

TIMING THE SERVE OF WORLD'S TOP PLAYERS

DOES THE KINETIC CHAIN MODEL BENEFIT TENNIS-TEACHING TECHNIQUE?

by James R. Shaughnessy, USPTA Master Professional

The sciences of kinesiology and biomechanics have long lauded the benefits of the kinetic chain model and Duane Knudson, PHD explains that, in 1955 the term “kinetic chain” was modified from what was, originally, an engineering term - the “kinematic chain.” “Despite the original major problem classifying human movement in engineering terms, the ‘kinetic chain model’ is currently, a commonplace tool in the top professional, fitness, allied health, and sports coaching realms. In their literature, both the International Tennis Federation (ITF) and the United States Tennis Association High Performance Coaching Program (USTAHPCP) have adopted the kinetic chain concept as a crucial teaching construct.

By coaching players to obey the principles of the kinetic chain, it is thought that, players will create the most effective tennis shot, with the most efficient use of energy and a low chance for injury. This article examines a recent study quantifying the frequency of use of the kinetic chain model by ATP World

Tour #1 ranked players, and examines ways the USPTA pro can easily detect and employ three newly identified paired technique events used by these #1 players.

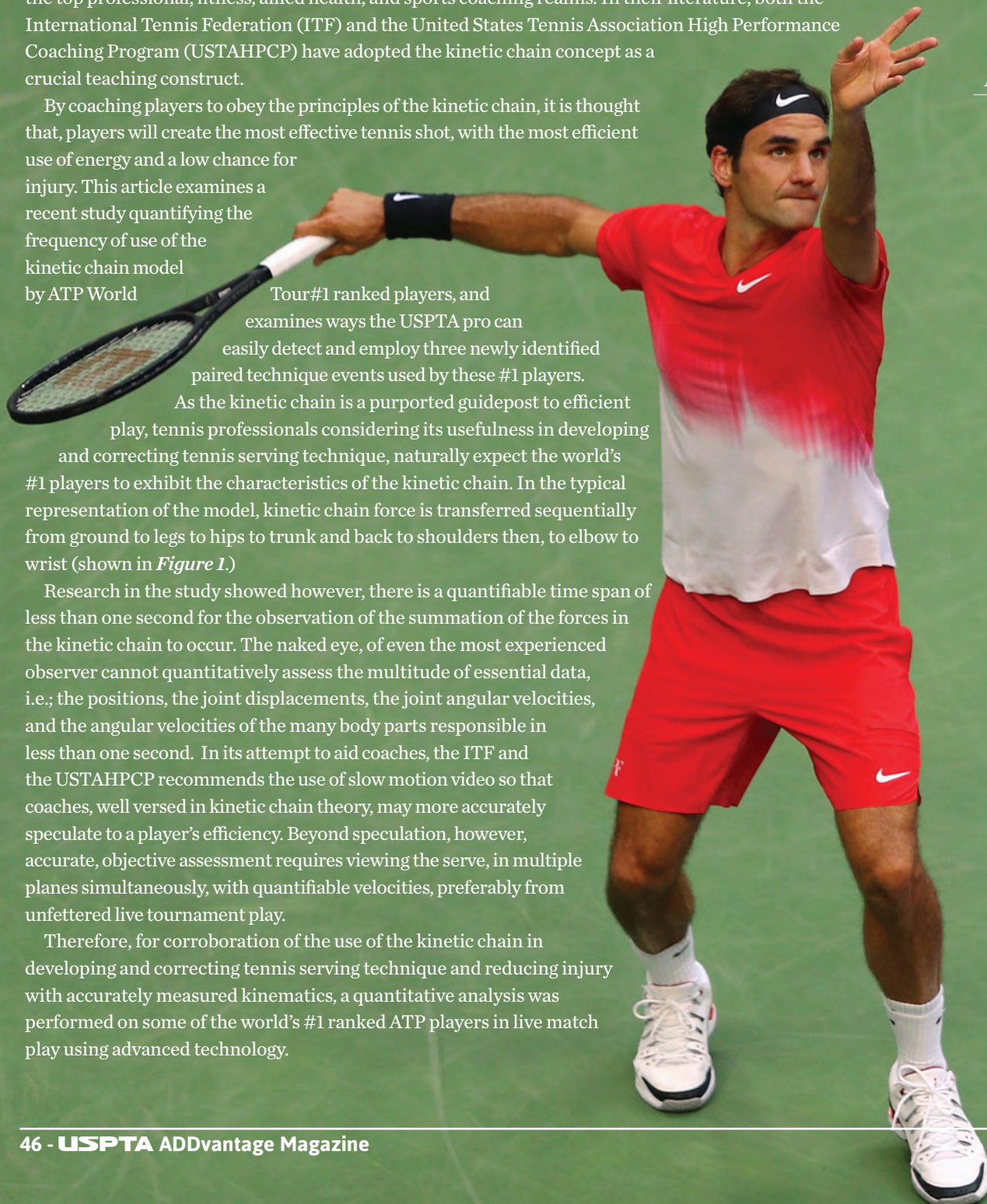
As the kinetic chain is a purported guidepost to efficient play, tennis professionals considering its usefulness in developing and correcting tennis serving technique, naturally expect the world's #1 players to exhibit the characteristics of the kinetic chain. In the typical representation of the model, kinetic chain force is transferred sequentially from ground to legs to hips to trunk and back to shoulders then, to elbow to wrist (shown in *Figure 1*.)

Research in the study showed however, there is a quantifiable time span of less than one second for the observation of the summation of the forces in the kinetic chain to occur. The naked eye, of even the most experienced observer cannot quantitatively assess the multitude of essential data, i.e.; the positions, the joint displacements, the joint angular velocities, and the angular velocities of the many body parts responsible in less than one second. In its attempt to aid coaches, the ITF and the USTAHPCP recommends the use of slow motion video so that coaches, well versed in kinetic chain theory, may more accurately speculate to a player's efficiency. Beyond speculation, however, accurate, objective assessment requires viewing the serve, in multiple planes simultaneously, with quantifiable velocities, preferably from unfettered live tournament play.

Therefore, for corroboration of the use of the kinetic chain in developing and correcting tennis serving technique and reducing injury with accurately measured kinematics, a quantitative analysis was performed on some of the world's #1 ranked ATP players in live match play using advanced technology.



Roger Federer



Roger Federer photo courtesy of Wilson Sports

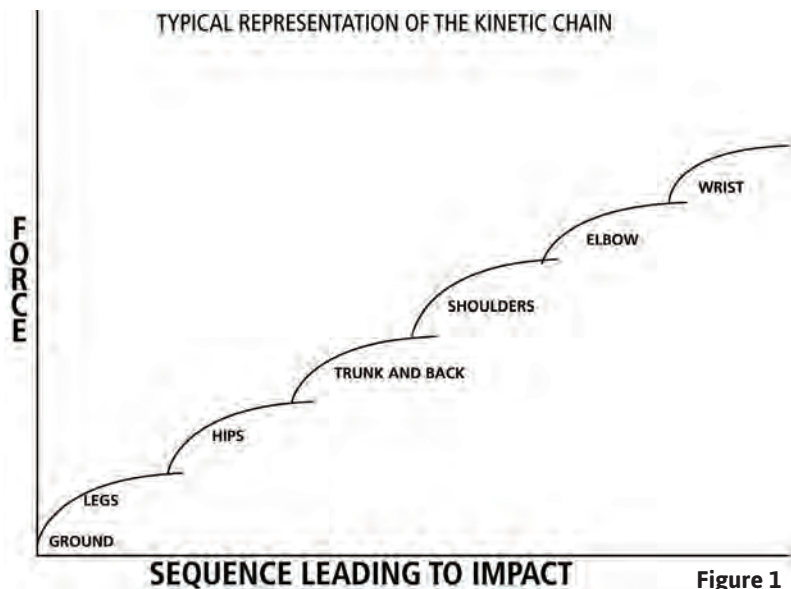


Figure 1

Two methods of quantitative analysis were used to check for evidence of use of the kinetic chain model (shown Figure 1.) For example, does use of the chain transfer force (dependent on linear velocity) or muscle torque (dependent on rotational velocity?) Are these forces blended in a certain sequence? Therefore, linear velocity and rotational velocity was measured both independently and blended using advanced software and multiple highspeed video cameras. (Ariel Performance Analysis System and SCIO 3D Library of Live Match Play.)

RESULT #1

Djokovic, Federer, Murray, and Roddick break the kinetic chain model. None of the 10 serves displayed the perfect sequencing of segment rotations demanded by the kinetic chain model.

Figure 2 displays the results of the average sequencing of serving events of Djokovic, Federer, Murray, and Roddick.

RESULT #2

Surprisingly, the study also revealed three events that occur simultaneously in the motion of all the #1's in the study, in all 10 serves. These three identified events are easily seen by slow motion video and might be used by tennis pros daily for more easily assessing a players' kinetic energy transfer while serving. The serves of Djokovic, Federer, Murray, and Roddick all sequence three pairs of events which occur simultaneously:

- a) The toss arm begins to drop (upper arm abduction) at the same moment the ball toss reaches its peak.
- b) The left toes leave the ground at the same instant the racket reaches its lowest point in the power loop or windmill position.
- c) When the toss hand and forearm complete their dropping or braking action, the hitting hand wrist reaches maximum extension at the wrist (hand bent back.)

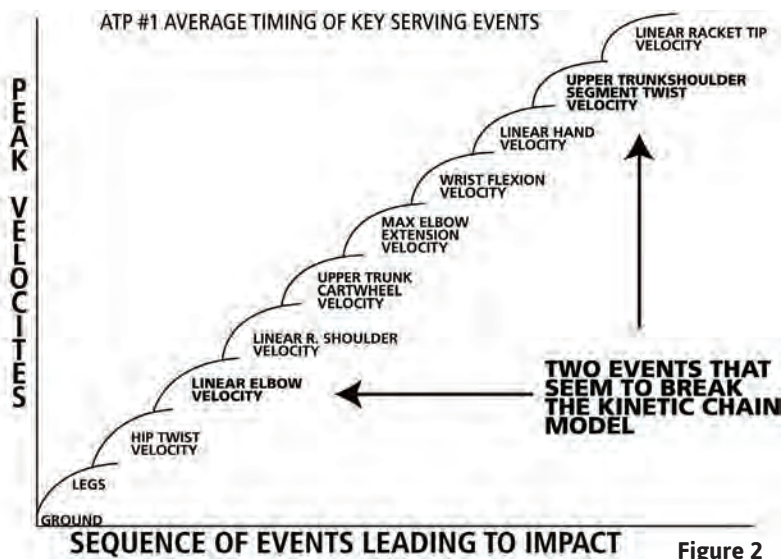


Figure 2

THE ANALYSIS

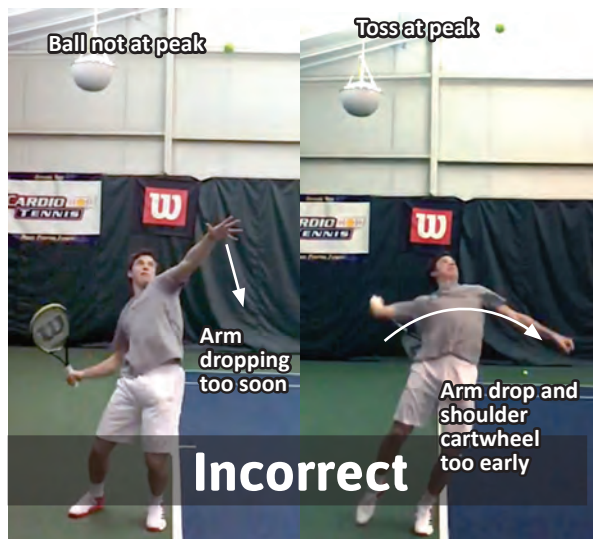
Four players with a #1 ranking on the ATP Tour were analyzed. The players were Novak Djokovic (before and after changing his serve), Roger Federer, Andy Murray (before and after back surgery), and Andy Roddick.

Players' data was captured from 2009-2014 at ATP Tour 1000 events during live match play. 10 strokes were selected for analysis - seven ace serves of 127-134 mph and three second serves of 97-104 mph.

RESULT #3

For the most part the concept of a summation of forces via a "kinetic chain" held true, although the sequence used by the #1's does not match the commonly taught kinetic chain model. See Figure 2.

1



HOW THE ANALYSIS CAN BE USED

Coaches can use the new knowledge and observation of the three newly revealed sequenced pairs to:

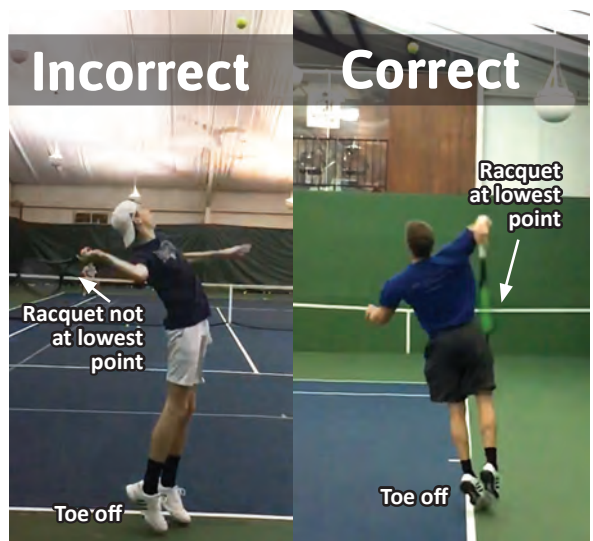
1) Peak and Drop

Improve timing and maximize cartwheel motion of the shoulders and upper trunk (which research shows, is responsible for most of the momentum created by the trunk motion.)

2) Toe Off Racket Down

Perfectly time the leg drive. Timing the left toe off correctly is an indication of efficient momentum transfer from the legs to the trunk and back which is said to be responsible for 54 percent of the force in serving according to Dr. Ben Kibler. Additionally, Bruce Elliot PhD states that, timing the leg correctly will efficiently transfer momentum into a maximum stretch on the internal rotators of the humerus at the shoulder joint.

2



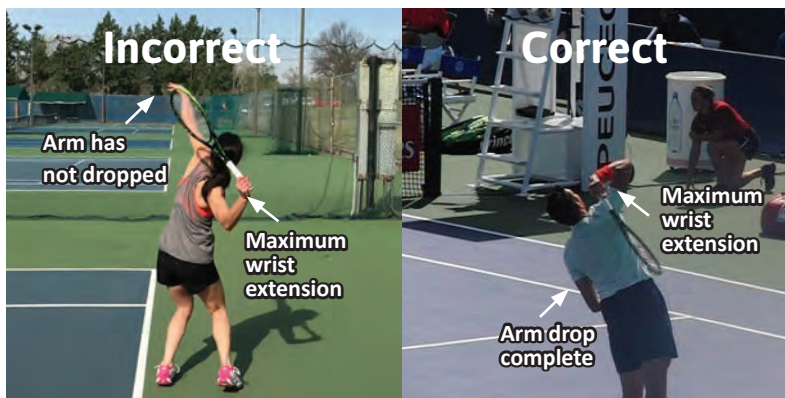
3) Brake and Bend

Perfect the timing of maximum hand extension at the wrist, to ensure an efficient stretch shortening cycle of the muscles which are responsible for rotating the hand and racket about the wrist into impact. (In this study, Andy Roddick reached a maximum hand rotation angular velocity of 2216° per second while Roger Federer achieved 2397° per second.)

CONCLUSION

The analysis of the serving technique data of Djokovic, Federer, Murray, and Roddick to confirm their use of the kinetic chain model revealed that, they do not perfectly conform to the classic model in every way. Additionally, three pairs of cues were discovered in every serve studied regardless of player, stance, toss height, or backswing style. With the use of a simple camera phone these paired technique points can easily be detected in any student's serve and used to contribute to maximal summation of forces. ⚡

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