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"Biomechanical Analysis of Tennis Players' Forehand, Backhand, and Serve and Activities to Improve Tennis Skills for Physical Education"

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"Biomechanical Analysis of Tennis Players' Forehand, Backhand, and Serve and Activities to Improve Tennis Skills for Physical Education"

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ABSTRACT:

Physical educators and coaches of the world are faced with students and athletes of all ability levels when it comes to games and sports. Throughout this project, I analyzed an “expert” tennis player and three average tennis players, all possessing different abilities in performing the tennis serve, forehand, and backhand. Using a computer program called Dartfish; I was able to break down each subject's skill into its critical instances and phases. Then I compared the average players to the expert to show where improvements should be made with explanations as to why. Following, activities and games were provided for those who are looking for more options when teaching tennis.
Tennis is a sport dating back thousands of years. It originated when monks in Europe created a game of entertainment during religious ceremonies. The first “racket” was the human hand, which then was modified using a leather glove. From there came the first actual racket, which has made many advancements improving the game of tennis still to this very day. Even the tennis ball, which began as a wooden ball, has seen great advancements so we can see the high paced, powerful matches we see today (Masters, 1997).

Tennis is an important sport to understand, because it is a lifetime sport; meaning that it can be played all throughout life since it is inexpensive and can be set up easily. I performed this study, “Biomechanical Analysis of Tennis Players’ Forehand, Backhand, and Serve and Activities to Improve Tennis Skills for Physical Education”, as a way to help those who are less skilled in tennis and/or for physical education teachers and coaches who need help with instruction. The purpose of this paper is not to create professional tennis players, but to create a way for teachers and coaches, as well as students and athletes, to be able to see their performance and recognize which skills need improvements. I analyzed the three main skills of the tennis game: forehand, backhand, and serve using Dartfish. When using this software, each skill is broken down into Critical Instances or elements, which are the main positions each player should go through while performing the skill. To get from position to position, the player will go through phases. These will be illustrated through text and pictures throughout the paper.

I began with the Critical Instances to perform each skill and then I compared those to my “expert”, who was a Club Tennis Player for Northern Illinois University. Then I compared my “expert” to three average players, who are people who have only played tennis as a recreational activity and did not play it frequently. I chose to analyze everyday people because my goal is to be a future physical educator, health educator, and coach. These are people that my future fellow
colleagues and I will be working with. Some students are extremely skilled, while others need to focus on the basics. As a physical educator and coach, one cannot expect a student or athlete to pick up the skills right away nor are they all on the same level. Everyone is different in their skill abilities and preferences in tennis, and all sports for that matter. As a physical educator, one has to be ready to experience many types of students.

An important process to know regarding what makes tennis serves and ground strokes happen is the Kinetic Chain. The Kinetic Chain is a process the body goes through in many sports and “...describes a sequence or a chain of events...that take place in order for an athlete to throw” or in this case, serve or perform a forehand and backhand (Blake, 2011). In other words, it means the whole body is involved. An example of the serve from the United States Tennis Association (USTA) is the body “…build[s] force from the ground through the hips and trunk to the shoulder and into the arm, hand and racquet” (Kibler et al, 2004). Figure A shows how the energy begins in the ground and then moves up through the body as if the body is the conductor transferring the energy to the racket at the end of a serve.

**FIGURE A**

(Kibler et al, 2004)
The main element of tennis that uses the Kinetic Chain and one of the most integral parts of a tennis match is the serve. The serve is "...a stationary position, and the only stroke over which the player has total control" (Roetert et al, 2009). Since the serve is the start of every point, the player who has a better serve will most likely have the upper hand in the match. After I have stated proper form for the tennis serve, I address how my "expert" compares to it and then relate her performance to the performances of my three average players. These are displayed in the form of media books, or the CDs which are attached created through Dartfish.

The player starts the serve in the **Preparation** position. The placement of the racket will be different for many players depending what they are accustomed to. However, the part that will be similar between players is their base. All players should have their feet at shoulder width, to set a sturdy base. Also, the player should be standing perpendicular to the net. The racket is brought back and then is the **Start of the Toss**. The player will begin the Kinetic Chain in this phase. Energy is created when the player flexes the knees and then in a quick motion, extends the knees and the hips; transferring the energy upward. The arm is extended up completely and the racket and tennis ball begin to move upwards, which begins the **Ball Toss**. The tennis ball begins to go up and then the **Ball Release** follows. The ankles, knees, and hips will be in extension during this phase as well. When tossing the ball, one wants to get it to the **Highest Point** it can from the amount of energy that naturally flows through the tossing arm. During the time the ball is reaching its highest point, the player is dropping the racket back into what I called the "**Max Back Scratch**" Position. The racket will be over the player's shoulder, behind them, as if they are scratching their back with it. This motion is caused by shoulder rotation and flexion of the elbow. The further back the player brings the racket, the more momentum they will have during their swing. Shoulder rotation occurs again, giving the arm that "flinging" motion. As the racket
is continuing its swing up and forward, the head of the racket should be behind the wrist, as if the wrist is pulling the racket behind it; this is the early swing. Right before the strings contact the tennis ball; the *Wrist will Begin to Flex* or create a “snapping” motion, which is the late swing. The “snap” of the wrist allows for contacting the tennis ball at a higher point on the racket, which is what we want. At *Contact*, one wants their racket arm to be fully extended.

Immediately after contact, the arm goes into a *Controlled Follow Through* and then eventually it breaks movement, or the arm relaxes, losing tension. Thus, the arm naturally finishes the *Full Follow Through*. As soon as the player has finished the follow through, they should move right back into their *Ready Stance* or the *Preparation Phase* for the return (de Subijana & Navarro, 2010), (Roetzert et al, 2009).

Appendix A shows the expert’s serve performance broken down into the critical elements of a serve. The expert begins the serve in the *Preparation* position. She has her base set by placing her feet shoulder width apart and allowing her knees to be slightly bent. Her racket starts in front of her, allowing more “wind-up” time when she begins the actual serve. She brings her racket back and we can see the *Start of the Toss* is low, allowing more momentum to come from underneath; helping it to go higher, which makes for better contact. We can also see by the placement of her feet that she is beginning to push off the ground and absorb the energy, which will be released in the swing. She brings the racket and tennis ball up and then comes the *Ball Release*. The racket is in a continuous motion behind the player, while the tossing arm releases the tennis ball upward. Eventually that arm will reach its *Highest Point*, as will the tennis ball. The tossing arm will be pointing up at the ball, while the racket continues to drop behind the player’s back. The racket will hit a point where it cannot go any further. This position of the serve is called the *“Max Back Scratch” Position*. The racket is in a position where is looks like
it is a back scratcher that is reaching down over the shoulder to as far as it can reach. Also, notice the expert is beginning to lift off the ground, because the energy from the ground is beginning to move the Kinetic Chain into the lower extremities, propelling her up. Once the racket cannot go back any further, it begins to make its forward motion, or the early swing. The energy has reached the arm by this point, "flinging" it forward. The head of the racket "trails" behind the wrist, which changes right before contact. At that point, the wrist "snaps", which is the \textbf{Start of Wrist Flexion}, bringing the racket head up in the late swing, making contact with the tennis ball. This "snapping" motion releases the energy that has been traveling up the body, into the racket; giving it as much power as it can. At the point of \textbf{Contact}, the racket head needs to be vertical to allow for an accurate shot. If the head of the racket is tilted upward, then the tennis ball will tend to sail. The same goes for if the racket head is facing downward; increasing the chances the ball will be served into the net. Following the contact point, the racket arm will stay tense in the early follow through, completing the \textbf{Controlled Follow Through}. Then the arm will seem to lose tension in the late follow through, then naturally finishing the \textbf{Full Follow Through}. Here is where the body starts to rebalance itself and following the momentum, seems to bring the player to the court, preparing them for their ready stance, to allow them to respond to the return. The motion of the serve is a continuous process from the \textbf{Preparation} position to the \textbf{Ready Stance}.

Using Dartfish, I recorded a media book on CD A of the three average players' serving performances and how they relate to the expert's. CD A is attached in Appendix A, which also contains the still images of the expert's and three average players' serving performances.

Now that we have gone through the serve, we will discuss the first of two ground strokes in tennis, the forehand. Just as in the serve, "...forehand swings are initiated in the knee-to-hip region of the body, and gradually build velocity up the whole kinematic chain" (Nesbit et al,
2008). In other words, the energy builds up in the lower extremities and moves its way up the body to the racket. All players must begin in a **Preparation** position. Just as the serve, this is to help them be agile when it comes to deciding which direction one needs to move and which shot would best suit the return. In the ready stance, the player will be parallel with the net, holding the racket with two hands in front of their body. The feet should be shoulder width apart, creating a sturdy base and the knees slightly bent. Even the torso should be slightly leaning forward, allowing the player to move quickly into a new position. When the shot from the opponent comes over the net, one has to turn towards the shot, becoming perpendicular to the net. At the beginning of this action, the player’s back foot will plant, setting the base for contact of the ball. The racket will be brought to **Max Racket Back** position, or the racket will be brought back to its farthest point. Then the **Front Foot will Plant**, setting the base. At this point, if the player has not already, they will bring the **Racket Back and Low**, beginning for the “wind-up” of the swing. The player brings the racket up and forward in the late swing; **Contacting** the ball with a flat racket head. It should be perpendicular to the ground. Like the serve, there will be a period of **Controlled Follow Through** which happens directly after contact. Here is where the player has control over the motion of the arm, and then there will be almost a “release of tension” and the arm will naturally continue up and over the opposite shoulder. Completion of the **Full Follow Through** will then lead the player back into **Ready Position**.

Appendix B shows the “expert’s” forehand performance broken down into the critical elements. Again we see our expert in the **Preparation** position. Reviewing this position the player has her feet shoulder width apart creating a steady base for herself. Her knees are bent and her torso is leaning slightly forward to help balance herself so she can switch positions and move quickly. The expert’s racket is out in front of her, held with both hands so as she reads her
opponent’s shots she can adjust. The player then sees the opponent’s return is on her forehand side. She turns towards the tennis ball, becoming perpendicular to the net. Beginning to set her base, she plants her back foot and brings her racket back to the farthest point, or **Max Racket Back**. This is causing a “rubber band” effect. The arm acts as the rubber band; pulling it back to cause tension and then when it comes forward it releases and snaps it forward. The further back, yet controlled, the arm is the momentum will be great. Bringing her non-racket hand out in front, helps to prepare her for the swing phase. As the weight transfers from the back to the front foot, she **Plants the Front Foot**, which is setting the base. Her racket moves in a forward, downward motion and eventually will reach its **Lowest Point**. The racket needs to be brought down instead of straight across because again it is building momentum and tension. Moving the racket in a straight, forward motion does not allow for any energy to be put into the shot because it has to build. Remember the energy is moving up the body from the knees, into the hips, and then eventually into the arms to the wrist and racket. Rushing through the movements does not allow for the body to build up enough energy to correctly complete the stroke. She begins her late swing and then we can see the **Contact Point**, where the energy is transferred to the tennis ball. Notice all her weight is forward, allowing for more power. The racket is perpendicular to the surface when it contacts the tennis ball, making sure that the path of the ball goes straight; rather than up or down. Like with the serve, the expert completes a **Controlled Follow Through** where the body is still containing some of that tension. Once the body releases that extra tension, the arm will follow its natural course completing the **Full Follow Through**; bringing the expert back into her **Ready Position**.
Using Dartfish, I recorded a media book on CD B of the three average players’ forehand performances and how they relate to the expert’s. CD B is attached in Appendix B, which also contains the still images of the expert’s and three average players’ forehand performances.

The final tennis skill I focused on was the backhand. The critical elements of the backhand are very similar to that of the forehand. The Kinetic Chain is present again in this tennis skill, as it was in the others. With this specific stroke, the order in the chain is the knees, hips, trunk, shoulder, and wrist (Roetert et al, 2009). During the Preparation position, the player needs to have their feet at shoulder width apart, while being parallel with the net. Knees need to be slightly flexed and the torso needs to be leaning forward at a slight angle. The racket is held in front of the body with two hands, just as the forehand. The ready stance is a position the player takes in order to be ready to take on whatever the opponent sends at them. It allows for quick movement in any direction; one direction leading to forehand and the other leading to backhand. Once the opponent has made their shot towards the player’s backhand side, they must turn perpendicular to the net and plant the back foot. Again this allows for a sturdy base. The racket, again, will be at the farthest point back, or Max Racket Back position. Shortly after the player will Plant their Front Foot, entirely setting their base. The player will then rotate their trunk bringing the racket back and low, away from the net. Trunk rotation creates a momentum, which allows for more power behind the shot. The shoulder would have to work 34% harder to receive the same effect if there was no rotation in the trunk (Kibler et al, 2004). Therefore once the swing begins, it is almost like the “snapping of a rubber band”. The racket begins to come forward and up, while the torso begins to rotate back towards the net. The late swing is followed by the Contact of the tennis ball. The head of the racket needs to be straight up and down, because if it is tilted up, the tennis ball will fly high, and if it is tilted down, the tennis ball will
go into the ground or net. Then the player goes into the Controlled Follow Through, which then will break into the End of the Full Follow Through; where the racket and arms naturally go up and over the opposite shoulder. With this, the torso continues to rotate towards the net and in the end the shoulders will be parallel to the net.

Appendix C shows the expert’s backhand performance broken down into the critical elements. Similar to the forehand, the expert begins in the Preparation position. Her feet are at shoulder width apart, knees are bent, and her torso is leaning slightly forward all allowing for quick action in determining her next move. Once she has decided the best way to return her opponent’s shot is a backhand, the expert turns towards the shot, planting her back foot and beginning to set her base. As with the forehand, we can see her bringing back the racket for that “wind-up” effect, or the Max Racket Back position. Her torso also gives this “wind-up” effect and contributes to the momentum that comes from it by rotating away from the net and eventually rotating back during the swing. It is hard to see a difference between the back foot plant and the Front Foot Plant. It is a very small movement, yet, very important. The expert needs to set her base so she does not lose her balance when performing the swing and shot. During this, she continues to bring her racket low and back, creating more tension. Once her racket reaches the farthest point back, or Max Racket Back position, she begins to release the tension and begins her swing. Her base is still set because she continues building energy which is quickly transferred up her body in the late swing before Contact. At contact, the energy moves to the tennis ball and as one can see, the head of the racket is perpendicular to the ground. Same as the forehand, this is very important to control the path of the ball. We can see her completing her Controlled Follow Through, where the tension is still present and the expert has complete control over her movements. She releases all energy and her racket follows its natural path up
and over the opposite shoulder, completing the *Full Follow Through*. It is important to allow the follow through to continue on its natural path because stopping too soon can cause injury to the player. Naturally her body moves back into the *Ready Stance* so she is prepared for the return.

Using Dartfish, I recorded a media book on CD C of the three average players' backhand performances and how they relate to the expert's. CD C is attached in Appendix C, which also contains the still images of the expert's and three average players' backhand performances.

As we can see with just this study, there was a broad range of ability levels concerning only three skills of tennis. Imagine having a class or team of 20 to 30 students, possibly more. How about when one has to add in the tennis lob, volley, spin serve, or forehand with topspin? I will now go over a few strategies to help teach tennis to either beginners or to help those expert players continue to grow.

The Dartfish software is an excellent tool to help all students and athletes learn and reflect on their performances. With this, they can also see the correct ways of performing the skill and compare it to their own right there and then. Players can use checklists when watching their performances to mark their strengths and weaknesses so the teacher or coach can see if the player has an understanding of the skill and critical elements. Peer assessments are another way to check for students' understanding of the skills, whether they are watching the performance live or through Dartfish. While students are growing and learning new skills on tennis, or improving the ones they had, keeping journals can help them to track their improvement and where they still need to focus. If the class or team has more advanced players, it can also be very beneficial to allow the novice players to observe them and even be taught by them. Peer teaching creates a sense of respect and sportsmanship in the class or team. Not to mention a level of self-
esteem, this is a huge factor when students or athletes may be learning a new tennis skill. It is important to include activities that the students can use their critical thinking skills and analyze their own performance or a peer’s, because that helps to show that they truly understand the skill and allow them to grasp concepts they may have missed (Mitchell & Kernodle, 2004).

Of course the most important part of learning tennis is the physical component, or actually practicing the skills. As with any sport, drills and scrimmages are excellent ways to practice the skills. However, students and athletes can get bored of performing the same activities everyday to learn the same skills. I want to introduce some out of the ordinary activities or games, which focus on the same skills as drills. An activity that students find fun and challenging is similar to the basketball game of “H-O-R-S-E”. Students call out the shot they are going to make and the area of the court that it will end up in. For example, the student may say “forehand in the front court” and if they make it, then the next student must try the same thing. If there are specific shots and skills the players are to be working on, the teacher or coach can have a list of shots typed up for the students to go off of. Another activity is “Under the Line”. Here the students are told to perform certain shots, but the goal is to keep the shot controlled so that it does not go beyond the baseline. If the students are working on volleys or drop-shots, the service line can be used (Kahan, 2006). Having students go through the motions of certain skills, for example the serve, without equipment and focusing just on the motions, is another activity that is very helpful but usually overlooked. Again, Dartfish can be used with all these activities to pinpoint the skills and break them down into Critical Instances so the students can understand their performance.

Through this study, I introduced the Dartfish software. I hope that this will become an important part of physical education classes and athletic teams in schools everywhere. It is
necessary for students to reflect on their performances so they can comprehend their strengths and weaknesses. Also, I introduced the basic tennis skills: serve, forehand, and backhand, and the correct way to perform them. Now teachers and coaches may call the critical instances and phase’s different names to help their students and athletes remember them better. The phases and instances are what I believe to be the main parts of each of these skills and I put them together as a guide to show the usefulness of Dartfish and a way to visualize the skills broken down. As a future educator, I hope that this study will help open the eyes of many educators and coaches to take more interest in the students’ learning of their own skills. Whether expert or average, they will all succeed at their own rate, and with Dartfish, they can see and understand their own accomplishments.
References


Expert Serve

Phase 1: Racket Back

CI 1: Preparation

Phase 2: Racket and Tennis Ball Up

CI 2: Start of Toss

Phase 3: Tennis Ball Going Up

CI 3: Ball Release

Phase 4: Dropping Racket Back

CI 4: Ball at Highest Point
Phase 5: Early Swing
Phase 6: Late Swing

CI 5: Max Back Scratch
CI 6: Start of Wrist Flexion

Phase 7: Early Follow Through
Phase 8: Late Follow Through

CI 7: Contact
CI 8: End of Controlled Follow Through

Phase 9: Back to Ready Stance

CI 9: End of Full Follow Through
CI 10: Ready Stance
Subject 1 Serve

Phase 1:
Racket Back

Phase 2:
Racket and Tennis Ball Up

CI 1: Preparation

CI 2: Start of Toss

Phase 3:
Tennis Ball Going Up

Phase 4:
Dropping Racket Back

CI 3: Ball Release

CI 4: Ball at Highest Point

Phase 5:
Early Swing

Phase 6:
Late Swing

CI 5: Max Back Scratch

CI 6: Start of Wrist Flexion
Phase 7:  
Early Follow Through

Phase 8:  
Late Follow Through

CI 7: Contact

CI 8: End of Controlled Follow Through

Phase 9:  
Back to Ready Stance

CI 9: End of Full Follow Through

CI 10: Ready Stance
Subject 2 Serve

CI 1: Preparation
Phase 1:
Racket Back

CI 2: Start of Toss
Phase 2:
Racket and Tennis Ball Up

CI 3: Ball Release
Phase 3:
Tennis Ball Going Up

CI 4: Ball at the Highest Point
Phase 4:
Dropping Racket Back

CI 5: Max Back Scratch
Phase 5:
Early Swing

CI 6: Start of Wrist Flexion
Phase 6:
Late Swing
Phase 7: Early Follow Through
Phase 8: Late Follow Through

CI 7: Contact
CI 8: End of Controlled Follow Through

Phase 9: Back to Ready Stance

CI 9: End of Full Follow Through
CI 10: Ready Stance
Subject 3 Serve

Phase 1: Racket Back

Phase 2: Racket and Tennis Ball Up

CI 1: Preparation

CI 2: Start of Toss

Phase 3: Tennis Ball Going Up

Phase 4: Dropping Racket Back

CI 3: Ball Release

CI 4: Ball at Highest Point

Phase 5: Early Swing

Phase 6: Late Swing

CI 5: Max Back Scratch

CI 6: Start of Wrist Flexion
Expert Forehand

Phase 1: Racket Back

Phase 2: Setting

CI 1: Preparation

CI 2: Max Racket Back

Phase 3: Racket Lowering

Phase 4: Late Swing

CI 3: Front Foot Plant

CI 4: Racket at Lowest Point

Phase 5: Early Follow Through

Phase 6: Late Follow Through

CI 5: Contact

CI 6: End of Controlled Follow Through
**Phase 7:**

*Back to Ready Stance*

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**CI 7:** End of Full Follow Through

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**CI 8:** Ready Stance
Subject 1 Forehand

CI 1: Preparation

Phase 1:
Racket Back

CI 2: Max Racket Back

Phase 2:
Setting

CI 3: Front Foot Plant

Phase 3:
Racket Lowering

CI 4: Racket at Lowest Point

Phase 4:
Late Swing

CI 5: Contact

Phase 5:
Early Follow Through

CI 6: End of Controlled Follow Through

Phase 6:
Late Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through
CI 8: Ready Stance
Subject 2 Forehand

CI 1: Preparation
- Phase 1: Racket Back

CI 2: Max Racket Back
- Phase 2: Setting

CI 3: Front Foot Plant
- Phase 3: Racket Lowering

CI 4: Racket at Lowest Point
- Phase 4: Late Swing

CI 5: Contact
- Phase 5: Early Follow Through

CI 6: End of Controlled Follow Through
- Phase 6: Late Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through

CI 8: Ready Stance
Subject 3 Forehand

Phase 1: Racket Back
Phase 2: Setting

CI 1: Preparation
CI 2: Max Racket Back

Phase 3: Racket Lowering
Phase 4: Late Swing

CI 3: Racket at Lowest Point
CI 4: Front Foot Plant

Phase 5: Early Follow Through
Phase 6: Late Follow Through

CI 5: Contact
CI 6: End of Controlled Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through

CI 8: Ready Stance
Expert Backhand

Phase 1: Racket Back

Phase 2: Setting

CI 1: Preparation       CI 2: Max Racket Back

Phase 3: Racket Lowering

Phase 4: Late Swing

CI 3: Front Foot Plant       CI 4: Start of Swing

Phase 5: Early Follow Through

Phase 6: Late Follow Through

CI 5: Contact       CI 6: End of Controlled Follow Through
Phase 7: 
Back to Ready Stance

CI 7: End of Full Follow Through

CI 8: Ready Stance
Subject 1 Backhand

Phase 1:
Racket Back

Phase 2:
Setting

CI 1: Preparation

CI 2: Max Racket Back

Phase 3:
Racket Lowering

Phase 4:
Late Swing

CI 3: Front Foot Plant

CI 4: Start of Swing

Phase 5:
Early Follow Through

Phase 6:
Late Follow Through

CI 5: Contact

CI 6: End of Controlled Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through

CI 8: Ready Stance
Subject 2 Backhand

Phase 1: Racket Back

Phase 2: Setting

CI 1: Preparation

CI 2: Max Racket Back

Phase 3: Racket Lowering

Phase 4: Late Swing

CI 3: Front Foot Plant

CI 4: Start of Swing

Phase 5: Early Follow Through

Phase 6: Late Follow Through

CI 5: Contact

CI 6: End of Controlled Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through  CI 8: Ready Stance
Subject 3 Backhand

CI 1: Preparation

Phase 1:
Racket Back

CI 2: Max Racket Back

Phase 2:
Setting

CI 3: Front Foot Plant

Phase 3:
Racket Lowering

CI 4: Start of Swing

Phase 4:
Late Swing

CI 5: Contact

Phase 5:
Early Follow Through

CI 6: End of Controlled Follow Through

Phase 6:
Late Follow Through
Phase 7:
Back to Ready Stance

CI 7: End of Full Follow Through

CI 8: Ready Stance