INCREASING VERTICAL JUMP HEIGHT IN HIGH SCHOOL FEMALE VOLLEYBALL PLAYERS THROUGH THE USE OF PLYOMETRIC TRAINING AND RECOVERY

A THESIS

Submitted to the Faculty of the School of Graduate Studies and Research of California University of Pennsylvania in partial fulfillment of the requirements for the degree of

Master of Science

by

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CALIFORNIA, PA

THESIS APPROVAL

Graduate Athletic Training Education

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Next, I would like to thank my committee members Dr. Tom West, Dr. Rebecca Hess, and Dr. Ronald Wagner. Their help, patience, and great experiences were much appreciated and the final thesis was a success because of them.

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1. Maximum, Minimum, and Mean Jump Heights by testing session.
INTRODUCTION

Vertical jump height is an essential component of playing volleyball. The ability to jump high and reach maximum height quickly helps to create a successful volleyball player at any age. While explosive leg power is a critical component for successful performance in many athletic events, there are two factors that are key to enhancing vertical jump ability: (1) refining jump mechanics, and (2) developing explosive strength in the lower extremity muscles responsible for jumping. Plyometric training has been used to help enhance an athlete’s vertical jump ability.

The goal of plyometric training is to increase the rate of the muscle’s stretch shortening cycle (SSC), which involves an eccentric muscle contraction of the agonist muscle and a stretch of the antagonist muscle, immediately followed by an explosive contraction of the same muscle. Plyometrics is a type of training that develops the ability of muscles to produce force at high speeds, or power, in dynamic movements. When the optimal length tension of the muscle is achieved, a greater amount of force will be produced.
With plyometric movements, the muscles undergo a very rapid switch from the eccentric phase to the concentric phase this is termed as the amortization phase.\textsuperscript{11} This decreases the time of the amortization phase, that in turn, allows for a more powerful contraction in these muscles.\textsuperscript{1,6,11,12} Training programs that utilize plyometric exercises have been shown to positively affect performance in power-related movements such as jumping and speed.\textsuperscript{6,12}

Vertical jump ability is critical for success in volleyball. Jumping ability exercises are very dynamic, and mobilize all muscle groups into organized actions. These exercises are a functional result of speed and strength, and demand a good amount of coordination.\textsuperscript{1,13,14}

The mechanics of the vertical jump can be analyzed using three phases, the preparatory phase, take off phase, and landing phase.\textsuperscript{4,14} During these three phases, the muscles will undergo an eccentric contraction of the agonist muscle and/or stretch of the antagonist muscle to prepare for the jump. In turn, the muscles will then produce a concentric contraction, or a shortening of the muscle during take-off, and then move into a decelerated motion using eccentric muscle contraction to prepare for another jump.\textsuperscript{4,14,15} The arm swing assists the vertical jump during the take off phase. The use of the arms has been shown to have a significant
effect on peak force in jumping,\(^4\) an average of 10\% to the take-off velocity.\(^{14}\) This indicates that there is a technique, or skill component to vertical jumping, rather than just leg power.\(^{4,16,17}\) To maximize jump height, the athlete must coordinate a head-to-toe effort.\(^4\)

Another factor that is a key variable in determining whether plyometrics will succeed in developing power or muscular endurance would be the amount of recovery time taken.\(^5\) Without allowing proper recovery, fatigued muscles may cause the athlete to have a poor exercise technique which may lead to injury. Recovery between workouts must be adequate, otherwise overtraining or injury may occur.\(^6,18\)

In a recent study, Luebbers and Potteiger demonstrated the importance of a recovery period following a plyometric program. The study showed when allowed four weeks to recover, that period of recovery had a powerful effect upon performance. It is unclear if the results would have increased more with a longer recovery, but it is clear that a recovery period should be included following a plyometric training program to achieve maximum results.\(^{12}\)

As a training tool, studies have demonstrated the effectiveness of plyometric training for improving power, generally expressed as an increase in vertical jump height.\(^{21,22}\) Therefore, it is suggested for plyometrics to be
included in any program aimed at improving vertical jump ability.\textsuperscript{19} When plyometric drills are combined with a resistance training program, vertical jump performance appears to be enhanced to a significantly greater extent than if each of the training programs were performed alone.\textsuperscript{10,22}

Plyometrics have been criticized for having a greater risk of injury than other methods due to the increased forces of landing and immediate rebounding.\textsuperscript{5,7,14} When starting a plyometric training program, many factors should be taken into consideration including age, sex, strength gains, landing surfaces, and progression of exercises.\textsuperscript{6,10,18,20} However, as plyometrics are a natural part of most movements, as evidenced by the jumping, hopping and skipping movements that are typically seen on any school playground,\textsuperscript{10} qualified coaching and age-appropriate instruction can make plyometric training a safe, effective, and fun method of conditioning for young adolescents.\textsuperscript{10,20}

There is no indication that younger, and/or female athletes cannot perform plyometrics with the same degree of skill, proficiency, and intensity as males.\textsuperscript{5,8} However, more instruction for the female athlete to control excessive mediolateral knee movement and lack of knee flexion with jumping and landing is done in order to guard against
possible knee injury. As long as the coach, athletic trainer, or strength and conditioning coach maintains an adequate strength base, and correct landing techniques have been achieved, the progression is very similar in female and male athletes.

Sufficient strength is something an athlete needs before starting any plyometric training program. Previous literature has mentioned that an athlete should be able to squat twice their weight before beginning any plyometric training. This idea lacks substantiation, and is not accepted by most performance enhancement coaches. 

Plyometric training should take place on gym-like, spring-loaded floors or Resilite™ mats for easing the shock of landing.

The purpose of this study was to examine if plyometric training and recovery would increase the vertical jump height of high school female volleyball players. This study attempted to answer the following questions: (1) If there would be an increase in vertical jump height from pre to posttest, and (2) Will there be a greater additional increase from posttest to follow-up testing after two weeks of recovery.
METHODS

Research Design

A pre-experimental research design was used for this seven week study, using a one-group (female volleyball players) pre-posttest design in which all subjects receive the same training. The dependent variable for this experiment was the vertical jump height, measured in inches. The independent variable was the test sessions (pre, post, and follow-up). The training was conducted over five weeks. It required subjects to perform the plyometric exercises two days, and strength training one day a week (M, W, TR) for approximately one hour after school. At completion of the five weeks, the subjects were then asked not to participate in any plyometric activity for two weeks. This was done to look at the effects of recovery after a training program.

During this study, the amount of jumps that each subject performed, along with the amount of times that they performed the plyometric exercises were controlled by the researcher. Limitations of the pre-experimental design include maturation of the subjects, their age, attention, drive, and their motivation to complete the experiment over
the five weeks; along with the strength levels and the landing techniques of the subjects that are needed to perform these plyometric exercises. To control some of these limitations the researcher had each of subjects perform an overhead squat before participating in the study to examine proper mechanics. Progressing the subjects from low to high intensity also helped control for limitations. By creating variations to the exercises also created difficulty when a few subjects could easily perform the exercises. Also, making the training program interesting and having the researcher be very motivating during the training sessions helped keep the interest of most of the subjects.

Subjects

The subjects for this study were female volleyball players at Burgettstown High School, aged 14-17 years old (N~10). Subjects participated in a pre, post, and follow-up testing sessions. Sampling was accomplished by the selective use of a small 1A high school volleyball team. Only those that volunteered took part in the study. There was no influence for participation in the study from the coaches.
Since the subjects were minors, an informed consent form (Appendix C1) was sent home to be signed by their legal guardian. Subjects were then asked to read and sign a Child Ascent form (Appendix C2) prior to testing. These consent forms all met the requirements of California University of PA Institutional Review Board. All subjects completed a medical health history questionnaire (Appendix C3) and were judged as healthy according to guidelines established by the YWCA.\textsuperscript{23} This was in addition to the fact that all subjects have already had a physical to participate in their sport. Any subject that had sustained any previous injury to the lower extremity within the past six months that had resulted in them missing four consecutive practices was asked not to participate.

Each of the high school volleyball players were briefed on the procedures of the study. Measurements and the plyometric training took place during the team’s off-season (January-March, 06). The researcher assumed that each subject performed the plyometric exercises to their full potential. Athletes were asked not to participate in any plyometric exercises.
Preliminary Research

The purpose of the preliminary research was to set up the time frames and familiarize the researcher with the instruments that were used throughout the study. The use of two female high school volleyball players who were not participating in the study ran through the trials to help accomplish this. Trials were completed by taking the measurements and performing a session of the training protocol to determine the time frame that was required. These trials were also helpful to see if the subjects could perform the exercises, and if so, if they could be performed correctly. Trials with the instruments (establish training protocol and Vertec™) were made in order for the researcher to familiarize themselves and become proficient in using these devices.

Instruments

A health history questionnaire, an established plyometric training protocol, (NASM) Overhead squat assessment, and the Vertec™ were used to collect the data.
Testing

A health history questionnaire (Appendix C3) was administered to the subjects and it has met the requirements set by California University of PA Institutional Review Board. Each subject was required to have this form filled out by their parents before they are able to participate in the study. This informed the researcher on each subject’s previous history, age, height, and previous injuries (if any).

The Vertec\textsuperscript{TM} was used to measure the subjects vertical jump height during the pre, post, and follow-up tests. It allows for the normal actions, which occur in both the execution of a vertical jump from a standing and/or running position. The Vertec\textsuperscript{TM} allows for true optimal jump testing efforts.\textsuperscript{24} It is a vertical jump; lower limbs power measurement, and training instrument. The reliability of the Vertec\textsuperscript{TM} vertical jump test has been reported to be quite high (r=.93).\textsuperscript{27}

The Vertec\textsuperscript{TM} can be adjusted to the different heights of each of the subjects with protruding colored swivel vanes that displace as the athlete jumps and hits them at their maximum height. It can measure vertical jump heights from 6 to 12ft, each vane is $\frac{1}{2}$ in apart.\textsuperscript{25} The researcher measured each subjects standing vertical reach, and moved
the vanes that they touch out of the way, allowing the subject to perform a two-step approach jump and attempt to make contact with their fingers at the highest vane.\textsuperscript{9} Counting the displaced vanes on the Vertec\textsuperscript{TM} after the two-step approach jump had been performed is what was used to calculate the maximum vertical jump height.\textsuperscript{26} Subjects performed three vertical jumps. All scores were recorded with the best measurement out of the three used for statistical analysis.

The researcher was the only one to administer the plyometric training program and all vertical jump height measurements. If there were any adjustments to be made to the training program, they were all done by the researcher. This was done to help increase the reliability of the pre, post, and follow-up evaluations, and decrease the amount of external factors that might have affected the testing and training.

Training Protocol

The overhead squat was used as a prescreening tool. The subjects would not perform any of these plyometric exercises until they were able to perform this squat correctly.\textsuperscript{7,18,20} A total body profile checklist for the overhead squat (Appendix C5) outlined in the Performance
Enhancement Specialist Manual was used for screening the subjects. It is assumed that a few of the subjects would not be able to perform the overhead squat correctly, so by adding in corrective exercises for any faults in the warm-up and cool down helped correct the subjects form.

An established plyometric training protocol specific to volleyball (Appendix C4) created by Donald Chu was used for training. It involved two days of plyometrics and one day of strength training. The exercises ranged from low intensity to high intensity, according to the ranges set up by Donald Chu in “Jumping into Plyometrics”. The subjects performed these exercises, but only progressed when they were physically ready. This was determined by whether the subjects could perform the exercise with proper form and could do the exercise a few times with no problem.

Procedures

The first step to starting this study was for the researcher to obtain permission from the Superintendent, Principal, Athletic Director, and the Volleyball coaches at Burgettstown Junior/High School (Appendix C6). After doing so the proposal had to be approved by California University

The researcher obtained volunteers from the Burgettstown Junior/High School Volleyball team to participate in the study without any involvement from the coaches. Subjects acquired a verbal or written description of what the study entails, as did each of their parents. The researcher had to obtain an informed consent form (Appendix C1) from each of the parents, a child Ascent form (Appendix C2) from each of the subjects, and a health history questionnaire (Appendix C3) was also obtained of the subject’s demographics.

Testing

The subjects then perform a pretest evaluation. First they performed a timed five to seven minute warm up in pairs to help maintain the warm-up (Appendix C8) of each subject. The warm-up (Appendix C8) was the same for each subject, which involved jogging around the gym and dynamic stretching (ex: butt kicks, high knees, and Overhead lunges).27 The researcher involved a second tester whose responsibility was to monitor the subjects during the warm up. The same instructions were given to each of the subjects to jump as high as they could for the three jumps.
No verbal encouragement was given to the subjects (ex: You can jump higher). Each subject then separately performed three two-step approach vertical jumps, taking the best measurement with the use of the Vertec™. They also were prescreened for corrective mechanics through the use of the overhead squat assessment (Appendix C5). This was done in order for them to be able to participate in any of the plyometric exercises. By doing so, the researcher was able to examine each of the subject’s mechanics and recorded this for additional information.

The study was performed over a seven-week period of time, during which subjects underwent two days of plyometric training and one day of resistance training each week (M, W, TR) for approximately one hour right after school for five weeks. Subjects would start out each day with a daily warm-up (Appendix C8) routine five to seven minute warm up with also static, dynamic stretching, and corrective exercises. Then they would move into the plyometric training program (Appendix C4) and perform these exercises twice a week. A mass training system was set up for training the subjects in this plyometric program. Creating five lines, two girls in each line, allowed for the researcher to be able to insure that each subject was performing the exercises correctly. This system also
allowed for the proper recovery period that is needed between each exercise. The only time they did not perform exercises in the five lines was when the use of the plyometric boxes was incorporated. At the completion of the training session for each day a cool down (Appendix C9) was included to help continue to work on corrective exercises along with decreasing risk of injury and muscle soreness. The cool down (Appendix C9) occurred for five to seven minutes involving a cool down jog, static stretching and some corrective exercises.27

Each subject was training at different levels appropriate to their physical ability. So progression to the next level of intensity was needed to be done together, but not every subject was able to progress. Variations were added if necessary to the exercise routines to help keep interest in the subjects that physically adapted easily.

The third day of this five-week program was set up as a resistance-training day. Here each of the subjects used the same warm-up together for five to seven minutes involving some dynamic and static stretching, along with some corrective exercises. The purpose of incorporating in the resistance-training day was to help maintain the strength of each of the subjects throughout the program.
Resistance training is an ideal counterpart of plyometric training for it helps prepare the muscles for the rapid impact loading of plyometric exercises. If any subjects miss two consecutive days they were not allowed to continue to participate in the study.

After the five weeks of training the subjects were post tested on their vertical jump height using the Vertec™. The second tester was also used to help maintain control over the warm-up for each of the subjects. Three vertical jumps were performed and all three were recorded but the best measurement was the one recorded for statistical analysis.

Subjects then were asked not to participate in any competitive sport or plyometric exercises for the next two weeks, as an act of recovery. At the end of these two weeks the subjects were tested again on their vertical jump height. The follow up test was evaluated with the use of the Vertec™. The second tester was used one last time, to help maintain control over the warm-up for each of the subjects. Three vertical jumps were performed, all three were recorded and the best was recorded for statistical analysis. The purpose of this follow-up measurement was to examine if the vertical jump height had increased with the factor of rest and recovery.
The researcher was available for any questions that might have come up before, during, and after the study had been completed, by the subjects, parents, and administrators.

**Hypotheses**

The following hypotheses were based on the available research and researcher’s opinion after reviewing articles on plyometrics and increasing the vertical jump height.

1) There will be an increase in vertical jump height from pretest to posttest over the five weeks.
2) There will be a greater additional increase from posttest to follow-up testing after the two weeks of recovery.

**Data Analysis**

A Repeated Measures ANOVA test was used to evaluate the data that was recorded in this study. A Post Hoc paired-t test was used to determine the differences among the three testing sessions. When analyzing the data, the level of significance was established as $P \leq 0.05$. SPSS
12.0 was used to analyze the data that was recorded in this study.
RESULTS

The purpose of this study was to examine if there were any changes in the vertical jumps between the three testing sessions after performing a plyometric program and recovery session. A plyometric protocol was utilized, consisting of two days of plyometrics and one day of strength training a week for five weeks. This was followed by two weeks of recovery.

Demographic Data

Ten female high school volleyball players from Burgettstown Junior/Senior High School participated in this study. The average age of the subjects was 15 years old and ranged from 14 to 16 years old. The average height was 5’4 and ranged from 5’2 to 5’8. None of the subjects had any previous injury to the lower extremity in the past six months.

Hypotheses Testing

The following hypotheses were tested for in this study. Both hypotheses were combined and tested together
through the use of a repeated measures ANOVA. The maximum jump height was the scored used for the hypotheses testing.

Hypotheses 1: There will be an increase in vertical jump height from pretest to posttest over the five weeks.

Hypotheses 2: There will be a greater additional increase from posttest to follow-up testing after the two weeks of recovery.

Conclusion: The first and second hypotheses were supported by the results revealed in the data. Findings demonstrated a significant increase from pretest to posttest, along with an additional increase from posttest to follow-up. The means were calculated for the test sessions of pretest, posttest, and follow-up test of the maximum jump height of each of the subjects (Table 1). The standard deviation that has been calculated and presented in Table 1, show a decrease with each testing session. This indicates that the subjects may have become more consistent in their jumping ability. The maximum, minimum and mean jumps were all graphed in Figure 1 to show the ranges of the jump heights in each testing session.
Table 1. Maximum Jump Height Means

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*Means were calculated in inches

To test for significance, a repeated measures ANOVA was used. This was calculated by comparing the vertical jump height scores of each of the subjects at the three different testing sessions: pre, post, and follow-up. A significant effect was found ($F(1,9)=539.338, P < .001$). Follow-up paired t-test was performed to confirm differences between pre to posttest, post to follow-up test, and also pre to follow-up test. The paired t-test
revealed the vertical jump height scores increased significantly from pretest \((m=14.950, SD=2.7834)\) to posttest \((m=17.600, SD=2.3898)\), and an additional increase from posttest \((m=17.600, SD=2.3898)\) to follow-up \((m=18.92, SD=2.011)\), with a significant difference from pretest \((m=14.950, SD=2.7834)\) to follow-up \((m=18.92, SD=2.011)\).

Table 2. Tests of Between-Subjects Effects for Maximum Jump Heights

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Table 3. Paired t-test for Maximum Jump Heights

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Additional Findings

The data were further analyzed to determine if there were any additional findings present. In the hypothesis testing the maximum jump height out of three trials was used. In additional findings a repeated measures ANOVA was calculated comparing the averages of the vertical jump height scores of each of the subjects at the three different test sessions: pre, post, and follow-up. As in
the hypothesis testing, a significant effect was found 
\( F(1,9)=482.420, \ P < .001 \). A follow-up paired t-test was 
done to examine if there was a significant effect of the 
average jump heights between the test sessions. The paired 
t-test revealed that the average of the vertical jump 
scores increased significantly from pretest 
(m=14.0500,SD=2.99593) to posttest (m=16.8500, SD=2.29257), 
and from posttest (m=16.8500,SD=2.29257) to follow-up 
(m=17.8333,SD=1.93250) and again there was a significant 
difference from pretest (m=14.0500,SD=2.99593) to follow-up 
(m=17.8333,SD=1.93250). The standard deviation with average 
jump heights decreased with each test session which was the 
same result seen with the maximum jump height. This also 
indicates that the subjects may have become more consistent 
in their jumping ability.

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DISCUSSION

In discussion of the findings of this study, the following sections are presented: (1) Discussion of Results, (2) Conclusions, and (3) Recommendations.

Discussion of Results

This study was conducted to investigate if plyometrics and recovery would increase the vertical jump heights of high school volleyball players. This will allow athletic trainers and coaches to see if these two factors should be considered when designing programs to increase jump height. Jump heights are important to volleyball players, along with explosive muscle contraction necessary for movement from one position to the next. While explosive leg power is a critical component for successful performance in many athletic events, there are two factors that are key to enhancing vertical jump ability: (1) refining jump mechanics, and (2) developing explosive strength in the lower extremity muscles responsible for jumping. 
Plyometric training has been used to help enhance an athlete’s vertical jump ability.
The researcher hypothesized that there would be an increase in the vertical jump height from pretest to posttest and there would also be an additional increase from posttest to follow-up test. This was indeed what the data indicated.

This research study involved 10 female high school volleyball players. These subjects all volunteered to perform in a seven-week study consisting of five weeks of plyometrics and two weeks of recovery. This plyometric protocol consisted of two days of plyometrics and one day of strength training which was done to help maintain strength gains. No subjects were eliminated from the study due to the corrective exercises that were set-up to be performed in the warm-up and cool-down to make up for any deficiencies that were exhibited during the overhead squat assessment.

The results from the data collected in this study demonstrated that there was an increase in the vertical jump heights from pretest to posttest and there also was an additional increase from posttest to follow-up test. Throughout the study each subject at least increased 2 inches in their vertical jump heights between each of the testing sessions. The greatest increase for a subject's vertical jump height was 4 inches. The greatest increases
in the vertical jump heights occurred between the pretest and posttest after the subjects had completed the five-week plyometric training program. It is possible that the increases might have been even greater if the program was longer than five weeks. The standard deviation also lowered with each testing session, showing that each subject may have improved their jumping ability. This improved jumping ability is a critical factor in performing successfully, and increasing vertical jump height. This decrease in variability may indicate that plyometrics can help improve jump mechanics, especially in relatively untrained female athletes. Finally the use of a pre-experimental design may have decreased the ability to clarify the total effects of this study on the subjects.

This training program was a combination of plyometrics and strength training. The strength training was used to help maintain the strength of the subjects but many professionals feel that when plyometric drills are combined with a resistance training program, vertical jump performance appears to be enhanced to a significantly greater extent than if each of the training programs were performed alone.\textsuperscript{14,21} The large increases in jump height lend some evidence to this. There have been studies that have demonstrated the effectiveness of plyometric training
for improving power, generally expressed as increases in vertical jump height.\textsuperscript{20,21} This study shows similar results, also concluding that plyometrics increase vertical jump heights.

Another component to this study was the recovery session. Here there was an additional increase seen from posttest to follow-up testing. This is thought to have been possible due to the two weeks of recovery that would allow the muscles to rest and repair, which could create greater strength increases. In a recent study, Luebbers and Potteiger demonstrated the importance of a recovery period following a plyometric program. They showed that no one had a great improvement right after the training program, but when they were allowed four weeks to recover there was an increase in performance.\textsuperscript{12} In this study a two week recovery period was used and a significant additional increase in jump height was found. It is unclear if jump height would have increased more with a longer recovery. What is clear, is that a recovery period should be included following a plyometric training program.\textsuperscript{12}

The increase in jump height was large with all 10 subjects. This may be due to the fact that none of these girls have ever done any plyometric exercises before. This did not come to much of a surprise. It was thought that
there would be some type of increase, but it was not thought that the increase would be of that magnitude.

When training athletes, an important factor to consider is getting the athlete to peak in their performance during a particular portion of the season. This study demonstrates that plyometrics should be considered as a training method and that a rest period should also be considered.

Conclusion

Plyometrics and recovery both were seen to contribute significantly to an increase in vertical jump heights of high school volleyball players that participated in this study. Vertical jump heights increased at least two inches between each testing session for each of the ten subjects indicating that plyometrics and recovery may be valuable when training to increase vertical jump heights.

Recommendations

The findings from this study are very significant to athletic trainers and coaches who are working with athletes
to improve performance and increase vertical jump heights. A well-designed plyometric training program with appropriate supervision is the key to improving the vertical jump height of athletes. Recovery is a factor that should be used with any training program when trying to improve an athlete’s performance. This study also provides some guidance to athletic trainers and coaches in determining when to start their athletes on the training program to have them peak in their performance during the season.
REFERENCES


22. Fitness Assessment: Health history questionnaire. Waukesha Young Women’s Christian Association. Waukesha, WI; YWCA.


APPENDIX A

Review of the Literature
Vertical jump height is an essential component of playing volleyball. The ability to jump high and reach maximum height quickly helps create a successful volleyball player. Explosive leg power is a critical component for successful performance in many athletic events.\textsuperscript{1-3} Strength conditioning coaches and Athletic Trainers feel that jump height and power of athletes could be improved through the use of plyometric training.\textsuperscript{4} A common misconception is that plyometrics are high impact so they also must have a high injury rate, but in fact plyometrics are safe and very effective if instructed and performed correctly.\textsuperscript{4,5} Many different college coaches use plyometrics in their training programs for their volleyball teams. Mean while high school volleyball coaches typically do not. Most coaches understand the value of plyometrics, but few understand how to safely and effectively make them a part of their off season training program.\textsuperscript{4,5,6} The purpose of this literature review is to determine the impact of using plyometric training and recovery on increasing vertical jump. The following sections will be discussed: (1) Training to Improve Vertical Jump, (2) Plyometric Training Progression, (3) Vertical Jump Testing Assessment, and following the sections, a Summary.
Training to Improve Vertical Jump

When incorporating plyometrics into a teams training program, one must first understand how plyometrics work. Muscles, along with bones, provide for posture and movements in the human body. Plyometrics are exercises that enable a muscle to reach maximum strength in as short a time as possible. Two factors that are key to enhancing vertical jump ability include: refining jumping mechanics and developing explosive strength in the muscles responsible for jumping. In order to understand how plyometric exercises work, one must understand basic muscle physiology and the actions the muscles will perform.

Muscle Physiology

Muscles are our only musculoskeletal structures that have the ability to lengthen and contract. In this way, they possess a unique ability to impart dynamic activity to the body. Each muscle is comprised of extrafusal and intrafusal muscle fibers. Extrafusal fibers contain myofibrils, the elements that contract, relax and elongate the muscles. Intrafusal fibers, also called muscles spindles, are the main stretch receptors in the muscles. During plyometric exercises, the muscle spindles are
stimulated by a rapid stretch, causing a reflexive muscle action. Both extrafusal and intrafusal muscle fibers play an important role in the muscle contractions that are initiated during the plyometric exercises.

Muscle contractions can be generated by the body and are used during all movement, including sports activities. The muscle contractions that are involved during these movements are eccentric, isometric, and concentric contractions. Lengthening of the muscle under tension is an eccentric contraction, and is used to help decelerate the body. When there is no change in the muscle, yet tension is applied and an isometric, or static contraction occurs, which activates when the body comes to a halt. Concentric contraction occurs when the muscle shortens to produce force, which results in the acceleration of the limb segments and/or body.

Vertical jump performance is determined by five factors, the strength of the muscles of the lower body, the rate at which the muscles can develop force, and the speed with which the muscles can contract and still maintain force output. The ability to utilize the stretch-shortening cycle to maximize the jump height, and finally the degree of coordination and skill in performing the movements.
**Stretch-Shortening Cycle**

The goal of training with plyometrics is to increase the rate of the stretch shortening cycle (SSC), as well as the power behind it, so that the stored elastic energy transfers more rapidly to the next explosive movement.³ This means the volleyball player will spend as little time as possible on the floor between jumps, while elevating as high as possible during both jumps.⁶ Plyometrics is a type of training that develops the ability of muscles to produce force at high speeds (power) in dynamic movements.³,⁵,⁹ These movements involve an eccentric lengthening or stretch of the muscle immediately followed by an explosive contraction of the muscle.³,⁴,⁹,¹²

During a plyometric movement, the muscles rapidly switch from the eccentric phase to the concentric phase.⁵,¹³ This SSC decreases the time of the amortization phase, which is the time from the beginning of the eccentric action to the beginning of the concentric action, that in turn allows for greater than normal power production.¹,⁹,¹²,¹⁴ The shorter the amortization phase, the more powerful the contraction will be.¹,⁹,¹² Plyometrics train muscles to switch rapidly from eccentric to concentric movements.¹³ The muscles stored elastic energy and stretch reflex response are essentially exploited in this manner, permitting more
work to be done by the muscle during the concentric phase of movement.\textsuperscript{14-16} Training programs that have utilized plyometric exercises have been shown to positively affect performance in power-related movements such as jumping and speed.\textsuperscript{14,17} Also, with plyometric training, the nervous system is conditioned to react more quickly to the SSC.\textsuperscript{5,18}

According to Kramer and Newton, most jumping and power activities involve a counter movement (wind-up, back swing, crouch) during which the muscles involved are first stretched rapidly and then shortened to accelerate the limb or body. It is also called a plyometric contraction.\textsuperscript{15} The faster the muscle is stretched the greater amount of force it will produce. An example would be an elastic rubber band. The more you pull the elastic back, the faster it returns to its original length, and the further it will fly. Muscles react the same way, during the stretch reflex.\textsuperscript{4}

This SSC has been demonstrated to enhance power performance to a greater extent than concentric training alone.\textsuperscript{1,19} The faster the muscle is stretched, the greater amount of force it will produce. Plyometric exercises that involve stretching an active muscle prior to its shortening have been shown to enhance performance during the concentric phase of muscular contraction.\textsuperscript{14,17}
Sports that require jumping, throwing, or sprinting rely heavily on the strength-speed or power of the athlete.\textsuperscript{1,2} Plyometrics are used to improve power output and increase explosiveness by training the muscles to do more work in a shorter amount of time in these activities.\textsuperscript{13,14}

**Jump Mechanics**

Vertical jump ability is critical for success in volleyball. Jumping ability exercises are very dynamic.\textsuperscript{6,20} These exercises mobilize all muscle groups and organize their actions. They are a functional result of speed and strength, and demand good coordination.\textsuperscript{19,21} Jumping is utilized during the jump set; jump serve, blocking and spiking movements in volleyball.\textsuperscript{18} The ability to jump high and reach maximum height quickly creates a successful volleyball player. This requires an ability to generate power in a very short time.\textsuperscript{18} Exercises like plyometrics are able to link strength with speed of movement to produce power very effectively.\textsuperscript{5}

Athletes feel that jumping is something that they just do and they do not need training for it, when actually jumping up vertically is a skill that can be taught to them.\textsuperscript{8,18,22} When one examines the vertical jump, they can see that as an athlete jumps in the air, that jump is
preceded by a counter-movement. It is during this
countermovement, where the center of gravity takes over,
causing the athlete to drop rapidly.\textsuperscript{7,10}

The vertical jump can be analyzed in three different
phases; the preparatory phase, take off phase, and landing
phase.\textsuperscript{7,8} When looking at vertical jump, the starting
position (preparatory phase) is the flexed position. In
this position, the hips, knees, and ankles are
simultaneously flexed, as well as the trunk. Here, the
muscles are actually being stretched (eccentric
contraction) stimulating the stretch receptors (muscle
spindles) increase here.\textsuperscript{7-10} As the athlete moves into the
take off phase, and the body extends, the muscles quickly
contract to produce a greater amount of force (concentric
phase). The takeoff velocity ultimately determines the
jump height.\textsuperscript{11} The necessary force to take off is
facilitated by the “stretch”. As the body is pulled down
by the center of gravity in the landing phase, the body
returns to the flexed deceleration position, places an
eccentric contraction again on the muscle to absorb the
force that is placed on the limbs.\textsuperscript{7,8,10}

The arm swing during the take off phase is an
important component that assists the vertical jump. During
the starting position, the arms are extended back, and then
as the body moves into extension the arms swing upward into flexion. Past this point they are only able to decelerate, which allows the body to begin to liftoff.\textsuperscript{7,8,18} For maximum force development, the athlete would want to have their arms extended and straight to increase lever length. The use of the arms has been shown to have a significant effect on peak force in jumping.\textsuperscript{7,16} Harman et al, found that the arms contribute an average of 10% to the takeoff velocity during a vertical jump.\textsuperscript{4} Arm swing is important to vertical jumping performance, which may indicate there is a technique or skill component to vertical jumping, rather than just leg power.\textsuperscript{8,18,22}

Although both anticipation and practice will help the athlete reach their vertical jump height, it is the strength of muscles and coordination that will produce a good vertical jump height.\textsuperscript{1,8} To maximize jump height, the athlete must coordinate a head-to-toe effort.\textsuperscript{8} This provides a good reason for including plyometric exercises in the overall training program.\textsuperscript{1}

Plyometric Training Progression

There are many components with a plyometric training program. One important component is the progression in the
training program. When thinking of progression with plyometric training exercises you should consider intensity, volume, recovery, and detraining effects. These progressions are all interrelated, the higher the intensity, the lower the volume, the longer rest period.\textsuperscript{7,9}

Intensity is the effort that is put forth in performing an exercise. In plyometrics, intensity is controlled by the type of exercise being performed, whereas in weight training it is the amount of weight lifted.\textsuperscript{7,9} Intensity is also dependent on the rate of the stretch shortening cycle (movement from eccentric to concentric contractions).\textsuperscript{23} Plyometric exercises range from simple tasks like hip-twist ankle hops to highly complex and stressful exercises such as depth jumps.\textsuperscript{7} These plyometric exercises are classified by the degrees of intensity that are used.\textsuperscript{7,23}

Volume is thought of as the number of foot contacts and/or distance that the athlete performs. The number of foot contacts will depend on the intensity of the exercises, skill level, body weight, and time of year (off-season, pre-season, and in-season).\textsuperscript{9,23} The volume of specific jumps will vary as the intensity of the exercise program increases. A plyometric exercise program will have a higher volume of jumps when starting out at a low
intensity level. As the athlete progresses and increases the intensity in the exercise program, the volume of specific jumps will decrease.

Recovery

Recovery is a key variable in determining whether plyometrics will succeed in developing power or muscular endurance. Recovery is expressed as many different time periods. It can be seen as the rest time after each exercise, the rest time between each set of exercises, and the rest time and recovery after each workout. Plyometric training is based on the athlete’s ability to perform maximal, quality efforts. Short recovery periods (10 to 15s) between sets will not allow for proper recovery. Recovery time for very low stress exercises amounts to one day, moderate stress exercises should provide rest for one to two days, and high stress exercises should be given two to three days of rest. Rest intervals should be increased if the athlete is unable to maintain consistent high intensity throughout the training period. Without allowing for proper recovery, fatigued muscles may cause poor exercise techniques, which may lead to injury. Recovery between workouts must be adequate, otherwise over training or injury may occur.
In a recent study, Luebbers and Potteiger demonstrated the importance of a recovery period following a plyometric program. Neither group in the study showed an improvement directly after the training program. However, when allowed four weeks to recover, the study showed the powerful effect recovery/rest can have on performance. It is unclear if the results would have increased more with a longer recovery. What is clear, is that a recovery period should be included following a plyometric training program.

Along with recovery the detraining effects that occur after a training program should be considered when designing any program. Detraining occurs when the athlete reduces the training duration, intensity, or stops training altogether, due to injury, or illness. By doing so it may result in the loss of anatomical and physiological adaptations as well as decreases in athletic performance. The degree of the detraining period depends on the length of time and how highly trained the individual is. In adolescents, unlike adults, the evaluation of strength changes during the detraining period is complicated by the associated growth-related strength increases during the same period of time.

One study performed by Faigenbaum and colleagues demonstrated rapid and significant decreases in strength of
preadolescents who trained for 8 weeks and were reevaluated 8 weeks after training had ceased.\textsuperscript{25,26} A research study also investigated whether there were any changes in vertical jump performance after detraining had occurred, it showed there were no changes over a two week period of time, but there was a reduction of 3-5\% of reduction after 12 weeks of detraining.\textsuperscript{27} Another study also showed that six weeks of detraining in a recreationally trained person had a significant reduction in peak isometric production of the muscles, whereas maximal isometric and 1RM strength and vertical jump performance can be maintained during short periods of training cessation.\textsuperscript{27}

To avoid some of the effects of detraining, the use of other training modes may be beneficial.\textsuperscript{9} It is also necessary to provide maintenance programs for adolescents to sustain the strength gains that they have achieved during the exercise program.\textsuperscript{26} The precise mechanism responsible for the detraining response remains unclear, but it seems likely that changes in neuromuscular functioning are at least partly responsible for this response.\textsuperscript{9}
Training Considerations

There are some limitations when working with middle and high school aged athletes. Programs for these athletes are less common and offer unique challenges. Physical and emotional maturity levels vary widely in this age group. Some adolescents are more mature and more physically developed than their counterparts who are still immature and less developed. Also, athletes in middle and high school often have a busy schedule that involves participation in multiple sport activities. This can pose a problem when trying to start an off-season program.

Plyometrics have been criticized for having a greater risk of injury than other methods due to the increased forces of landing and immediate rebounding. When starting a plyometric training program, many factors should be taken into consideration. The factors include age, sex, strength gains, landing surfaces, and progression of exercises.

The age at which you start performing a plyometric training program is debated by coaches, athletic trainers, and strength and conditioning coaches alike. Due to the high intensity of some plyometric drills and the potential risk of injury to growth plates, Allerheiligen and Holcomb both recommend that athletes under the age of 16 years old
should not perform plyometrics of shock intensity levels.\textsuperscript{23,24} They feel depth jumps and other high intensity exercises should not be performed until the epiphyseal plates are closed.\textsuperscript{5,23,24} However, plyometrics are a natural part of most movements, as evidenced by the jumping, hopping and skipping movements typically seen on any school playground.\textsuperscript{5} With qualified coaching and age-appropriate instruction, plyometric training can be a safe, effective, and a fun method of conditioning for young adolescents.\textsuperscript{5,28} Adolescents should develop an adequate baseline of strength before participating in a plyometric training program, or they should simply begin plyometric training with lower intensity exercises and gradually progress to higher intensity exercises over time.\textsuperscript{5,9,28}

A common myth that females must train differently than males exists. There is no reason why female athletes cannot perform plyometrics with the same degree of skill, proficiency, and intensity as males.\textsuperscript{7,12} However, more instruction for the female athlete to control excessive mediolateral knee movement and lack of knee flexion with jumping and landing is needed in order to guard against possible knee injury.\textsuperscript{12} As long as the coach, athletic trainer and strength conditioning coach sticks to the factors of having a good solid strength base, and correct
landing techniques have been achieved the progression is very similar in female and male athletes.\textsuperscript{12}

Neuromuscular adaptations are another factor in which plyometrics are seen to prevent injuries.\textsuperscript{29} Wilk et al suggested that muscular performance gains after plyometric training are attributed to these neural adaptations, rather than to morphologic changes.\textsuperscript{4,29} For this reason, plyometric training may enhance neuromuscular function and prevent knee injuries by increasing dynamic stability.\textsuperscript{4} Neuromuscular adaptations are believed to enhance dynamic knee stability and performance.\textsuperscript{4}

Females are also seen to have a lack of muscle stiffness, which can contribute to injuries. Wagner and Blickman feel that active muscle stiffness is essential for maintaining joint stability (in Tillman).\textsuperscript{30} Granata, Padua, and Wilson have said that recent research has shown that female athletes demonstrate less than 77\% of the active muscle stiffness compared to males during hopping activities (in Tillman).\textsuperscript{30} This lack of stiffness observed in female participants may contribute to the increased incidence of injury in this population.\textsuperscript{30}

The surface on which the athletes perform plyometric exercises should be on gym-like spring-loaded floors or Resilite\textsuperscript{TM} mats for easing the shock of landing.\textsuperscript{5,22,23} Wooden
basketball courts, synthetic tracks, and some artificial turf surfaces are also generally good to use. Various types of artificial turf have the ability to restrict the shoe from sliding, which can cause stress on the lower body, and create a greater chance of injury. Plyometric, high intensity exercises should never be performed on asphalt, concrete, or carpet.\textsuperscript{6,22,23} When performing the plyometric exercises, athletes should wear supportive athletic footwear.\textsuperscript{5,6}

Another factor to take into consideration is the strength an athlete needs before starting a plyometric program. Previous literature has mentioned that an athlete should be able to squat twice their weight before beginning any plyometric training.\textsuperscript{6,28} This thought lacks substantiation and is not accepted by most performance enhancement coaches.\textsuperscript{6} This poses a problem for athletes who are very large, and even athletes who have been strength training for years.\textsuperscript{24} It is important for a coach or athletic trainer to observe strength levels that are exhibited during play, not just those demonstrated in the weight room.\textsuperscript{6,23}

These guidelines from the NSCA position statement should be followed when performing a plyometric training program:
A thorough set of warm-up exercises should be performed before beginning a plyometric training session.

Footwear and landing surfaces used in plyometric drills must have good shock absorbing qualities.

Only athletes who have already achieved high levels of strength training through standard resistance training should engage in plyometric drills.

Less demanding drills should be mastered prior to attempting more complex and intense drills.

How does one know when an athlete is ready to progress to the next level of plyometrics? Plyometrics require an emphasis on correct technique. Observation becomes a key factor for determining this. When an athlete is struggling to complete the plyometric movement, then the exercise is inappropriate for that athlete. If the athlete has been able to complete the exercise repeatedly and correctly, they are ready to move to the next level. Athletes open themselves up to a greater risk of injury when they exhibit poor biomechanics. Some examples that might indicate an athlete is not ready to progress to the next level.

- If the athlete shows extensive bending at the waist, their torso flops forward or from side to side; more core work may be needed.
- If the athlete exhibits prolonged contact with the floor, they may not have the overall body strength and power necessary to proceed.
- If the athlete’s knees are collapsing towards each other, this can mean a lack of quadriceps strength. It can cause joint pain, tendonitis and can also decrease the ability to explode.
- Ideally, the knees should be aligned over the middle toe of each foot.
Testing for Power and Assessment

Vertical jump testing is commonly used (1) to measure improvements in the vertical jump for sports in which jumping ability helps performance, and (2) as a general measure of lower body power in sports that require high levels of lower body power. The easiest way to measure vertical jump performance is to simply measure the athlete’s vertical jump height. There are various other tests that can help assess different components of vertical jump performance. These tests include the athlete’s maximal leg strength, the maximal rate at which force can be developed, the ability of the athlete to increase power by employing the SSC during the crouch before the jump, and the athletes ability to coordinate the movements involved in jumping. Maximal strength can be measured through the squat or leg press. When jumping with minimal contact and maximal height, this is useful in showing the maximal force of rate development. When these tests are accomplished, the results can help increase the vertical jump height.

To measure the vertical jump height the easiest way is to use the Vertec™ apparatus. It allows for normal natural actions, which occur when an athlete performs vertical jumps. The vertec™ allows for true optimal jump testing
efforts. It can challenge the athlete to reach for a higher result and go beyond the prior achieved results. It is also very visible and easy to interpret.\textsuperscript{31,32}

**Plyometrics versus Resistance Training**

The primary training method for training athletes that coaches, athletic trainers and strength conditioning coaches have used is traditional resistance training programs. Traditional training programs use high intensity training in slow velocity movements.\textsuperscript{16,19} Plyometric training is another method that has been used more often when training for enhancing power performance. Plyometric training requires the athletes to accelerate and decelerate their body weight rapidly during dynamic movements.\textsuperscript{19} Studies have demonstrated the effectiveness of plyometric training for improving power, generally expressed as increases in vertical jump height.\textsuperscript{16,19} Therefore, it is suggested to be included in any program aimed at improving vertical jump ability.\textsuperscript{13} Adam, O’Shea, and Climsteam feel that traditional resistance training has been shown to improve vertical jump performance as well.(in IAFF)\textsuperscript{19} However Hakkinen and Komi, feel these improvements may be limited in experienced strength-trained individuals, as does Hoffman, Maresh, Armstrong, and Kramer who feel it
does in athletes who have a high pre-training vertical jump ability. (in IAAF)\(^\text{19}\) When plyometric drills are combined with a resistance training program, vertical jump performance appears to be enhanced to a significantly greater extent than if each of the training programs were performed alone.\(^5,\text{19}\) Plyometrics are not intended to be a stand-alone exercise program and should be incorporated into a well-designed overall conditioning program that also includes strength, aerobic, flexibility, and agility training.\(^5\)

Summary

Explosive leg power is a critical component for successful performance in many athletic events.\(^1,\text{3}\) Vertical jump ability is critical for success in volleyball, and jumping ability exercises try to help accomplish this goal. They work all muscle groups, are a functional result of speed and strength, and demand good coordination.\(^1,\text{2},\text{8}\) Muscles in the body have the ability to lengthen and contract, and in that way, they possess a unique ability to impart dynamic activity to the body.\(^6,\text{7}\) These muscles are effected by muscles fibers, and eccentric and concentric
muscle contractions that are initiated during plyometric exercises.\textsuperscript{9}

Plyometrics are used to increase the rate of the stretching and shortening, as well as the power behind it, so the stored elastic energy is more rapidly transferred to the next explosive movement.\textsuperscript{5,6,13} During a plyometric movement, the muscles undergo a very rapid switch from the eccentric phase to the concentric phase.\textsuperscript{5,13} This stretch-shortening cycle decreases the time of the amortization phase.\textsuperscript{1,13,14} The shorter the amortization phase, the more powerful the contraction will be.\textsuperscript{1} The stretch-shortening cycle has been demonstrated to enhance power performance to a great extent.\textsuperscript{10,14,17} This shows that the faster the muscle is stretched, the greater amount of force it will produce.

Progression of plyometric exercises deal with the progression of intensity, volume, and recovery. Low intensity exercises have a higher volume and a shorter recovery time, while high intensity exercises have a lower volume and a longer recovery time to allow for the muscles to repair. Recovery is a major factor and must be adequate, otherwise over training or injury may occur.\textsuperscript{9,22} Along with recovery the detraining effects that occur after a training program should be considered when designing any program. Detraining occurs when the athlete reduces the
training duration, intensity, or stops training altogether, due to injury, or illness.\textsuperscript{9,25,26} By doing so it may result in the loss of anatomical and physiological adaptations as well as decreases in athletic performance.\textsuperscript{9,25,26}

When working with middle and high school volleyball players there are some limitations and unique challenges to face when having them participate in an exercise routine.\textsuperscript{8} When starting a plyometric training program, many factors should be taken into consideration. These factors include age, sex, strength gains, landing surfaces, and progression of exercises.\textsuperscript{7,9,23,24} Young adolescents can safely perform plyometric exercise, as long as they follow age-specific guidelines.\textsuperscript{5,28} Females do not have to train differently than males when participating in a plyometric training program.\textsuperscript{5,7,12} The footwear and landing surfaces used in plyometric drills must have good shock absorbing qualities.\textsuperscript{6,9} Only athletes who have already achieved high levels of strength training through standard resistance training should engage in plyometric drills. Less demanding drills should be mastered prior to attempting more complex and intense drills.\textsuperscript{5,6,9,28} Observation is the key factor for determining if the athlete is ready to progress to the next level.\textsuperscript{6}
Vertical jump testing is commonly used (1) to measure improvements in the vertical jump for sports in which jumping ability helps performance and (2) as a general measure of lower body power in sports that require high levels of lower body power.\textsuperscript{16} Measuring the vertical jump height of an athlete could be done with the use of the Vertec\textsuperscript{TM}. This allows for normal natural actions, which occur when an athlete performs vertical jumps. It also allows for true optimal jump testing efforts.\textsuperscript{31}

Plyometric training has the athletes accelerate and decelerate their body weight rapidly during dynamic movements.\textsuperscript{19} Studies have demonstrated the effectiveness of plyometric training for improving power, generally expressed as increases in vertical jump height.\textsuperscript{16,19} Coaches, athletic trainers and strength conditioning coaches primarily use the traditional weight training methods. Both methods increase vertical jump height, when used together it shows a significant increase in vertical jump height. Therefore it is suggested that plyometric exercises should be included in any program aimed at improving vertical jump ability.\textsuperscript{16}
APPENDIX B

The Problem
Statement of the Problem

One of the primary training goals for any volleyball player or coach is to increase the vertical jump height and have explosive power of the athletes. Incorporating plyometrics into a training program could become a helpful tool in increasing the vertical jumps of those volleyball players. Coaches, Athletic Trainers, and Strength conditioning coaches know about plyometrics and that doing plyometric exercises can help increase the explosive power of an athlete, but not many know how to safely and effectively add them into their off season training programs. Another variable in increasing the vertical jump height would be the use of recovery. Recovery is a key variable in determining whether plyometrics will succeed in developing power or muscular endurance. It will also attempt to help determine when is the best time to implement a training program. The purpose of this study was to determine if vertical jump height can be increased in female high school volleyball players through the use of plyometrics and further increased by recovery.
Definitions of Terms

The following are definitions of terms that were operationally defined throughout this study.

1) Amortization phase- is the time from the beginning of the eccentric action (lengthen of the muscle) to the beginning of the concentric action (shortening of the muscle) and is often referred to as the rate of eccentric action.12

2) Concentric- is a contraction in which the muscle fibers pull together and shorten.7

3) Eccentric- is a contraction, which occurs when the muscle lengthens under tension.7

4) Extrafusal fibers- are the muscle fibers that contain myofibrils, the elements that contract, relax, and elongate muscles.7

5) Intrafusal fibers- also known as muscles spindles. These fibers are the main stretch receptors of the muscles.7

6) Plyometrics- is defined as exercises that enable a muscle to reach maximum strength in as short a time as possible.7

7) Stretch shortening cycle- where the muscles involved are first stretched rapidly and then shortened to accelerate the body or limb.15
Basic Assumptions

The following were the basic assumptions for this study.

1) All subjects performed to the best of their ability when performing the exercises.
2) The subjects did not participate in any other competitive sport or recreational activity during the study.
3) Proper use of the Vertec™ was executed.

Limitations of the Study

The following were possible limitations of this study.

1) The study only involved members of a small 1A high school female volleyball team; the results cannot be generalized for other high schools (2A, 3A, and 4A).
2) Subject attrition may occur due to factors dealing with illness, lack of interest, and injury. This subject attrition may keep the subject from being able to complete the rest of the study.
3) The use of pre-experimental design would be a limitation because the design controls very few of the sources of invalidity. This design does not use random assignment of subjects to groups.
Significance of the Study

Bursts of power are important to athletes that want to improve their game and get to the next level.\textsuperscript{17} While quickness is a very essential component for any competitive sport, quickness from the up to down movements is particularly important to volleyball players.

Many studies have shown that plyometrics have increased balance and coordination and can also increase strength and agility.\textsuperscript{1,17,18,21} Research has also shown that recovery after a plyometric training program can further increase the vertical jump height.\textsuperscript{14} It is still unclear as to the amount of time that is needed for recovery to reach the maximum increase on the vertical jump height.\textsuperscript{14} With these studies you can see that plyometric training and recovery are essential factors that should be placed in a training program.

This study measured the vertical jump levels before and after the five weeks of plyometric training to see if there will be an increase. It looked at the recovery period two weeks after the training program has been completed has an effect on vertical jump. It will attempt to show that incorporating plyometrics safely and effectively will have an affect on increasing an athlete’s skill level.
Athletic Trainers should know what movements in each sport will benefit from plyometric training and should be able to help combine these exercises to develop the speed-strength components for that sport. In the end, hopefully that this study will help tell coaches when to perform a plyometric program with the athletes and also when the athlete will peak in performance.
APPENDIX C

Additional Methods
APPENDIX C1
Informed Consent
Informed-Consent Form

Sarah Tipsword, who is a Graduate Assistant Athletic Training student, has requested my child’s participation in a research study for her master’s thesis at California University of Pennsylvania. The title of the research is Increasing Vertical Jump Height in High School Volleyball Players with the Use of Plyometrics and Recovery.

I have been informed that the purpose of the research is to look at the effects that a Plyometric training program and recovery has on the Vertical Jump Height of a High School Volleyball Player. This study will involve the use of 15 volunteer female Volleyball Players at Burgettstown Junior/Senior High School.

My child’s participation will involve a five week Plyometric training program, where they will meet with the researcher three times a week (M, T, TR) for an hour right after school. In addition to the five weeks of training, my child will also participate in three days of testing (Pre, Post, and Follow-up testing two weeks after the program) to measure the results from the training program and recovery. The researcher, Sarah Tipsword, will set up and arrange for these days.

I understand there are foreseeable risks or discomforts to my child if I agree for them to participate in the study. The possible risks and/or discomforts include muscle soreness after performing the exercises. There could be minimal risk of injury, if the exercises are performed incorrectly. The minimal risk of injury would be no more than what would be seen with participation in the sport. To minimize the expected risks stretching after the program will be done to help offset muscle soreness. Also rest periods will be used to allow the muscles to recovery and repair. The participants will be shown and coached on the correct form that should be used when performing the exercises.

I understand that in case of injury I can expect my child to receive treatment or care in the Athletic Training room at Burgettstown Junior/Senior High School which will provided by the student researcher, Sarah Tipsword a Graduate Assistant Athletic Trainer, of which whom can administer emergency and rehabilitative care. Additional services needed for prolonged care past 3 days will be referred to our family physician or emergency room for further care.

There are no feasible alternative procedures available for this study.

I understand that the possible benefits of my child’s participation in the research are to contribute to existing research. Also to help inform High School coaches on the effects of using a Plyometric training program with High School athletes.

I understand that the results of the research study may be published but that my child’s name or identity will not be revealed. In order to maintain confidentiality of my records, Sarah Tipsword will maintain all documents in a secure location in which only the student researcher and research advisor can access. During the
recording of the research my child’s name will be coded for confidentiality. All results will be kept with the researcher, and only will be shared with the research advisor.

I have been informed that my child and I will not be compensated for their participation.

I have been informed that any questions I have concerning the research study or my child’s participation in it, before or after my consent, will be answered by the student researcher Sarah Tipsword, who can be reached at tip4084@cup.edu, (address) 947 Cross St Apt 3, California PA 15419, home number 301-848-9854, or the research advisor Tom West, who can be reached at west_t@cup.edu, (address) 250 University Avenue, California PA 15419, office phone 724-938-4562.

I understand that written responses may be used in quotations for publication but my child’s identity will remain anonymous.

I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waving any legal claims, rights, or remedies. A copy of this consent form will be given to me upon request.

Parent’s Signature ____________________________ Date _____________

Other signature(if appropriate) ____________________________ Date _____________

I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature.

I have provided the subject/participant parents a copy of this signed consent document if requested.

Investigator’s signature ____________________________ Date _____________

Approved by the California University of Pennsylvania IRB
APPENDIX C2
Child Ascent Form
Child Assent Form

I, ____________________________, understand that my parents have given permission for me to participate in a study concerning trying to Increase Vertical Jump Height in Volleyball Players through the use of Plyometric Training and Recovery under the direction of Sarah Tipsword the Graduate Student Athletic Trainer at Burgettstown Junior/Senior High School.

My involvement in this project is voluntary, and I have been told that I may withdraw from participation in this study at any time without penalty and loss of benefit to myself.

_______________________________
Signature

Approved by the California University of Pennsylvania IRB.

APPENDIX C3
Health History Questionnaire
# HEALTH HISTORY QUESTIONNAIRE

## ADMINISTRATIVE INFORMATION

<table>
<thead>
<tr>
<th>Last Name</th>
<th>First Name</th>
<th>Initial</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Mailing Address: ____________________________ Zip Code: ________

Telephone Number: Business: ____________________________ Home: __________

In Case of Emergency, Contact: ____________________________ Phone #: ________

Address: ___________________________________________ Phone #: ________

Personal Physician: ____________________________ Phone #: ________

Age: ________ Date of Birth: __________ Height: ________ ft. ________ in. Weight: ________ Sex: __ M __ F

Staff Use: ____________________________

### General Health

- Have you undergone a physical examination in the last 5 years? [ ] Yes [ ] No
- Are you on a special diet? [ ] Yes [ ] No
- What type? ____________________________
- Have you gained or lost more than 10 lbs. in the last 6 months? [ ] Yes [ ] No
- Have you had any illness in the last 2 weeks? [ ] Yes [ ] No
- Specify: ____________________________
- Do you have any allergies? [ ] Yes [ ] No
- Specify: ____________________________

### Musculoskeletal / Orthopedic

- Varicose Veins: [ ] Yes [ ] No
- How long ago? ____________________________
- Phlebitis: [ ] Yes [ ] No
- How long ago? ____________________________
- Stroke: [ ] Yes [ ] No
- How long ago? ____________________________
- High Blood Pressure: [ ] Yes [ ] No
- Current: [ ] Yes [ ] No
- Past: [ ] Yes [ ] No

### Have you ever had any of the following:
- Hernia or rupture? [ ] Yes [ ] No
- Number of years ago? ____________________________
- Present or recurrent, lower back pain or stiffness? [ ] Yes [ ] No
- Arthritis/Bursitis? [ ] Yes [ ] No
- Current: [ ] Yes [ ] No
- Spinal Disc Problem? [ ] Yes [ ] No
- Joint Dislocation? [ ] Yes [ ] No
- Ligament Strain? [ ] Yes [ ] No
- Carpal Tunnel? [ ] Yes [ ] No
- Tendon Tear? [ ] Yes [ ] No
- Intermitent Leg Cramps? [ ] Yes [ ] No
- Swollen Painful Joints? [ ] Yes [ ] No
- Polio? [ ] Yes [ ] No
- Surgery? [ ] Yes [ ] No
- Please specify: ____________________________
- Other? [ ] Yes [ ] No
- Please specify: ____________________________

### Personal Medical History

- Have you ever been told you have any of the following:
  - Documented heart disease: [ ] Yes [ ] No
  - Myocardial Infarct (Heart Attack): [ ] Yes [ ] No
  - Bypass / Valve Surgery: [ ] Yes [ ] No
  - Mitral Valve Prolapse: [ ] Yes [ ] No
  - Diabetes Type I: [ ] Yes [ ] No
  - Diabetes Type II: [ ] Yes [ ] No

### Pulmonary Respiration

- Have you ever experienced any of the following?
  - Asthma? [ ] Yes [ ] No
  - Bronchitis? When: ____________________________
  - Pneumonia? [ ] Yes [ ] No
  - Empysema? When: ____________________________
  - Lung disease? When: ____________________________

- Please specify: ____________________________

### Have you ever been told you have any of the following:
- Heart Murmur: [ ] Yes [ ] No
- Rheumatic Fever: [ ] Yes [ ] No
- Childhood: [ ] Yes [ ] No
- Recent: [ ] Yes [ ] No
- Resting Electrocardiogram: [ ] Normal [ ] Abnormal [ ] Don't know
- Exercise Electrocardiogram: [ ] Normal [ ] Abnormal [ ] Don't know

### Comments:

- ____________________________

---

71
### Medications

<table>
<thead>
<tr>
<th>Medication</th>
<th>Dose</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- [ ] Yes
- [ ] No

**Do you currently take ANY medication?**

**Other: Specify:**

### Exercise Patterns

**Are you presently involved in any personal exercise program?**

If yes, please list the information below:

- **Activity:**
- **Time spent in activity:**
- **Number of times per week:**

### Other Information

Please discuss any significant medical problems that you consider important for us to know:

### Please list other sports or activities you are involved in along with time spent per week.

### Please list the position(s) you play.

### What is your skill level (varsity, junior varsity, or freshman)?

### How many years have you participated in organized Volleyball?

### Have you ever participated in an organized weight training program before?

### Are you currently on an organized weight training program?

---

Approved by the California University of Pennsylvania IRB

Health History Questionnaire adapted from YWCA Fitness Assessment, Waukesha, WI.
APPENDIX C4
Plyometric Training Protocol
Week One

Preparation
Use high-volume, low-intensity resistance training and low-intensity plyometrics to allow the body’s soft tissues to accommodate to the stress of jumping and the impact of landing.

Progression
Include enough variety to challenge the athlete to learn new skills

Performance
Concentrate on proper landing techniques and the use of the arms in performing low-intensity exercises. Make sure the concept of the amortization phase is understood.

Monday: Weight Training
- 3 x 12 parallel squats with 70% 1 RM
- 3 x 10 each leg split squats with 50% of body weight
- 4 x 8 inverted leg presses
- 4 x 8 push presses (front)
- 4 x 5 shrugs

Tuesday: Plyometrics
- 1 x 10 two-foot ankle hops
- 2 x 20 side to side ankle hops
- 2 x 20 hip-twist ankle hops
- 2 x 10 each leg split squat jump
- 1 x 6 standing jump-and-reaches

Thursday: Plyometrics
- 1 x 10 two-foot ankle hops
- 2 x 20 side-to-side ankle hops
- 2 x 20 hip-twist ankle hops
- 2 x 10 rim jumps
- 2 x 20 single leg push-offs from a 12-inch box
- 2 x 20 alternating push-offs from a 12-inch box

Week Two

Preparation
Use resistance training to stress basic strength in the lower extremities
Progression
Integrate higher levels of intensity into plyometric exercises to add complexity and intensity to resistance training.

Performance
Remember that quality, not quantity, is the key in performing plyometric exercises.

Monday: Plyometrics
- 3 x 10 front box jumps (18 inches)
- 1 x 10 standing jump over barrier (36 inches)
- 3 x 3 double leg hops
- 2 x 10 rim jumps
- 3 x 10 two-foot ankle hops

Tuesday: Weight Training
- 3 x 8 front squats
- 4 x 8 inverted leg presses
- 2 x 8 push presses (front)
- 2 x 8 high pulls

Thursday: Plyometrics
- 3 x 10 side-to-side ankle hops
- 3 x 10 single leg push-offs
- 3 x 10 front box jumps (18-inch box)
- 3 x 10 rim jumps
- 1 x 5 standing triple jumps

Week 3

Preparation
Emphasize heavy plyometric work. Use resistance training as a form of recovery.

Progression
Concentrate on building basic strength in those muscle groups associated with plyometric exercises for vertical jumping. Continue to build on both volume and intensity.

Performance
Emphasize quality of effort by applying time and distance goals.
Monday: Plyometrics
- 3 x 10 depth jumps (from 18-inch box)
- 3 x 10 standing jumps over barrier (18-24 inch)
- 3 x 5 double leg hops
- 3 x 10 single leg hops with cone
- 3 x 10 side-to-side ankle hops

Tuesday: Weight Training
- 3 x 8 front squats
- 4 x 8 inverted leg presses
- 3 x 8 behind-the-neck push presses
- 3 x 5 stiff knee cleans

Thursday: Plyometrics
- 3 x 10 front box jumps (18-inch box)
- 1 x 3 standing triple jumps
- 3 x 10 lateral cone hops (12 to 18 inches)
- 3 x 10 alternating push-offs
- 3 x 10 rim jumps

Week Four

Preparation
Emphasize low-volume, high intensity exercises. Neuromuscular preparation is directed toward maximal efforts with full recovery in both plyometrics and weight training.

Progression
The challenge is to work toward maximal efforts in plyometrics. Maximal vertical efforts with minimal ground contact time are a must.

Performance
Resistance training as well as plyometrics should now be focused on power. The concept of maximal force applied rapidly is the key to developing vertical jump.

Monday: Plyometrics
- 3 x 10 depth jumps (from 18 inch box)
- 3 x 10 standing jumps over barrier (18 to 24 inches)
- 3 x 10 single leg hops over cone
- 3 x 10 double leg hops
Tuesday: Weight Training
- 5 x 3 quarter-squats
- 5 x 5 inverted leg presses
- 3 x 8 hamstring curls
- 5 x 3 front squats to push presses

Thursday: Plyometrics
- 3 x 10 depth jumps to 24-inch or higher box
- 3 x 10 alternating push-offs
- 3 x 10 lateral jumps over cone (12 to 18 inches)
- 3 x 10 rim jumps

Week Five

Monday: Plyometrics
- 3 x 10 depth jumps (from 18 inch box)
- 3 x 10 standing jumps over barrier (18 to 24 inches)
- 3 x 10 single leg hops over cone
- 3 x 10 double leg hops

Tuesday: Weight Training
- 5 x 3 quarter-squats
- 5 x 5 inverted leg presses
- 3 x 8 hamstring curls
- 5 x 3 front squats to push presses

Thursday: Plyometrics
- 3 x 10 depth jumps to 24-inch or higher box
- 3 x 10 alternating push-offs
- 3 x 10 lateral jumps over cone (12 to 18 inches)
- 3 x 10 rim jumps

This Plyometric Training Protocol has been taken from:
APPENDIX C5
Total Body Profile
Overhead Squat
# TOTAL BODY PROFILE

## Overhead Squat

**Objective:**
To observe for total body neuromuscular efficiency, integrated functional strength and functional flexibility

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>🗿 Feet flatten (pronate): Y / N</td>
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<td>🗿 Externally rotate (turn out): Y / N</td>
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</table>

<table>
<thead>
<tr>
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<tr>
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<td>🗿 Knees bow outward: Y / N</td>
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<td>🗿 Low back arches: Y / N</td>
</tr>
<tr>
<td>🗿 Low back rounds: Y / N</td>
</tr>
<tr>
<td>🗿 Abdomen protrudes: Y / N</td>
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</tbody>
</table>

<table>
<thead>
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<tr>
<td>🗿 Shoulder abduction: Y / N</td>
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<tr>
<td>🗿 Scapular winging: Y / N</td>
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</tbody>
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<tbody>
<tr>
<td>🗿 Forward Head: Y / N</td>
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</tbody>
</table>
APPENDIX C6
Letter of Permission
To Whom It May Concern:

My name is Sarah Tipsword and I am a Graduate Assistant Athletic Training student at California University of Pennsylvania. I am working on my thesis this year and would like to conduct a volunteer study at Burgettstown Junior/Senior High School. This study will involve little if any risk to the participants, and will be approved by California University of PA’s Institutional Review Board (IRB) for the protection of human subjects prior to being implemented.

The purpose of the study is to examine the effects that a plyometric training program and recovery has on vertical jump height. Plyometric training involves jumping, landing, and other fast powerful movements. Over the five weeks the girls who volunteer from the junior varsity/varsity volleyball teams will undergo an established plyometric training program. The girls will be asked to come in three times a week (M, W, F) for training. Measurements of their vertical jumps will be taken before the plyometric training program, after the five weeks of the training program, and 4 weeks after the training program has finished to look at the effects of rest after the training program has been completed. This study will be conducted during the volleyball teams’ off-season (January, 06).

A description of the study along with an informed consent will be sent home to the parents for their approval to have their child participate. The girls that volunteer will have to sign a child ascent form and be briefed on the study before they are allowed to participate. The participants will be athletes so they should all have obtained a yearly physical, for the benefit of the study a health history form will be sent home for the parents to fill out. Subjects will not be exposed to any risk greater than normally seen from participation in athletics. Thank you for your time. I would greatly appreciate your approval to perform this study. Feel free to contact me if you have any questions. You can reach me at 301-848-9854.

Sincerely

Sarah Tipsword

A member of Pennsylvania’s State System of Higher Education
APPENDIX C7
Warm-up Protocol
Warm-up Protocol
This warm-up will be performed before any testing or training sessions.

- 1 minute of jogging around the gymnasium
- 1 minute of jump roping

Active Warm-up (20 Yards each)

- High knee skips
- High knee run
- Heel ups
- Straight-leg dead lift walk
- Backpedaling
- Overhead squat lunge walk
- Straight-leg crossover

*Corrective Exercises (These exercises will only be performed on the training days.)

- Bridging up: Hold for 5 sec, 10 reps
- Squats: No weight, 10 reps
  • Note that the knee is aligned over the second toe.

This warm-up has been taken from a Linear active warm-up, and Linear flexibility warm-up in: Boyle M. Functional Training for Sports. Human Kinetics.2004.pg31-40.
APPENDIX C8
Cool down Protocol
Cool Down Protocol
This cool down will be performed after any testing or training sessions.

- 3 minutes of jogging around the gymnasium

Stretching Exercises (10 Yards each)
- High knee walk with external rotation
- Heel up with internal rotation
- Walking heel-up
- Walking heel-up with straight-leg dead lift walk
- Straight dead lift walk
- Straight-leg crossover

*Corrective Exercises (These exercises will only be performed on the training days.)

- Bridging up: Hold for 5 sec, 10 reps
- Squats: No weight, 10 reps
  - Note that the knee is aligned over the second toe.

This cool down has been taken from a Linear flexibility program in: Boyle M. Functional Training for Sports. Human Kinetics. 2004. pg31-40.
APPENDIX C9
Institutional Review Board
PROTOCOL for Research Involving Human Subjects

Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects (Reference IRB Policies and Procedures for clarification)

Project Title: Increasing Vertical Jump Height in High School Volleyball Players with the use of Plyometrics and Recovery

Researcher/Project Director: Sarah Tipsword

Phone #: 301-848-9854  E-mail Address: tip4084@cup.edu

Faculty Sponsor (if required): Dr. Tom West

Department: Health Science and Sport Studies

Project Dates: Fall 2005 to Spring, May 2006

Sponsoring Agent (if applicable)

Project to be Conducted at: Burgettstown High School

Project Purpose: ☑ Thesis ☐ Research ☐ Class Project ☐ Other

Keep a copy of this form for your records.

Required IRB Training

The training requirement can be satisfied by completing the online training session at http://irb.ucp.edu . A copy of your certification of training must be attached to this IRB Protocol. If you have completed the training at an earlier date and have already provided documentation to the California University of Pennsylvania Grants Office, please provide the following:

Previous Project Title

date of Previous IRB Protocol
Please attach a typed, detailed summary of your project AND complete items 2 through 6.

1. Provide an overview of your project-proposal describing what you plan to do and how you will go about doing it. Include any hypothesis(es) or research questions that might be involved and explain how the information you gather will be analyzed. For a complete list of what should be included in your summary, please refer to Appendix B of the IRB Policies and Procedures Manual.

The focus of this study will be to examine the effect that a plyometric training program and recovery has on improving vertical jump height in female High School volleyball players. First I have obtained approval from Burgettstown High School Superintendent, Principle, and Athletic Director to perform the study at the high school. Next this study will be conducted over seven weeks and will require subjects to perform plyometric exercises two times, along with one day of resistance training each week for a duration of five weeks. Each subject will perform a vertical jump pretest prior to participating in the training program to establish a baseline. At the completion of the five weeks the subjects will participate in a vertical jump posttest to compare the results, subjects will then be asked not to participate in any competitive sport or plyometric exercises for two weeks. At the end of those two weeks each subject will be tested again as a follow up to look at the effects that recovery has on the vertical jump height. The Vertec® will be used to measure the subjects vertical jump height during the pre, post, and follow-up tests. The subjects will be allowed to perform a two-step approach three times, all scores will be recorded but the best measurement out of the three will be used for statistical analysis. A repeated measures ANOVA test will be used in SPSS 12.0 for statistical analysis. If necessary a post hoc test will be used to determine the differences between the testing sessions. The subjects for this study will be female volleyball players at Burgettstown Junior/Senior High School, aged 14-17 years old. Sampling will be accomplished by the selective use of a small 1A high school volleyball team and they will all be volunteers with no outside influences to participate. This research intends to answer two important questions of “Does the use of plyometric training increase the vertical jump height of an athlete?” Also “Does the period of rest and recovery after a training program show an increase in the vertical jump height?”

2. Section 46.11 of the Federal Regulations state that research proposals involving human subjects must satisfy certain requirements before the IRB can grant approval. You should describe in detail how the following requirements will be satisfied. Be sure to address each area separately.

   a. How will you insure that any risks to subjects are minimized? If there are potential risks, describe what will be done to minimize these risks. If there are risks, describe why the risks to participants are reasonable in relation to the anticipated benefits.

The possible risks and/or discomforts that the subjects might experience when participating in this study may be muscle soreness after performing the exercises. There is a minimal risk of injury, if the exercises are performed incorrectly. The minimal risk of injury would be no more than what the subject might experience when participating in the sport. To minimize the expected risks rest periods will be used to allow the muscles to recover and repair. The participants will be shown and coached on the correct form that should be used when performing the exercises. If a subject reports pain lasting for three days will be referred to their family physician or emergency room for further care.
b. How will you ensure that the selection of subjects is equitable? Take into account your purpose(s). Be sure you address research problems involving vulnerable populations such as children, prisoners, pregnant women, mentally disabled persons, and economically or educationally disadvantaged persons. If this is an in-class project describe how you will minimize the possibility that students will feel coerced.

Sampling of the subjects will be accomplished by the selective use of a small 1A high school volleyball team. They will all be volunteers and will not be participating in any winter sport that might interfere with the study. There will also be no outside influences to participate in this study. Limitations will be encountered when working with a young age group. These limitations could be maturation of the subjects, attention, drive and want to complete the experiment, and the strength levels that are needed to perform these exercises. To control these limitations the researcher will have each of subjects perform an overhead squat as a prescreening tool before participating in the study to examine proper mechanics. Progressing the subjects from low to high intensity can help control for the limitations. By creating variations to the exercises will create difficulty if a few subjects easily perform the exercises. Also making the training program interesting and having the researcher be very motivating during the training sessions can help keep the interest of each of the subjects.

c. How will you obtain informed consent from each participant or the subject’s legally authorized representative and ensure that all consent forms are appropriately documented? Be sure to attach a copy of your consent form to the project summary.

The subjects that will be used in this study will be of the age of 14-17 years old and are considered minors. With using minors in this study an informed consent will be sent home to each of the subjects parents to be signed, along with a health history questionnaire to be filled out. This is done for the researchers knowledge; all girls have had their yearly physical. In addition, each of the subjects will be asked to sign a child assent form. Subjects will not perform in this study unless all three forms have been completed and turned into the researcher, prior to testing.

d. Show that the research plan makes provisions to monitor the data collected to insure the safety of all subjects. This includes the privacy of subjects’ responses and provisions for maintaining the security and confidentiality of the data.

In order to maintain confidentiality of the records, all documents will be maintained in a secure location. All results will be kept with the researcher in a file cabinet and will only be shared with the research advisor. During the recording of the research the subject’s names will be coded with a number for confidentiality, and will not be revealed if the research study might be published.
3. Check the appropriate box(es) that describe the subjects you plan to use.

☐ Adult volunteers  ☐ Mentally Disabled People
☐ CAL University Students  ☐ Economically Disadvantaged People
☐ Other Students  ☐ Educationally Disadvantaged People
☐ Prisoners  ☐ Fetuses or fetal material
☐ Pregnant Women  ☒ Children Under 18
☐ Physically Handicapped People  ☐ Neonates

4. Is remuneration involved in your project?  ☐ Yes or ☒ No. If yes, Explain here.

5. Is this project part of a grant?  ☐ Yes or ☑ No  If yes, provide the following information:
   Title of the Grant Proposal ____________________________________________
   Name of the Funding Agency __________________________________________
   Dates of the Project Period __________________________________________

6. Does your project involve the debriefing of those who participated?  ☐ Yes or ☑ No
   If Yes, explain the debriefing process here.

7. If your project involves a questionnaire interview, ensure that it meets the requirements of
Project Director's Certification
Program Involving HUMAN SUBJECTS

The proposed investigation involves the use of human subjects and I am submitting the complete application form and project description to the Institutional Review Board for Research Involving Human Subjects.

I understand that Institutional Review Board (IRB) approval is required before beginning any research and/or data collection involving human subjects. If the Board grants approval of this application, I agree to:

1. Abide by any conditions or changes in the project required by the Board.
2. Report to the Board any change in the research plan that affects the method of using human subjects before such change is instituted.
3. Report to the Board any problems that arise in connection with the use of human subjects.
4. Seek advice of the Board whenever I believe such advice is necessary or would be helpful.
5. Secure the informed, written consent of all human subjects participating in the project.
6. Cooperate with the Board in its effort to provide a continuing review after investigations have been initiated.

I have reviewed the Federal and State regulations concerning the use of human subjects in research and training programs and the guidelines. I agree to abide by the regulations and guidelines aforementioned and will adhere to policies and procedures described in my application. I understand that changes to the research must be approved by the IRB before they are implemented.

Professional Research

Project Director's Signature

Student or Class Research

Student Researcher's Signature

Supervising Faculty Member's Signature if required

Department Chairperson's Signature

ACTION OF REVIEW BOARD (IRB use only)

The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigation;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved;
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm

☐ Approved  ☐ Disapproved

Chairperson, Institutional Review Board

Date

Draft, April 7, 2005
The Institutional Review Board for Research Involving Human Subjects has reviewed this application to ascertain whether or not the proposed project:

1. provides adequate safeguards of the rights and welfare of human subjects involved in the investigations;
2. uses appropriate methods to obtain informed, written consent;
3. indicates that the potential benefits of the investigation substantially outweigh the risk involved.
4. provides adequate debriefing of human participants.
5. provides adequate follow-up services to participants who may have incurred physical, mental, or emotional harm.

[ ] Approved  [ ] Disapproved

Chairperson. Institutional Review Board  Date

1/12/06
Subjects Demographics Sheet

Name: ______________________________________

Subjects Number: __________

Age: __________

Height: _________

Sport: Volleyball

Position: ______________

Year in school: ______________

Have you had any previous injury to the lower extremity in the past 6 months: YES/NO
If so what: _______________________

How many practices did you sit out due to this injury: ______________
Vertical Jump Height Recording Sheet
### Vertical Jump Height Recording Sheet

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<tr>
<th>Subjects Number</th>
<th>Standing Reach Height</th>
<th>Vertical Jump Height: Pretest</th>
<th>Vertical Jump Height: Posttest</th>
<th>Vertical Jump Height: Follow-up test</th>
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REFERENCES


ABSTRACT

Title: INCREASING VERTICAL JUMP HEIGHT IN HIGH SCHOOL FEMALE VOLLEYBALL PLAYERS THROUGH THE USE OF PLYOMETRICS TRAINING AND RECOVERY

Researcher: Sarah Tipsword

Advisor: Dr. Tom West

Date: May 2006

Research Type: Master’s Thesis

Purpose: The purpose of this study was to examine the effects of a five week plyometric training program and two weeks of recovery on high school female volleyball players.

Method: A pre-experimental research design was conducted, using a one-group pre-posttest design in which all subjects received the same training. This study consisted of five weeks of training, where subjects performed plyometrics two days, and resistance training one day a week. Then after two weeks of recovery was done, where subjects were asked not to participate in any plyometric activity. An established plyometric protocol was used for training along with a Vertec™ to calculate the vertical jump heights of each of the subjects.

Findings: A significance increase was reported between the two testing sessions from pretest to posttest. There was also an additional increase seen in the vertical jump heights from posttest to follow-up test.

Conclusion: Plyometrics and recovery do have an significant effect on the vertical jump heights of high school volleyball players.