Modern Tennis Movement: Learning from Rafael Nadal
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PART I – CHANGING PHYSIOLOGY, DEMANDS OF MOVEMENT AND THE CASE STUDY OF NADAL

Traditional tennis movement has been taught as involving quick, small, shuffle and adjustment steps. The traditional clay court game has been taught with additional sliding movement involving long, grinding points. However, today's matches don't involve as many long rallies as 40 years ago. Research on modern tennis movement shows today's game has some different characteristics. Points are shorter and faster creating greater demands on speed, agility and quickness.

Tennis-specific movement is generally regarded as 70% lateral, 20% forward and less than 10% backwards movement (Weber et al 2006, Kovacs 2009). That is, most movement occurs laterally on the baseline, with some movement forward or backwards. Forward movement may be slightly in front of the baseline or up to close to the net. Studies show that the average tennis point lasts 6-11 seconds and as much as 15.7 sec during the average baseline rally (Bernardi et al 1998). Playing style was a major factor in the length of rallies as shown in Table 1.

TABLE 1. STYLE VS RALLY DURATION

	RALLY DURATION	% PLAY/MATCH
ATTACKER	4.8 sec	21.0%
ALL-COURTER	8.2 sec	28.6%
BASELINER	15.7 sec	38.5%

(from Bernardi et al, 1998)

A typical rally lasts around 4.5-5.5 shots depending on surface and style of player (Kovalchik, 2017). Clay courts tend to produce the longest rally since the ball loses the most speed when it hits the clay surface. Typical running lengths are 3-4 m (Kovacs 2009, Weber et al 2007). At Roland Garros, on clay courts, it has

been found that 80% of movement is for distances under 2.5 m (Ferrauti A., Weber K 2001). Players change directions (COD) an average of 4 times during a point (Roetert and Ellenbecker 2007, Kovacs et al 2007).
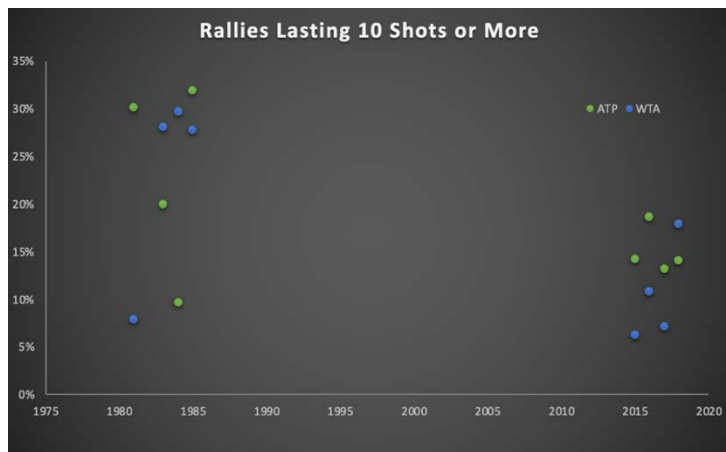

Figure 1: Rallies Lasting 10 Shots or More at Roland Garros (clay courts). Comparison of 1981-1985 vs 2015-2018 for ATP (men) and WTA (women).

Specifically, the clay court game has changed. Figure 1 shows length of rallies lasting over 10 shots comparing 1981-1985 to 2015-2018 at Roland Garros (aka French Open), the most important clay court event. Rallies have become shorter in number of shots due to the faster, more aggressive tempo. ATP (green points) refers to the men's pro tour and WTA (blue points) refers to the women's pro tour. The range from 1981-1985 was 7.9 to 31.9% of all rallies lasted 10 or more shots. On the right side of Figure 1, clay court matches from 2015-2018 had 6.2 to 18.7% of total rallies lasting 10 or more shots. Thus, rally lengths are shorter. Today, WTA and ATP professionals typically hit groundstrokes over 70 mph. Forty years ago, groundstroke ball speeds were 10-15 mph less which encouraged longer rallies and slower movement. Today, athletes are stronger and better conditioned to sustain faster swings and faster movement. Another primary change is lighter, more powerful graphite racquets and polyester strings which allow up to 25% more spin than nylon strings (Cross and Lindsey, 2011). Biomechanically, strokes are more rotational with increased angular momentum as players hit heavier spin. Table 2 shows time between groundstrokes (or baseline to baseline rallies) in several ATP matches from 1985-1989 compared to 2015-2019. For all shots, the typical time between two players' contact points was 1.451 seconds in 1985-1989 and 1.264 seconds in 2015-2018. The difference of 0.19 seconds represents a 14.8% increase in ball velocity. We can also see the average rally length predictably decrease from 4.22 to 3.64 in Table 2.

TABLE 2: GROUNDSTROKES CONTACT TO CONTACT

ATP Matches on Hard Courts

	1985-1989	2015-2019
N (# Shots)	138	177
Average Rally Length	4.22	3.64
Groundstrokes: Time - Contact to Contact		
All Shots (sec)	1.451	1.264
Topspin (sec)	1.35	1.23
Slice (sec)	1.63	1.54
Forehand (sec)	1.38	1.25
Backhand (sec)	1.45	1.27

The faster rallies require quicker movement to the ball and quicker recovery after hitting to get back into favorable court positioning. Movement even at the high school or college level requires more athletic training in explosiveness and cutting ability. Consequently, movement has changed to involve less shuffling and greater stride lengths and more powerful hip drives. Today, the best movers in tennis include Novak Djokovic, Rafael Nadal, Roger Federer, Simona Halep, Ashleigh Barty and Angelique Kerber (Tandan, 2016). Nadal, considered the greatest clay court player, represents an excellent case study.

NADAL'S CASE STUDY

Figure 2. Backhand Square Stance with Recovery Step. Photos 4-6 (right 3 photos) Nadal uses the back/right leg to swing around, plant and push back to his left.

Today's changes in the tempo of tennis require a reconsideration of how a model athlete moves. For this case study, Rafael Nadal, who just won his 12th Roland Garros title, is considered. Figure 2 shows Nadal's typical topspin backhand groundstroke. At right, he is in an athletic (two-point) stance and already has the racquet slightly tilted or positioned to the backhand side. In the second photo, he starts his unit or shoulder turn. We can see the stance changes from facing the net (aka *open stance*) to about 30° rotated to his right or backhand. Nadal's weight shifts to the backfoot and in the third photo he uses a *pivot step* with the left foot to get his *square stance* parallel to the sideline. Photo 4 shows the contact point in the square stance with his weight shifted forward onto the left foot. In the last two photos, one can see the right foot swinging around back into an open stance with the racquet finishing over his left shoulder. Nadal's weight shifted slightly to the left or center of the court. That allows his left foot to push back toward the court center for the next shot. The typical swinging around of the rear foot is known as the *recovery step* which allows the outside (or right, in this case) foot to push the athlete back towards the center of the court into a better court position.

Today's faster speeds require more rigorous training for movement not only toward the ball but also after hitting the ball. A more powerful recovery step is a necessary essential in movement in the modern tennis game. The basic recovery step shown in Figure 2 is best for moderate distances in lateral movement. Nadal's center of gravity is relatively high and the moderately wide stance creates modest ground forces. Typically, this basic recovery step is used over distances less than 3 m and under 15 kph. Shorter steps and shuffling can be used for distances under 2 m. If there is time pressure or greater distances, the athlete must use greater forces for faster movement.

Figure 3. Open Stance Forehand with a Crossover Step and Mogul Step for Recovery. Photo 2 shows a cutting move or crossover step. Photos 4-6 show the mogul recovery move. Note length of strides.

Figure 3 shows an example at greater distances and speeds. In this case, Nadal runs laterally toward the forehand side. The first photo shows a significant weight shift, known as a *gravity step* where the left leg shifts under the body to allow the upper body and head to effectively lean to the direction of movement or in this case, to the left. The second photo shows a powerful hip action as Nadal uses a crossover cutting move, or *crossover step* for greater acceleration and longer strides. The last three photos (photos 4-6) on the right show an open stance with a short slide into a *mogul move*. Photo 4 shows just before contact where the feet have slightly left the ground which allows a quick shift of the toes inwards back towards the center of the court as shown in photo 6. This quick shift of toe/feet positions in photos 4-6 is known as a *mogul move recovery*. The toes quickly turn inward and the weight shifts quickly back toward the center of the court.

The footwork terms including pivot step, gravity step, crossover step and mogul move are defined by several sources including Kovacs (2012, 2018) and Bailey (2016).

In Figure 3, Nadal takes only 2 large steps and the mogul move recovery. The two were a long crossover stride (photo 2) and then a wide step into the open stance (photos 3). The slide and mogul move are effectively a braking action and change of direction. Players like Djokovic and Nadal can typically get to either sideline with only 2-3 strides. Tennis Australian's GIG (Game Insight Group) recorded Nadal at 26.84 kph over 3 m distance. The player with the highest speed over 3 m was Djokovic at 36.02 kph (Tandan, 2016) as shown in Table 2.

TABLE 2: SPEED OVER 3+ METERS (SELECTED ATHLETES)

Player	Top Speed (kph)	Avg Top Speed (kph)
WTA		
Simona Halep	23.04	13.69
Carla Suarez Navarro	22.48	13.56
Dominika Cibulkova	21.98	13.43
Agnieszka Radwanska	21.82	13.79
Angelique Kerber	21.46	14.27
Garbine Muguruza	21.32	13.21
Maria Sharapova	20.61	13.60
Serena Williams	20.52	13.50
ATP		
Novak Djokovic	36.02	14.89
Andy Murray	34.87	15.89
Grigor Dimitrov	28.91	15.05
Stan Wawrinka	27.66	15.17
Milos Raonic	27.28	15.36
Kei Nishikori	27.17	14.52
Rafael Nadal	26.84	15.38
Roger Federer	26.03	15.55

Source: Tandon (2016)

One of Nadal's favorite tactics is the serve and forehand combination. Often known as the *serve+1*, this offensive tennis tactic often favors the more powerful forehand over the backhand. Most players hit more powerful forehands than backhands. Effectively, the player attempts to use two offensive strikes in the serve and forehand to win the point quickly. With the serve+1 or serve+forehand combination, players like Nadal often elect not to play the backhand even if the ball is over on that side. Instead, Nadal runs around the backhand to play the forehand as shown in Figure 4.

Figure 4. Running Around the Backhand to Play the Forehand. Nadal is moving to his right using a Reverse Lateral Crossover (photo 1) where the left leg goes behind the right leg. In Photo 3 he uses a Forward Crossover with the left leg again to keep sideways into the square stance (Photo 4). Photos 5-6 show a powerful stride as he hits the forehand.

The fastest way to move laterally isn't shuffling but using crossover steps as seen in Figure 4. In photo 1 (left), Nadal uses the reverse crossover to move backwards laterally or to his right and keep the body aligned for the forehand. The alternative is using the slower shuffle steps which covers approximately 30% less distance. Some athletes use a more basic *drop step* where in Nadal's case, the left foot would move directly behind the right foot but not cross over. In order, shuffling is the slowest, drop step is intermediate speed, and the reverse crossover (which Nadal chooses in photo 1) is the fastest to run around the backhand. Photo 3 shows another crossover step, a forward crossover to again allow the body to keep sideways into the square stance (photo 4). Photos 4-6 show the forehand stroke from a powerful square stance. Note how wide and high Nadal's feet are in Photos 5-6. Clearly Nadal is playing a powerful offensive forehand in this photo sequence.

The important points to take away in the analysis of Nadal include:

1. Tennis movement toward the ball over distances of 3-4 meters requires longer strides including crossover steps rather short shuffling sides.
2. After a stroke, tennis movement often requires recovery steps with greater eccentric forces to push back into the court. Discussed were two variations: a simple recovery step and a mogul step (at higher speeds).

PART II. PRACTICAL TRAINING EXERCISES FOR TENNIS ATHLETES

From analysis of Nadal's movement, one can summarize 3 general movements tennis athletes can be trained to utilize.

    A. The basic recovery step and mogul move recovery involving ability to change directions and sustain loads during eccentric overload.
    B. Crossover steps to develop faster speeds.
    C. Initial acceleration towards the ball with an external stimulus.

Following are some useful exercises that can develop faster and quicker movement in tennis. These exercises incorporate 1) initial acceleration, power development output and development of ground forces, 2) crossover steps and continued acceleration, 3) eccentric movement and recovery/mogul steps, 4) change of directions, and 5) external stimulus which increases realistic physical demands on athlete.

    1. Skaters Plants with Single Cone – is a simple exercise to develop the recovery step and mogul move using weight shift during light eccentric overload. The athlete shifts the outside leg well laterally into a modest lateral lunge keeping the inside foot by the cone. The athlete reaches down to touch the cone and springs up and shifts the legs the opposite direction and gets low again. Using a skating slide board produces similar movement. The athlete can do a set of 16-20 plants/touches.
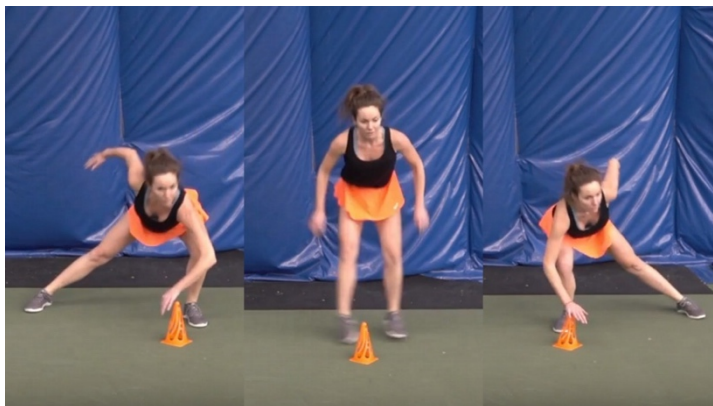

Figure 5. Skater Plants with Single Cone.

    2. Skater Plants and Shuffle with Two Cones – is a simple exercise to develop the recovery step and mogul move using weight shift during light eccentric overload. It has a similar set-up to exercise #1 except two cones are place 1-2 m apart. The athlete shifts the right leg well laterally into a modes lateral lunge keeping the inside or left foot by one cone. The athlete reaches down to touch the cone with the left hand and springs up and shuffles laterally (to the left) to the second cone. The athlete shifts the left leg out in the opposite direction, keeping the right leg near the cone and gets low again and touches the cone with the right hand. Repeat. The athlete can do a set of 16-20 plants/touches.
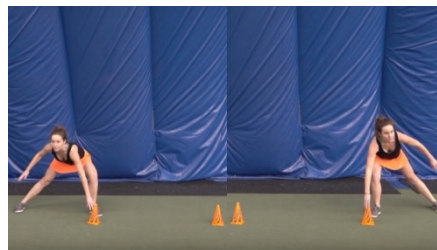

Figure 6: Skater Plants and Shuffle with 2 Cones.

3. Lateral Hops with Sprint – is a natural progression after skater plants. The athlete starts outside the sideline and hops over the sideline with feet together, making sure the head is centered over the sideline. The athlete hops back to the outside keeping the head centered over the sideline. Note in the two center photos in Figure 8 show the natural lean. The athlete quickly pushes off the outside foot and turns the inside foot inwards into a quick sprint. Sprint about 4 m and decelerate to the other sideline. Repeat in the other direction back. A set might have 12-16 sprints with 10 sec rest between each sprint.

Figure 8: Lateral Hops with Sprint

4. Base Rotations – is useful to develop the recovery step and the mogul move. It is also a good intermediate warm-up drill that involves quickly shifting the feet and swinging the arms in opposite directions. Knees should remain slightly bent as feet quickly rotate about 30-45° with arms/shoulders in opposite direction. Quickly spring back (feet landing simultaneously) and rotate in the opposite direction. Tempo should be about 30-40 hops in 20 seconds.

Figure 7: Base Rotations

5. Crossover Skips – "hip skips" develops the crossover move for faster movement after the initial split step. It is an intermediate to advanced skill which requires good flexibility and coordination. When skipping, make sure the knee gets hip high and swivels across in the direction of movement. Skip about 6-8 times (about the width of the tennis court) in one direction and change directions. A set can last about 30 seconds.


Figure 8: Crossover Skips

6. Half-Court Repeaters – time for 20-30 seconds. Start with the racquet involve touching one sideline. Quickly move and touch the center line. Repeat to the first sideline. Repeat back to the center line. It is an intermediate conditioning drill (when done in multiple sets, e.g, 4 x 30 sec) but also for quick COD (change of direction) movement. Most athletes can do 24-34 touches in 30 seconds. Rest 45-60 seconds and repeat. For a more tennis-specific drill, do in 20 second intervals or use a stopwatch for 8-16 touches (6-15 sec) which more closely mimics the length of a tennis point.


Figure 9: Half-Court Repeaters

7. Lateral Box Shuffles – develops strength and power in the recovery step, mogul move and initial split step or acceleration towards the ball. Use a box less than knee high which allows faster repetitions. The athlete starts on one side of the box with the right foot on the ground and the left foot on the box. The athlete uses the right leg on the ground to push off and land on the left foot on the other side of the box while the right foot lands on the box. Quickly push off again back into the original position. Repeat at a tempo of about 30 hops in 20 seconds.
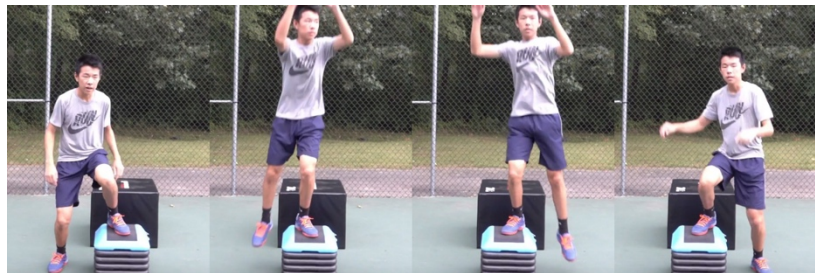
Figure 10: Lateral Box Shuffle

8. Alley Bounds – start with feet on one side of the doubles alley as shown in Figure 11. Bound across the doubles alley landing on the outside foot. Hold the landing on that one foot for a second. Push off again across the doubles alley and land on the outside foot. Repeat. Sometimes called alley hops, it's more a bound since the start is off one foot and the landing off the other foot.
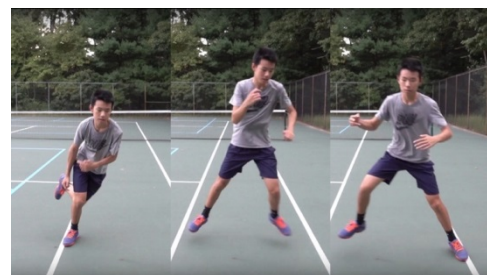
A set is typically about 16-20 bounds.

Figure 11: Alley Bounds

9. Drop Jump and Sprint with Stimulus – is a great drill for the split-step and improving first step speed. A tennis-specific variation is start on the box and lightly spring off the box with both feet (rather than step off with one foot). Just as the athlete leaves the box, a verbal external stimulus is called (e.g., a call "left" or "right") or a visual external stimulus is used (e.g, ball toss left or right or finger pointing either way). The athlete then lands on both feet, but a split second earlier on the foot farther away from the intended direction and pushes off into a sprint. Just before landing, the athlete slightly externally rotates the hips in the direction of the sprint. Sprint about 3-4 m and walk back to the box and repeat. A set can have 8-12 jumps.

Figure 12: Drop jump and sprint with stimulus

10. Base Rotations and Sprint with Stimulus – exercise 4 showed base rotations but a progression can include a visual external stimulus such as a ball. The athlete does a series of base rotations while a partner can toss a ball. The athlete reads and reacts pushing off with the foot farthest away from the toss and sprints to catch the ball before it bounces twice. A set can have 8-12 sprints.

11. 180° Spin and Sprint with Stimulus – the athlete starts at the baseline with back to court and partner. Partner calls "spin" (verbal cue) and the athlete jumps 180° around to face the court as the partner tosses (visual external stimulus). The athlete sprints to the ball to catch it before it bounces twice. A set can have 8-12 sprints. Partner may use 2-3 balls in which the balls are release just before the athlete catches the earlier ball. Athlete may have to change directions (COD) to get to the second and third balls. Partner should toss so that most movement is lateral.

Figure 13 (left). Base Rotations and Sprint with Stimulus.

Figure 14 (right). 180° Spin and Sprint with Stimulus.

REFERENCES

Bailey, D. https://baileytennisfootwork.com/wp-content/uploads/2016/07/The-Bailey-Method-Explained.pdf 2016.

Bernardi M, De Vito G, Falvo ME, et al. Cardiorespiratory adjustment in middle-level tennis players: are long term cardiovascular adjustments possible? Lees A, Maynard I, Hughes M, Reilly T, editors.Science and racket sports II. London: E & F Spon, 1998:20–6.

Cross, R., Lindsey, C. Which strings generate the most spin? January 30, 2011 http://twu.tennis-warehouse.com/learning_center/spinexperiment.php

Eng, D. unpublished data 2019.

Eng, D. unpublished data 2019 based on data http://www.tennisabstract.com/charting/

Ferrauti A., Weber K. Stroke situations in claycourt tennis. *Unpublished data.* 2001.

Kovacs, M. Applied physiology of tennis performance. Br J Sports Med. 40(5): 381–386, 2006.

Kovacs M, Chandler WB, Chandler TJ. *Tennis training: enhancing on-court performance.* Vista, CA: Racquet Tech Publishing; 2007.

Kovacs, M. Movement for Tennis: The Importance of Lateral Training, Strength and Conditioning Journal 31(4):77-85, 2009.

Kovalchik, S, Spence, G. http://on-the-t.com/2016/12/03/aoleaderboard-rally-lengths/

Game Insight Group at Tennis Australia, 2016.

Kovalchik, S, Spence, G. http://on-the-t.com/2017/01/26/ao2017-rally-lengths/

Game Insight Group at Tennis Australia, 2017.

Roetert EP, Ellenbecker TS. *Complete Conditioning for Tennis.* 2nd ed. Champaign, IL: Human Kinetics; 2007.

Tandon, K. Tennis Australia: Djokovic, Halep are the Sport's Fastest Players, http://www.tennis.com/pro-game/2016/11/fastest-players-tennis-djokovic-halep-murray-kerber-dimitrov/62637/ based on Game Insight Group at Tennis Australia

Weber K., Pieper S., Exler T. Characteristics and significance of running speed at the Australian Open 2006 for training and injury prevention. *Medicine and Science in Tennis* 12(1):14-17, 2007.