, 1988). One thing to remember when designing a training program is that the response of different athletes to the same training regimen may differ greatly (Kraemer et al., 1988). Factors such as an athlete's genetics, goals, motivation, and/or pretraining status can all influence an athlete's response to training (Kraemer & Baechle, 1989).

The quality of a training program is determined by the structuring of the exercises comprising a microcycle. Microcycle, developed by the combination of micros in Greek meaning small, and cyclus in Latin meaning a regular sequencing of activities, is a crucial element of a training regimen. When referring to athletics, a microcycle is a weekly training period. The sequencing of microcycles in an overall training program should be determined by considering the particulars of the sport and the individualized training needs of each athlete (Bompa, 1983).

Previous research has determined that, from a psychological and physiological viewpoint, four to six weeks of power training at a high intensity is the most advantageous time-frame in which to stress the central nervous system before unwarranted exhaustion or damage occurs. Similarly, in order to allow for proper recovery following each training session, only two training sessions should be performed each week (Adams et al., 1992).

Five variables combine to make effective resistance training programs: 1) the exercises to be completed, 2) the order in which to perform the exercises, 3) the intensity (resistance) used, 4) the number of sets of each exercise, and 5) the length of the rest period between sets. It is through the varying of the aforementioned variables that the desired physiological and psychological responses can be achieved (Kraemer, Fleck, & Evans, 1996).

Variation, the manipulation of load, sets, and repetitions, is an important component to consider when developing strength-training programs. There is a finite time span in which an athlete will respond to any type of stress. Once beyond this time frame an athlete can experience declines in training. By varying the intensity and volume of training throughout the training duration, and by incorporating proper resting periods, the achievement of the desired physiological adaptations becomes more likely (Kraemer, 1988). Research has led to the conclusion that when strength-power is the favored outcome of training, two to five minutes of rest should be taken between each exercise set in order for ample recovery and a better conduction of the neural signal to the working muscle (Kraemer, 1989).

The number of sets of a given exercise performed primarily determines the volume used. With increases in strength and power the sought after goal of training, three to eight sets of a given exercise seems to be the optimal number (Kraemer, 1989).

Progressive Overload

The achievement of power, strength, and endurance can be obtained through the application of the principle of progressive overload. To implement overload into a training program, frequency, intensity, and duration can all be manipulated throughout the training period in order to force the neuromuscular system to work at higher intensities (Radcliffe et al., 1999). During overload, changes occur to the physiological systems. There comes a point in which the tissues no longer experience overload and so more overload must be applied (Baechle & Earle, 2000). By increasing the height of the box used during the performance of plyometric box jumps one is applying the principle of progressive overload. Similarly, increasing the load lifted during barbell squats, or increasing the number of plates on the weight stack of the KOR TRAINER causes the neuromuscular system to work harder.

Specificity

The principle of specificity can easily be applied to any training program by incorporating exercises similar to the athlete's sport in respect to the joints being used and the movements occurring at those particular joints. The range of motion the joints go through when completing the exercises should be at least as great as the range of motion experienced when performing the target sport (Baechle et al., 2000). To account for the effect of training velocity on actual performance, athletes should train at speeds comparable to that used in competition (Kanehisa & Miyashita, 1983). In order to obtain the desired training result, the exercises prescribed for an athlete must resemble the skills completed while participating in a given sport. For example, when incorporating plyometric training into an athletes training schedule, 80% of the total foot contacts should pertain to the exercises that are similar to the skills that will be performed in the desired sport. General conditioning exercises should compose the remaining 20% of total foot contacts (Chu, 1998).

Example Program to Increase Vertical Jump

The squat is an effective exercise to perform when looking to increase vertical jump. Squatting leads to an increase in strength of the major muscles involved in proper execution of a vertical jump (O'Shea, 1985). The complex actions of the squat allow for increased efficiency of the neuromuscular system. Because of this enhanced neuromuscular response, the body is capable of generating higher levels of power when performing skills, like the vertical jump, that are biomechanically comparable to the squat. Similarly, the application of plyometric activities to an athletes training program can aid the athlete in developing explosive power. This power is developed as a result of the storing of kinetic energy within the elastic components of the muscle and the enhanced recruitment of motor units that are facilitated via plyometric training. Thus, the neuromuscular system can quickly switch between eccentric and concentric contractions (Adams, et al., 1992).

Baker (1994) proposed that an athlete's vertical jumping ability could be enhanced through the application of general, specific, and special strength training. A muscles ability to contract is increased via general strength training (i.e. squats). Specific training (i.e. depth jumps) allows for enhancements in the stretch-shortening cycle. Finally, special strength training exercises (i.e. jump squats) train for the conversion of strength into power (Baker, 1996).

In a survey of the practices of National Football League (NFL) strength and conditioning coaches, results indicated that 19 of 26 NFL strength and conditioning coaches incorporated plyometrics in their conditioning programs. Of the exercises used regularly, seventeen coaches reported using multiple jumps or hops, fifteen used box drills, and seven coaches implemented depth jumps into their programs. Complex training was practiced by seven coaches, nine coaches used plyometrics prior to weight lifting but on the same day, six coaches performed plyometrics following resistance training but on the same day, and four coaches incorporated plyometrics and weight training on different days (Ebben & Blackard, 2001).

Chu (1998) proposed a vertical jump training program in which the athlete participates in low-intensity, high-volume resistance training exercises and low-intensity plyometrics during the initial week of training. This combination is used to allow the athlete's body to adjust to the stress and strain of jumping and impact forces experienced during landings. The second week of training utilizes resistance training for the development of lower limb strength and begins to incorporate a higher level of plyometric activity. The third week places emphasis on high-intensity plyometric activities and incorporates weight training as a type of recovery. The final week of training involves high-intensity, low-volume exercises. Recovery is stressed after both resistance training and plyometric activities as effort exerted is near maximal. The above four weeks of an entire training cycle is begun only after individual considerations for each athlete has been accessed, testing has been performed on each athlete, the length of time of the training cycle and the time of year of its application have been thought through, and the design of the program according to preparation, progression, and performance has been determined (Chu, 1998).

Physiological Adaptations

Neuromuscular Adaptations to Resistance Training

Development of the reactive capability of the neuromuscular system is of primary importance in helping an athlete attain the highest level of performance possible (Verhoshansky, 1969). For a specific movement, increased activation of agonist muscles and proper adjustments in the activation of antagonist and synergist muscles are the possible mechanisms of neural adaptation to strength training. A more powerful force can be produced in the desired direction of movement as a result of this increased activation and coordination of the involved muscles (Sale, 1988).

Resistance training is important in helping prepare an athlete's muscles for the quick impact experienced during performance of plyometric activities. Early Europeans deemed it necessary that an athlete be able to squat 2.5 times their body weight before participating in any type of plyometric activity. More current research has led conditioning specialists to ensure that an athlete can squat 60 percent of their body weight five times in five seconds before a low intensity plyometric program is initiated (Chu, 1998).

Numerous studies have resulted in findings leading researchers to conclude that during the first six to eight weeks of a strength-training program, gains made in strength are primarily due to neural factors (Moritani & DeVries, 1979). Ikai and Fukaunaga (1970) observed a 92% increase in strength with only a 23% improvement in muscle cross-sectional area (Kraemer, 1988). In a study by Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman, and Hikida (1994), evidence suggesting that, in addition to the neural adaptations occurring within the initial weeks of training, intramuscular changes that contribute to strength gains are taking place as well (Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman, & Hikida, 1994).

According to Sale (1992), neural adaptations contributing to increases in strength are most influenced by the type of resistance training program applied. Neural adaptations appear to occur more readily during the early phases of a training program (2-8 weeks) and it has been suggested that they contribute more to strength gains in low volume, high intensity (>90% 1RM) training protocols where the stimulus for the growth of muscle tissue is inadequate to elicit muscle hypertrophy. Greater strength gains as a result of neural adaptations could be due, in part, to the ability of a novice weight lifter being able to recruit all of the accessible motor units when learning resistance training techniques, but a diminishing recruitment once the learning period is over (Kraemer et al., 1996).

Muscular Adaptations to Resistance Training

Programs that advocate the growth of muscle tissue may reduce the initial contribution to strength and power usually experienced as a result of neural adaptations. Research has shown that significant increases in muscle hypertrophy do not occur until after at least 16 workouts. Sale et al. (1992) stated that after the initial weeks of a training program (6 – 10 weeks) when neural factors prevail, muscle hypertrophy begins to dominate as training continues past ten weeks. Like neural adaptations to strength and power gains, however, contributions of muscle fiber hypertrophy on increases in strength and power eventually taper off as well. Most researchers completing studies of long enough duration to elicit hypertrophy have measured increases in muscle fiber cross-sectional area ranging from 20 to 45%, with some recording up to 50% gains. Hakkinen (1989, 1994) determined that there is a genetic upper boundary of neuromuscular adaptations that governs the extent to which the activation and progressive overloading of muscles can contribute to increases in strength and power (Kraemer et al., 1996). It should be noted that the athlete's strength base at the initiation of a training program has been shown to dictate the amount by which strength and power training can increase vertical jump. On more than one occasion it has been concluded that previously strength-trained athletes experience less of an increase in vertical jump than athletes beginning the training program with no, or limited previous strength training (Fatouros et al., 2000).

Adaptations to Plyometrics

Researchers performing electromyographic (EMG) studies have been successful in not only observing neuromuscular adaptations to resistance training but they have also discovered neural adaptations resulting from the participation in plyometric activities (Sale, 1988).

Complex training is the alternating of weight lifting and plyometric activities within the same training session. Lyttle, et al. (1996) found that by incorporating the idea of complex training into an athlete's training schedule, the stretch reflex is facilitated to a greater extend than if maximal power training were performed without plyometric exercises. Maximal power training was composed of bench press exercises and jumping activities on machines designed to enhance maximal power development for these certain skills (Chu, 1998).

The neuromuscular system can be stimulated through the application of complex training. When performing strength training exercises, it is proposed that there exists a small time frame, following a heavy (near maximal or maximal) set of a strength exercise (i.e. squat), in which the athlete's body remains in an increased state of stimulation. It is during this time period that an athlete can perform higher quality plyometric activities (i.e. depth jumps or box jumps) due to the body's physiological condition (Chu, 1998). According to Chu (1993), however, Complex training should not be implemented into an athlete's training schedule until the athlete has developed a suitable strength base. The volume of plyometric activities performed during a training session should be reduced to a number that can be fit in between the sets of the complimenting strength exercise (Chu, 1998).

Training Approaches

Plyometrics

Fred Wilt, one of the United States most advanced track and field coaches, invented the term *plyometrics* in 1975. The Latin roots *plyo* and *metrics* concatenate to give the meaning of "measurable increases". It didn't take long before those in the world of athletics began to view plyometrics as a way of producing power via the combination of strength and speed (Chu, 1998).

A number of researchers have completed studies that indicate that an athlete's vertical jump can be increased through the use of plyometric training (Gehri, Ricard, Kleiner, & Kirkendall, 1998). Athletes in sports such as basketball, high jumping, sprinting, volleyball, long jumping, and throwing have benefited greatly due to the incorporation of plyometrics into their training program's (Hamill & Knutzen, 1995).

Plyometric exercises require a muscle to perform both concentric and eccentric muscular contractions (Toumi, Thiery, Maitre, Martin, Vanneuville, & Poumarat, 2001). Plyometrics is a method of training in which a quick, dynamic stretching (eccentric muscle action) of an active muscle leads to a powerful contraction (concentric muscle action) of the same working muscle (McLaughlin, 2001). When in series, these muscle actions are known as the stretch-shortening cycle (Holcomb, Lander, Rutland, & Wilson, 1996). The stretch-shortening cycle is composed of two important factors: 1) the muscle's elastic components such as tendons and the cross-bridging actions of the actin and myosin (elements that compromise the muscle fiber), and 2) the proprioceptors ability to activate the stretch reflex by detecting muscle tension and delivering sensory information associated with quick muscle lengthening (Chu, 1998). This sequence of stretch-contract is responsible for roughly 25 to 30% of the increase in force production. During the stretching phase of the cycle, elastic potential energy is stored. The remaining 70-75% of the force produced during the plyometric activity is a result of this storing of energy (Hamill et al., 1995). Given the contraction immediately proceeds the rapid stretch, this increased muscle tension, combined with the normal voluntary tension of the muscle, allow for a contraction greater in power than an ordinary shortening of muscle could produce (Holcomb et al., 1996). This powerful reaction resulting from the myotactic stretch reflex is what has helped plyometrics become known as the link between strength and speed (Adams, O'Shea, O'Shea, & Climstein, 1992).

The myotactic, or stretch, reflex is one of the quickest reflexes in the human body. This is because the connection from sensory receptors to the muscle fibers eliciting the muscle contraction is direct via the cells in the spinal cord whereas other reflexes travel through a number of different interneurons to the brain before a muscle can contract (Chu, 1998).

Yuri Verhoshansky is the researcher and coach most responsible for the descriptions of plyometrics and its various forms of using it (Yessis & Frederick, 1986). Verhoshansky believed that in order to increase and sustain explosiveness, weight lifting programs should be accompanied by plyometric training (Adams, et al., 1992).

Similarly, Fatouros et al. (2000) stated that for an athlete to experience the numerous benefits of plyometric training, they must first be strength trained (Fatouros et al., 2000).

During a twelve-week, three-day per week training program that followed the principle of progressive overload, Fatouros et al. (2000) found that by combining weight training and plyometric training into an athlete's training regimen, both vertical jump and leg strength could be significantly increased by an amount greater than either training method would elicit when applied alone. Subjects were all novice weight lifters. One group underwent a weight-training protocol (WT), another completed only a plyometric protocol (PT), the third group (PWT) performed a combination of plyometrics and weight training (where the weight-training portion was completed three hours after the plyometric protocol), and the control group underwent no training at all. During the initial training phase (first eight weeks) the strength training protocol was composed of resistance training exercises intended for increasing the strength of the muscles of the thigh and lower leg (i.e. squats). During the final phase (last four weeks) of training more specific exercises, intended to convert strength to power in a manner similar to the actions involved in jumping, were performed (i.e. jump squats, snatches, and cleans). The plyometric exercises performed during the first two weeks of the study were performed at a low volume and intensity in order for the subjects to adjust to the plyometric training. Box jumps and depth jumps were introduced during the sixth week of the study. Results at the end of the study indicated that the PT group increased their mean vertical jump by 6.0 cm (52.9 to 58.9) and squat by 16.4 kg (132.4 to 148.8), the WT group increased their vertical by 5.4 cm (58.1 to 63.5) and squat by 28.9 kg (133.0 to

161.9) and the PWT group improved their vertical by 8.6 cm (5.8 to 67.4) and squat by 36.1 kg (125.0 to 161.1). The improvement in vertical jump for the PWT was significantly different between pre and post training values, and also differed significantly from the post training values for both the PT and WT groups. (Fatouros et al., 2000).

Studies aiming to determine the effectiveness of plyometrics in improving vertical jump and power have been mixed in their findings. Researchers have attained evidence that support plyometrics and their role in increasing power, however, evidence supporting plyometrics role in improving vertical jump is still in need of further research. Gehri, Ricard, Kleiner, & Kirkendall (1998) found, that by applying the plyometric training principle via either depth jumps or countermovement jumps, that an athlete's ability to jump could be enhanced. After a twelve week training program, those subjects who trained with depth jumps increased their mean vertical jump from pre to post-testing by 113.61% for the squat jump (SJ), 108.04% for the countermovement jump (CMJ), and 110.95% in the depth jump (DJ). The subjects that performed countermovement jumps in training saw a mean increase of 106.83% for the SJ, 105.40% for the CMJ, and 108.74% for the DJ between pre and post-test measurements. This improvement in height was attributed more to an increase in the muscles ability to contract as opposed to the utilization of stored elastic energy. This can be seen in the change in positive elastic energy, or the contractile abilities of a muscle during a concentric contraction, experienced by both groups from the time of pre-testing to the end of the twelve-week training period. The group training via depth jumps had an increase in energy production of 11.25%, 8.32%, and 13.93% for the DJ, CMJ, and SJ respectively. The countermovement groups improved their positive energy production by 10.23%, 5.04%, and 6.13% for the DJ, CMJ, and SJ correspondingly (Gehri et al., 1998).

Adams, O'Shea, O'Shea, and Climstein (1992) found that a six week, two-day-per-week, combined plyometric and weight training program improved vertical jump by 10.67 cm,. whereas the plyometric group achieved a gain of only 3.81 cm and the weight lifting group a gain of only 3.30 cm (Adams, O'Shea, O'Shea, & Climstein, 1992). Other researchers, however, found that plyometric training alone was no more effective, and at times even less effective, in increasing vertical jump than a weight training program (Holcomb et al., 1996). In an earlier yet similar study of the effects of depth jumps and weight training on vertical jump, Clutch, Wilton, McGown, and Bryce (1983) did not make the same conclusions as Adams et al (1992).

Although numerous research has been completed to study the effects of plyometrics, weight training, and complex training (training combining both plyometrics and weight training), researchers are still in disagreement as to which method is more beneficial in training for vertical jumping skill. Discrepancies in the results could be due to the pretraining status of the subjects, the varying lengths of time of the studies, or the differing program designs (exercises, loads, and volumes) (Fatouros et al., 2000).

The box jump is an example of a plyometric exercise in which a box, varying in height between 12 and 24 inches, is needed (Radcliffe & Farentinos, 1999). When working with advanced athletes, however, a box height of up to 42 inches could be appropriate. The top of the box should have a non-slip landing surface that is a minimum of 18 to 24 inches (Chu, 1998). An athlete stands about one arms length away from the box and, by swinging the arms during the countermovement, propels his/her body upward and forward onto the box. Once contact is made (simultaneously by both feet) with the top of the box, the athlete immediately jumps backwards down to the same starting point and keeps repeating this sequence until the desired number of reps is completed. The contact time of the feet with the floor and box should be kept minimal (Radcliffe & Farentinos, 1999). The intensity of the box jump depends on the height of the box used. Box drills are useful in developing basic athletic skills such as both vertical and horizontal jumping ability (Chu, 1998), as well as the reduction of the amortization (the time in which the feet are in contact with the ground) phase as the neuromuscular system is developed to better initiate take-off immediately following ground contact (Chu & Plummer, 1984).

Movement Velocity

The velocity in which a movement is performed is speculated to be of importance when training an athlete for improvements in his/her vertical jump (Morrissey, Harman, Frykman, & Han, 1998). The electrical activity of a muscle experiences a velocity-specific change when the weight an athlete lifts during training is altered to control the speed of the movement (McBride, Triplett-McBride, Davie, & Newton, 2002). Discrepancies arise when considering the optimal speed in which to perform resistance training. Some researchers believe that in order to be strong at a fast velocity, resistance exercises must be performed at fast velocities. Other researches have found slow movement velocities to be more beneficial (Fleck & Kraemer, 1997).

Moffroid and Whipple (1970) determined that an increase production of torque at slow velocities could be achieved through high-load, slow-velocity training and that low-load, high-velocity training led to gains in torque at that velocity of training as well as any velocity lower than the training velocity (Ewing, Wolfe, Rogers, Amundson, & Stull, 1990).

The results of several researchers have indicated that a person's vertical jump could be improved by 5-15% (2-8 cm) through the application of a resistance training regimen composed of explosive lifts performed at lighter weights (Fatouros et al., 2000).

Morrissey, Harman, Frykman, & Ham (1998) found that training with fast barbell squats resulted in a two to three fold greater increase in hip, knee, and ankle power during the execution of a vertical jump than did training with slow barbell squats. They also found that the muscles surrounding the ankle and hip were more affected by fast training in terms of average power, whereas the muscles around the knee were more affected by slow training in terms of average torque. However, no differences in vertical jumping ability between the fast and slow groups were observed, but the concept of training velocity specificity was demonstrated when the groups training via fast isokinetic exercises experienced greater strength gains at faster training velocities where the strength gains were consistent at all testing velocities for the slow group. Thus, the researchers concluded that fast training may be necessary for one activity whereby slow training may be more beneficial for another (Morrissey et al., 1998).

Ewing, Wolfe, Rogers, Amundson, & Stull (1990) determined that the gains made in power and peak force via isokinetic training are affected by the velocity of the testing and training. Increases in hypertrophy of muscle fibers also appeared to result from isokinetic training but the extent to which hypertrophy occurred was not affected by the velocity of training. For subjects performing right knee extension and flexion exercises at slow-velocity, the area of slow-twitch muscle fibers increased by 17.1% and the area of fast-twitch muscle fibers increased by 10.2%. For those subjects performing exercises at a fast velocity of training, slow-twitch muscle fiber area increased by 13.5% and fast-twitch muscle fiber area increased by 13.3%. After ten weeks of training, it was concluded that the percentage of both fast and slow-twitch muscle fibers did not change from their pretraining values. (Ewing, Wolfe, Rogers, Amundson, & Stull, 1990).

Sale and MacDougall (1981) concluded that the nervous system is trained though fast movements while the muscular system is trained through slow movements. Therefore, both types of training are needed in an overall conditioning regimen in order to produce the most optimal results (Canavan, Garrett, & Armstrong, 1996).

In a seven and one half week study of the effects of training speed on hypertrophy, muscular power, and strength, Young and Bilby (1993) concluded that novice weight trainers can develop all these variables by taking care to control the speed in which they execute the exercise. Results of their study were that the group training at a fast velocity experienced a 68.7% increase in force production whereas the group training at a slow velocity experienced only a 23.5% gain. For absolute isometric strength, the fast group increased by 12.4% and the slow group by 31%. No notable differences in hypertrophy were measured in either group (Young, & Bilby, 1993).

After reviewing the literature on the optimum velocity at which to train, Fleck and Kraemer (1997) concluded that: 1) if only a single movement velocity is employed in a training program it should be of intermediate speed, and 2) there is a range above and below the training velocity in which gains in strength are experienced (Fleck et al., 1997).

Olympic Lifting Techniques

Many strength and conditioning coaches have employed Olympic lifting into the training programs of their athletes involved in sports requiring quick and powerful muscles. It is believed that due to the multi-joint explosive movements involved in Olympic lifting, the contracting of the muscles can be synchronized in a manner similar to that used in jumping. Canavan et al. (1996) found a close relationship between a squatting vertical jump and the hang snatch (Olympic) lift (Canavan et al., 1996).

Olympic lifting can be characterized by the performance of both fast, explosive lifts, and slow-velocity, heavy lifts. In contrast to Olympic lifting, power lifting is composed of slow lifts in which a maximal effort is desirable. In a study comparing power lifting, Olympic lifting (strength, power), and sprinters (performance, power), McBride, Triplett-McBride, Davie, & Newton (1999) concluded that Olympic lifters are able to jump high, generate high force measurements, and produce high power output simultaneously. Although the sprinting group could jump high, they could not produce a lot of force while doing so. The Olympic lifting group produced significantly higher peak force measurements than either the sprinting group or power lifting group for both the 20 lb load and 40 lb load countermovement jumps. Peak power for the Olympic lifting group was higher than the power lifters for both countermovement jump conditions and higher than the sprinting group for the 20 lb load countermovement jump. Overall jump height for Olympic lifters and sprinters was significantly higher than the power lifting group and controls for all three conditions (BW, 20 lb, 40 lb) (McBride, Triplett-McBride, Davie, & Newton, 1999).

Closed- vs. Open-Kinetic Chain Exercises

The training programs of most athletes are comprised of both weight machine (open-kinetic chain) exercises and free weight (closed-kinetic chain) exercises. Strength and conditioning professionals differ in opinion on which training method is the most optimal. The importance of functionality and the direct applicability of close-kinetic chain exercises to actual sporting activities is why some conditioning professionals are in favor of closed-kinetic chain training. On the other hand, supporters of open-kinetic chain exercises favor this method because less coordination is needed and weight machines are generally safer than free weights (Augustsson, Ekso, Thomee, & Svantesson, 1998).

Hudson (1986) stated that jumping is a closed-kinetic chain skill (Hudson, 1986). Since the major propulsive forces are experienced during contact with the ground, closed-kinetic chain exercises would be beneficial to include in a training program to improve closed-kinetic chain movements (Baechle, 2000).

Augustsson, Ekso, Thomee, & Svantesson (1998) found that, after six weeks of training, those subjects undergoing a closed-kinetic chain training program experienced a gain of 5 cm (10%) in the height of their vertical jump where those subjects following an open-kinetic chain protocol experienced no significant changes (Augustsson et al., 1998).

Summary

In searching for the optimal way in which to increase vertical jump, strength and conditioning coaches, researches, and athletes alike have all experimented with numerous training strategies in order to find the training approach that would lead to the greatest improvement in vertical jumping ability. After reviewing the literature it is apparent that a number of different techniques have been shown to increase vertical jump, however, complex training, or the combining of plyometrics with weight training exercises, is one current approach that is quickly gaining in acceptance. Because a variety of factors, some of which include training age and genetics, can play a role in the amount by which vertical jump is enhanced, further research is warranted that strictly controls for these other factors.

CHAPTER 3

METHODOLOGY

Introduction

The purpose of this study was to determine which training method was more effective in increasing an athlete's vertical jump. A training method using only the KOR TRAINER, or a more conventional method consisting of back squats and plyometrics. Although conventional methods have proven effective in previous research, newer techniques, which provide greater or faster results, are continually being sought by coaches and athlete's looking to gain an edge on the competition.

Subjects

Twenty female (18-22 yrs) cheer and dance squad members were recruited to participate in this study. Those subjects with no involvement in any other lower body weight-training program during the duration of the study and who were free of any lower or upper body extremity injuries met the criteria for inclusion of the study. Criteria for exclusion were those subjects with an existing injury that could compromise the results of the study. Those subjects who met inclusion but not exclusion criteria were informed of the purposes and procedures of the study and each signed an informed consent form before any testing was initiated in accordance with Montana State University procedures.

Procedures

All testing and training was performed in the D'Agostino Strength Training Center at Montana State University (Bozeman, MT). For the first day of the test and familiarization week, subjects reported to the D'Agostino Strength Training Center where they read and signed the informed consent form and filled out the Physical Activity Readiness Questionairre (PAR-Q) (Appendix B). The session then proceeded with the gathering of all necessary anthropometric measurements, followed by an initial recording of each subject's pre-training vertical jump. On the second day of the test and familiarization week, subjects again reported to the Training Center where vertical jump was re-measured in order to rule out any learning effects. Subjects were then coached on the proper squatting technique and a three repetition maximum (3RM) was determined for each subject. Before the session concluded, subjects were assigned to either the KOR TRAINER Group (KG) or the Conventional Group (CG). A resistance in which eight repetitions could be performed on the KOR TRAINER was determined for each subject assigned to the KOR TRAINER Group.

The six-week training program started the week following the initial familiarization week and subjects reported to the Training Center for training two times a week for the entire six-week period. Vertical jump measurements and 3RM were taken on a third day, 48 to 72 hours after the second training session of the third week (fourth week of the seven weeks), to track improvements. Following the sixth week of testing (seventh week of the study), a final testing session was held, 48 to 72 hours after the final training session, in which anthropometric measurements and a post-training vertical jump and 3RM were again recorded.

It is important to mention that since the training was split into two different training periods (October 22– December 12, 2002, and January 14 - March 2, 2003) the first eight subjects tested on Sunday of the 4th week and trained on Tuesday (performing the workout listed for Thursday) but missed Thursday due to the Thanksgiving Holiday. The final twelve subjects trained both Tuesday and Thursday of the 4th week as is outlined in the following tables.

Anthropometric Assessment

Anthropometric data measurements, including body height, body mass, and circumference measurements (calf and thigh) were obtained during the first testing session of the familiarization week. The collection of height and mass measurements were obtained first using a scale (Fairbanks Scales, Kansas City, Missouri), followed by circumference measurements. For height and mass measurements, subjects stood barefoot on the scale, feet together, hands at their sides, wearing comfortable athletic shorts and a t-shirt. Height and mass measurements were recorded to the nearest millimeter (mm) and Kilogram (Kg), respectively. All circumference measurements were obtained using an anthropometric tape measure. Table 1 lists circumference locations as determined by their proximal and distal anatomical locations. Circumference measurements were taken at a point halfway between the proximal and distal ends. Each measurement was taken three times to ensure the measurements where within a criterion range of two to three millimeters. All circumferences were measured on the subject's right side of the body and all measurements were recorded to the nearest millimeter. To ensure the accuracy and reliability of segment length measurements, the same researcher performed measurements on all subjects.

Table 1. Anatomical landmarks defining segment ends used to determine the midpoint of each segment for circumference measurement recording.

Segment	Proximal End	Distal End
Thigh	Greater Trochanter of Femur	Lateral Epicondyle of Femur
Calf	Lateral Epicondyle of Femur	Lateral Maleoleous of Fibula

To warm-up, subjects jumped rope for approximately three minutes and then vertical jump height was obtained by taking the best of three trials. Each subject performed a counterjump in which they stood with feet shoulder-width apart, used a countermovement, and jumped, reaching with one hand to touch the highest rod possible on the Vertec vertical jump measuring device. The second day of the familiarization week consisted of re-measuring vertical jump to rule out any learning effects. Then a measure of each subject's 3RM (using a squat bar and squat rack) was determined using the protocol described in Table 2. After all 3RM were obtained, subjects were assigned to either the KOR TRAINER or Conventional group. A resistance in which eight repetitions could be performed on the KOR TRAINER was determined for each subject assigned to the KOR TRAINER Group.

Table 2. Protocol used for determining subjects' 3RM.

Sets and Repetitions	Resistance
1 x 6	Bar (45 lbs)
1 x 3	65 lbs
1 x 3	85
1 x 3	95
1 x 3	Appropriate increments

Training Sessions

Warm-Up and Cool-Down. Subjects began each training session with three minutes of jump roping followed by a warm-up squatting protocol described in Table 3 or the KOR TRAINER squatting protocol described in Table 4. Once one set of three repetitions was performed at 105 lbs, subjects in the conventional group increased their weight, performing one set of three repetitions, in appropriate increments until a resistance of 73% (or whatever the target resistance for the day) of the subjects estimated 1RM (determined by multiplying each subjects 3RM by 1.13) was reached. The protocol used depended on the group each subject was assigned to. At the end of each training session subjects completed a light stretching routine before being dismissed from the Training Center. Stretches included the quad stretch, hamstring stretch (performed with foot on the floor or on a box), calf stretch, and cobra stretch.

Table 3. Conventional group warm-up.

Sets and Repetitions	Resistance
2 x 5	Bar (45 lbs)
2 x 5	65 lbs
1 x 3	85 lbs
1 x 3	105 lbs
1 x 3	Appropriate increments

Note: As the weeks progressed and technique improved, warm-up decreased to 1 x 3 for all resistances.

Table 4. KOR TRAINER group warm-up.

Sets and Repetitions	Resistance
1 x 6	1 Plate (45 lbs)
1 x 6	2 Plates (90 lbs (if appropriate))
1 x 6	+1 Plate (45 lbs) until target number of plates is reached

Note: One subject performed her four sets using three plates. All other subjects used two plates (during the first week).

KOR TRAINER Group (KG). The group training on the KOR TRAINER began the six weeks of training by performing four sets of six backsquats followed by three sets of six jump-squats (Appendix A) on the first training day (Tuesday) and four sets of eight backsquats followed by three sets of eight jump squats on the final training day of the week (Thursday). A one-minute rest was given between each set of squats and jumps. A progressive training approach was followed. Tables 5 and 6 list the progressive training programs, beginning with the initial testing session and familiarization period and continuing through the six-week training period to the final testing session. It is important to note that the increase in plates was determined according to each subject's individual capabilities. Therefore, some subjects increased in number of plates lifted at a faster rate than others (Appendix C).

Table 5. KOR TRAINER Protocol (Squats).

	Initial Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Final Testing
Sunday	Initial Testing				Testing			Final Testing
Tuesday	Technique Coaching	4 x 6 2-3 Pl	4 x 8 3-4 Pl	5 x 5 3-4 Pl	4 x 4 4-5 Pl	6 x 3 4-6 Pl	2 x 2 4-6 Pl 2 x 2 5-7 Pl 2 x 2 5-8 Pl	
Thursday	Technique Coaching	4 x 8 2-3 Pl	4 x 8 3-4 Pl	5 x 5 3-4 Pl	3 x 4 4-5 Pl	6 x 3 4-6 Pl	2 x 2 4-5 Pl 2 x 2 5-7 Pl 2 x 2 6-8 Pl	

Note: One minute of rest was taken between each set.

Table 6. KOR TRAINER Protocol (Jump Squats).

	Initial Week	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Final Testing
Sunday	Initial Testing				Testing			Final Testing
Tuesday	Technique Coaching	3 x 6 1 Pl	3 x 8 1 Pl	3 x 10 1 Pl	4 x 6 2 Pl	4 x 8 2 Pl	4 x 8 3 Pl	
Thursday	Technique Coaching	3 x 8 1 Pl	3 x 8 1 Pl	3 x 10 1 Pl	4 x 6 2 Pl	4 x 8 2 Pl	4 x 4 4 Pl	

Note: One minute of rest was taken between each set.

Conventional Group (CG). Initially, subjects in the Conventional Group performed four sets of six backsquats using a squat rack followed by three sets of six box jumps from a height of 12 inches. Three minutes rest was given between each set of squats and a one-minute rest was given between each set of box jumps. A progressive training approach was followed in that the height of the box increased, as did the resistance being applied during the performance of back squats. Tables 7 and 8 list the progressive training programs for the conventional group for both back squats and plyometrics respectively (Appendix D).

Table 7. Conventional Protocol (Squats).

	Initial Week	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Final Testing**
Sunday	Initial Testing				Testing			Final Testing
Tuesday	Technique Coaching	4 x 6 73%	4 x 8 73%	5 x 5 76%	4 x 4 80%	6 x 3 85%	2 x 2 80% 85% 90%	
Thursday	Technique Coaching	4 x 6 75%	4 x 8 75%	5 x 5 80%	3x 4 82.5%	6 x 3 87.5%	2 x 2 80% 85% 90%	

Note: Three minutes of rest was taken between each set.

Table 8. Conventional Protocol (Plyometric Box Jump).

	Initial Week	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Final Testing**
Sunday	Initial Testing				Testing			Final Testing
Tuesday	Technique Coaching	3 x 6 12"	3 x 8 18"	3 x 10 18"-24"	4 x 6 24"	4 x 8 24"	4 x 4 30"	
Thursday	Technique Coaching	3 x 6 12"	3 x 8 18"	3 x 10 18"	4 x 6 24"	4 x 8 24"	4 x 4 30"	

Note: One minute rest was taken between each set.

Post-Training Assessment

Following the six-week training period, all circumference measurements were re-assessed, a final vertical jump (best out of three successful jumps) measurement was recorded, and a post-training 3RM was obtained, in the aforementioned order.

Instrumentation

KOR TRAINER

The purpose for the development of the KOR TRAINER is to ultimately maximize human ground based movement by providing an effective and efficient means to perform free-bodied squat resistance training. This is claimed to be accomplished via the application of a torque-free, 2G gravity based resistance that is believed to obey the principle laws of physics associated with accelerating ones own center of gravity, thus preserving the users own proprioception model (that as would be experienced if in a free-body state). A self-engaging resistance was applied to subjects in the KG through the application of a thoracic harness. Unlike conventional methods, the KOR TRAINER allows the resistance to stay in phase with the subject. The 2G environment provides for the completion of twice the amount of work in the same amount of time (M. Deden, personal communication, September 23, 2002).

Vertec

The Vertec (Perform Better, Cranston, RI) is a common device used to measure vertical jump. The fingers of the jumping subject displace a series of plastic vanes, attached to a freestanding pole. The height of the jump is obtained by reading the highest vane moved (Young, MacDonald, Heggen, & Fitzpatrick, 1997).

Statistical Analysis

The mean values of the dependent variables were analyzed using a 2 x 3 (group x time) repeated measures analysis of variance (ANOVA). To detect significant differences between mean values of each dependent variable across time, Tukey's post-hoc test was performed. An alpha level of 0.05 was used to evaluate all statistical analyses. A single factor repeated measures ANOVA was used to determine intraclass reliability for all dependent measures. The software package, Statistix 7.0 (Analytical Software, Inc., Tallahassee, Florida), was utilized for all statistical analyses.

CHAPTER 4

RESULTS

Subject Characteristics

Twenty female collegiate level cheer and dance squad members volunteered to participate in the study. The age of the subjects ranged from 18 to 22 years (mean = 19.5 ± 1.50 years), mean weight was 61.17 ± 9.08 kg and mean height was 164.88 ± 6.44 cm. Ten subjects were randomly assigned to the Conventional Group (CG) and the other ten subjects were assigned to the KOR TRAINER Group (KG). Table 9 lists the demographic and anthropometric data for the Conventional Group and KOR TRAINER Group. All subjects were compliant with the inclusion and exclusion criteria and were dutiful in attending all training sessions. Subjects were allowed to miss one training session before being excluded from the study; however, attempts were made to make up all missed sessions within twenty-four hours of the actual training time. All subjects adhered to this requirement and therefore all twenty subjects completed the study.

Reliability Data

Pre-vertical jump measurement was measured and recorded twice in order to evaluate test-retest reliability. Table 10 lists the ANOVA for test-retest reliability. Intraclass reliability across both trials (Rxx(k = 2)) was 0.913. When extrapolated to one trial, intraclass reliability (Rxx(k = 1)) was 0.837. The standard error of measurement (SEM) for the two trials was ± 0.539.

Table 9. Demographic and Anthropometric Data for the Conventional Group (CG = 10) and KOR TRAINER Group (KG = 10).

Variable	Pre-Training	Post-Training
Age (yrs)		
CG	19.9 ± 1.3	----
KG	19.1 ± 1.7	
Stature (cm)		
CG	164.85 ± 8.15	164.85 ± 7.84
KG	164.91 ± 4.59	164.85 ± 4.37
Mass (kg)		
CG	62.99 ± 8.94	62.93 ± 8.91
KG	59.35 ± 9.31	59.01 ± 10.32
Thigh Circumference (cm)		
CG	54.45 ± 3.25	54.93 ± 3.55
KG	51.71 ± 4.07	51.67 ± 3.86
Calf Circumference (cm)		
CG	34.94 ± 1.80	34.74 ± 1.71 *
KG	32.58 ± 2.03	32.07 ± 2.28 *

Values = mean ± standard deviation.
* $p < 0.05$ compared to pre-training.

Table 10. 2 x 2 Repeated Measures ANOVA Table for Pre-Vertical Jump Test-Retest.

Effects	Degrees of Freedom (df)	Sums of Squares (SS)	Mean Square (MS)	F-ratio	p-value
Subject	19	121.40	6.389	12.64	0.000 *
Trial	1	0.10	0.100	0.21	0.649
S x T Interaction	19	8.90	0.468		

* $p < 0.05$

<u>Analysis of Vertical Jump Data</u>

Data collected during the pre-testing, mid-testing, and post-testing sessions were used to analyze vertical jump. The ANOVA for subject reach (subjects walked under the Vertec with arms extended above their head, one hand stacked on top of the other, and squeezing their ears with their arms) (Table 11) indicated no significant interaction (p = 0.947), as well as no significant main effects across the two groups (p = 0.958) or three time periods (0.149). Thus, subjects were consistent in their reach measurements from trial to trial. The ANOVA analysis for vertical jump (Table 12) indicated no significant main effects between the two groups (p = 0.278), across the three time periods (p = 0.511), or for the interaction effect (p = 0.477). The mean value for the Conventional Group had a non-significant change of 1.143 cm with a range of -5.08 cm to 3.81 cm from pre-testing to mid-testing and a mean change of -0.127 cm with a range of –2.54 cm and 3.81 cm from mid-testing to post-testing (Table 13). The mean value for the Conventional Group's vertical jump fluctuated by 1.016 cm with a range of –2.54 cm to 3.81 cm from pre-testing to post-testing. The KOR TRAINER Group's mean value for vertical jump changed by 0.127 cm with a range of –5.08 cm to 3.81 cm from pre-testing to mid-testing and again by –0.381 cm with a range of –3.81 cm to 2.54 cm from mid-testing to post-testing (Table 13). From pre-testing to post-testing the KOR TRAINER group's mean value for vertical jump changed by –0.254 cm with a range of –5.08 cm to 2.54 cm. Tukey's Post Hoc analysis detected no significant differences between vertical jump measurements at any of the three testing periods.

Table 11. 2 x 3 Repeated Measures ANOVA Table for Subject Reach.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	0.672	18	235.558	0.00	0.958
Time	2	3.978	36	1.983	2.01	0.149
G x T Interaction	2	0.108	36	1.983	0.05	0.947

Table 12. 2 x 3 Repeated Measures ANOVA Table for Vertical Jump.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	117.097	18	93.471	1.25	0.278
Time	2	2.043	36	2.987	0.68	0.511
G x T Interaction	2	2.258	36	2.987	0.76	0.477

Table 13. Vertical Jump Means and Standard Deviations (Mean ± SD) reported for the Conventional and KOR TRAINER Groups. The measurements are given at pre-testing, at the mid-point of the six-week training period (4th week of the study), and at the conclusion of the study (7th week).

Group	Pre-Testing (cm)	Mid-Testing (cm)	Post-Testing (cm)	Pre-Post Difference (cm)
CG	45.466 ± 4.856	46.609 ± 6.107	46.482 ± 5.558	1.016 ± 2.142
KG	43.434 ± 5.281	43.561 ± 6.560	43.18 ± 6.017	-0.254 ± 2.59

Values = mean ± standard deviation

Analysis of 3RM Data

Results of the ANOVA for 3RM (Table 14) indicated that the group x time interaction was not significant (p = 0.717); however, significant main effects were present for both group (p = 0.002) and time (p = 0.000). For the Conventional Group, mean values increased by 12.4 kg with a range of 4.5 kg to 26.1 kg from pre-testing to mid-testing and again by 11.1 kg with a range of 2.3 kg to 20.5 kg from mid-testing to post-testing for an increase of 23.5 kg with a range of 14.8 kg to 33.0 kg throughout the training period (Table 15). The KOR TRAINER Group experienced a mean increase of 10.7 kg with a range of 4.0 kg to 23.9 kg in 3RM values from pre-testing to mid-testing.

From mid-testing to post-testing mean increase in 3RM was 10.4 kg with a range of 0.0 kg to 22.7 kg. Overall the KOR TRAINER Group had an increase of 21.1 kg with a range of 8.0 kg to 31.8 kg (Table 15). Table 16 reveals the results of Tukey's Post Hoc analysis used to determine significant differences between 3RM at any of the three testing periods.

It should be noted that, due to illness, two subjects did not attempt a 3RM at mid-testing and therefore their mid-testing 3RM's were calculated by averaging their pre and post training values for 3RM.

Table 14. 2 x 3 Repeated Measures ANOVA Table for 3RM.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	4713.79	18	370.065	12.7379	0.0022 *
Time	2	2494.28	36	22.509	110.8081	0.0000 *
G x T Interaction	2	7.554	36	22.509	0.3356	0.7171

* $p < 0.05$

Table 15. 3RM Means and Standard Deviations (Mean ± SD) reported for the Conventional (CG) and KOR TRAINER (KG) Groups. The measurements are given at pre-testing, at the mid-point of the six-week training period (4th week of the study), and at the conclusion of the study (7th week). 3RM was measured in kilograms (kg).

Group	Pre-Testing (kg)	Mid-Testing (kg)	Post-Testing (kg)	Pre-Post Difference (kg)
CG	67.72 ± 10.90 *	80.17 ± 11.12 *a	91.25 ± 10.99 *ab	23.52 ± 6.90
KG	51.36 ± 11.23	62.10 ± 13.52	72.5 ± 12.56	21.14 ± 8.04

Values = mean ± standard deviation. * $p < 0.05$ compared to KG, a $p < 0.05$ compared to pre-testing, b $p < 0.05$ compared to mid-testing.

Table 16. Tukey HSD test for 3RM.

Group	Time	CG(1) 67.727	CG(2) 80.170	CG (3) 91.250	KG (4) 51.364	KG (5) 62.102	KG (6) 72.500
CG	Pre		0.0001 *	0.0001 *	0.432	0.8884	0.941
CG	Mid	0.0001 *		0.0002 *	0.0003 *	0.3302	0.6928
CG	Post	0.0001 *	0.0002 *		0.0001 *	0.0003 *	0.2940
KG	Pre	0.4322	0.0003 *	0.0001 *		0.0003 *	0.0001 *
KG	Mid	0.8884	0.3312	0.0003 *	0.0003 *		0.0004 *
KG	Post	0.9406	0.6928	0.2940	0.0001 *	0.0004 *	

* $p < 0.05$

Analysis of Circumference Data

The ANOVA analysis for subject mass (Table 17) indicated that no significant differences were present for the group main effect ($p = 0.379$), time main effect ($p = 0.509$), or interaction effect ($p = 0.640$). Similarly, results of the ANOVA (Table 18) for subject stature displayed no significant difference for the group x time interaction ($p = 0.845$), time effect ($p = 0.845$), or group effect ($p = 0.991$). For the statistical analysis of thigh circumference, the interaction effect ($p = 0.200$), group main effect ($p = 0.084$), and time main effect ($p = 0.275$) revealed that no significant differences in thigh hypertrophy occurred over the six-week training period (Table 19). On the other hand, significant differences in calf circumference for the group ($p = 0.009$) and time ($p = 0.036$) main effects were indicated but the interaction effect ($p = 0.333$) was not determined to be significant (Table 20).

Table 17. 2 x 3 Repeated Measures ANOVA table for Subject Mass.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	142.850	18	175.340	0.81	0.3787
Time	1	0.409	18	0.903	0.45	0.506
G x T Interaction	1	0.205	18	0.903	0.23	0.639

Table 18. 2 x 3 Repeated Measures ANOVA table for Subject Stature.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-valu0.8451e
Group	1	0.010	18	83.778	0.00	0.9914
Time	1	0.010	18	0.257	0.04	0.8451
G x T Interaction	1	0.010	18	0.257	0.04	0.8451

Table 19. 2 x 3 Repeated Measures ANOVA table for Subject Thigh Circumference.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	90.000	18	26.950	3.34	0.0843
Time	1	0.484	18	0.383	1.26	0.2755
G x T Interaction	1	0.676	18	0.383	1.77	0.2004

Duration of Workout

Those subjects in the KOR TRAINER group took approximately half the time to complete their workouts than those subjects in the Conventional Group. The time for the

KOR TRAINER group was estimated to be approximately fifteen minutes, whereas the Conventional Group's time was along the lines of twenty-five minutes to half an hour.

Table 20. 2 x 3 Repeated Measures ANOVA table for Subject Calf Circumference.

Effects	Degrees of Freedom (df)	Mean Square (MS)	df error	MS error	F-ratio	p-value
Group	1	63.378	18	7.482	8.47	0.0083 *
Time	1	1.278	18	0.250	5.11	0.0364 *
G x T Interaction	1	0.248	18	0.250	0.99	0.3325

* $p < 0.05$

<u>Summary</u>

In conclusion, although increasing vertical jump was the sought after goal of the study, vertical jumping ability was not enhanced in either the Conventional Group or the KOR TRAINER Group. Changes in strength, however, were observable in that 3RM increased significantly in both groups. Because no indications of hypertrophy were present in either the calf or thigh, increases in strength can be attributed to neural adaptations.

CHAPTER 5

DISCUSSION

Introduction

The primary goal of this study was to determine the effectiveness and efficiency of the KOR TRAINER, as compared to the widely used conventional method of back squats and plyometrics, in improving vertical jumping ability of athletes. A secondary goal of the study was to determine which of the aforementioned training methods was more effective in increasing an athlete's strength, as was measured by a squatting 3RM. Both vertical jump and 3RM were measured three times throughout the six-week training period, before the initial training session, mid way through the training period, and following the final training session. In regards to both the major and minor goals, the conventional method improved vertical jumping ability and increased 3RM by a greater amount than did the KOR TRAINER, however, the difference was not significant. In terms of the amount of time spent performing the protocol for the training day, the KOR TRAINER Group spent less time completing their assigned exercises than did the Conventional Group.

Subject Characteristics

Of the twenty female subjects who participated in this study, eight were cheerleaders at Montana State University – Bozeman (MSU) and the remaining twelve were members of the MSU dance team. Both the Conventional and KOR TRANIER

Groups were comprised of an equal number of cheerleaders and dancers (four cheerleaders and six dancers). All subjects were fairly equal with their daily physical activity as was determined by the requirements of their sporting activity. All subjects practiced an average of three times a week and most engaged in additional exercise on a regular basis. Other than the soreness that is expected as a result of participating in a resistance-training program, the only complaint expressed by some of the subjects in the Conventional Group was soreness from the bar resting on their back just inferior to the posterior deltoid. Two subjects in the KOR TRAINER Group experienced back pain from the harness that must be worn when utilizing the KOR TRAINER in order to attach the resistance cables to the athlete.

Subject Comments

Although the Conventional training program resulted in a slightly greater, although not significant, increase in vertical jump and 3RM, it is important to note that the subjects training on the KOR TRAINER finished their workouts in approximately fifteen minutes whereas the Conventional protocol took 25 to 30 minutes.

Reliability Data of Criterion Measures

Pre-vertical jump was measured twice to determine whether the day one versus day two measurements could be considered reliable. Vertical jump was found to be reliable from day-to-day. Thus, there was not an improvement effect based on familiarization of the vertical jumping protocol, the fact that it was the second time performing the test, or the subject's confidence in jumping.

In retrospect, it would have probably been advantageous to measure pre-3RM twice before initiating training to account for any learning effects associated with squatting and the techniques involved. However, this might have only influenced increases in 3RM at week three of the study but not post-training values.

Vertical Jumping Ability

It was expected that through the application of a six-week training program, either combining squats and plyometric box jumps or utilizing the KOR TRAINER to perform squats and squat jumps, an athlete's vertical jump could be enhanced. Results of this study indicated otherwise. Changes in vertical jump were not found to be statistically significant for either the Conventional Group or the KOR TRAINER Group. No prior research has been done using the KOR TRAINER and therefore no comparisons can be made with respect to the findings of the subjects in the KOR TRAINER Group. For the subjects in the Conventional Group, however, the results of the present study are in agreement with the findings of Ford, Puckett, Drummond, Sawyer, Knatt, and Fussel (1983) who found that vertical jump stayed the same after completing a combined plyometric and weight training protocol (Fatouros et al., 2000).

However, according to past studies in which enhancements in vertical jump through resistance training and plyometrics was the desired outcome, the findings of the present study, at least with respect to the Conventional Group, are somewhat surprising.

As was stated in the literature review, in a two-day per week, six-week training study, Adams et al. (1992) was able to increase vertical jump by an average of 10.67 cm in those subjects combining squats and plyometrics, whereas the plyometric group increased their vertical jump by only an average of 3.81 cm and the squat group by only an average of 3.30 cm (Adams et al., 1992). Evidence in support of Adams et al. (1992) can be found in the studies by Bauer, Thayer, and Baras, (1990), and Blakey and Southard (1987) who also measured increases in vertical jumping ability through the application of a combined plyometric and weight training program (Fatouros et al., 2000).

A number of different factors could have contributed to the discrepancies in past research and the present study, including the daily activities and training level of the subjects, the number of weeks of the training period, or the designs of the studies (Fatouros et al, 2000). The current study used members of a collegiate cheer and dance squad. The subjects, with the exception of a couple, were not previously strength trained but due to the nature of their sport and the jumping involved in stunting and dancing, it was decided that it was safe for them to perform plyometric box jumps or squat jumps on the KOR TRAINER. According to Fatouros et al. (2000), in order for an athlete to reap the benefits of plyometric training, they must first be strength trained (Fatouros et al, 2000). Along the same lines, Chu (1998) stated that the benefits of complex training are better achieved if the athlete has a pre-existing strength base in which to build upon (Chu, 1998). The fact that the subjects were not previously strength trained could have played a role in the outcome of the study with respect to vertical jump. The subjects also partake in a lot of jumping while stunting or dancing at games and in practices. Thus, the demands of their sport could have played a major role in why vertical jump did not increase for either group. The subjects may already be near their physiological peak in terms of jumping height. Descriptive data for vertical jump in competitive female athletes of college age gives a vertical jump measurement of 41 to 47 cm (Baechle et al., 2000). The subjects in the present study had vertical jumps within this range.

According to Adams et al. (1992) the six-week training period should have been sufficient enough for significant improvements in vertical jumping ability to be measured (Adams et al., 1992). Perhaps a study of longer duration (8 to 12 weeks) and greater frequency (three times a week) would have been more appropriate. Twelve weeks is still within the maximum time frame, suggested by Chu (1998), in which complex training can safely be implemented (Chu, 1998). Fatouros et al. (2000) performed an eight week, three day per week study of plyometrics, weight training, and their combination on vertical jump enhancement. Three days per week of training was found to be an effective frequency in which to train for improvements in vertical jumping ability (Fatouros et al., 2000). However, three days per week is in disagreement with Adams et al. (1992) who stated that a frequency of only two times per week was needed in order for the athlete to fully recover (Adams et al., 1992).

The current study was composed of one resistance training exercise (squat) and one plyometric exercise (box-jumps). Adams et al. (1992) had subjects in the Squat-Plyometric Group perform only one resistance exercise (squat) as well. For the plyometric portion of the training, however, subjects executed depth jumps, double leg hops, and both walking and standing split squats (Adams et al., 1992). Based on the protocols used in Adams et al. (1992) and Fatouros et al. (2000), it is clear that in order for improvements in vertical jump to occur, more than one plyometric training drill should be completed during a workout (Fatouros et al., 2000).

3RM

A subject's 3RM for squatting was used to track improvements in strength throughout the course of the six-week training period. 3RM was accessed prior to beginning training, midway through the training, and at the end of the training period. Due to the statistical significance of both the Conventional and KOR TRAINER Groups, it was concluded that increases in strength could be achieved through the performance of back squats on both the KOR TRAINER and the squat rack. No prior research has been done in regards to strength gains achieved via the use of the KOR TRAINER. However, results of the present study, with respect to the Conventional Group, are in agreement with those of Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman, and Hikida, (1994). After only four weeks of training, these researchers observed significant increases in both relative and absolute maximal strength after subjects performed squats, leg press, and leg extension exercises. The relative dynamic strength for the women in the study increased by 20% (68-88%), 30% (77-107%), and 22% (67-89%) for the squat, leg press, and leg extension respectively (Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman, and Hikida, 1994).

Strength gains were somewhat greater for the Conventional Group, but this increase over the KOR TRAINER Group was not found to be statistically significant.

One possible explanation for the slightly greater increase in strength gains achieved by the Conventional Group is that the Conventional Group performed squats on the squat rack during each training session and therefore were more familiar with squatting at a squat rack. The KOR TRAINER Group completed all their squatting exercises on the KOR TRAINER and only used the squat rack for the purpose of re-testing 3RM.

Kraemer, Deschenes, and Fleck (1988) stated that relative strength gains are greatly affected by the initial strength status of an athlete (Kraemer, Deschenes, and Fleck, 1988). The subjects in the present study were all novice weight lifters with virtually no strength training experience. Hakkinen et al. (1987) indicated that, when compared to experienced weight trainers with a greater strength base, beginning weight lifters could achieve almost twice the increase in strength in half the time period (Kraemer et al., 1988). The increases in strength observed by all subjects in the current study are not surprising given the aforementioned finding.

Circumference Measurements

Thigh and calf circumference were measured both pre and post training in order to attribute strength gains to neural adaptations or muscle hypertrophy. Staron et al. (1994) found no significant changes in anthropometric measurements following an eight\-week, twice per week, progressive lower body resistance training program (Staron, Karapondo, Kraemer, Fry, Gordon, Falkel, Hagerman, and Hikida, 1994). Results of the present study are in agreement with the findings of Staron et al. (1994) in that no significant changes were observed in thigh circumference. Significant changes in calf circumference were detected, however, but these decreases can potentially be attributed to toning effect or systematic measurement error.

Because no significant increases in thigh circumference were detected and because human error may have been a factor in the decrease in calf circumference, it is suggested that strength gains were a result of neural adaptations as opposed to muscle hypertrophy. Moritani and DeVries (1979) stated that strength gains, resulting from improvements in neural function, are most noticeable during the first three to five weeks of a training program (Kraemer, et al., 1988). Much of the literature examining the time course of neural and hypertrophic adaptations to resistance training have observed a huge increase in neural factors in the first six to ten weeks of a training program. Muscle hypertrophy, on the other hand, usually does not occur until after the tenth week of training (Kraemer, Fleck, and Evans, 1996). The current study involved only six weeks of combined resistance and plyometric training.

Exercise Protocol Justification

When looking to improve vertical jumping ability, the use of back squats performed on a squat rack and plyometric box jumps performed on boxes ranging in height from 12 to 30 inches can be justified by the continually increasing acceptance of the method of complex training (Chu, 1998). Complex training, or the integration of heavy lifting and plyometrics, has proven to be effective in improving power output and thus, vertical jumping ability. The current study utilized the concept of complex training. Support for the above training method can be validated in Adams et al's (1992) six-week complex training study, also mentioned in the literature review, that found a 10.67 cm increase in vertical jumping ability by those subjects performing a training protocol combining both weight training (squats) and plyometrics as opposed to subjects undergoing only squats (3.30 cm increase) and those performing only plyometric training activities (3.81 cm increase) (Adams et al., 1992). The use of squats as the weight training exercise is supported in the belief that neuromuscular efficiency can be enhanced through their performance, which consequently results in the transfer of this efficiency to movements, such as the vertical jump, that are biomechanically similar to the squat (O'Shea, 1985).

The current study was six training weeks in duration where two workouts were completed each week. Training twice a week for six weeks can be justified in the aforementioned study by Adams et al. (1992) who stated that from a psychological and physiological viewpoint, four to six weeks of power training at a high intensity is the most advantageous time-frame in which to stress the central nervous system before unwarranted exhaustion or damage occurs. In addition, in order to allow for proper recovery following each training session, only two training sessions should be performed each week (Adams et al., 1992). Similarly, Chu (1998) affirmed this training duration when he acknowledged that complex training is of high intensity and so it should not be used for training periods extending beyond 12 weeks (Chu, 1998).

Due to the newness of the KOR TRAINER there was no previous research to help guide the researcher in developing a training protocol for those subjects utilizing the KOR TRAINER for their workouts. Therefore, the researcher designed a program that mimicked the Conventional Groups training protocol in the exercises performed, number of sets, and number of reps based on what was feasible given the capabilities of the KOR TRAINER.

Further Discussion

When observing the data collected, it is of interest to address whether the KOR TRAINER is an effective piece of equipment to use in training athletes for improvements in vertical jump and lower body strength. Although the KOR TRAINER may adhere to the concept of specificity of training for a variety of sporting activities, it may not adhere to this concept in terms of specificity relating to timing and acceleration when looking to improve vertical jump. Because performance of a vertical jump requires an athlete to rapidly apply a force to the ground in order to accelerate the body upward, exercises used in training need to be explosive. The mass on the weight stack of the KOR TRAINER remains constant throughout the movement being performed and thus does not allow the athlete to enhance the acceleration component of vertical jumping. By training using jump squats on the KOR TRAINER it is proposed that the athlete may in fact be altering the timing of jumping which could have a negative effect on the actual performance of a vertical jump. On the other hand, it is believed by the researcher that although no improvements in vertical jump were observed in the present study, the fact that almost identical increases in strength were achieved by the KOR TRAINER Group as in the Conventional Group in almost half the amount of time, it is worth noting that the KOR

TRAINER is an efficient and effective way for strength and conditioning coaches to increase lower body strength in their athletes.

Because the current study is the only study involving the KOR TRAINER to date, further research, perhaps of a longer duration or different design, is warranted to say for certain whether the KOR TRAINER can be used as an effective and efficient means by which vertical jumping ability can be enhanced.

CHAPTER 6

CONCLUSION

The purpose of this study was to test the effectiveness of the KOR TRAINER in improving vertical jumping ability in athletes. The KOR TRAINER (Deden Technologies, Missoula, MT) was developed in an attempt to provide an effective and efficient way of maximizing human ground-based movement by preserving the user's natural proprioception model (what the user would experience if performing the same movement while in a free-body state).

A six-week exercise protocol was implemented in two groups of ten female subjects each. The subjects were members of either a collegiate-level cheer squad or dance team. The groups were comprised of an equal number of cheerleaders and dancers. The first group, or Conventional Group, performed back squats on a squat rack and plyometric box jumps on boxes of varying heights. The second group, or KOR TRAINER Group, executed both back squats and jumps squat on the KOR TRAINER. Strength measurements (as measured via a 3RM) and vertical jump measurements were taken prior to, after week three, and immediately following the study. Thigh and calf circumference measurements, however, were taken only before the initiation of training and again at the conclusion of the study.

The results of the study indicated that no significant changes in vertical jump were elicited by either the Conventional Group's protocol or the KOR TRAINER Group's protocol. Significant increases in strength were observed in both groups, however, suggesting that the KOR TRAINER is as effective in improving lower body strength as the widely accepted method of back squats and plyometrics. In addition, it is important to note that the time to complete the training protocol for any given day of the study was reduced to nearly half the amount of time for those subjects in the KOR TRAINER Group. Thus, it appears as though the KOR TRANER provides a more efficient means by which strength and conditioning professionals can increase the lower body strength of their athlete's.

Further research, perhaps using subjects of a different athletic activity in which the type of lower body involvement as is demanded with collegiate level cheerleaders and dancers is not a factor, is also suggested to test the KOR TRAINER'S ability in increasing vertical jump.

To conclude, the KOR TRAINER did prove to be an efficient and effective way of increasing lower body strength, but that further research is warranted in determining its effectiveness in improving vertical jumping ability.

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APPENDICES

APPENDIX A

THE KOR TRAINER

The KOR TRAINER

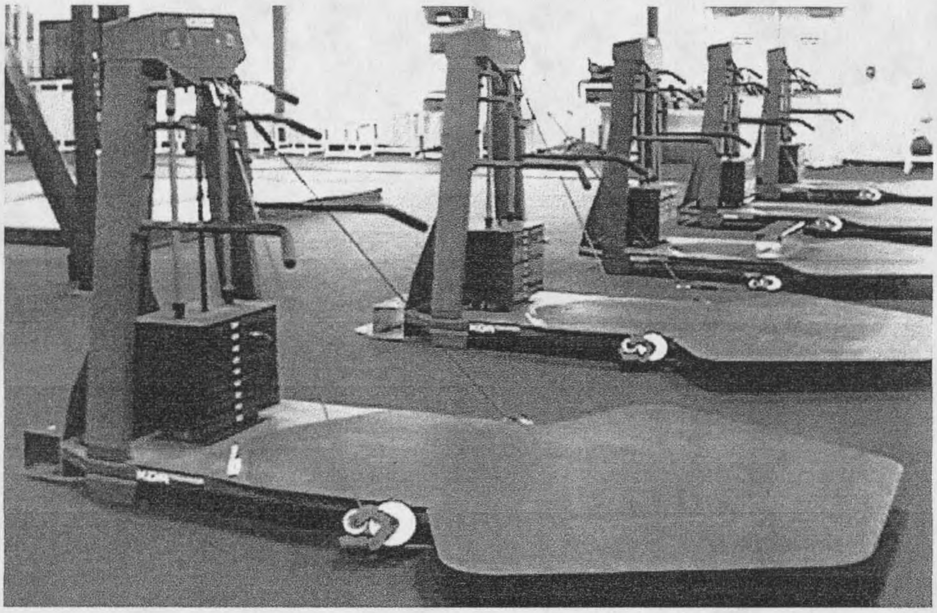

Figure 1. The KOR TRAINER

KOR TRAINER Squat

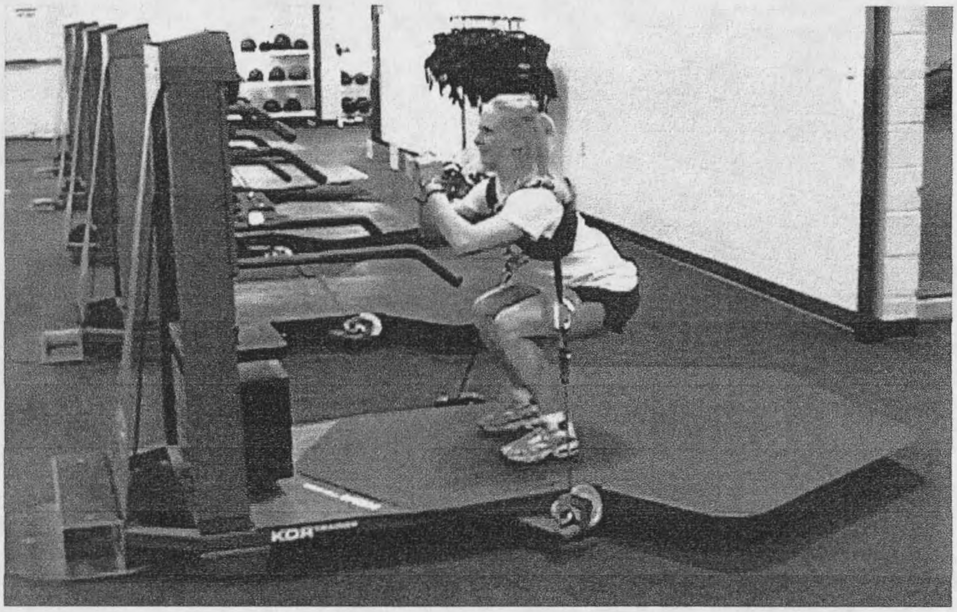

Figure 2. The model is demonstrating a squat on the KOR TRAINER.

KOR TRAINER Jump Squat

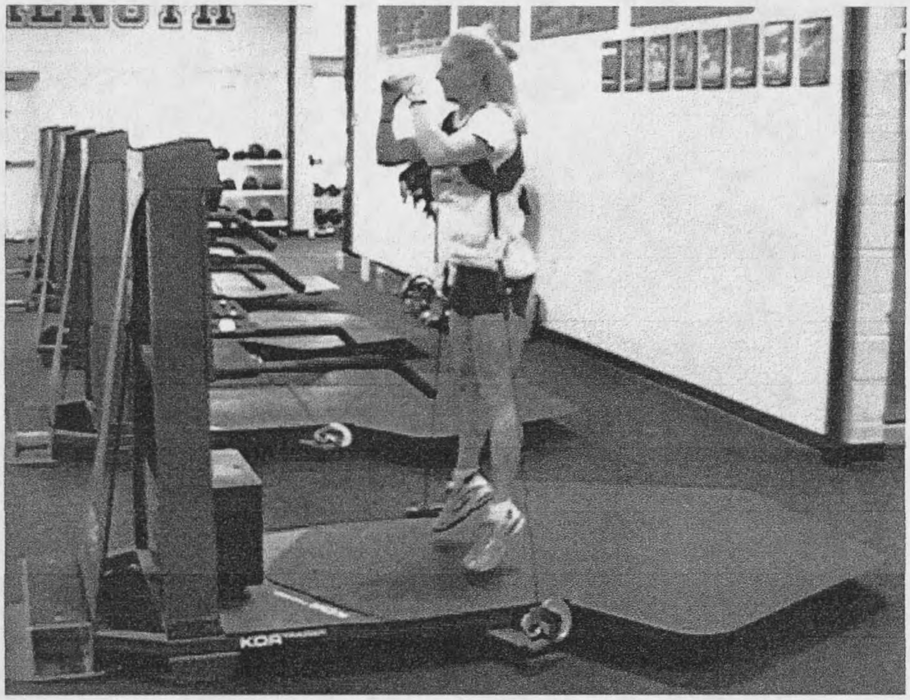

Figure 3. The model is demonstrating a jump squat on the KOR TRAINER.

APPENDIX B

SUBJECT INFORMATION FORMS

SUBJECT CONSENT FORM FOR PARTICIPATION IN HUMAN RESEARCH MONTANA STATE UNIVERSITY

Study Title: Vertical Jump Study: A look at the KOR-TRAINER

Funding: This study is not funded.

Investigators: Minde Erickson, Graduate Student
Mary P. Miles, Ph.D., Graduate Advisor
Dept. of Health and Human Development
Hosaeus 101, Montana State University
Bozeman, MT 59717-3540
Phone: (406) 585-1483

You are being asked to participate in a study aimed to prove the effectiveness of the KOR-TRAINER in improving vertical jump by comparing a training program composed of exercises completed using the KOR-TRAINER with a more conventional training program of back squats on a squat rack and depth box jumps (plyometrics). The vertical jump has become an important measure of athletic success, and strength and conditioning professionals continually are searching for a safe and efficient way in which to increase it. The KOR-TRAINER was designed to allow the user to perform strength-training exercises while preserving his/her natural proprioception model (that as would be experienced if the user where performing the same movement while in a free-body state). Subjects will report to the Varsity Strength and Conditioning room two times a week for seven weeks where the first week will be used solely as a familiarization period. Each training session will last approximately 45 minutes and will be composed of a warm up, completion of the assigned training protocol, and a cooldown. A measure of the subject's vertical jump will be taken at the beginning, three weeks into (week four of the study), and end of the six-week training period. In addition to the vertical jump measurements, anthropometric data, such as height, weight, and calf and thigh circumference, will be taken at the beginning and end of the training.

The purpose of this study is to determine whether the KOR-TRANER is a more effective method for increasing an athlete's vertical jump given a six-week training period when compared to the more conventional method of bar squats and depth box jumps (plyometrics).

If you agree to participate in this study you will do the following things:

1) You will read and sign this document, and fill out a

Physical Activity Readiness Questionnaire (PAR-Q). The PAR-Q will be used as a medical clearance form to determine if you have a medical condition that might make it unsafe for you to participate in this study.

2) Your height and weight measurements will be taken both at the beginning and end of the seven-week period.
3) The circumference of both your thighs and calves will be measured using a cloth tape measure both pre and post-training period.
4) Your vertical jump will also be measured using the Vertec vertical jump measuring device at the start, three weeks into (week four of the study), and end of the training period.
5) Half of the subjects will be randomly assigned to the KOR TRAINER group while the other half will be in the conventional training group. Both groups will train two times a week for seven weeks, under the supervision of the researchers. The initial week will be used solely as a familiarization period. Each training session will last approximately 45 minutes.
6) You will attend all training sessions. If a training session must be missed then you will make up that training session at a time convenient for both you and the researcher.
7) You will not participate in a weightlifting program (other than the one prescribed for this study) for the entire duration of the study.
8) You will wear comfortable athletic shorts, a t-shirt, and tennis shoes to all training sessions.

The following is a list of possible side effects or risks associated with participation in this study:

1) You may feel soreness in the muscles of your lower extremities and possibly core (abdominal) area due to the resistance training and training using the KOR-TRAINER. The exercise training will begin slowly and gradually increase in an attempt to avoid this problem.
2) Pain may be felt in your muscles while you are actively engaged in each training session. This is because a molecule called lactate is produced during this type of muscle use and because the contraction of the muscle reduces the flow of blood to the muscle tissue. Both of these are temporary and do not pose a risk to health and are not indications of injury.
3) If you do not breathe while producing maximal forces with your muscles, the pressure in your chest can build up. This can be uncomfortable and can cause dangerous increases in blood pressure. You will be instructed not to hold your breath while performing the exercises. However, the temporary increase in blood pressure that could occur is not likely to cause any harm in a young, healthy person.

4) Injuries such as sprains and strains are possible risks involved with the participation in a strength-training program. The wrists are a common area of injury as well as overuse injuries of the back and knee.

Possible benefits you could receive as a result of participating in this study are:

1) Information about your vertical jump and lower extremity circumference.
2) Exposure to a protocol for increasing the vertical jump of an individual.
3) You will learn proper technique for training for improving your vertical jump.

No other benefits are promised to you.

Confidentiality: The data and personal information obtained from this study will be regarded as privileged and confidential. A code number will identify the data that we collect from you, and all data will be kept in a locked office in the Varsity Strength and Conditioning room at Montana State University. The information obtained in this study may be published in scientific journals, but your identity will not be revealed. They will not be released except upon your written request/consent. If during the study you decide to cease your participation, your name will be removed from our study records, and we will not contact you again regarding this study. You will not be penalized in any way.

You will not incur any costs beyond those related to your transportation to and from the Varsity Strength and Conditioning room as a result of your participation.

Freedom of Consent: You may withdraw consent in writing, by telephone, or in person with the investigator (Minde Erickson at 585-1483) and discontinue participation in the study at any time and without prejudice or loss of benefits (as described above). Participation is completely voluntary.

In the unlikely event that your participation during the study results in physical injury to you, the principal investigator will advise and assist the participant in receiving medical treatment. In addition, Montana State University will not be held responsible for injury, accidents, or expenses that may occur as a result of traveling to and from your testing and/or training sessions.

You are encouraged to express any questions, doubts or concerns regarding this study. The investigator will attempt to answer all questions to the best of her or his ability. The investigator fully intends to conduct the study with your best interest, safety, and comfort in mind. *The Chairman of the Human Subjects Committee, Mark Quinn can answer additional questions about the rights of human subjects at 406-994-5721.*

STATEMENT OF AUTHORIZATION

Study Title: Vertical Jump Study: A Look at the KOR-TRAINER

AUTHORIZATION: I have read the above and understand the discomforts, inconvenience and risks of this study. I, ______________________________ (PRINT YOUR NAME), agree to participate in this research. I understand that I may later refuse to participate, and that I may withdraw from the study at any time. I have received a copy of this consent form for my own records.

Signed:____________________________________ Date:__________
Subject's Signature

Witness:____________________________________Date:__________
(if other than the investigator)

Investigator:______________________________ Date:__________
Minde Erickson

PAR-Q and YOU

Physical Activity Readiness Questionnaire

Regular Physical activity is fun and healthy, however, some people should check with their doctors before they start becoming much more physically active. If you are planning on participating in the KOR-TRAINER Vertical Jump Study please answer the following seven questions. Thesis questions will help us determine whether you can safely and actively participate in this study without physician approval. Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly.

Yes	No	
___	___	Has your doctor ever said that you have a heart condition and that you should do only physical activity recommended by your doctor?
___	___	Do you feel pain in your chest when you do physical activity?
___	___	In the past month, have you had chest pain when you were not doing physical activity?
___	___	Do you lose your balance because of dizziness or do you ever lose consciousness?
___	___	Do you have a bone or joint problem that could be made worse by your participation in this study?
___	___	Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
___	___	Do you know of any other reason that you should not do physical activity?

If you Answered YES to one or more questions:
Talk with your doctor by phone or in person BEFORE you agree to participate in this study or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which question you answered YES to. You may be able to safely participate in this study.

If you answered NO to all questions:
You can be reasonably sure that you can safely participate in this study.

I have read, understood, and completed this questionnaire. Any questions I had were answered to my full satisfaction.

Signature:______________________________ Date:________
Witness:_______________________________ Date:________
Signature of parent or guardian if under 18:______________________________

APPENDIX C

KOR TRAINER GROUP PROTOCOL

KG Week 1 (Tuesday)

Subject 5
1 x 8 no plate
1 x 6 1-plate
1 x 6 2-plates
4 x 6 3-plates

Jumps: 3 x 6 1-plate

Subject 6
1 x 8 no plate
1 x 6 1-plate
4 x 6 2-plates

Jumps: 3 x 6 1-plate

Subject 7
1 x 8 no plate
1 x 6 1-plate
4 x 6 2-plates

Jumps: 3 x 6 1-plate

Subject 8
1 x 8 no plate
1 x 6 1-plate
4 x 6 2-plates

Jumps: 3 x 6 1-plate

KG Week 1 (Thursday)

Subject 5
1 x 8 no plate
1 x 6 1-plate
1 x 6 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

Subject 6
1 x 8 no plate
1 x 6 1-plate
4 x 8 2-plates

Jumps: 3 x 8 1-plate

Subject 7
1 x 8 no plate
1 x 6 1-plate
4 x 8 2-plates

Jumps: 3 x 8 1-plate

Subject 8
1 x 8 no plate
1 x 6 1-plate
4 x 8 2-plates

Jumps: 3 x 8 1-plate

KG Week 2 (Tuesday)

Subject 5
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
1 x 8 3-plates
4 x 8 4 plates

Jumps: 3 x 8 1-plate

Subject 6
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

Subject 7
1 x 8 no plate
1 x 8 1-plate
1 x 8 2 plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

Subject 8
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

KG Week 2 (Thursday)

Subject 5
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
1 x 8 3 plates
4 x 8 4-plates

Jumps: 3 x 8 1-plate

Subject 6
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

Subject 7
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

Subject 8
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
4 x 8 3-plates

Jumps: 3 x 8 1-plate

KG Week 3 (Tuesday)

Subject 5
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
1 x 8 3-plates
5 x 5 4 plates

Jumps: 3 x 10 1-plate

Subject 6
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
5 x 5 3-plates

Jumps: 3 x 10 1-plate

Subject 7
Sick

Subject 8
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
5 x 5 3-plates

Jumps: 3 x 10 1-plate

KG Week 3 (Thursday)

Subject 5
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
1 x 8 3 plates
5 x 5 4-plates

Jumps: 3 x 10 1-plate

Subject 6
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
5 x 5 3-plates

Jumps: 3 x 10 1-plate

Subject 7
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
5 x 5 3-plates

Jumps: 3 x 10 1-plate

Subject 8
1 x 8 no plate
1 x 8 1-plate
1 x 8 2-plates
5 x 5 3-plates

Jumps: 3 x 10 1-plate

KG Week 4 (Sunday)

Subject 5

Vertical Jump
3RM Testing

Subject 6

Vertical Jump
3RM Testing

Subject 7

Vertical Jump
3RM Testing

Subject 8

Vertical Jump
3RM Testing (Didn't get…hurt back)

KG Week 4 (Tuesday)

Subject 5
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
4 x 4 5-plates

Jumps: 4 x 6 2-plates

Subject 6
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
4 x 4 4-plates

Jumps: 4 x 6 2-plates

Subject 7
NO SHOW!!

Subject 8
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
4 x 4 4-plates

Jumps: 4 x 6 2-plates

KG Week 5 (Tuesday)

Subject 5
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
1 x 6 5-plates
6 x 3 6-plates

Jumps: 4 x 8 2-plates

Subject 6
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
6 x 3 5-plates

Jumps: 4 x 8 2-plates

Subject 7
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
6 x 3 4-plates

Jumps: 4 x 8 2-plates

Subject 8
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
6 x 3 4-plates

Jumps: 4 x 8 2-plates

Total Time = 13 minutes 15 seconds

KG Week 5 (Thursday)

Subject 5
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
1 x 6 5-plates
6 x 3 6-plates

Jumps: 4 x 8 2-plates

Subject 6
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
6 x 3 5-plates

Jumps: 4 x 8 2-plates

Subject 7
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
6 x 3 4-plates

Jumps: 4 x 8 2-plates

Subject 8
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
6 x 3 4-plates

Jumps: 4 x 8 2-plates

KG Week 6 (Tuesday)

Subject 5
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
1 x 6 5-plates
2 x 2 6-plates
2 x 2 7-plates
2 x 2 8-plates

Jumps: 4 x 8 3-plates

Subject 6
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
2 x 2 5-plates
2 x 2 6-plates
2 x 2 7-plates

Jumps: 4 x 8 3-plates

Subject 7
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
2 x 2 4-plates
4 x 2 5-plates

Jumps: 4 x 8 3-plates

Subject 8
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
2 x 2 4-plates
4 x 2 5-plates Jumps: 4 x 8 3-plates

KG Week 6 (Thursday)

Subject 5
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
1 x 6 5-plates
2 x 2 6-plates
2 x 2 7-plates
2 x 2 8-plates

Jumps: 4 x 4 4-plates

Subject 6
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
1 x 6 4-plates
2 x 2 5-plates
2 x 2 6-plates
2 x 2 7-plates Jumps: 4 x 4 4-plates

Subject 7
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
2 x 2 4-plates
2 x 2 5-plates
2 x 2 6-plates Jumps: 4 x 4 4-plates

Subject 8
1 x 6 no plate
1 x 6 1-plate
1 x 6 2-plates
1 x 6 3-plates
2 x 2 4-plates
2 x 2 5-plates
2 x 2 6-plates Jumps: 4 x 4 4-plates

APPENDIX D

CONVENTIONAL GROUP PROTOCOL

CG Week 1 (Tuesday)

Subject 1
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
4 x 6 137.5lbs

Jumps: 3 x 6 @ 12”

Subject 2
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
4 x 6 110lbs

Jumps: 3 x 6 @ 12”

Subject 3
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
4 x 6 105lbs

Jumps: 3 x 6 @ 12”

Subject 4
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
4 x 6 125lbs

Jumps: 3 x 6 @ 12”

CG Week 1 (Thursday)

Subject 1
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
4 x 6 142.5lbs

Jumps: 3 x 6 @ 12”

Subject 2
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
4 x 6 112.5lbs

Jumps: 3 x 6 @ 12”

Subject 3
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
4 x 6 107.5lbs

Jumps: 3 x 6 @ 12”

Subject 4
2 x 5 Bar
2 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
4 x 6 130lbs

Jumps: 3 x 6 @ 12”

CG Week 2 (Tuesday)

Subject 1
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
4 x 8 137.5lbs

Jumps: 3 x 8 @ 18”

Subject 2
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
4 x 8 110lbs

Jumps: 3 x 8 @ 18”

Subject 3
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
4 x 8 105lbs

Jumps: 3 x 8 @ 18”

Subject 4
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
4 x 8 125lbs

Jumps: 3 x 8 @ 18”

CG Week 2 (Thursday)

Subject 1
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
4 x 8 142.5lbs

Jumps: 3 x 8 @ 18”

Subject 2
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
4 x 8 112.5lbs

Jumps: 3 x 8 @ 18”

Subject 3
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
4 x 8 107.5lbs

Jumps: 3 x 8 @ 18”

Subject 4
1 x 5 Bar
1 x 5 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
4 x 8 130lbs

Jumps: 3 x 8 @ 18”

CG Week 3 (Tuesday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
5 x 5 145lbs

Jumps: 3 x 10 @ 18"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
5 x 5 115lbs

Jumps: 3 x 10 @ 18"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
5 x 5 110lbs

Jumps: 3 x 10 @ 18"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
5 x 5 132.5lbs

Jumps: 3 x 10 @ 18"

CG Week 3 (Thursday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
5 x 5 150lbs

Jumps: 3 x 10 @ 18"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
5 x 5 120lbs

Jumps: 3 x 10 @ 18"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
5 x 5 115lbs

Jumps: 3 x 10 @ 18"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
5 x 5 137.5lbs

Jumps: 3 x 10 @ 18"

CG Week 4 (Sunday)

Subject 1

Vertical Jump
3RM Testing

Subject 2

Vertical Jump
3RM Testing

Subject 3

Vertical Jump
3RM Testing

Subject 4

Vertical Jump
3RM Testing

CG Week 4 (Tuesday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
4 x 4 155lbs

Jumps: 4 x 6 @ 24”

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
4 x 4 125lbs

Jumps: 4 x 6 @ 24”

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
4 x 4 120lbs

Jumps: 4 x 6 @ 24”

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
4 x 4 142.5lbs

Jumps: 4 x 6 24”

CG Week 5 (Tuesday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
6 x 3 160lbs

Jumps: 4 x 8 @ 24"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
6 x 3 127.5lbs

Jumps: 4 x 8 @ 24"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
6 x 3 122.5lbs

Jumps: 4 x 8 @ 24"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs6 x 3 145lbs

Jumps: 4 x 8 @ 24"

CG Week 5 (Thursday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
6 x 3 165lbs

Jumps: 4 x 8 @ 24"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
6 x 3 132.5lbs

Jumps: 4 x 8 @ 24"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
6 x 3 127.5lbs

Jumps: 4 x 8 @ 24"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
6 x 3 150lbs

Jumps: 4 x 8 @ 24"

Total Time = @30 minutes

CG Week 6 (Tuesday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
2 x 2 150lbs
2 x 2 160lbs
2 x 2 170lbs

Jumps: 4 x 4 @ 30"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
2 x 2 120lbs
2 x 2 127.5lbs
2 x 2 135lbs

Jumps: 4 x 4 @ 30"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
2 x 2 115lbs
2 x 2 122.5lbs
2 x 2 130lbs

Jumps: 4 x 4 @ 30"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
2 x 2 137.5lbs
2 x 2 145lbs
2 x 2 155lbs
Jumps: 4 x 4 @ 30"

CG Week 6 (Thursday)

Subject 1
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
1 x 3 125lbs
2 x 2 150lbs
2 x 2 160lbs
2 x 2 170lbs

Jumps: 4 x 4 @ 30"

Subject 2
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
2 x 2 120lbs
2 x 2 127.5lbs
2 x 2 135lbs

Jumps: 4 x 4 @ 30"

Subject 3
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
2 x 2 115lbs
2 x 2 122.5lbs
2 x 2 130lbs

Jumps: 4 x 4 @ 30"

Subject 4
1 x 3 Bar
1 x 3 65lbs
1 x 3 85lbs
1 x 3 105lbs
1 x 3 115lbs
2 x 2 137.5lbs
2 x 2 145lbs
2 x 2 155lbs
Jumps: 4 x 4 @ 30"