



Training The Rotational Athlete

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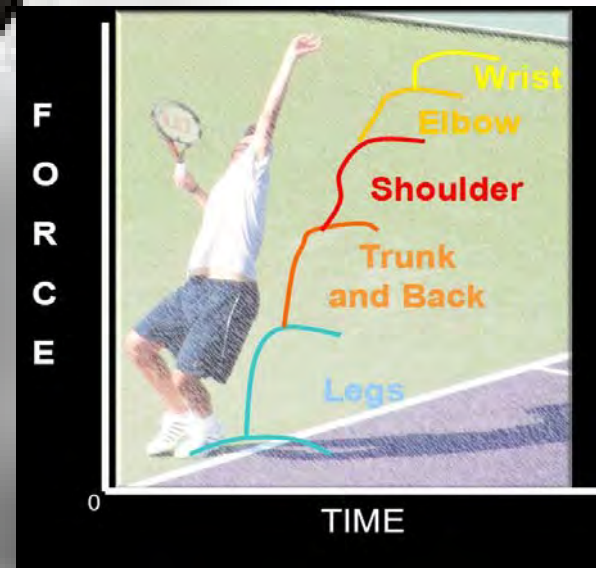


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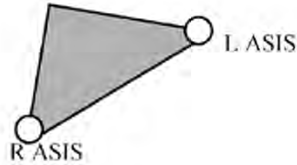
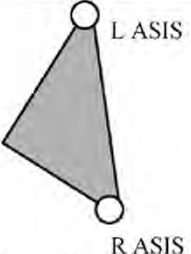


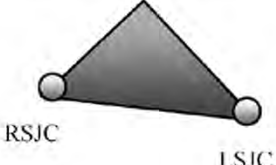
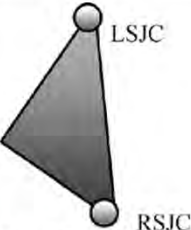
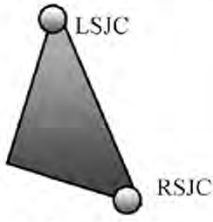
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The Kinetic Chain



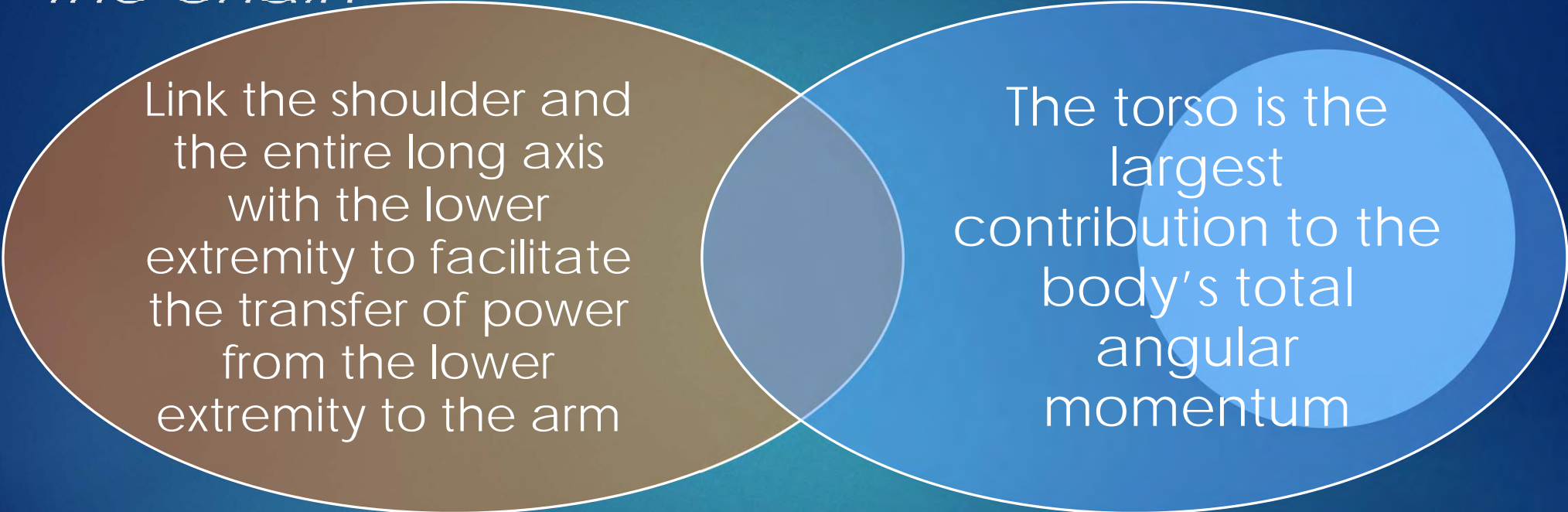
Baseball Pitch Pelvis vs Thorax



	Foot Contact	MER	BR	Home Plate
PELVIS	 $-64 \pm 12^\circ$	 $+11 \pm 10^\circ$	 $+18 \pm 8^\circ$	
THORAX	 $-92 \pm 11^\circ$	 $+10 \pm 12^\circ$	 $+25 \pm 9^\circ$	

► Nissen et al. MSSE 2007

Focus more time and training down the chain



Link the shoulder and the entire long axis with the lower extremity to facilitate the transfer of power from the lower extremity to the arm

The torso is the largest contribution to the body's total angular momentum

Bahamonde RE. Changes in angular momentum during the tennis serve. *J Sports Sci.* 2000;18:579-592.

Dapena JA. Method to determine the angular momentum of a human body about three orthogonal axes passing through its center of gravity. *J Biomech.* 1978;11:251-256.

Putnam CA. Sequential motions of body segments in striking and throwing skills: description and explanations. *J Biomech.* 1993;26:125-135.

The Science of Power In The Rotational Athlete

A stable core will transfer the forces with minimal rotation and minimal energy loss

(Shinkle et al Effect of core strength on the measure of power in the extremities. JSCR 2012)

Lift and Chop Exercises Are A Major Source of Training

The mean peak power outputs for chop and lift ranged from 404 - 494W and 277-314W respectively, the power outputs differing minimally (2.7-6.3%) between the left and right sides. Coefficients of variation of 7.4% - 19% were reported, with intraclass correlation coefficients of 0.54 - 0.94 observed between testing occasions.

Zois J, et al. (2016) The Reliability of a Rotational Power Assessment of the Core. J Athl Enhanc 5:5.

Overall Training Protocol Philosophy

- ▶ Bilateral Stability
- ▶ Unilateral Stability
- ▶ Bilateral Strength
- ▶ Unilateral Strength
- ▶ Bilateral Power
- ▶ Unilateral Power

Daily Protocol and Order

- ▶ Stability & Activation (Dynamic Warm-Up)
- ▶ Power Bilateral
- ▶ Power Unilateral
- ▶ Power Rotational
- ▶ Bilateral Strength
- ▶ Unilateral Strength
- ▶ Auxillary Exercises/Correctives etc



Stability Assessments and Training



High prevalence of poor single-leg squat test results in these athletes (seen in both Baseball and Tennis).



Both Kibler et al. and Beckett et al have reported an association between scapular dyskinesis and hip abduction weakness.

Kibler WB. Role of the scapula in the overhead throwing motion. Contemp Orthop 1991;22:525-532.

Beckett M, Hannon M, Ropiak C, Gerona C, Mohr K, Limpisuasti O. Clinical assessment of scapula and hip joint function in preadolescent and adolescent baseball players. Am J Sports Med 2014;42: 2502-25

► Beckett M, Hannon M, Ropiak C, Gerona C, Mohr K, Limpisuasti O. Clinical assessment of scapula and hip joint function in preadolescent and adolescent baseball players. Am J Sports Med 2014;42: 2502-2509.

► Ellenbecker and Kovacs (2014)

Ki KOVACS
PHYSIO



The Hips In The Rotational Athlete

Disruption of the kinetic chain at the hip could lead to shoulder injuries.

Less force transferred from the lower extremity,
= greater stress on the upper extremity,
thereby increasing the risk of injury.

Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology. Part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy. 2003;19(6):641-661.

Baseball players with a history of shoulder lesions had less internal rotation in the nondominant hip than those without.

Mean loss was only 5%, and the authors questioned its clinical significance.

Scher S, Anderson K, Weber N, Bajorek J, Rand K, Bey MJ. Associations among hip and shoulder range of motion and shoulder injury in professional baseball players. J Athl Train. 2010;45(2):191-197.



KI Hip Progressions

	Exercises	Volume (Sets x Reps/Time)	Coaching Cues	Criteria / Check points	Common incorrect techniques
Level 1	1. Mini Band Isometric Hip Flexion	x10 hold 10 sec	Keep hip at 90/90 position, neutral spine	<input type="checkbox"/> Keep pelvis/lumbar spine in neutral <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	- Excessive pelvic rotation or hip ADD/ABD/ER - Inc lumbar lordosis - significant sway, hand held assist
	2. Supine Glute Sets	X10 hold 10 sec	Lie supine with legs straight, contract glutes		
	3. Supine B hip ER	X10 hold 10 sec (green mini band)	Lie supine, place mini band around knees, keep feet together		
	4. SLS	3x30 sec	Opposite leg must not touch the ground or stance leg		
	5.				
Level 2	1. Seated Hip Flexion	3x10 hold 5 sec	Maintain knee flexion and lumbar spine in neutral, support contra limb	<input type="checkbox"/> keep pelvis/lumbar spine in neutral <input type="checkbox"/> Full ROM when compared to performing clam w/o resistance <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	- lumbar flexion - Excessive pelvic rotation or hip ABD/ER - Inc lumbar lordosis - excessive trunk sidebending - significant sway, hand held assist

Level 3	1. SLR	3x10 hold 5 sec (up to #5)	Maintain knee extension, contra limb bent with foot on table, raise limb to height of knee on contra limb	<ul style="list-style-type: none"> □ Keep pelvic/lumbar in neutral, contract quadriceps □ Knee aligned with hip and toes □ Upright torso, hips squared fwd, fwd heel flat, thigh parallel to ground □ □ 	<ul style="list-style-type: none"> - knee flexion evident, excessive pelvic rotation - toes lead instead of heel - excessive fwd trunk lean, knee alignment medial to foot, weight on ball of foot
	2. Quadruped Hip Ext / add knee/hip on 90/90	3x10 hold 5 sec	Same as above without bench		
	3. Hip ABD	3x10 hold 5 sec (up to #5)	Sidelying w/ top leg straight, bottom leg 90/90, quad contracted, lead w/ heel and raise top leg		
	4. Split squat with Hip abd Isometric	3x10 (blue t-band) 25% BW	T-band around knee pulling knee medially, perform movement pushing knee against tband with ascent and descent		
	5. SLS w/ Oscillation UE/LE	3x20 (blue t-band)	Hold band in hands/wrap around contra ankle, move shoulder/hips back in forth fwd/bkwd or M/L		
Level 4	1. Longsitting Hip Flexion	3x10 hold 5 sec (up to #5)	Maintain knee extension, contra limb knee to chest/hug knee, keep spine straight, raise limb >4 in off floor/table	<ul style="list-style-type: none"> □ Maintain neutral spine and contra knee to chest □ Maintain mini squat position □ upright torso, hips squared, fwd heel flat, thigh parallel to ground □ □ 	<ul style="list-style-type: none"> - excessive spinal flexion, dec ROM - inc lumbar lordosis - excessive fwd lean, knee alignment is medial to foot, weight on ball of front foot - significant sway or LOB
	2. Quadruped Hip Ext w/ knee ext	3x10 hold 5 sec (up to #5)	Same as above with knee in ext, without tennis ball		
	3. Standing Hip ER	3x20 hold 5 sec (blue mini band)	Mini squat position 45° knee flexion, mini band around knees		
	4. Elevated Split Squat	3x10 (w/ blue t-band) 25% BW	Same as above, dorsum of back foot on weight bench or 18" step		
	5. SLS w/ Oscillation UE/LE unstable surface Monster walk/side step w band Step ups/hold on top (stability) add band/weight if needed	3x20 (blue t-band)	Same as SLS w/ Oscillation but on an airex pad, half foam roll, wobble board		

The golf swing is considered to be a sequential movement with power development beginning with ground reaction forces (GRFs) in the lower extremity and peaking at club head impact (Hume et al. Sports Med 35, 2005).



OPTIMIZING ENERGY TRANSFER

The tennis serve and groundstrokes have a similar progression



The baseball swing also has a similar energy transfer to the tennis forehand and backhand

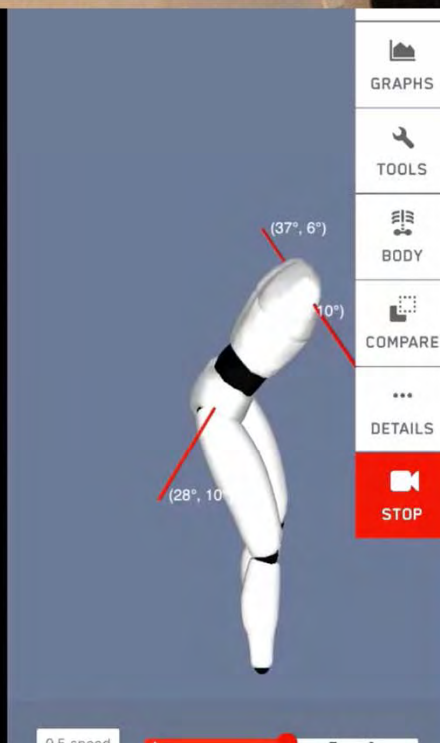
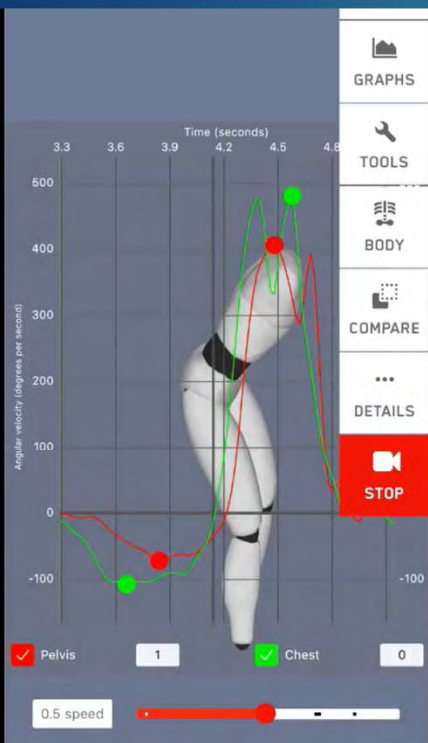
Golf



With all other aspects being equal, an increase in club head speed of 3.29 mp/h (5.3 km/h) has been shown to result in 11–17 yards increased carry distance from the tee (Thomson et al. JSCR 2007)

The ability to load the rear foot and then transfer this GRF from the rear foot to the lead foot during the downswing is something that skilled golfers do better than novices which results in increased club head speed (Hume et al Sports Med, 2005; Kawashima et al 1998)

GOLF MECHANICS





Baseball



1. Getting started

The motion begins as the body coils. Strasburg raises the ball to cheek level, then lifts his left knee above his waist, twisted in front of his trunk in a balanced position, ready to begin.

2. Stride

His legs start the chain. The right leg pushes off the pitching rubber. Simultaneously, his arms swing below his hips and apart like pendulums as his left knee goes forward and down.

3. Momentum

After his front foot lands, energy is transferred to his pelvis, which begins to turn to face the batter. After a slight, momentum-building lag, his upper trunk follows, but his right arm is still back with the elbow flexed.

4. Acceleration

As momentum from the trunk twist moves to his shoulder, it rotates forward at the frightening rate of 20 rotations per second. The elbow extends and straightens.

5. Release

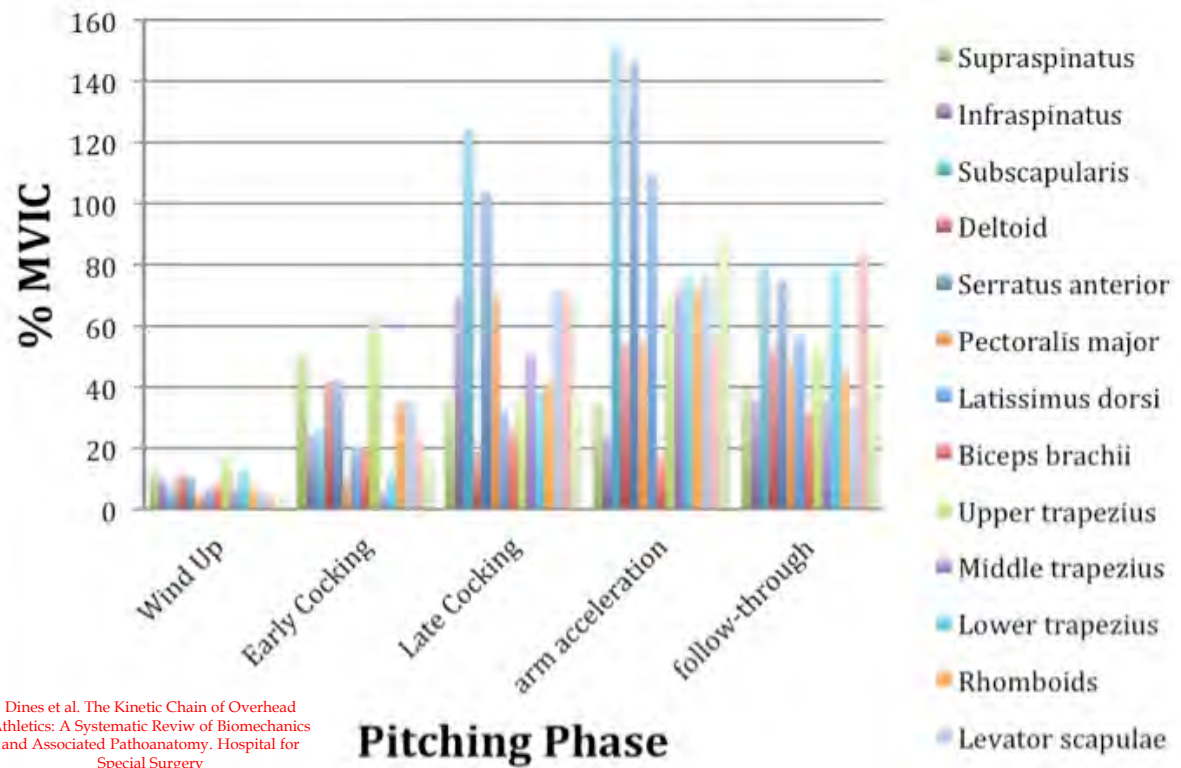
His wrist straightens as energy in his stretched elbow tendons whips the hand forward. His fingertips give the ball a final push and end up pointing straight down.

6. Follow-through

His left knee straightens more as momentum bends his trunk farther and carries his right leg forward. His trunk rotates so much that the batter can see his back, but he ends up in a balanced position.

Angular velocities
reaching 7250 °/s and
anterior shear forces
approaching 50% of
body weight

Escamilla RF, Barrentine SW, Fleisig GS, et al. Pitching biomechanics as a pitcher approaches muscular fatigue during a simulated baseball game. *Am J Sports Med* 2007;35:23-33.



Dines et al. The Kinetic Chain of Overhead Athletics: A Systematic Review of Biomechanics and Associated Pathoanatomy. Hospital for Special Surgery

To Decrease Peak Glenohumeral Compressive Force

Increasing Stride Length

Increasing Pelvis Lateral Flexion away from the throwing arm throughout the early stages of the pitching motion.

Train for decreased axial rotation velocity with regard to the pelvis at ball release

*It may be possible to focus on individually **INCREASING STRIDE LENGTH**, **INCREASING PELVIS LATERAL FLEXION** toward the glove side at shoulder maximum external rotation, and/or **DECREASING PELVIS AXIAL ROTATION VELOCITY** at release in an effort to decrease peak glenohumeral compressive force.*

Rotational Power



Lower Body Link With The Upper Body In Power Production

Improving Bat Swing Velocity (Baseball) = strength training with multi-joint leg exercises and explosive hip and torso rotational strength.

In order to develop bat velocity, baseball players need to develop power.

Developing sport-specific, sequential, ballistic torso rotational strength by using medicine balls increases bat speed *(Szymanski et al. Relationships between sports performance variables and bat swing velocity of collegiate baseball players. JSCR 2005).*





TENNIS







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To Work on All The Explosive
Movement Aspects and Rotations
We Need To Be Able To Stabilize
First and Foremost



Outside Leg Catch and Release



Single Leg Catch, Load and Explode



Hip Range of Motion and Association With Injury in Female Professional Tennis Players

Simon W. Young,* MD, FRACS, Jodie Dakic,[†] PT, Kathleen Stroia,[†] PT, ATC, Michael L. Nguyen,[‡] MD, Alex H.S. Harris,[‡] PhD, and Marc R. Safran,^{‡§} MD
Investigation performed at Stanford University, Stanford, California, USA

Unlike at the dominant shoulder, the hip does not show side to side ROM differences in tennis athletes

However, asymmetric illopoas hypertrophy is known to occur in tennis players

Young et al. Hip range of motion and association with injury in female professional tennis players. AJSM 42 (11) 2014 2654-2658

TABLE 2
Hip ROM Data^a

Variable	ROM, deg
Hip IR: prone	
Dominant	41 (13-62)
Nondominant	38 (7-59)
Hip ER: prone	
Dominant	24 (2-50)
Nondominant	23 (9-42)
Hip IR: 90° of flexion	
Dominant	38 (18-56)
Nondominant	38 (18-55)
Hip ER: 90° of flexion	
Dominant	29 (10-48)
Nondominant	27 (8-47)
Tot: prone	
Dominant	60 (22-83)
Nondominant	65 (41-101)
Tot: flexed	
Dominant	65 (37-85)
Nondominant	67 (46-88)

^aValues are expressed as mean (range). ER, external rotation; IR, internal rotation; ROM, range of motion; Tot, total rotational arc.

RHD, right hand dominance (= left hip dominance).

An 8-Stage Model for Evaluating the Tennis Serve: Implications for Performance Enhancement and Injury Prevention

Mark Kovacs, PhD, CSCS^{1*}, and Todd Ellenbecker, DPT, MS, SCS, OCS, CSCS^{2,3†}

Background: The tennis serve is a complex stroke characterized by a series of segmental rotations involving the entire kinetic chain. Many overhead athletes use a basic 6-stage throwing model; however, the tennis serve does provide some differences.

Evidence Acquisition: To support the present 8-stage descriptive model, data were gathered from PubMed and SPORTDiscus databases using keywords tennis and serve for publications between 1980 and 2010.

Results: An 8-stage model of analysis for the tennis serve that includes 3 distinct phases—preparation, acceleration, and follow-through—provides a more tennis-specific analysis than that previously presented in the clinical tennis literature. When a serve is evaluated, the total body perspective is just as important as the individual segments alone.

Conclusion: The 8-stage model provides a more in-depth analysis that should be utilized in all tennis players to help better understand areas of weakness, potential areas of injury, as well as components that can be improved for greater performance.

Keywords: biomechanics; serve; tennis; kinetic chain

The tennis serve is the most complex stroke in competitive tennis.²³ The complexity of the movement results from the combination of limb and joint movements required to summate and transfer forces from the ground up through the kinetic chain and out into the ball. Effective servers maximally utilize their entire kinetic chain via the synchronous use of selective muscle groups, segmental rotations, and coordinated lower extremity muscle activation (quadriceps, hamstrings, and hip rotators, internal and external). This lower body-core force production is then transferred up into the upper body and out through the racket into the ball. If any of the links in the chain are not synchronized effectively, the outcome of the serve will not be optimal.²⁶

The serve has been studied in a similar manner to the throwing motion in baseball, although some significant differences do exist between the serving motion and the throwing motion. These differences include planes of motion, the nondominant arm tossing the tennis ball, the trajectory of

forces produced and released, the tennis racket (which alters the lever arm), the technical components of the serve, and the variety of placements and goals of the motion (spin, speed, angle, direction, etc).

The components usually seen in the traditional throwing analysis^{26,28} have been altered in this proposed 8-stage tennis-specific serve model (Figure 1). The 8-stage model has 3 distinct phases: preparation, acceleration, and follow-through. Each stage is a direct result of muscle activation and technical adjustments made in the previous stage. When a serve is evaluated, the total body perspective is just as important as the individual segments alone.

THE KINETIC CHAIN AND THE TENNIS SERVICE MOTION

Over a quarter century ago, the kinetic chain was first studied in nationally ranked tennis players.²³ Players increase

A Performance Evaluation of the High-Performance Tennis Serve: Implications for Strength, Speed, Power, and Flexibility Training

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¹Player Development, United States Tennis Association, Boca Raton, Florida; ²Physiotherapy Associates, Scottsdale Sports Clinic, Scottsdale, Arizona; and ³Association of Tennis Professionals (ATP) World Tour, Ponte Vedra Beach, Florida

SUMMARY

THE TENNIS SERVE IS THE MOST POWERFUL AND POTENTIALLY DOMINANT SHOT IN TENNIS, YET VERY FEW PLAYERS PERFORM THIS WITH MAXIMUM VELOCITY, POWER, OR SPIN ON A CONSISTENT BASIS. THIS ARTICLE WILL DISCLOSE 3 PHASES AND 8 STAGES OF THE TENNIS SERVE WITH HIGHLIGHTED EVALUATION MARKERS THAT CAN AID THE COACH OR TRAINER IN DEVELOPING TRAINING PROGRAMS WITH SPECIFIC EXERCISES AND DRILLS TO IMPROVE THE QUALITY OF THE ATHLETE'S TENNIS SERVE. THE 8 STAGES ARE THE (A) START, (B) RELEASE, (C) LOADING, (D) COCKING, (E) ACCELERATION, (F) CONTACT, (G) DECELERATION, AND (H) FINISH. THIS ARTICLE WILL HIGHLIGHT COMMON FLAWS IN TECHNIQUE AND PROVIDE SUGGESTED EXERCISES AND RECOMMENDATIONS TO IMPROVE THE

RELIABILITY, VELOCITY, AND SPIN OF THE SERVE.

INTRODUCTION

The tennis serve provides strength and conditioning specialists, sport scientists, players, coaches, physical therapists, and athletes a great opportunity to improve performance. It can also lead to potential injury if the stroke is not performed with appropriate technique or if the physical aspects of the athlete (strength, speed, power, flexibility, muscular endurance, and muscular balance) are not trained correctly. It is the only stroke in tennis that is 100% under control of the player, and it is not a response to a ball hit by an opponent. The serve does produce large loads on the shoulder and lower back, which can result in overuse injuries (4,12,18,20). It is also a highly complex stroke because of the reliance on multiple segments in the kinetic chain to produce power through properly timed rotations and complex coordinated muscular activations (26), as well as the most important from a strategic

standpoint (15,19). The difficulty in the movement results from the summation of forces from the ground up through the kinetic chain and out into the ball. This summation of forces is also required in forward and backward groundstrokes for successful stroke performance. On the serve, if this is successfully performed, this summation of forces is achieved while also throwing the ball upward (with the nondominant hand) and impacting the ball just below its peak on its downward flight (2). Effective servers use the kinetic chain via a muscle activation synchrony of the coordinated lower extremity muscles that provide a stable base for the trunk/core to rotate and extend and flex while also helping to produce force. If any of the links in the chain are not synchronized effectively, the outcome of the serve will not be optimal (i.e., velocity, spin, placement, and reliability) (27).

KEY WORDS: coaching; overhead athlete; biomechanics

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Lower Body Stability with Upper Body Rotation



Take Care of The Details

Use Evidence To Guide
Your Assessment,
Treatment and Training
Plans

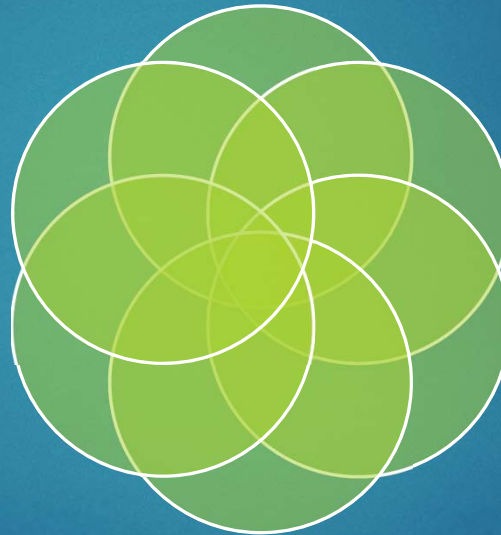
Test, Train,
Treat,
Measure -
REPEAT

Stability
Before
Strength

Ankle and Hip Need
Greater Focus During
Testing and Assessment

Focus on The
Kinetic Chain

Lower Body
First



Stability before strength

Develop unilateral stability and strength for all rotational athletes

Focus on technique of rotational development

Make sure you are able to transfer power rotationally

Focus on planes of motion training that are specific to the sport

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