

A COMPARATIVE ANALYSIS BETWEEN TRADITIONAL AND SWING BLOCKING
AMONG DIVISION II FEMALE VOLLEYBALL PLAYERS

by

Taylor L. Linebach

An Abstract

of a thesis submitted in partial fulfillment
of the requirements for the degree of
Master of Science
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ABSTRACT

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Taylor L. Linebach

The purpose of this study was to compare the vertical jump height and peak landing vertical ground reaction forces (VGRF) produced by traditional and swing blocking in volleyball. Twenty NCAA Division II female volleyball players were recorded on a Kistler force platform performing 4 blocks (i.e. 1 traditional & 1 swing block to the right and left). Repeated measures ANOVA revealed no significant differences for vertical jumps ($F=1.223$, $p>.05$). However significant differences in landing did occur ($F=4.613$, $p<.05$). Post-hoc t-test using Bonferroni adjustments revealed significantly higher peak landing VGRF for swing blocking to the right in all cases. It was concluded that swing blocking to the right produced significantly greater peak landing VGRF than traditional blocking and swing blocking to the left. Vertical jump height was not affected by blocking style in this investigation.

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CHAPTER 1: NATURE AND SCOPE OF THE STUDY

The National Federation of High School Sports Associations (2009) reported that more young Americans are participating in volleyball scholastic sports programs than ever. USA Volleyball, the national governing body of volleyball in the US, reported that its club memberships had grown from 17,349 in 1980 to 234,922 in 2008 (Lyman, 2009). Much of this growth was attributed to the success of women's intercollegiate volleyball programs, as well as the versatility of the sport. This game is played either recreationally or competitively on multiple surfaces such as indoor, grass, and sand courts, and is popular with all ages (Lyman, 2009). Since Title IX was passed in 1972, the popularity of women's volleyball has risen steadily. The number of women in collegiate athletics has grown from under 30,000 pre-Title IX to around 200,000 today (Buchanan, 2012). This game is played by a wide range of individuals possessing differing skills (e.g., quick defensives specialists, smart and decisive setters, powerful hitters, and explosive blockers who are in charge of the team's defense).

According to Lobietti (2009), a successful defense in the game of volleyball starts with a well-trained and disciplined block. Blocking in the game of volleyball is one of the key components to a team's success. As volleyball has evolved and hitting has become more powerful, the skill of blocking has become a crucial aspect of the game and is highly correlated with team success. There are many styles of blocking, and between the two styles of traditional and swing blocking, the debate continues on which style of blocking moves the blockers to the opponents the quickest and allows the blocker to jump the highest and penetrate over the net to block the opponent's hit. Both blocks consist of lateral movement along the net and a vertical jump pushing the arms and hands back over the net with the body in a pike position in the air.

Major known differences in these two blocks include the footwork technique in the lateral movement and the arm movement until penetration over the net. Potential differences in these two blocks that are in need of research are vertical jump heights and vertical jump landings.

According to Hughes, Watkins, and Owen (2010), the game of volleyball is composed of frequent landings, decelerations, and rapid changes in direction. These aspects of the sport greatly increase the rate of ACL injuries. Greater ground reaction forces during landing may increase the load on the passive support structures of the knee, which can increase the risk of injury. The average number of jumps performed during a five-set volleyball match is approximately 96, with even more jumps performed during practices. It is not surprising that 63% of injuries in volleyball are due to jumping and landing. Lobietti, Coleman, Pizzichillo, and Merni (2010) revealed that fifteen percent of jumping and landing injuries occur in the landing phase, and 60% of acute injuries happen when landing after a block or attack with or without contact with another player.

Need for the Study

Research has been conducted in the area of speed of footwork of various blocking techniques using timing lights and pressure sensitive floor mats to determine which technique (swing, traditional, or chicken wing block) enabled athletes to perform a more effective block (Neves, Johnson, Myrer, & Seeley, 2011). However, no known research has been conducted on vertical jump and peak VGRF in landing between a traditional and swing block technique. Results of this investigation may help coaches decide between a traditional and swing block when considering vertical jump heights and the peak landing VGRF produced from the two different techniques.

Statement of the Problem

This study focused on the examination of vertical jump and peak VGRF in landing a traditional and/or swing block, two block techniques used extensively in the sport of volleyball when played at the elite level. This study was conducted to examine if there are differences in vertical jump and landing VGRF produced in a traditional and swing blocking technique.

Purpose of the Study

The purpose of this study was to compare vertical jump heights and peak landing VGRF produced from various blocking techniques commonly used in elite-level volleyball. The two types of techniques examined were the traditional and swing block. Twenty members of a Division II, NCAA women's collegiate volleyball team volunteered to participate as subjects. Subjects were recruited from the University of Central Missouri volleyball team, and all had played competitive volleyball for at least 8 years. All subjects trained for volleyball at a high level for a minimum of 12 hours per week. The procedures were fully explained to the subjects and they gave their written consent before testing (Appendix A).

Research Questions

The research questions (RQ) in the study were:

RQ1: Is there a difference in vertical jump height for a traditional and swing block?

RQ2: Is there a difference in peak landing VGRF produced in landing from these two blocking techniques?

Hypotheses

It was hypothesized that:

- 1) The swing blocking technique would produce greater vertical jump heights;
- and

- 2) the swing blocking technique would produce a greater peak landing VGRF on the Kistler Force Plate.

Assumptions

It was assumed that:

- 1) all subjects complied with the researcher's request to perform each block to the best of their ability;
- 2) each subject had prior knowledge of how to correctly perform each block technique;
- 3) each subject had previous experience in performing each block technique; and
- 4) each subject did not have an injury that affected her ability to perform each block technique.

Delimitations

The study was delimited to:

- 1) twenty collegiate level players from the University of Central Missouri volleyball team;
- 2) not all players performed these types of blocking techniques regularly in a game or scrimmage situation; and
- 3) the block technique order for each subject was selected randomly.

Limitations

The study was limited to:

- 1) knowledge of the prior day's activities to determine if they had recently blocked, possibly causing fatigue;
- 2) the potential use of performance enhancing drugs was not controlled;
- 3) being conducted in a lab without a net or hitter;

- 4) using a wooden platform, not the typical sport court found in indoor venues; and
- 5) each player performed a traditional and swing block to their best ability.

Definitions

For the purpose of this study, the following terms were defined:

Swing Blocking: This blocking technique is also known as the running technique along the net.

The blocker swings their arms down by their side and as they run to block and swings their arms back up and over the net penetrating to the opponent's side as they jump. This block is timed with the opponent's jump.

Swing Blocking to the Left: Blockers will move left using a left, right, left run while swinging their arms down by their side and back up over the net while they jump.

Swing Blocking to the Right: Blockers will move right using a right, left, right run while swinging their arms down by their side and back up over the net while they jump.

Traditional Blocking: This blocking technique uses a step, cross, hop movement to move to a specific spot along the net. Blockers will move with their arms and hands in front of their face and plant with both feet to jump and penetrate their hands over the net to the opponent's side. This block typically sets before the opponent's jump.

Traditional Blocking to the Left: Blockers will step with their left foot, cross over step with their right foot, and hop with both feet to the desired position while keeping their hands by their face.

Traditional Blocking to the Right: Blockers will step with their right foot, cross over step with their left foot, and hop with both feet to the desired position while keeping their hands by their face.

CHAPTER 2: REVIEW OF LITERATURE

The purpose of this study was to compare the vertical jump and the peak landing VGRF produced from two blocking techniques commonly used in elite-level volleyball. The purpose of the review of literature was to examine any previous research related to traditional or swing blocking techniques. The literature presented within this chapter is organized into the following sections: (1) Effective Blocking, (2) Traditional vs. Swing Blocking Technique, (3) Vertical Jump Analysis, (4) Blocking and Injury, (5) Landing Analysis, and (6) Summary.

Effective Blocking

Lobiatti (2009) and Ficklin, Lund, and Schipper (2014) explained that blocking is a key component in a team's success and examined the importance of the block in the game of volleyball in terms of relationships with match results. Blocking footwork techniques were classified and data relative to the frequency of blocking to stop the opponents attack were collected and analyzed. Lobiatti (2009) also examined the kinematics of blocking technique that were performed at their laboratory of the Faculty of Exercise and Sport Science at the University of Bologna, Italy. Lobiatti (2009) explained "key points for the effectiveness of the block are anticipation, decision-making, movement speed, and jumping ability" (pp. 94). The present investigation stressed that to block effectively, players should use a technique allowing the shortest time to arrive at the target, the longest lateral movement along the net, a vertical jump, and the angulation and penetration of the hands relative to the net plane are necessary to form the correct surface over the net and to control the rebound of the ball. Two types of blocking footwork were explained as a slide or 2-step and the cross over or three step block. In the slide step, the right foot moves laterally and the left foot follows close to the leading foot, and then the feet push up for the jump. In the cross over step, the left foot crosses over the right foot, passing

closer to the net and then the right foot closes the movement crossing back, then both feet align and jump. When the cross over follows a previous short slide of the right foot, this technique is called three step footwork.

Lobiatti (2009) used a system for three-dimensional analysis of motion (Vicon Motion System) and markers fixed on anatomical landmarks of joints, six male volleyball players were recorded performing 4 trials of each type of movement (one and two consecutive slide, a single cross step, and a slide-cross in both directions). The testing revealed that outside blockers should use the single cross step when moving to outside, and use the one and two consecutive slide steps to the middle. The middle blockers should use mostly the slide cross step and single cross step.

Lobiatti's (2009) second study included 4 male volleyball players, and the two types of blocks (read block system and commit block system) used to defend a quick attack were filmed. In the read block system, the blocker starts close the net with hands up and bent legs, and is ready to react jumping vertically from his position to defend a quick set or move his feet to follow the ball in case of an outside set. In the commit block system, the middle blocker has to jump at the take off of the quick hitter's spike without worrying about the set. This study revealed that in the read block system, elevation was lower and the arm extension allowed the hands to arrive over the net in a shorter time. The commit block system revealed higher jumps because of the countermovement. The vertical jump at the moment of the maximal flexion in the knee angle was around 90 degrees, and the lateral movement, the knee angle of the pivot foot was also 90 degrees.

Traditional vs. Swing Blocking Technique

In the study by Neves, et al. (2011), various types of blocking techniques along with the specific footwork for each were compared to determine which technique enabled athletes to

perform a more effective block. As volleyball evolves and hitting is becoming more explosive and offensive, the skill of blocking is becoming a more crucial aspect of the game and is becoming highly correlated with team success. According to Bodasinska and Pawlik (2008), “blocks are the major measure designed to defend a team against attacks of its opponent” (pp. 43). Neves, et al. (2011) also explained that each scenario changes for the blockers, and the athletes have to incorporate decision-making to their athletic ability. An effective block can be defined as lateral movement speed, quickness in getting off the ground and getting the hands above the net, jump height, and hand penetration across the net. Using timing lights and pressure sensitive floor mats, researchers showed that the running step technique (incorporated in the swing block) was significantly faster than the slide step or the cross over step techniques. The researchers believed that the running step technique could be used to get athletes from the middle of the court to the right side of the court and into the outside blocking position. The faster the athlete can get to the desired spot and the further the hands penetrate over the net, the more court area is denied and the more the rebound of the ball can be controlled.

Fickin, et al. (2014) explained that the added arm swing causes the blocker’s jumping motion to be more like that of a countermovement jump. In contrast, the traditional block requires a player to keep their hands about shoulder level throughout the whole blocking motion until the jump, and the swing block utilizes the full arm swing where the arms are initially swing backward and then moved forward with the elbows fully extended throughout the entire blocking motion, and last, the chicken wing block uses the upper arm swing is the same as the swing block except that the elbows are flexed to a 90 degree angle throughout the back and forward swing movements.

Neves, et al. (2011) tested thirteen NCAA Division 1 volleyball athletes who performed the three different blocking techniques with retroreflective markers and a seven camera Vicon Motion Analysis System. The athletes were told to not workout 24 hours prior to data collection, to eat a good meal, and were told to be in bed before midnight. Start time, which was considered to be the instant when the right toe marker resultant velocity exceeded 1 m/s, was recorded as well as take-off time, which was considered to be the instant when the height of the right toe marker exceeded the static standing height of the right toe marker by six times. The first dependent variable was the time that elapsed between start and takeoff. Start time for the athlete to get their hands above the net started as soon as the athlete raised their fingers above the net, and the slowest hand was used for statistical analysis. Repeated measures ANOVA was performed to determine the difference between the groups, and the dependent variables were the time to take off or the amount of time it took the athlete to get off the ground from the start of the block, the amount of time it took the athlete from the start of the blocking motion to get their hands above the net, the athlete's jump height, and the amount of hand penetration the athlete had over the plane of the net. Both swing and chicken wing techniques allowed the athletes to get hands above the net faster and jump higher, and the swing block resulted in the greatest hand penetration (Neves, et al., 2011).

Vertical Jump Analysis

Before a jump landing can be discussed, the vertical jump must be understood. In the study by Umberger (1998), the biomechanical research on the vertical jump is discussed. Since the vertical jump is crucial to the success of sports such as basketball and volleyball, the testing of verticals of athletes has become a way to monitor improvements in jumping ability following a strength and conditioning program. Past research has suggested that a maximal vertical jump

may even give a rough estimate of lower extremity power output. Although the vertical jump is prevalent in research, specific muscle distributions and actions are rarely discussed. Many muscles in the lower extremity cross more than one joint, with examples being the rectus femoris, gastrocnemius, semimembranosus, semitendinosus, and the longhead of biceps femoris. Using videography, muscle electrical activity detection, and ground reaction force measurement, biomechanists have been able to explore the mechanical interactions of the musculoskeletal system during the vertical jump.

A vertical jump begins with a preparatory phase, which involves eccentric muscle activity with gravity providing the driving force, and flexion at the hip and knee joints, and dorsiflexion at the ankle joint (Vaverka, et al., 2013). Umberger (1998) explained that the takeoff phase begins with extension of the hip joint, followed by the knee and ankle joints. Past research has revealed that there is a high power output at the ankle joint during the latter part of the jump takeoff, and further research then revealed that maximal power output at the ankle during a max-effort vertical jump was up to six times as high as the maximal power that could be generated during isolated ankle plantar-flexion. A considerable amount of the additional mechanical energy at the ankle seemed to have been transferred there from the hip and knee by two-joint muscles, although the storage and reutilization of mechanical energy in the elastic components of the tendons and muscles have been believed to be the reason for enhanced jump performance in the past. Two joint muscles exert high forces during the period of contraction because of the force-velocity relationship of the muscle.

In Umberger's (1998) study using 7 elite athletes, 21% of the work done in extending the knee was found to come from the hip extensors via transfer through the rectus femoris and at the ankle, and 25% of the work done in plantarflexion was derived from the knee via the

gastrocnemius The hamstrings acted to transfer energy back to the hip from the knee during the takeoff phase of the jump, and the effect was small compared to the proximal-to-distal transfer of energy by the rectus femoris. Because the amount of mass of the leg is located proximally, the moment of inertia is reduced, which decreases the resistance to rotation about the hip joint. The decreased moment of inertia allows for a more efficient movement (by increasing angular velocity of the leg about the hip). This article suggests that lifts such as power clean, snatch, hang clean, or plyometrics should be chosen to improve the vertical jump. Also, exercises that stress the gastrocnemius and rectus femoris at a low or zero-contraction velocity may be incorporated in strength and conditioning programs for athletes who perform many maximal intensity jumps because these muscles must transmit very high loads at a low contraction velocity during such jumps. Exercises suggested for the rectus femoris are slow, heavy squats, or isometric squats in a safety cage. Exercises suggested for the gastrocnemius are slow, heavy heel raises with the knees near full extension.

The current inquiry produced results that are helpful to coaches that are debating between the swing and traditional block. With the contact point of a hitter's swing getting higher as training advances and vertical jump heights increase, the height of a block can be crucial to a team's defense. Time-in-air was recorded among twenty well-trained volleyball players performing a traditional and swing block in each direction on a force platform. These results showed which block produced the higher vertical, which can influence a coach on their decision about their team defense.

Blocking and Injury

According to Hughes, et al. (2010), research has shown that approximately 70% of anterior cruciate ligament injuries occur in sporting activities, and 70% to 90% of those injuries

occur in noncontact situations. The game of volleyball is composed of frequent landings, decelerating, and rapid change of direction, and these aspects of the game greatly increase the rate of ACL injuries. Women have a 6-8 times greater chance for noncontact ACL injuries than men competing in the same sport, and women also tend to make ground contact with their knees in a more extended position than men. Due to the effect of knee flexion on the patella-tendon-tibia shaft angle, a given load acting through the patellar ligament places a greater strain on the ACL if there is a small knee flexion angle. In cutting and landing, studies investigating the frontal plane kinematics reported greater knee valgus angle range of motion in women compared to men. Studies have also shown that noncontact ACL injuries occurred more frequently when the knee exhibited a valgus movement, and since women have shown greater maximum knee valgus angle, this increases their risk for ACL injury. Last, greater VGRF during landing may increase the load on the passive support structures of the knee, which can increase the risk for injury, and some studies have shown that women had greater normalized peak ground reaction force in landing than men.

In the study by Hughes, et al. (2010), six female and six male university volleyball players performed an unopposed and an opposed volleyball block jump and landing. Participants performed a consistent 10-minute warm-up, and a rope was fixed horizontally 5 cm in front of the force platform to act as a volleyball net at the respective standard heights. A volleyball was suspended above the net, and the participants performed an unopposed and an opposed volleyball block jump and landing, with their hands touching the top of the suspended volleyball. The first jump consisted of the subject jumping with their right foot on the force platform and pretending to block the volleyball, and landing back on the force platform. For the second jump, participants timed their attempt to block the spiked ball, and landed back on the force platform with their

right foot. There were no significant interaction between the level of opposition and gender for all variables. For most of the landing period, the normalized VGRF was greater for the opposed jumps than the unopposed jumps, and there was no significant effect for level of opposition for normalized VGRF and MAX. For sagittal plane knee angle at MAX, there was a significant effect for gender where women displayed greater knee flexion than men, and also women displayed greater knee flexion ROM than men. Women showed a greater knee valgus angle ROM than men.

Another study by Didier and West (2011) investigating noncontact ACL injuries considered vertical jumping and landing mechanics a key influence. The researchers looked at noncontact ACL injuries in contact sports (soccer, basketball, handball, volleyball, field hockey, softball) compared to noncontact sports (dancers and cheerleaders) who also perform activities that involve turning, jumping, and landing. Possible reasons for the difference of ACL injury rates for female athletes participating in different sports are athletes who participate in different sports may use different biomechanical techniques during generation of propulsive force and jump landing, and also anticipatory muscle activation may play an important role in stabilizing the knee during performance of stressful maneuvers like jump landing, which may be developed to a greater extent through participation in specific sports. The purpose of this landing mechanics study was to compare the VGRF and the joint angles of female athletes who participate in sports that present low-risk versus high-risk sports for ACL and nonathletic controls during landing and loading phases of a vertical jump. The researchers predicted that the peak VGRF and knee joint angle would have a greater extension during landing for the high-risk group than the low-risk group. Also, the group of nonathletes would have the highest peak vertical ground reaction force and largest landing angles.

Fifty-nine healthy female collegiate undergraduates participated in this vertical jumping and landing study, including NCAA Division 1 high-risk and low-risk athletes and a general student population. Each participant performed 3 maximal vertical jumps on the force platform, and separate ANOVAS were performed for each dependent variable (maximum dorsiflexion, maximum knee flexion, and peak VGRF). The “nonathlete” group demonstrated the greatest amount of knee flexion during the loading phase, and the low-risk group landed with significantly greater dorsiflexion than both the high-risk and nonathlete groups (Dider & West, 2011). The low-risk group landed with the smallest peak vertical ground reaction force and the high-risk group landed with the greatest peak VGRF. The authors believe that high-risk sport athletes need to create a more rigid kinetic chain to impart force to the ball during blocking and heading, and when told what movement in the specific sport to perform, it may translate different for all of the athletes.

Another research study by Lobiatti, Coleman, Pizzichillo, and Merni (2010) compared jumping activities during official men’s and women’s volleyball games. Since anterior cruciate ligament lesions and patellar tendonitis injuries are frequent in volleyball, the researchers analyzed landing techniques in 12 top-level matches from the Italian men’s and women’s professional league. These landing techniques were broken down into specific categories such as left or right foot or both feet together, court position, and ball trajectory. The authors explained that average number of jumps performed during a five-set volleyball match is approximately 96, and even more jumps are performed during practices. With this statistic, it is not surprising that 63% of injuries are due to jumping and landing, with 15% of those injuries occurred in the landing phase, and 60% of acute injuries happened when landing after a block or attack with or without contact with another player. Studies have shown that there is a high frequency of

bilateral landings and a tendency for players to land on the left foot when attacking (35%) and on the right foot when blocking (27%). The authors hypothesized that there would be differences between the sexes, role specializations, types of set, and court position. They also anticipated that players performing higher velocity movements would tend to land much more frequently on one foot. According to Tilp and Rindler (2013), “one-footed landings result in higher ground reaction forces and muscle activity than two-footed landings because the momentum of the body must be absorbed by one instead of two legs” (pp.447).

Forty-eight men and forty-eight women were analyzed in 6 women’s and 6 men’s professional volleyball matches played during the 2004-2005 Italian league. Using slow motion video, researchers recorded types of landing when jumping during the games. Each time a player landed, his/her landing technique, defined as on the left foot, on the right foot, or on both feet, was identified and recorded. The researchers decided that spiking and jump serving were asymmetric in execution, and setting and blocking were asymmetric in execution. Results showed that for serving, right-handed players tend to land on the left foot, and vice versa for left handed servers. Right handed hitters tend to land on the left foot when attacking from the left side of the court, and left handed hitters tend to land on the right foot when attacking from the right side of the court. When right-handed players were attacking from the right side and vice versa, there was a tendency to land bilaterally for both groups. Women were recorded landing with two feet more often than men in blocking, and landed more on one foot when setting than men do. Middle blockers landed on one foot in most cases (specifically the right foot), and outside blockers tended to land bilaterally.

According to McCaw and Cerullo (1999), ankle stabilizers may affect block jump landings in volleyball. Epidemiological evidence suggests the use of ankle stabilizers is cost

effective for reducing the frequency of ankle injuries. In sports, ankle injuries are prevalent and a common mechanism of ankle ligament injury is an applied inversion stress while the ankle is in a plantarflexed position, which may damage lateral structures of the joint (specifically the anterior talofibular and calcaneofibular ligaments). It was proposed 20 years ago that an ideal stabilizer would not impinge on the usual range of motion of the ankle joint, and restriction should occur only at the anatomical limits of joint motion, which is the position beyond which joint capsule or ligament damage begins to occur. Studies have shown alterations in the relative contribution of the ankle, knee, and hip joints to energy absorption between soft and stiff landings, and have also demonstrated the importance of eccentrically controlled ankle dorsiflexion to energy absorption during landing. As landing stiffness increases, the posterior hip and anterior knee musculature decrease as the posterior ankle musculature contributes more to relative energy absorption.

Fourteen college students were split into four groups of various ankle stabilizers. The first group had their ankles taped for the experiment by the same certified athletic trainer. The second group used a lace-up, boot style stabilizer, which covers the medial/lateral and anterior/posterior surfaces of the ankle joint from above the malleoli to the base of the metatarsals, has been recommended as a cost reducing alternative to taping the ankle joint. The third and fourth groups used two semirigid plastic outer shells hinged to a plastic stirrup at the malleoli, which were held in place by two self-stick straps spaced approximately .02 m apart encircling the distal shank superior to the malleoli (one was lined with inflatable air cells, the other was lined with foam). All subjects wearing the same type of running shoe, positioned themselves on a platform with both arms flexed to shoulder height and the heel of the right foot resting against the front edge of the platform. Subjects then leaned forward off the platform and landed (10 trials) with either maximum knee flexion during soft landings or minimum knee flexion during stiff landings.

Each trial was recorded using a sagittal plane video system, and reflective tape markers on anatomical landmarks were used to track and digitize the landings. A five-trial mean value of each dependent variable was calculated for each of the 10 landing styles by stabilizer conditions and used in the statistical analysis. A univariate repeated measure ANOVA and a repeated measure MANOVA was used to indicate significance. At ankle joint angle at touch down, there was no significant landing style effect, but there was a significant stabilizer effect. At ankle angle at maximum knee flexion, there were significant main effects of landing style and stabilizer. At ankle joint range of motion, there were significant main effects of landing style and stabilizer, with less ankle range of motion in the Aircast, Swede-O, and tape conditions compared to the Active Ankle and no stabilizer conditions. At maximum ankle angular velocity and time to maximum angular velocity, there was no significant main effect of landing style.

Landing Analysis

According to Devita and Skelly (1992), researchers focus on the forces and energy necessary to propel into the air, and need to also focus on the biomechanical implications of impact in landing and the resulting loads placed on lower extremity tissues. Joint positions, joint moments, and muscle powers (VGRF) in the lower extremity were compared between stiff and soft landings from a vertical fall (59 cm). This study evaluates the potential for injury in various landing situations, and also reports only externally applied VGRF.

Using 8 healthy intercollegiate basketball and volleyball players, Devita and Skelly (1992) digitized six body points and the front corner of the force platform, and the platform point was used as a reference point and to locate the center of pressure in the kinematic reference frame. The location and magnitude of the lower extremity segmental masses and their moments of inertia were estimated, segmental masses were reported, and joint reaction forces and net joint

moments of force were calculated. Positive power phases indicated concentric muscle contractions and work being performed by the muscles on the skeletal system, resulting in positive accelerations of body segments, and negative phases indicated eccentric contractions and work being performed by the skeletal system on the muscles and producing negative accelerations

Zhang, Bates, and Dufek (2000) explained that the body experiences a great deal of impact forces during foot contact with the ground in vigorous locomotion, and in previous research, maximum VGRF values as high as 14.4 times body weight have been reported for landings such as single-leg landings from a double back somersault. Changes in lower extremity joint energy absorption for different landing heights and landing techniques were investigated in this study. After a volleyball block jump, the first peak of the vertical component of VGRF ranged from 1,000 to 2,000 Newtons, and the second peak values ranged from 1,000 to 6,500 Newtons in landings. Accumulation of high impact forces may pose a threat to the integrity of the lower extremity and related overuse injuries are often direct consequences of these impacts, and many injuries are associated with the knee joint structure.

Nine active men volunteered for this study, and subjects performed five step-off landing trials from a raised platform in each of the 10 conditions for a total of 50 trials. The data of the kinematic coordinates, VGRF, and moments were imported into customized software to compute typical joint kinematics, segmental inertia properties, and joint kinetics via an inverse dynamics model. The VGRF and joint kinetic values were normalized to the body mass for each individual subject while the representative moment and power curves were normalized to landing phase. The latter was defined as follows: the time from foot contact to the minimal vertical center of gravity position during landing. The typical time-history curve of the vertical ground

reaction force demonstrated two distinctive maximums with first peak related to the toe contact and second peak related with the heel contact of the landing. Results demonstrated a trend of the increased loading to the body with increase in either landing height or landing stiffness. The researchers concluded that the ankle muscle group was less capable of energy absorption compared with hip and knee muscle groups, especially at the two higher heights.

Dufek and Zhang (1996) evaluated landing performances of skilled volleyball players longitudinally throughout a competitive and training season, aiming to these two research questions: Does the landing impact mechanism vary across the season? Also, which performance variables are related to greater impact forces during landing? In this study, lower extremity landing performance of elite volleyball players were evaluated. The game of volleyball consists of many movement patterns including the jump-land sequence, with the jump portion of the movement being the force producing phase (typically used for hitting, blocking, jump-setting, or jump-serving) and the landing portion, which requires energy absorption of the energy generated by the jump. When vertical jump heights are increased to improve a player's performance, the jump height is accompanied with a proportional increase in the magnitude of kinetic energy, which must be safely dissipated at landing to avoid injury. In past research, numerous authors have investigated general characteristic responses of the body to jumping phase, and several studies have also concentrated on the knee joint as a potential injury site from lower extremity impacts in landing. Nearly 90% of all volleyball injuries occur in the lower extremity (knee joint the most prevalent), and over 70% of all injuries that occur during volleyball play are associated with block or spike activities. Frequent jumps and a loss of balance during landing have been a primary cause for injury during these jump-land movements, so this study's goal was to expand

upon the current knowledge base relative to impact force attenuation mechanisms during landing activities.

All members of a NCAA Division 1 women's volleyball team participated in this landing models study. The research study divided the three phases of a competition season into preseason, postseason, and off-season. A dual AMTI force platform system and a single NEC high speed video camera were used, and the subjects were instrumented with seven retro-reflective markers placed on the right side of the body. When the subject performed a block, vertical and antero-posterior force data were obtained for each leg during the jump and land phase in addition to simultaneous right sagittal view video data. The data in this study included the seven athletes who participated in all three across-season test sessions while data obtained from all 20 subjects were incorporated in the variable reduction phase of the analysis to augment the statistical power by increasing sample size since the only reason for exclusion was their inability to participate in all three testing sessions. The block jump, split into the jump, airborne, and landing phase, included the first and second peak vertical forces, the maximum braking, and propulsive forces. The three dependent variables in the landing phase were the first and second peak vertical forces and knee joint range of motion from contact to second peak force was identified to represent aspects of landing impact. Repeated measures ANOVA for jump height across experimental conditions and first and second peak vertical forces were not significant, and Turkey tests for K_{ROM} suggested a comparative kinematic change in landing technique during the non-competitive performance phase.

This current study of traditional verses swing block technique produced results that are helpful to coaches when deciding between a traditional and swing block when they're considering the VGRF produced from the two techniques. Considering nearly 90% of all

volleyball injuries occur in the lower extremity, knee joint being the most prevalent, and over 70% of all injuries that occur during volleyball play are associated with block or spike activities, coaches need to be conscious of their athletes and the injuries that occur with jump landings during a block. When considering vertical jump and landing analysis, this current study revealed results of which type of block produced the higher vertical jump and greater VGRF produced with landings of each technique.

Summary

The purpose of the review of literature was to examine any previous research that was related to traditional or swing blocking techniques. Most of the literature reviewed mentioned the various blocking techniques and jump height with both swing and traditional blocks, but not the VGRF produced with landings from the blocks. Vertical jumps were analyzed to better understand the process involved blocking and landings were analyzed, but not in relation to volleyball blocks. Effective blocking was discussed to better understand the importance of blocking in the game of volleyball and how it has evolved over the years, and last, injuries were discussed in relation to volleyball.

As a result of the literature review, it was apparent that VGRF in block landings was a unique study, and one that yielded distinct information. The uniqueness of the study increased even further as a result of the blockers specifying which direction with each block they prefer. It was hypothesized that the swing blocking technique will produce greater vertical jump height, and also a greater VGRF on the Kistler force plate. Through this realization the researcher was able to determine the safest form of blocking to better prevent the common injuries found in volleyball, which are most common found in jump landings.

CHAPTER 3: METHODOLOGY

The purpose of this study was to compare the vertical jump and the peak landing VGRF produced from various blocking techniques commonly used in elite-level volleyball. The two types of techniques that were looked at were the traditional and swing block. Each of the subjects have had prior experience in these blocking techniques. The methodology chapter is organized into: (1) sample, (2) design of the study, (3) instrumentation, (4) data collection procedures, (5) data analysis.

Sample

Twenty members of a Division II, NCAA women's collegiate volleyball team volunteered to participate as subjects (between 18 & 23 years of age). Subjects were recruited from the University of Central Missouri volleyball team, and all had played competitive volleyball for at least 8 years. All subjects trained volleyball at a high level for a minimum of 12 hours per week. The procedures were fully explained to the subjects and they gave their written consent before testing.

Design of the Study

The study was designed to investigate and compare vertical jump and peak landing VGRF produced from a traditional and swing blocking technique. All twenty players attended a data collection session in the Biomechanics lab in the North Morrow basement. Participants' age, weight, height, and preferred direction of each block were recorded. Procedures were fully explained and informed consents were given to each subject a few days before testing to ensure enough time for the subject to read and accept or decline the invitation to participate in this study.

Instrumentation

The hardware that was involved in this study was a Kistler Force Platform and Vicon Motus Systems of Centennial, Colorado. The software known as Peak Motus was version 9.2. The force platform had piezoelectric or strain gauge transducers attached at each corner to give an electrical output that was proportional to the force on the plate. Curves of force time, velocity time, acceleration time, displacement time, and force displacement were calculated from the ground reaction force record.

Data Collection Procedures

Data was collected during a one-day collection period. Subjects were informed to come in their volleyball shoes and athletic apparel. Subjects were also informed to not exercise the morning prior to testing. After a warm up of 20 sumo squats, 20 mini block jumps, and 20 tuck jumps, subjects practiced each block in both directions and found the correct starting position to the force platform. In the traditional block, subjects stepped laterally, crossed over their feet, and hopped with both feet to the desired position while they faced the net for the block jump, and kept their arms at their shoulders the entire sequence, and pressed their arms and hands straight up and penetrated over the net. In the swing block, subjects stepped laterally, crossed over their feet, and stepped again to face the net, swung their arms down by their side and back up over the net as they performed the block jump, and also pressed their arms and hands straight up and penetrated over the net. In random order, subjects continued to perform these blocks in each direction taking off and landing on the force platform until they decided the block was at maximum speed and height, and that block was taken for data collection. To encourage maximum vertical jump heights in each blocking technique, a target net height was provided at 2.24 meters, which was equivalent to a women's volleyball net height.

Data Analysis

The researcher analyzed the data aiming to examine the vertical jump height and peak landing VGRF differences of the two blocking techniques. Time of take off and touch down was identified to determine vertical jump height in meters using $d_v=4.9(t/2)^2$, and peak landing VGRF for each block jump was also recorded in Newtons. A repeated measures ANOVA was performed on both the vertical jump heights and the peak landing VGRF of each block to determine significance. If significant, Post-hoc paired comparisons T-tests using Bonferroni adjustment of .0083 were performed in the six block comparisons (Swing Left vs. Swing Right, Swing Left vs. Traditional Right, Swing Right vs. Traditional Right, Swing Left vs. Traditional Left, Swing Right vs. Traditional Left, and Traditional Left vs. Traditional Right) to determine where differences occurred. The Bonferroni adjustment was used to reduce the chances of obtaining type 1 errors and also because it is considered a conservative adjustment (Napierala, 2012).

CHAPTER 4: RESULTS

The purpose of this study was to compare the vertical jump and the peak landing VGRF produced from two blocking techniques commonly used in elite-level volleyball. The two types of techniques analyzed were the traditional block and swing block. Using a Kistler force platform and Vicon Motus software, time-in-air and VGRF were measured with each block in each direction. This investigation included 20 individuals from the volleyball team at the University of Central Missouri.

Upon completion of data-collection, the data were organized into an Excel spreadsheet for further analysis. Time of take off and touch down were identified to determine vertical jump height in meters. Peak landing VGRF in Newtons for each block jump were also recorded. Take off time and time of touch down were recorded and analyzed using $d_v=4.9(t/2)^2$ to determine vertical jump height meters. Average vertical jump height across all trials was .35m(±.05m) (see Table 1). Average peak landing VGRF across all trials was 2,064.66N(±277.90N) (see Table 1).

Table 1

Means and Standard Deviation for Vertical Jump Height (m) and Peak Landing VGRF (N)

	Swing L	Swing R	Traditional L	Traditional R
Vertical Jump (m)	.358(.061)	.350(.046)	.330(.040)	.344(.040)
Landing VGRF (N)	1789.01(422.12)	2448.07(686.86)	2048.78(646.60)	1972.79(520.77)

Repeated measures ANOVA was performed on vertical jump heights to determine if any of the blocking styles produced significantly higher vertical jumps. The repeated measures ANOVA for vertical jump heights indicated that no blocking style produced significantly greater jump heights ($F=1.223, p>.05$) (see Table 2).

Table 2

Comparison of Vertical Jumps (m)

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	0.008289	3	0.002763	1.22297	0.307216	2.724944
Within Groups	0.171699	76	0.002259			
Total	0.179988	79				

Repeated measures ANOVA was performed on peak landing VGRF to determine if any of the blocking styles produced significantly greater peak landing forces. The repeated measures ANOVA for peak landing VGRF indicated significant differences in peak landing forces ($F=4.613$, $p<.05$) (see Table 3).

Table 3

Comparison of Peak Landing VGRF (N)

<i>Source of Variation</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between Groups	4633620.76	3	1544540.3	4.61315	0.005098885	2.724943949
Within Groups	25445747.5	76	334812.47			
Total	30079368.3	79				

Post-hoc paired comparison t-tests using a Bonferroni adjustment of .0083 were performed on the peak landing VGRF in each set of block comparisons to determine where significant differences occurred. The Post-hoc analysis revealed a significant difference for Swing Blocks to the Right vs. Swing Blocks to the Left ($t=2.093$, $p<.05$), Swing Blocks to the Right vs. Traditional Blocks to the Right ($t=2.093$, $p<.05$), and Swing Blocks to the Right vs. Traditional Blocks to the Left ($t=2.093$, $p<.05$).

CHAPTER 5 DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to compare the vertical jump and the peak landing VGRF produced from two blocking techniques commonly used in elite-level volleyball. As volleyball has evolved and hitting has become more powerful and offensive, the skill of blocking has become a more crucial aspect of the game. Between a traditional block and a swing block, the debate continues on which style of blocking moves the blockers to the opponents the quickest and allows the blocker to jump the highest and penetrate over the net to block the opponent's hit.

Discussion

The swing blocking technique is believed to produce a higher vertical jump from the blockers, but most coaches forget the repercussions of a greater VGRF in the landing of this block. Greater VGRF during landing may increase the load on the passive support structures of the knee, which can increase the risk of injury. The game of volleyball is composed of frequent landings, decelerations, and rapid changes of direction, and these aspects of the sport greatly increase the rate of ACL injuries (Hughes, et al., 2010). The average number of jumps performed during a five-set volleyball match is approximately 96, and 15% of jumping and landing injuries occur in the landing phase. Anterior cruciate ligament lesions and patellar tendonitis injuries are frequent in volleyball, and 60% of acute injuries happen when landing after a block or attack with or without contact with another player (Lobiatti, et al., 2010).

Women have a 6-8 times greater chance for noncontact ACL injuries than men competing in the same sport, and women also tend to make ground contact with their knees in a more extended position and have a greater normalized peak ground reaction force in landing than men (Hughes, et al., 2010). Didier and West (2011) explained that high-risk sport athletes such

as volleyball players need to create a more rigid kinetic chain to impart force to the ball during blocking. This study was able to produce results that are helpful to coaches when deciding between a traditional and swing block when they're considering vertical jump heights and the VGRF produced in landing from the two techniques. Considering nearly 90% of all volleyball injuries occur in the lower extremity, knee joint being most prevalent, and over 70% of all injuries that occur during volleyball play are associated with block or spike activities, coaches need to be conscious of their athletes and the injuries that occur with jump landings during a block (Dufek and Zhang, 1996).

A Kistler force platform and Vicon Motus System software were chosen to test the two techniques of blocking so the researcher could accurately identify take-off and touch-down time to reveal time-in-air and peak VGRF. The repeated measures ANOVA for peak VGRF was significant. Paired comparison t-tests were then performed and examined with Post-hoc analysis using a Bonferroni adjustment which revealed that swing blocking to the right in each comparison created a significantly higher peak landing VGRF. This was significant to the study in partially accepting the hypothesis that the swing blocking technique would reveal a greater peak VGRF upon landing.

Repeated measures ANOVA for vertical jump height differences of the blocking techniques revealed no significant differences. This was significant to the study to reject the hypothesis that the swing blocking technique would produce greater vertical jump heights. Ficklin, et al. (2014) found that swing blocking did in fact reveal greater vertical jump heights in comparison to traditional blocking. Differences between studies may be due to Ficklin, et al. (2014) using Division I volleyball players and the current study using Division II, which could potentially alter the vertical jump height results with the different calibers of athletes. Another

difference could be Fickin, et al.'s (2014) use of kinematic analysis and the current study's use of kinetic analysis.

Although not statistically significant, swing blocking to the left revealed a 2.23% higher vertical jump height than swing blocking to the right, a 7.82% higher vertical jump height than traditional blocking to the left, and a 3.91% higher vertical jump height than traditional blocking to the right. According to Table 1, swing blocking to the left also revealed the smallest (1789.01 N) average peak landing VGRF. Nineteen of the subjects were right-handed and stated they prefer swing blocking to their left since their footwork for an approach to hit is left, right, left. When swing blocking to the right, the footwork is opposite using a right, left, right approach. With one left-handed hitter in this study, the significance of peak landing VGRF when swing blocking to the right may be due to the unfamiliar approach in this direction. An increased peak landing VGRF could present problems by increasing the load on the passive support structures of the knee, which can increase the risk for injury (Hughes, et al. 2010).

Conclusions

The analysis of VGRF produced in landing in each blocking technique supported the hypothesis that swing blocking would produce a greater peak VGRF than traditional blocking. The analysis of time-in-air of each blocking technique rejected the hypothesis that swing blocking would produce greater vertical jump than the traditional block. This analysis is significant because coaches can utilize this information when deciding between a traditional and swing block and make an educated decision that both blocking techniques produce similar vertical jumps, and the traditional block produces a smaller peak VGRF which may help prevent injury.

Recommendations

Based on the findings and conclusions of this study the following recommendations are made for further research:

1. Studies should include an equal number of left-handed blockers and right-handed blockers.
2. Studies should be conducted using players of other levels including youth, high school, Division I, or professional to see if these results of this study would be similar to the results of different ages and levels of play.
3. Studies should include an opposing hitter making an approach to the force platform to ensure maximum effort when using both blocking techniques.
4. Studies should include an additional blocker alongside the subject to ensure game-like time-in-air and VGRF.
5. Studies should include an analysis of take-off of each blocking technique jump to further compare the swing and traditional block.

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APPENDIX A

INFORMED CONSENT FORM

Identification of Researchers: This research is being done by Taylor Linebach, a graduate student, and Dr. H. Scott Strohmeyer, a professor. We are with the Nutrition and Kinesiology Department at University of Central Missouri.

Purpose of the Study: The purpose of this study is a comparative analysis between a traditional and swing block in volleyball.

Request for Participation: We are inviting you to participate in a study on blocks in volleyball. It is up to you whether you would like to participate. If you decide not to participate, you will not be penalized in any way. You can also decide to stop at any time without penalty. You may withdraw your data any time before we test you on the force platform. Once we test you on the force platform, we will not know which test is yours.

Exclusions: You must be at least 18 years of age to participate in this study and on the UCM Volleyball team.

Description of Research Method: This study involves completing a traditional and swing block on the force platform. This study will take about 20 minutes to finish. After you finish, we will explain the purpose of the study in more detail. You will also have a chance to ask questions. Please note that we cannot give you your individual results because the data are confidential.

Privacy: All of the information we collect will be confidential. We will not record your name, student number, or any information that could be used to identify you.

Explanation of Risks: The risks associated with participating in this study are similar to the risks experienced in a volleyball practice or match. Any medical treatments provided if an injury occurs will be at the expense of the participant. You will be asked to take the PAR-Q before participating in this study.

Explanation of Benefits: You will benefit from participating in this study by getting firsthand experience in kinesiology research. You may also enjoy completing the blocking test. We will provide you with a coupon that you may use if any of your instructors award credit for research participation.

Questions: If you have any questions about this study, please contact my advisor Dr. Strohmeyer. He can be reached at strohmeyer@ucmo.edu or at (660) 543-8191. If you have any questions about your rights as a research participant, please contact the Human Subjects Protection Program at (660) 543-4621.

If you would like to participate, please sign a copy of this letter and return it to me. The other copy is for you to keep.

I have read this letter and agree to participate.

Printed Name: _____

Signature: _____

Date: _____

APPENDIX B

HUMAN SUBJECTS REVIEW BOARD APPROVAL



Human Subjects Protection Program
Ward Edwards 1800
Warrensburg, MO 64093
Office 660-543-4621
FAX 660-543-4778
www.ucmo.edu

12/5/2013

Taylor Linebach
linebach@ucmo.edu

Dear Taylor Linebach,

Your research project, 'A Comparative Analysis between a Traditional and Swing Block', was approved by the Human Subjects Review Committee on 12/5/2013. This approval is valid through 12/5/2014. Your informed consent is also approved until 12/5/2014.

Please note that you are required to notify the committee in writing of any changes in your research project and that you may not implement changes without prior approval of the committee. You must also notify the committee in writing of any change in the nature or the status of the risks of participating in this research project.

Should any adverse events occur in the course of your research (such as harm to a research participant), you must notify the committee in writing immediately. In the case of any adverse event, you are required to stop the research immediately unless stopping the research would cause more harm to the participants than continuing with it.

At the conclusion of your project, you will need to submit a completed Project Status Form to this office. You must also submit the Project Status Form if you wish to continue your research project beyond its initial expiration date.

If you have any questions, please feel free to contact me at the number above.

Sincerely,

A handwritten signature in blue ink that reads "Janice Putnam Ph.D. RN". The signature is fluid and cursive.

Janice Putnam Ph.D., RN
Associate Dean of The Graduate School
putnam@ucmo.edu

APPENDIX C

PAR-Q FORM

Physical Activity Readiness
Questionnaire - PAR-Q
(revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
<input type="checkbox"/>	<input type="checkbox"/>	1. Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
<input type="checkbox"/>	<input type="checkbox"/>	2. Do you feel pain in your chest when you do physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	3. In the past month, have you had chest pain when you were not doing physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	4. Do you lose your balance because of dizziness or do you ever lose consciousness?
<input type="checkbox"/>	<input type="checkbox"/>	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
<input type="checkbox"/>	<input type="checkbox"/>	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
<input type="checkbox"/>	<input type="checkbox"/>	7. Do you know of any other reason why you should not do physical activity?

**If
you
answered**

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active — begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal — this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever — wait until you feel better; or
- if you are or may be pregnant — talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

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

NAME _____

SIGNATURE _____

DATE _____

SIGNATURE OF PARENT
or GUARDIAN (for participants under the age of majority)

WITNESS _____

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.



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