ITF International Tennis Federation

COACHING & SPORT SCIENCE REVIEW

www.itfcoachingreview.com. April 2026. 34th Year. Issue 98. ISSN 2225-4757

Issue 98

COACHING & SPORT SCIENCE REVIEW

www.itfcoachingreview.com. April 2026. 34th Year. Issue 98. ISSN 2225-4757

Editorial

Luca Santilli & Miguel Crespo

Tennis Development, Development Department, International Tennis Federation, London, UK.

Welcome to the 98th issue of the ITF Coaching & Sport Science Review, the first edition of 2026, marking an impressive 34 years of continuous publication and contribution to the advancement of our sport.

This issue places a strong emphasis on topics such as the game development pathway, the progression from brain to court, the implications of tennis and shoulder injuries, the impact of rally length on break points, strategies on creating a tennis culture in national federations, reasons for incorporating time constraints in coaching, anthropometric comparison of female players, and the relationship between overhead ball throw and maximal serve speed, among others.

In this editorial, we also spotlight several key ITF initiatives designed to reinforce the global delivery of effective tennis development programmes. These efforts sit at the heart of the ITF's mission and reflect a long-term commitment to building inclusive pathways, supporting coaches, and ensuring that every player—regardless of age, ability, or background—has access to meaningful opportunities within the sport (ITF, 2025).

A Rising Tide for Tennis: Participation Surges and a Global Game Strengthens

The latest participation figures published by the United States Tennis Association paint an uplifting picture of a sport in full flight. Tennis in the United States has not only maintained its momentum—it has accelerated dramatically. In 2025 alone, 1.6 million new participants took to the court, pushing national participation to a record 27.3 million players. This surge continues an extraordinary five-year trend: since 2019, nearly 10 million Americans have joined the sport, a remarkable 54% increase that reflects tennis's widening appeal and cultural relevance.

What is perhaps most encouraging is the breadth of this growth. In 2025, 4.9 million people picked up a racket for the first time, a 9% rise that underscores the sport's ability to welcome new players of every age and background. Women's tennis participation grew by 1.1 million compared with the previous year, while historically under represented communities saw significant increases as well—including more than 450,000 additional Black/African American players, over 550,000 Hispanic/Latino players, and 260,000 Asian/Pacific Islander players joining the game. These numbers reveal a sport expanding not only in size but in diversity, accessibility, and cultural reach.

The story these figures tell is clear: tennis is thriving, its community is broadening, and its future is brighter than ever. The commitment to expanding participation globally is not just an aspiration—it is becoming a reality, one player at a time.

Expanding Opportunity: How the Grand Slam Player Development Programme Strengthens Global Pathways

One of the most powerful drivers of competitive equity in world tennis continues to be the ITF operated Grand Slam Player Development Programme (GSPDP). This season, the programme will support 65 professional and junior athletes from a wide range of nations, providing targeted financial grants that enable them to access international competition—including, for many, their first steps toward the Grand Slam stage.

Established in 1986 through a shared commitment by the Grand Slam tournaments and the ITF, the GSPDP was built on a simple yet transformative ambition: to ensure that promising players from underrepresented nations and regions have the same opportunity to rise as their peers from traditional tennis strongholds. Since its inception, the programme has contributed more than US$68 million to player development—an investment that has altered careers, expanded pathways, and strengthened the sport's competitive diversity.

The programme's impact is clearly visible at the highest levels. This year, 104 current and former grant recipients—representing men's, women's and junior categories—will compete across the Australian Open draws. Their presence on one of the sport's biggest stages is a testament to the power of strategic support and the global reach of the programme.

This season, players from Norway, Bulgaria and Austria will receive the programme's highest individual awards of US$50,000, helping cover the extensive travel and competition costs required to transition toward the professional ranks. A further group of players from South America, Europe, Asia, Africa, and Oceania will benefit from US$25,000 grants, reaching nations including Serbia, Andorra, Brazil, Peru, Kazakhstan, Puerto Rico, Lithuania, Denmark, Sweden, Mexico, Romania, Switzerland, Bulgaria, Ecuador, Bolivia, Croatia, Portugal, Finland, Paraguay, Colombia, Estonia, Turkey, China, Ukraine, Hong Kong, Argentina, Latvia, India, Bosnia and Herzegovina, Poland and Chinese Taipei.

The final group—receiving US$12,500 grants—includes players from Argentina, Thailand, Morocco, Mexico, New Zealand, Senegal, South Africa, and the Dominican Republic, further demonstrating how broadly the programme touches every region of the tennis world.

Eligibility for these grants is carefully structured to benefit players at critical points in their development: junior players aged 14–18 and emerging professionals aged 18–22. The programme's long-term impact is undeniable. In 2025 alone, eight GSPDP supported athletes broke into the Top 100, including standouts from Brazil and the Philippines, who ended the season ranked inside the ATP and WTA Top 50 respectively—a remarkable achievement that underscores the programme's value .

Uniting for Inclusion: How New Global Partnerships Are Shaping the Future of Disability Tennis

In a landmark moment for the future of inclusive sport, the International Tennis Federation (ITF) has strengthened its global commitment to accessibility and opportunity through two significant agreements—new Memoranda of Understanding (MOUs) with both the International Sports Federation for Athletes with Intellectual Impairment (Virtus) and the International Committee of Sports for the Deaf (ICSD). Together, these partnerships mark a decisive step toward a more equitable tennis landscape, one where athletes of all abilities can participate fully and pursue excellence.

The MOU with Virtus aims to deepen the ITF's understanding of tennis for athletes with intellectual impairment—from governance and regulation to classification systems and the practical environment required for high quality participation (Young et al., 2012). Through this partnership, the ITF will examine how the sport is organised globally and identify where new synergies, including alignment with wheelchair tennis, can enhance development. Virtus, which oversees a comprehensive annual programme of regional and world competitions, will in turn benefit from the ITF's expertise in governance, regulation and pathway development. Together, both organisations will work to strengthen coaching projects, expand participation, enhance event promotion and engage national associations more effectively (Hardoy et al., 2011).

Parallel to this, the newly signed MOU with the ICSD reinforces the ITF's commitment to supporting Deaf Tennis, particularly through understanding its governance models, participation pathways, and regulatory structures (Young & Browne, 2009). The collaboration will bolster the ICSD's leadership in major international events, including the Summer Deaflympics, the World Deaf Tennis Championships, and Deaf Tennis Open tournaments. By sharing expertise around classification, coaching, development and competition delivery, the ITF and ICSD will work jointly to strengthen the Deaf Tennis ecosystem and ensure that athletes can progress seamlessly from grassroots entry to elite level performance (Young, 2013).

Taken together, these partnerships represent more than administrative collaboration—they are a meaningful investment in the future of inclusive tennis. By sharing knowledge, resources and structures, the ITF, Virtus and the ICSD are laying the groundwork for sustained growth across all disability tennis disciplines. Their work will open doors for athletes around the world, creating stronger pathways, more competitive opportunities and a vibrant structure that supports long term development (Hardoy et al., 2011).

As these collaborations move forward, one message is clear: tennis is not only growing—it is evolving into a richer, more accessible global sport, determined to ensure that everyone, everywhere, has the chance to step onto the court and thrive (Orbán-Sebestyén et al., 2023).

A New Era of Fast Format Innovation: ITF Partners with Tie Break Tens to Inspire the Next Generatio n

The International Tennis Federation's latest partnership marks a bold step into the future of tennis, as the ITF formally recognises Tie Break Tens (TB10) as its official partner for short format tennis. This collaboration not only cements TB10's role as the "home of the tie break," but also signals a strategic investment in formats that excite modern audiences and encourage players of all ages to stay connected to the sport.

Since its debut in 2015, Tie Break Tens has transformed short format tennis into a global spectacle. Staged at iconic venues including Madison Square Garden, Indian Wells and the Australian Open, and featuring many of the sport's most recognisable champions, TB10 has welcomed more than 100 professional players in 13 elite tournaments, distributing over US$2 million in winner-take-all prize money. Its appeal is unmistakable: a rapid-fire, high intensity competition where eight or sixteen players battle through a series of single tiebreak matches, creating a full two-hour tournament packed with action .

For the ITF, the benefits extend well beyond entertainment value. Short format tennis offers a powerful tool to reengage lapsed players, attract new communities to the sport and build confidence in competitive environments, particularly among juniors. ITF President David Haggerty noted the potential impact of introducing TB10 through the JTI pathway, emphasising its ability to inspire young athletes and prepare them for high-pressure moments within traditional match play.

With this partnership, TB10 takes on a formal role across the global tennis ecosystem—fuelling participation, enriching player development and adding yet another exciting dimension to the sport's competitive landscape. By embracing innovation while respecting tradition, the ITF continues to strengthen tennis for the next generation, ensuring it remains vibrant, relevant and accessible to people everywhere (Crespo et al., 2021).

Looking Ahead: A Personal Note from Luca Santilli

As I bring this edition of the CSSR to a close, I would like to share some personal news with all of you. After 35 years dedicated to the growth of tennis—across the FITP, the ITF, and in partnership with so many of you around the world—I have decided that the time has come for me to step away from my full-time role at the ITF.

Since joining the ITF in 1999, I have had the privilege of working with exceptional colleagues, National Associations, Regional Associations, and partners committed to strengthening our sport. The journey has taken me to more than 100 countries and given me the honour of contributing to development programmes and shaping the ITF's global development strategy. These experiences, and the relationships formed along the way, have been the highlight of my career.

While I am retiring from my full-time responsibilities at the end of May, my passion for tennis and sport remains unchanged. I will continue to stay involved in new and different capacities, and I look forward to supporting the sport in ways that allow me to balance my time with family and personal pursuits. Injuries permitting, I hope to get my own tennis back on track, and I will also be dedicating time to another passion of mine—sailing—as I begin preparing for a Mediterranean voyage in 2027. My time will be happily split between the UK and my native Italy.

I want to express my heartfelt thanks to everyone I have had the privilege to collaborate with over the past decades. The work we have done together has been meaningful, and I am proud of the foundation we have built for the future. The ITF will soon begin the process of identifying a successor, ensuring continuity and ongoing progress for our sport.

Thank you once again for your trust, your partnership, and your friendship. It has been an honour to serve this community, and I look forward to supporting tennis in new ways in this next chapter.

Closing

Finally, we are pleased to open the year with this new edition of the ITF Coaching and Sport Science Review. We hope the reflections and perspectives shared here offer inspiration and stimulate constructive dialogue. This issue highlights a selection of key projects the ITF is driving to support the growth and development of tennis across the globe.

We also warmly encourage the submission of new articles through our dedicated platform. Our gratitude extends to all contributors whose work enriches this publication, as well as to everyone who has taken the time to share their expertise. Full submission and publication guidelines can be found on the platform and in the "Latest Issue" section of the ITF Academy.

We hope you enjoy exploring this first edition of the year and find it both insightful and engaging.

REFERENCES

Hardoy, M. C., Seruis, M. L., Floris, F., Sancassiani, F., Moro, M. F., Mellino, G., Lecca, M. E., Adamo, S., & Carta, M. G. (2011). Benefits of Exercise with Mini Tennis in Intellectual Disabilities: Effects on Body Image and Psychopathology. In Clinical Practice & Epidemiology in Mental Health (Vol. 7).

ITF. (2025). ITF Constitution. ITF Ltd. London. https://www.itftennis.com/en/about-us/governance/rules-and-regulations/?type=constitution

Orbán-Sebestyén, K., Szilárd, Z. S., Farkas, J., Ökrös, C., & Roswal, G. M. (2023). Attitude of elite tennis coaches working with athletes with intellectual disabilities participating in Special Olympics. Journal of Intellectual Disability Research, 67(2), 123–135. https://doi.org/10.1111/jir.12996

Young, J. A. (2013). Coaches´ Perspective on the Value of Working with Deaf Children. The Journal of Medicine and Science in Tennis, 1(18), 21–24.

Young, J. A., & Browne, A. (2009). Teaching Tennis to Deaf Children: A Review of an Australian-based Program. ITF Coaching & Sport Science Review, 17(49), 9–12. https://doi.org/10.52383/itfcoaching.v17i49.636

Young, J. A., Browne, A., & J. Pearce, A. (2012). The psychology of teaching tennis to persons with an intellectual disability. ITF Coaching & Sport Science Review, 20(58), 26–29. https://doi.org/10.52383/itfcoaching.v20i58.430

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 5-10
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.753

Tennis game development pathway

Hrvoje Zmajic

Croatia

ABSTRACT

The Pathway describes how the game evolves over time, progressing through specific stages shaped by the interactions of various factors that influence the game. When players remain in competitive tennis, they will go through six distinct stages of game development — "leaps" — with each stage marked by the emergence of something qualitatively new that wasn't present before. "Leaps" are a familiar concept when we look at human development. For instance, as children grow and acquire new skills, their ability to think abstractly or engage in complex social relationships emerges from earlier, simpler behaviors. When applying the Game Development Pathway, the coach evaluates the current level of the player's game and identifies the "drivers" essential for progressing to the next stage(s) of game development. Understanding the 'Pathway' should help coaches recognize these stages and adjust their training approach to develop the player's game.

Key words: Game development, complex systems, body and mind development, planning.

Received: 11 June 2025

Accepted: 27 January 2026

Corresponding author:
zmajic@me.com

INTRODUCTION

Have you ever experienced a scenario as a coach where, despite working hard with a player, there seems to be little improvement — or even a decline in performance? Then, unexpectedly, just when you lose faith in their abilities, the player achieves remarkable progress. According to learning theory, to demonstrate improved performance, a player must integrate different elements or add a new quality, which are typically not developed simultaneously (Andrilović & Čudina, 1996).

Given that both the tennis game and human development are complex systems influenced by various factors, it's reasonable to expect that players will experience periods of rapid improvement, combined with fluctuations in performance, and sometimes even declines (Qiu et al., 2021; Gray, 2017).

This article proposes the tennis game development pathway based on dynamic systems theory, consisting of six distinct stages through which players progress. Each stage is characterized by the emergence of new patterns, behaviours, or abilities not explicitly present in earlier stages.

At each stage of game development, players demonstrate the competencies required to perform effectively in the match environment. These competencies result from integrating the knowledge and skills acquired during practice (Takahashi, 2022).

By identifying the stages of game development, associated playing competencies, and essential skills for player progression, coaches can anticipate individual player development and define an optimal development pathway.

Long-term development of tennis game considered as dynamic system

When considered as a dynamic system, the long-term development of a tennis game refers to how the competitive ability evolves and changes over time, not only during a single match but also across a player's career (Crespo, 2009). The evolution of competitive ability is influenced by numerous interrelated factors that shift and transform continuously, often leading to nonlinear changes.

It incorporates multiple interacting elements such as physical growth, psychological development, adaptations to external conditions, tactical evolution, coaching, and competition (Torrents & Balague, 2006). Over time, these factors interact in complex and sometimes unpredictable ways, leading to shifts in how the game is played at various levels. Viewing this process through the lens of dynamic systems theory (DST) helps us understand how a player's game evolves, not through a single, linear trajectory, but through a constantly shifting, interactive set of variables (Farrow & Robertson, 2016).

- Physical Growth: A player's body changes as they grow, and their physical abilities (e.g., speed, strength, endurance, flexibility) evolve. Children may experience rapid changes in these factors, influencing their motor abilities in a non-linear manner. During adolescence, physical changes related to puberty, such as growth spurts or hormonal changes, interact with brain structure and function, affecting behavior, cognition, and emotional responses (Schoenborn, 2001).

- Cognitive Development: Shifts in cognitive development enable players to understand and apply more sophisticated tactical concepts (Rosenbaum et al., 2001). DST suggests that cognitive abilities, such as memory, reasoning, and problem-solving, develop in a non-linear way and are influenced by both biological maturation (e.g., brain growth) and environmental experiences (e.g., interactions with caregivers, education, culture) (Riley & Holden, 2012; Brito, 2020).
- Emotional Maturation: Emotional regulation helps players cope with the psychological pressure of the game (Mansel et al., 2023). This process is shaped by biological factors (such as the maturation of brain regions like the prefrontal cortex) and environmental influences (such as coaching, peer relationships, and socio-cultural expectations).
- Motivation and Drive: A player's motivation evolves over the course of their career. Early on, a player enjoys being with peers; as a teenager, the desire to improve intensifies; later, motivation becomes more about the passion to excel in competition (Elderton, 2022).
- Tactical Evolution: Over time, strategies and tactics employed in the game evolve (Sanchez-Mencia et al., 2023). A shift occurs from simple "just returning the ball" to using space, shortening response times, and applying individual patterns of play according to body type and preferred playing style.
- Tennis Skills: A player's skills (e.g., serve, forehand, backhand, volleys, movement) develop depending on teaching methods, environment, and equipment. The environment, such as playing on different surfaces (e.g., clay, hard courts, grass), and equipment like smaller rackets or softer balls, significantly impacts skill acquisition (Farrow & Reid, 2010; Buszard et al., 2020).
- Competition: The level of competition also affects player evolution (Perri et al., 2023). As players progress, they gain a better understanding of their strengths and weaknesses. Success and failure in competitions provide feedback that refines their techniques, mental resilience, and strategies, creating a self-improving cycle. For example, a player may adjust their style after losing to a specific type of opponent.

By considering these factors, we can understand why the competitive ability changes over time and moving toward specific stages. These stages are the result of interactions among various factors influencing game development, which, according to DST, fundamentally revolves around the emergence of something qualitatively new that wasn't there before (Spencer, 2011).

The qualitative change occurs when a new "driver" or combination of "drivers" is integrated into the game (Chart 1). The "drivers" relate to areas such as growth and maturation, mental skills, tactics, techniques, and motor skills.

For instance, for a beginner player to establish the "Cooperative rally" (Zmajic, 2003), they must integrate the ability to judge and respond to different ball trajectories, develop footwork precision for establishing balanced hitting positions, and control racket face orientation to manage the ball's direction while understanding the value of cooperation.

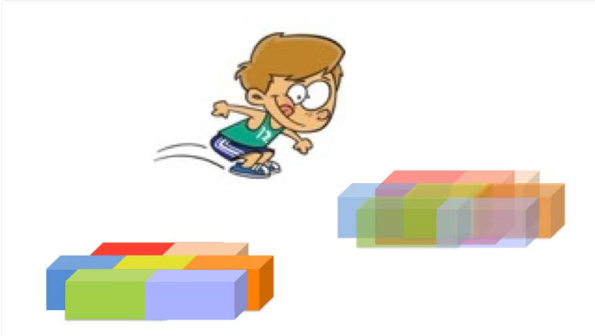


Figure 1. *Accumulation of the 'drivers' needed for the leap to the next level of the game.*

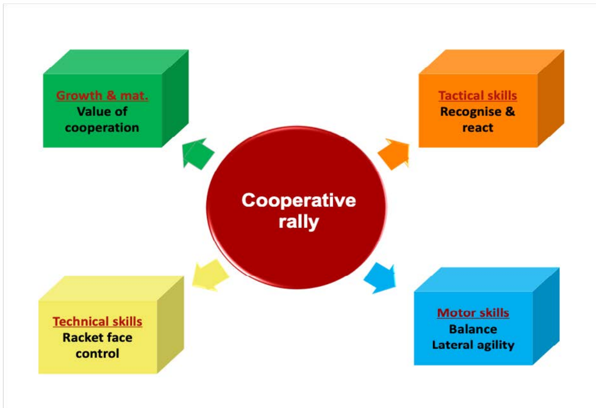


Figure 2. *Drivers related to 'Cooperative rally'.*

Whether it's perfecting stroke techniques, adjusting strategies during a match, or improving motor coordination, "drivers" guide a player's progression and facilitate their adaptation to the demands of various stages in game development. By focusing on developing the essential "drivers" at the right time, a player will be prepared to be able to demonstrate the required playing competencies during match play.

Stages of game development

Traditionally, "game development" relates to the generic model of athlete development — known as the "Long-Term Player Development Model" (LTPDM) (Tennis Canada, 2011). This model is directly tied to the physical and psychological standards of different stages in child and human development.

LTPDM provides insights into the causes of change between generic stages by identifying common laws of human growth and maturation. As a result, it defines "windows of opportunity" for developing skills needed in a particular sport.

By considering these "windows of opportunity," the "Tennis Game Development Pathway" identifies the "drivers" and "playing competencies" that enable a coach to anticipate and recognize a player's "leaping" to the next stage of the game (Table 1).

Table 1
Comparison of Long-term player development model (LTPDM) and Tennis game development pathway (TGDP).

	Long term player development model	**Tennis Game Development Pathway**
Stages of development	Described by characteristics of kids mental and body development	Described by game characteristics
Source of change	Describes causes of change	Describes qualitative changes in the Game
Elements' development	Describes possibilities („windows of opportunities ")	Describes criteria ('drivers' and 'playing competencies) for recognizing development
Standards	Related to average mental and body development	Related to achieved stage of game development
Process	Development of elements with the hope that the next level of the game will be achieved	Identify elements needed for particular Game level
Game	Look at the skills and abilities separately	Relates the skills and abilities to the game development
Consequences	„User manual"– What can be done at certain age!	„Process manual "– What to do to reach next level "

Development of competitive ability is characterized by the phenomenon of emergence, where new patterns, behaviours, or abilities arise that were not explicitly present in earlier stages of a player's game (Spencer et al., 2011). As players integrate new skills, techniques, and mental strategies, they undergo a qualitative leap that significantly transforms their performance. The evolving mental and physical capabilities of a player—combined with newly acquired technical skills and the specific characteristics of the performance environment (such as court size and equipment)—create opportunities for the emergence of novel solutions in information processing and action execution (Gibson, 1996).

This shift is not a gradual, linear progression, but rather occurs suddenly at key moments in a player's development—these are the "leaps" referenced earlier in the article. Such qualitative changes are not merely the result of improving isolated skills, but the outcome of complex, adaptive changes driven by the dynamic interaction between the child and their environment (Warren, 2006).

The stages outlined in the Tennis Game Development Pathway reflect these developmental leaps of competitive ability in a structured way. Each leap corresponds to a new set of drivers—physical, mental, tactical and technical—that enable players to transition to the next stage of their development.

Table 2 presents the six stages of competitive ability that young tennis players typically progress through, from beginner to advanced levels. Each stage highlights specific essential driver(s) and the new qualities that emerge as players mature in their game.

Application of the Tennis Game Development Pathway

When applying the Game Development Pathway (Chart 3), the coach should begin by evaluating the player's current level of play. The next step is to focus on acquiring the essential 'drivers' that enable progression to the next stage(s) of game development. Once these drivers are identified and consistently demonstrated in practice, a transition to the next level can be anticipated.

Figure 3. *Application of the Tennis Game Development Pathway.*

However, the leap to the next level is confirmed through (official) competitions, where the coach can evaluate whether the required playing competencies have been achieved. These playing competencies reflect the integration of several 'drivers' into observable behaviours during (official) matches and serve as evidence that the player has reached the subsequent stage of game development (see Table 3).

Playing competencies can be assessed through either subjective expert evaluation or objective, measurable indicators that help determine the playing level of different tennis players (Kovalchik & Reid, 2018). These competencies are identified through the analysis and observation of performance indicators (e.g., stroke efficiency) and other data (e.g., temporal characteristics) that offer objective insights into a player's efficiency and effectiveness (Takahashi, 2022).

The enclosed table below presents the standards of playing competencies for the "Competitive rally" stage across different game situations. Each playing competency incorporates multiple underlying 'drivers' that manifest as observable behaviour patterns within the match context.

Table 2
The ages in the table indicate timeframe from which the essential 'drivers' are usually ready to enable the leap to the next level of the game. These ages should be viewed as guidelines only, as individual variations can occur depending on factors such as talent, training volume, and other circumstances.

Stage of Game development	Description	Essential driver(s) and 'new qualities'
Competitive Rally (from 6/7 years)	At this stage, the outcome of a rally becomes important to players, and they begin to show a strong desire to return even very difficult balls back into the court. From a tactical perspective, consistency and accuracy become the key strategies for winning points.	Driver(s): Understanding the value of competition—players start to recognize the importance of the score and playing to win. New Quality: Playing for the score—players understand that rallies have a purpose beyond simply hitting the ball back and forth.
Using open space (from 8/9 years)	At this stage, players can create and exploit open space. By combining different ball trajectories and short balls, players can move opponents out of their comfort zones and provoke errors.	Driver(s): Inductive thinking— the cognitive process of drawing conclusions from specific observations or patterns. New Quality: Understanding/using shot combinations—players start to recognize how they can combine different shots (e.g., directions, spins) to move opponents around and dominate the point.
Using space and time (from 11/12 years)	In addition to creating pressure by using space, players at this stage are also capable of dominating their opponents by taking time away using offensive techniques. As a result, the opponent's available response time to react and prepare for the next shot is significantly reduced. Examples of such offensive techniques include playing on the rise and using drive volleys from the mid-court.	Driver(s): Offensive technique—playing on the rise, drive volleys etc. New Quality: Taking time away from the opponent—players use 'offensive technique' that reduce the opponent's ability to react and prepare for the next shot.
Using a weapon (from 13/14 years)	As players grow and gain strength, they become capable of hitting the ball with greater power. However, this power is often misused, leading to a high number of errors. Players who have reached this level begin to adopt high-percentage strategies and focus on creating situations where they can effectively use their strengths—or "weapons"—at critical moments in the match.	Driver(s): Physical growth and self-awareness—players become aware of their strengths - "weapons". New Quality: Players deliberately creating opportunity to use their most successful shots - weapons (serve, forehand, etc.) at critical moments in the match (i.e game or set point).
Imposing own Game Style (from 15/16 years)	At the beginning of this stage, players are already aware of their weapons and begin to build their game around them. They become more 'match wise,' playing percentage tennis and taking advantage of opponents' weaker serves. By the end of this stage, both boys and girls are capable of effectively applying their personal tactics by considering opponent's strengths and weaknesses and adapting their game when competing on different surfaces.	Driver(s): Abstract (strategic) thinking and developing personal playing patterns—players develop a deeper understanding of tennis strategy. New Quality: Ability to adapt their game—players can adapt their strategies to different opponents and situations.
Managing Match Flow (from 18/19 years)	The final stage of game development is characterized by a player's ability to apply their personal best option based on the specific situation in the match, particularly in relation to the score. To do this effectively, players must be able to manage their emotions, accept both their strengths and limitations, and demonstrate respect toward their opponents and the broader tennis environment.	Driver(s): Emotional regulation—manage emotions and maintain focus when under pressure. New Quality: Rapid, appropriate response to changing circumstances in the match—adjust their tactics and mental approach in reaction to the flow of the match.

Table 3

Competitive rally stage of game development with related playing competencies and the relevant drivers.

Competitive rally stage					
		Serving & returning	**Base line game**		**Net game**
PLAYING COMPETENCIES (observable behaviours during match play)		In 4 out of 5 points, the player can start a rally using overarm throw or underarm serve.	In neutral situation during the rally, the player returns at least 70% of the received balls back into the court.	In (at least) 50% of 'difficult' situations, the player remains in the point after the opponent unintentionally hits toward the corners, by aiming their shots toward the centre of the court.	When in favourable position, the player is able to intercept 70% of the balls at the net with the intention of staying in the point by aiming at the 'big target' (centre of the court).
DRIVERS	**Supporting environment**	**Smaller (red) court with a lower net (60-65cm), softer ball and an appropriate racket*.** * Appropriate equipment should be selected based on the player's age and motor skill level.			
	Mental aspects	**Understand the value of competition by showing emotions (joy / disappointment).**			
		Can keep score (up to 10 points) and recall it.			
	Tactical understanding and decision-making skills	**Understands and applies the concept of 'big target'** (player deliberately aims shots toward the centre of the court)			
		Recognizes and reacts appropriately to different ball trajectories (direction, height and depth)			
		Understanding the benefit of returning back toward the 'middle' of the court (same distance from opponent's possible shots)			
	Stroke mechanics	**Demonstrates racket face control at impact** (for controlling height, direction and depth of the outgoing ball)			
		Maintains alert ready attitude (position) for returning	Initiates backswing with trunk rotation as the ball crosses the net	Controls shot height and depth using an open racket face	To bring the racket above the contact point and meet the ball with 'blocking action'
		Uses underarm serve with synchronized toss and backswing	Executes smooth continuous swing aligned with the incoming ball		
		Applies consistent overarm throw to start the rally	Uses a convenient grip that facilitates effective rallying, with changing between forehand and backhand grips.		
	Motor and physical aspects	Maintains head-over-shoulders posture and straight trunk during movement and stopping (core control)			
		Shows precise footwork (in order to establish balanced hitting position)			
		Use tennis-specific movements: side steps, cross steps and back pedalling			

The Game Development Pathway connects the principles of biological development with the progression of tennis skills, enabling coaches to anticipate an individual player's development more effectively. The younger the player, the greater the uncertainty—but also the greater the developmental potential.

Development of competitive ability is a dynamic and nonlinear process, where sudden improvements or "leaps" occur once a player integrates the necessary physical, mental, tactical, and technical prerequisites (referred to as 'drivers'). Understanding the stages within the Game Development Pathway allows coaches to design long-term, adaptable training plans that keep players motivated and steadily progressing.

By understanding the Pathway, coaches are better equipped to recognize a player's current stage and adjust their training approach accordingly. The goal is to support players in developing competitive ability by focusing on developing the right skills at the right time.

Advantages of Applying the Game Development Pathway:

- Recognizing the player's current stage of game development.
- Identifying both short-term and long-term development priorities.
- Aligning competition with training objectives.
- Planning improvement of competitive abilities.

As a coach, I was always looking for ways to improve my players' game. I remember, when I was a young coach, my mentor once asked me: "Do you know how your player should play in order to succeed at top national junior tournaments and reach a 'top 5' ranking?" I started to think and realized that, although I knew which strokes or tactics I wanted to improve, I couldn't clearly define the kind of game the player needed to play to succeed.

As a coach educator, I've also realized that while coaches can often identify which strokes or tactics need improvement, they frequently struggle to define how their players should play to succeed at a specific level of competition.

Understanding the Game Development Pathway helps coaches identify the stages of game development and guide players in finding their own solutions to meet the challenges at each stage.

Limitations and future research

The Game Development Pathway is an original framework for outlining the developmental trajectory in tennis. Further research is required to validate the proposed stages of game development and to more precisely identify the sets of 'drivers' that prepare a player to leap from one developmental stage to the next.

DECLARATION OF CONFLICT OF INTEREST AND FUNDING

The author declares that he is not aware of any conflict of interest in writing this article and that he has not received any funding for this study.

REFERENCES

Andrilović, V., & Čudina-Obradović, M. (1996). Psychology of learning and teaching: (Educational psychology III.). Školska knjiga.

Buszard, T., Garofolini, A., Reid, M., Farrow, D., Oppici, L., & Whiteside, D. (2020). Scaling sports equipment for children promotes functional movement variability. Scientific reports, 10(1), 3111. https://www.nature.com/articles/s41598-020-59475-5

Crespo, M. Tennis coaching in the era of Dynamic systems, J Med Sci Tennis 2009; 14(2):20-25.

Elderton, W. Helping You Coach – Motivation Feedback – Part 8 https://oncourt.ca/2022/05/24/helping-you-coach-motivation-feedback-part-8/

Farrow, D., & Reid, M. (2010). The effect of equipment scaling on the skill acquisition of beginning tennis players. Journal of sports sciences, 28(7), 723-732. https://doi.org/10.1080/02640411003770238

Farrow, D., & Robertson, S. (2016) Development of a Skill Acquisition Periodisation Framework for High-Performance Sport, Sports Med DOI 10.1007/s40279-016-0646-2

Gray, W. D. (2017). Plateaus and asymptotes: spurious and real limits in human performance. Current Directions in Psychological Science, 26(1), 59-67. https://www.researchgate.net/profile/WayneGray/publication/313480430_Plateaus_and_Asymptotes_Spurious_and_Real_Limits_in_Human_Performance/links/62c480cca306865ac9219574/Plateaus-and-Asymptotes-Spurious-and-Real-Limits-in-Human-Performance.pdf

Low, W., Butt, J., Freeman, P., Stoker, M. A., & Maynard, I. (2022). Effective Delivery of Pressure Training: Perspectives of Athletes and Sport Psychologists. Sport Psychologist, 36(3), 162–170. https://doi.org/10.1123/tsp.2021-0178

Mansell, P., Sparks, K., Roe, L., Carrington, S., Lock, J., & Slater, M., (2023). „Mindset: performing under pressure" - a multiple cognitive-behavioural intervention to enhance the well-being and performance of young athletes. Journal of Applied Sport Psychology, 36(4), 623-642. https://doi.org/10.1080/10413200.2023.2296900

Perri, T., Duffield, R., Murphy, A. P., Mabon, T., & Reid, M. (2023). Macro periodisation of competition in international women's tennis: Insights for long-term athlete development. International Journal of Sports Science & Coaching. https://doi.org/10.1177/17479541231171695

Rabindran, D. (2020). Piaget's Theory and Stages of Cognitive Development- An Overview. 8(9), 2152–2157. https://doi.org/10.36347/SJAMS.2020.V08I09.034

Journal homepage: https://saspublishers.com/sjams/

Qiu, H., Liu, C., & Zhang, X. (2021). Intelligent Design of Tennis Player Training Schedule Based on Big Data of Complexity. Complexity, 2021, 1–11. https://doi.org/10.1155/2021/4759395

Riley, M. A., & Holden, J. G. (2012). Dynamics of cognition. Wiley Interdisciplinary Reviews: Cognitive Science, 3(6), 593–606. https://doi.org/10.1002/WCS.1200

Rosenbaum, D. A., Carlson, R. A., & Gilmore, R. O. (2001). Acquisition of intellectual and perceptual-motor skills. Annu Rev Psychol, 52, 453-470. https://doi.org/10.1146/annurev.psych.52.1.453

Sánchez-Mencia, E., Campos-Rius, J., González Santamaría, X., & Borrajo Mena, E. (2023). Tactical skills in tennis: A systematic review. International Journal of Sports Science & Coaching, 19(2), 894–907. https://doi.org/10.1177/17479541231216268

Schönborn, R. Leistungs Tennis, Aachen, 2001.

Spencer, J.P., Perone, S., Buss A.T. (2011) Twenty Years and Going Strong - A Dynamic Systems Revolution in Motor and Cognitive Development. Childe development perspectives, Vol. 5, Nr.4, 260-266.

Tennis Canada. (2011). Long term athlete development plan for the sport of tennis in Canada. Retrieved Jul 29, 2015, from http://www.tenniscanada.com/wpcontent/uploads/2015/01/LTADallenglish.pdf

Vilela Brito, A. (2020). Biological age vs. chronological age: the impact on the development of the young tennis athlete. ITF Coaching & Sport Science Review, 28(80), 38-41. https://doi.org/10.52383/itfcoaching.v28i80.69

Zmajić, H. (2003) Competitive tennis. 91-105 Zagreb. https://library.foi.hr/lib/knjiga.php?B=74&H=&E=&V=&lok=&zbi=&item=10063&upit=796#

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 11-15
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.744

From Brain to Court: How Executive Functions Shape Self-Regulation in Tennis

Francesco Di Muccio & Lionel Grossenbacher

EDGE International, Brain & Body Focus, Switzerland.

ABSTRACT

Tennis places high demands on player's cognitive and emotional capacities, requiring continuous attention, fast decision-making, emotional control, and sustained effort. This conceptual and narrative review examines the role of executive functions; specifically inhibitory control, working memory, and cognitive flexibility in supporting tennis performance. Drawing from research in cognitive neurosciences and sport psychology, we describe how executive functions influence performance both directly and indirectly through self-regulation. Self-regulation is described as a multidimensional process involving the regulation of attention, emotion, and effort, with each component influenced by underlying executive capacities. For coaches, the practical implication is that executive functions can be easily trained within regular tennis practice by manipulating cues, rules, and contextual demands to challenge these functions. We provide guidelines and concrete examples for integrating the training of inhibition, working memory, and cognitive flexibility into on-court exercises. Developing executive functions offers an accessible, evidence-informed approach to enhancing player's mental stability, adaptability, and overall performance.

Key words: Tennis, Neurocognitive functions, Executive Functions, Self-Regulation

Received: 4 December 2025

Accepted: 27 March 2026

Corresponding author: Francesco Di Muccio - brainbodyfocus@gmail.com

INTRODUCTION

Tennis is one of the most cognitively and emotionally demanding sports. Performance depends heavily on a player's ability to make fast decisions, regulate emotions, and sustain attention over time under unpredictable and high-pressure conditions. Today, success at high levels of play depends also on the ability to adapt efficiently to changing situations, rather than on purely physical or technical advantages (Vestberg et al., 2012).

Over the past decade, research in sport and cognitive neurosciences has highlighted the crucial role of executive functions (a set of mental processes that help us control our attention, emotions and behavior) (Diamond, 2013). They include inhibition (the ability to resist impulses or frustration), working memory (the ability to keep relevant information active while executing actions), and cognitive flexibility (the ability to adapt strategies when needed). Although these skills are not directly visible, they are deeply involved in how players manage their thoughts and actions during matches (and practices).

Beyond cognitive performance, these capacities form the foundation of mental self-regulation which is defined as the capacity to guide one's behavior toward the desired goals over time (Hofmann et al., 2012). For example, when a player stays calm after a double fault, adjusts their tactics during the point, or keeps concentration despite the noise and the pressure, executive functions are strongly engaged. In this sense, executive functions are not only cognitive capacities but also mechanisms of mental consistency.

Building on existing theoretical models and empirical findings, this article presents a conceptual and narrative review aimed at introducing executive functions in the context of tennis, clarifying their relationship with self-regulation, and discussing practical implications for coaching and player development.

EXECUTIVE FUNCTIONS AND TENNIS PERFORMANCE

In open-skill sports such as tennis, players must continually adapt their perception, decision-making, and motor responses to rapidly changing and unpredictable situations. These demands place a crucial importance on executive functions.

A growing body of evidence suggests that athletes who regularly engage in open-skill sports show higher executive functioning compared with those in closed-skill sports (where the environment is stable and movement patterns planned) (Krenn et al., 2018; C. H. Wang et al., 2013). The mental challenges inherent in open-skill contexts (anticipating opponent's behaviors, shifting between offensive and defensive modes, unpredictability etc.) seem to strengthen neural networks associated with executive functions. Within tennis, these processes are activated continuously. Indeed, performance relies on the ability to execute a tactical plan with precision while adapting to the fast pace of play and the constant flow of information on court. Players who can efficiently manage these demands, such as staying aligned with their tactical intentions and minimized the impact of external or match-related distractions, tend to maintain greater competitive consistency.

Empirical findings support this connection between executive functions and tennis performance. For example, a recent scoping review highlighted that athletes (from different sports) exhibit faster and more efficient inhibitory control than non-athletes, and that higher expertise levels are associated with superior inhibitory performance (Simonet et al., 2023). More specifically, (Ishihara et al., 2019) showed that young tennis players with higher executive function scores had greater ranking improvements over an 18-month period compared to those with lower executive function scores. This suggest that these capacities may facilitate learning, tactical adaptation, and long-term skill consolidation. Moreover, (Kuroda et al., 2023) reported that a decline in executive functions over the course of a tennis exercise was associated with a reduced second-serve precision in college tennis players. This finding illustrates how mental fatigue can directly affect technical execution under pressure. Together, these studies suggest that executive functions contribute positively to tennis performance in two ways: first, moment-to-moment decision making, and second, by maintaining performance consistency across extended periods of competition and training.

Table 1
Definitions of the core executive functions and their functional relevance to performance in tennis.

Executive Function	Definition	Match Play Example
Inhibitory Control	The ability to control attention, behavior, thoughts, and emotions to override distractions.	After an error, the player controls frustration and avoids rushing the next point.
Working Memory	The ability to hold and manipulate information mentally (e.g., planning, decision making).	The player remembers key information about the opponent and match situation and uses it to choose the best tactical option.
Cognitive Flexibility	The ability to adapt and shift tactics based on changing situations.	The player switches tactic when needed without increased mental strain.

HOW EXECUTIVE FUNCTIONS UNDERPIN SELF-REGULATION

Beyond their direct impact on performance, executive functions also play a role in supporting the self-regulation processes that underpin consistent and resilient play. Self-regulation capacity is defined by the ability to manage thoughts, emotions and behaviors to maintain goal-directed performance under pressure (Hofmann et al., 2012). Studies show that in competitive contexts, mental self-regulation is often what separates consistent performers from those who fluctuate in their level of play (Englert, 2025).

Successful self-regulation requires three key elements according to Hofmann et al. (2012):

1. People have clear ideas about how they want to think, feel, and act, which help guide them toward their goals.
2. They are motivated to reduce the gap between how things are and how they want them to be.
3. They can make those changes, even when it's difficult or tempting to give up. As well as resisting distractions and impulses that interfere with the goal pursuit.

In tennis, self-regulation refers to a player's ability to maintain control over attention, emotions, and effort to stay aligned with performance goals. Below, we outline how executive functions provide the cognitive foundation for self-regulation by influencing each of these three key domains.

Attention regulation

Attention regulation is an essential component in tennis. Players must track the ball, anticipate the opponent's intentions, and filter out irrelevant information such as previous mistakes, noise, or intrusive thoughts. Executive functions support this attentional stability by enabling players to maintain task-relevant goals in mind (working memory) and suppress distractions (inhibitory control). In this way, research showed a positive relationship between executive functions and visual attention capacity in sport (Brimmell et al., 2024) . More specifically, Furley & Wood, (2016) showed that strong working memory improves athlete's ability to maintain attentional focus during dynamic tasks. Also, meta-analytic evidence suggests that athlete generally outperform non-athlete in both inhibition and attentional task (Ren et al., 2025). Overall, these findings highlight that attentional regulation depends strongly on executive control. When players can efficiently suppress distractions and maintain task-relevant information, they are better able to perform consistently.

Emotion regulation

Tennis exposes players to frequent emotional challenges: frustration, anxiety, anger, pressure. Effective emotional regulation requires the ability to inhibit impulsive emotional reactions and maintain a clear focus on performance goals. Hofmann et al. (2012), identify inhibitory control as a central mechanism for resisting emotional impulses. Working memory is also increasingly recognized as a key resource for managing emotional responses. It provides the mental workspace necessary to regulate unwanted emotions and impulses. For example, research showed that higher working memory capacity supports cognitive reappraisal which is the ability to reinterpret a situation to reduce its emotional impact (Schmeichel & Demaree, 2010). In parallel, cognitive flexibility plays a protective role in emotional regulation. Recent evidence shows that individuals with higher cognitive flexibility experience better emotional regulation during stress exposure (X. Wang et al., 2025). Taken together, these findings show that emotional regulation depends strongly on executive control.

For tennis players, these executive capacities are essential. Strong inhibitory control helps suppress impulsive emotional reactions allowing them to pause, breathe, and avoid rushing into the next point. High working memory capacity enables athletes to hold their tactical goals in mind while processing emotional cues. In parallel, cognitive flexibility supports a more adaptative emotional response during momentum swings or stressful phases of a match, helping players shift from frustration to tactical adjustments.

Effort regulation

Maintaining effort and motivation across long matches or difficult moment requires self-regulation. Players need to hold long-term goals in mind, inhibit the urge to disengage or reduce effort as well as deal with challenges continuously. According to the strength model of self-regulation, maintaining effort under pressure relies on limited resources that can become depleted through stress, fatigue, and emotions (Baumeister et al., 2007). A growing body of research shows that executive functions play a central role in sustaining effort, especially under conditions of fatigue or psychological strain. Studies using endurance or exertion paradigms consistently show that when executive resources are depleted, athletes tend to disengage earlier. For example, Marcora et al. (2009) showed that mental fatigue induced by cognitive task targeting inhibitory control, working memory, and sustained attention reduced endurance performance, despite no physiological changes. Similarly, a systematic review by Van Cutsem et al. (2017) confirmed these findings, showing that mental fatigue consistently impairs physical performance by overloading executive mechanisms involved in effort regulation.

For tennis players, these findings highlight that the ability to sustain effort during demanding phases of a match depends partly on executive functioning. When executive resources are still available, players are better able to stay engaged, tolerate discomfort, and maintain intensity during demanding phase of a match.

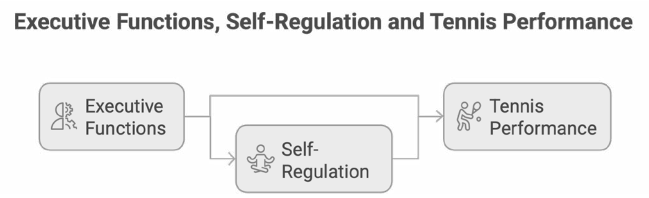


Figure 1. *This conceptual model illustrates how executive functions may contribute to tennis performance both directly and indirectly. Executive functions support performance by enabling players to manage cognitive demands leading to efficient decision-making, and tactical adaptation. They may also influence performance indirectly through their role in shaping self-regulation capacity, which encompasses the regulation of attention, emotions, and effort during competition.*

PRACTICAL IMPLICATIONS FOR TENNIS COACHING

For tennis coaches, understanding executive functions is essential because these cognitive skills directly affect a player's ability to stay focused, manage emotions, and make efficient decisions under pressure. Technical or tactical drills alone cannot guarantee consistent performance if a player struggles to inhibit frustration, maintain tactical plan, or adapt to changing match situations. Executive functions are not abstract constructs, they are measurable, trainable and influence the match-play intelligence, emotional stability and adaptability.

Importantly, executive-function training should be implemented progressively and in a controlled manner. Rather than being applied systematically in every session, cognitively demanding drills may be introduced one to two times per week, or in short sequences within a session, depending on the player's level and training phase. Excessive or constant cognitive load may lead to mental fatigue and reduced learning efficiency.

Coaches are therefore encouraged to carefully manage dosage by gradually increasing task complexity over time. In this process, monitoring mental load is particularly important. Simple tools such as a subjective mental RPE (Rating of Perceived Exertion) scale can help coaches identify at what level of intensity or complexity a player begin to experience cognitive overload. This information allows coaches to better individualize training, alternating between cognitively demanding and more automatic drills, and progressively increasing the player's tolerance to mental load. The objective is not to push player into constant overload, but to systematically build their cognitive reserve.

Finally, coaches are encouraged to clearly explain the cognitive objective of each drill and its relevance to tennis performance. Clarifying why a drill is important helps players better understand its purpose, increases engagement, and supports motivation. Moreover, in exercises where players are required to follow a specific direction or game plan, it is essential that these rules are respected regardless of how well they align with the immediate situational context. Without this consistency, the cognitive demands of the task are reduced, and the effectiveness of the training may be substantially diminished.

In the following sections, we outline practical ways for coaches to integrate executive function training directly into tennis practice.

Inhibitory control

Inhibitory control can be trained through exercises that require players to suppress automatic reactions (motor, attentional, or emotional). Inhibitory demands are highly important when players need to avoid rushing between points, prevent over-hitting under pressure, or resist the urge to react emotionally after a mistake. In practice, inhibitory control can be trained not only by imposing constraints, but also by designing situations that encourage players to inhibit impulsive decisions through meaningful incentives that preserve their autonomy.

Key elements to include in drills that target inhibitory control:

• Use of distractions (visual or auditory).

o Example: During a rally, the coach randomly introduces visual or auditory distractions (clapping, calling the player's name, moving an object in the visual field of the player etc.). The player must continue to play while ignoring the distractions and maintaining a high precision.

• A rule that encourages inhibition of an automatic pattern in course.

o Example: During a rally, the player always hits crosscourt unless the coach says "switch" then plays down the line. Decreasing the switch signal delay leads to a higher level of task difficulty (announced before, during, or after the ball bounces).

o Example: During a rally, the player is encouraged to attack any short ball, but when the coach raises a hand or claps, the player is also allowed to play a drop shot. A bonus point is awarded if he succeeds in the drop shot. In this exercise, the coach must choose carefully when to make the announcement.

• Emotional or competitive pressure.

o Example: During points situations, the coach may deliberately award the point to the opponent if a technical execution is judged imprecise, thereby encouraging the player to manage their frustration.

Working memory

Working memory is engaged when players must hold information in mind while playing, maintain a tactical intention, or update rules during action. Drills that require remembering sequences load this system effectively.

Key elements to include in drills that target working memory:

• A tactical instruction to maintain throughout the drill.

o Example: Play only cross with the backhand and change the direction (right/left) of your forehand on every shot. The change of direction on the forehand must alternate from point to point and at each change of game. This means that if the last forehand of the previous point was played to the right, the first forehand of the next point or game must be played on the left.

• A rule that must be updated based on cues.

o Example: The coach calls a color: red = defend, blue = attack, green = play a slice, yellow = play a dropshot etc. and the player must adjust instantly. The task can be further complexified by associating each color with an additional number that matches a color (1 = Red, 2 = blue, 3 = green, 4 = yellow).

• Short sequences to remember and execute during the whole match or set.

o Example: Serve on T → play deep crosscourt / Serve Wide → play the opposite direction. The goal of this exercise is to maintain a game plan in working memory over an extended period (e.g. an entire set or match).

• A dual task combining hitting and cognitive load.

o Example: Play a point after memorizing a sequence of numbers announced by the coach. Winning the point is only validated if the player can accurately recall the sequence afterward.

Cognitive flexibility

Cognitive flexibility is trained when players must switch strategies, adapt to sudden changes, or shift their mental state based on context. In tennis, this includes adjusting to different ball trajectories, tactical changes from the opponent, or shifts in momentum.

Key elements to include in drills that target cognitive flexibility:

• Switching between strategies within the same drill.

o Example: The player and the coach predetermine three playing styles. Before each point, the coach informs the player which style must be adopted for the upcoming point.

• Contextual changes requiring immediate adaptation.

o Example: When the coach raises a cone, the player must win the point within his next 2 shots.

• Mental state shift.

o Example: Whenever the player perceives a drop in intensity or attentional focus, they must deliberately modify their mental state by engaging in a predetermined behavioral strategy (e.g. shouting on every shot, intentionally slowing their steps between points, or adopting an exaggeratedly relaxed hitting style).

• Situations requiring reinterpretation or reframing.

o Example: The player adopts a highly aggressive playing style for the first three shots; if the rally continues (from the fourth shot onward), the player must switch to a more conservative style (e.g., playing crosscourt only).

CONCLUSION

Executive functions and self-regulation play a central role in tennis performance, shaping a player's capacity to stay focused, adapt tactically, manage emotions, and sustain effort under pressure. Although these processes operate "behind the scenes", their influence on consistency, resilience and decision-making is evident during a match. The evidence reviewed in this article highlight that executive functions support performance both directly by enabling players to process information efficiently, and indirectly through their contribution to self-regulation abilities.

For coaches, acknowledging the cognitive dimension of tennis allows them to actively contribute to their player's mental training in partnership with other sport professionals. Indeed, executive functions can be easily integrated into on-court drills by manipulating cues, constraints, and tactical demands to challenge inhibition, working memory, and cognitive flexibility. Such training can help to enhance not only cognitive skills on court, but also the mental stability and adaptability required for high-level performance.

However, several limitations and open questions should be acknowledged. Most existing studies examining executive functions in sport rely on laboratory-based or generic cognitive tasks, which may only partially reflect the complex and dynamic demands of real tennis environments. Moreover, the causal relationship between executive-function training and long-term performance improvements remains insufficiently established, particularly in tennis-specific contexts. Individual differences related to age, expertise level, and training history may also moderate the effectiveness of such interventions. Future research should therefore aim to develop more ecologically assessment tools, examine longitudinal effects of executive-function training, and clarify how these capacities interact with technical, physical, and psychological factors in player development.

As the game continues to evolve in speed, physical intensity, and tactical complexity, developing executive functions may represent a promising avenue for supporting player's long-term development. Rather than being viewed as a stand-alone solution, executive-function training may complement existing technical, physical, and psychological approaches by helping player better cope with the cognitive and emotional demands of competition. Training the brain alongside the body offers a promising practical, evidence-informed approach to improving the quality and consistency of tennis performance.

DECLARATION OF CONFLICT OF INTEREST AND FUNDING

The authors declare that they are not aware of any conflict of interest in writing this article and that they have not received any funding for this study.

REFERENCES

Baumeister, R. F., Vohs, K. D., & Tice, D. M. (2007). The strength model of self-control. Current Directions in Psychological Science, 16(6), 351–355. https://doi.org/10.1111/j.1467-8721.2007.00534.x

Brimmell, J., Edwards, E. J., & Vaughan, R. S. (2024). Executive function and visual attention in sport: a systematic review. International Review of Sport and Exercise Psychology, 17(2), 1278–1311. https://doi.org/10.1080/1750984X.2022.2145574

Diamond, A. (2013). Executive functions. In Annual Review of Psychology (Vol. 64, pp. 135–168). Annual Reviews Inc.

Englert, C. (2025). Self- control – A critical discussion of a key concept in sport and exercise psychology. Psychology of Sport and Exercise, 80, 102878. https://doi.org/10.1016/j.psychsport.2025.102878

Furley, P., & Wood, G. (2016). Working Memory, Attentional Control, and Expertise in Sports: A Review of Current Literature and Directions for Future Research. Journal of Applied Research in Memory and Cognition, 5(4), 415–425. https://doi.org/10.1016/j.jarmac.2016.05.001

Hofmann, W., Schmeichel, B. J., & Baddeley, A. D. (2012). Executive functions and self-regulation. In Trends in Cognitive Sciences (Vol. 16, Issue 3, pp. 174–180).

Ishihara, T., Kuroda, Y., & Mizuno, M. (2019). Competitive achievement may be predicted by executive functions in junior tennis players: An 18-month follow-up study. Journal of Sports Sciences, 37(7), 755–761. https://doi.org/10.1080/02640414.2018.1524738

Krenn, B., Finkenzeller, T., Würth, S., & Amesberger, G. (2018). Sport type determines differences in executive functions in elite athletes. Psychology of Sport and Exercise, 38, 72–79. https://doi.org/10.1016/j.psychsport.2018.06.002

Kuroda, Y., Ishihara, T., & Mizuno, M. (2023). Association between perceived exertion and executive functions with serve accuracy among male university tennis players: A pilot study. Frontiers in Psychology, 14, 1007928. https://doi.org/10.3389/fpsyg.2023.1007928

Marcora, S. M., Staiano, W., & Manning, V. (2009). Mental fatigue impairs physical performance in humans. Https://Doi.Org/10.1152/Japplphysiol.91324.2008, 106(3), 857–864. https://doi.org/10.1152/japplphysiol.91324.2008

Ren, S., Shi, P., Feng, X., Zhang, K., & Wang, W. (2025). Executive Function Strengths in Athletes: a Systematic Review and Meta-Analysis. Brain and Behavior, 15(1), e70212. https://doi.org/10.1002/brb3.70212

Schmeichel, B. J., & Demaree, H. A. (2010). Working Memory Capacity and Spontaneous Emotion Regulation: High Capacity Predicts Self-Enhancement in Response to Negative Feedback. Emotion, 10(5), 739–744. https://doi.org/10.1037/A0019355

Simonet, M., Beltrami, D., & Barral, J. (2023). Inhibitory control expertise through sports practice: A scoping review. Journal of Sports Sciences, 41(7), 616–630. https://doi.org/10.1080/02640414.2023.2230713

Van Cutsem, J., Marcora, S., De Pauw, K., Bailey, S., Meeusen, R., & Roelands, B. (2017). The Effects of Mental Fatigue on Physical Performance: A Systematic Review. Sports Medicine 2017 47:8, 47(8), 1569–1588. https://doi.org/10.1007/S40279-016-0672-0

Vestberg, T., Gustafson, R., Maurex, L., Ingvar, M., & Petrovic, P. (2012). Executive functions predict the success of top-soccer players. PLoS ONE, 7(4). https://doi.org/10.1371/journal.pone.0034731

Wang, C. H., Chang, C. C., Liang, Y. M., Shih, C. M., Chiu, W. S., Tseng, P., Hung, D. L., Tzeng, O. J. L., Muggleton, N. G., & Juan, C. H. (2013). Open vs. Closed Skill Sports and the Modulation of Inhibitory Control. PLoS ONE, 8(2). https://doi.org/10.1371/journal.pone.0055773

Wang, X., Shao, S., Cheng, H., Blain, S. D., Tan, Y., & Jia, L. (2025). Effects of cognitive flexibility on dynamics of emotion regulation and negative affect in daily life. Anxiety, Stress and Coping, 38(3), 365–378. https://doi.org/10.1080/10615806.2024.2423154

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 16-20
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.742

Reaching the baseline: A comparative case study of anthropometric extremes in Division I female tennis players

Bryan J. Lehecka

Wichita State University, USA.

ABSTRACT

The purpose of this case report was to contrast the biomechanical and physiological characteristics of two Division I female tennis players representing opposite ends of the anthropometric spectrum to determine how diverse somatic types achieve elite performance. Subject A (Height-Dominant) is a 188 cm server relying on lever length. Subject B (Power-Dominant) is a 157 cm all-court player relying on neuromuscular power. Both underwent comprehensive physical profiling (range of motion, isometric strength, countermovement jump) and match performance analysis using computer vision technology (SwingVision) during one competitive set. Outcomes revealed that Subject A generated substantially higher peak serve velocity (74 mph vs. 67 mph) and utilized sharp placement angles, leveraging her height. Subject B compensated for a 31 cm height deficit with superior neuromuscular output (CMJ: 34.9 cm) and a 100% deep return rate on second serves. The conclusion is that elite performance in collegiate tennis is not homologous. While anthropometric height provides a distinct advantage in serving velocity and geometry, shorter athletes can compete effectively through superior ground force production and rotational maneuverability. Training programs must be individualized: stability-focused for taller athletes to control long levers, and power-focused for shorter athletes to maintain kinetic chain efficiency. As this is a case study of two athletes, these findings highlight the need for individualized analysis rather than broad generalization.

Key words: Tennis, Anthropometry, Biomechanics, Performance, Somatotype

Received: 21 November 2025

Accepted: 29 February 2026

Corresponding author: Bryan Lehecka, bryan.lehecka@wichita.edu

INTRODUCTION

The physiological landscape of tennis has undergone a radical transformation over the last three decades. The transition from wood to graphite racquets, accompanied by changes in court surfaces and ball technology, has shifted the sport from a game of finesse and tactical patience to one of explosive power and high-velocity collisions. In this modern era, anthropometry—specifically height and limb length—has emerged as a critical variable in talent identification and performance modeling (Germic et al., 2025). Historical analysis of professional rankings indicates a steady increase in the average height of elite female players, supporting the hypothesis that taller athletes possess distinct biomechanical advantages that are increasingly necessary for success at the highest levels (Fernandez-Fernandez et al., 2014).

The primary argument for the "taller is better" paradigm centers on the mechanics of the service motion. Recent research confirms that anthropometric parameters, particularly body height, are strongly correlated with service velocity in elite competition (Baiget et al., 2023; Sanchez-Pay et al., 2021). The serve is the only closed-skill shot in tennis, where the athlete has complete control over the ball's placement and velocity. From a physics perspective, a higher release point provides two distinct advantages: trajectory and velocity. A taller player can strike the ball at a steeper angle of incidence relative to the court surface. This geometric advantage allows the ball to clear the net with a greater margin for error while still landing within the service box.

Roetert et al. (2009) suggest that for every inch of added height, the "serve window"—the theoretical area above the net through which a ball must pass to land in—expands significantly. Conversely, shorter athletes must rely on spin (the Magnus effect) to bring the ball down into the court, which often requires a sacrifice in linear velocity (Fett et al., 2020). Therefore, the prevailing biomechanical model suggests that taller athletes can generate higher velocities with less effort, utilizing their long levers to create racquet head speed through a wider arc of motion.

Despite the theoretical advantages of height, the collegiate landscape remains phenotypically diverse. Division I rosters are not populated exclusively by athletes over 180 cm; rather, they feature a wide distribution of body types. This persistence suggests that height is not the sole determinant of success and that alternative motor characteristics must exist (Luna-Villouta et al., 2021). Kovacs (2007) highlights the importance of the kinetic chain—the sequential transfer of energy from the ground up through the body segments—as a great equalizer.

Shorter athletes, who possess a lower center of mass, often exhibit superior agility, balance, and change-of-direction speed (Scamardella et al., 2025). Furthermore, they may compensate for their lack of lever length by generating superior ground reaction forces (GRF). By loading the legs more aggressively and utilizing a more explosive extension sequence, a shorter player can generate vertical and rotational forces that rival those of their taller counterparts. This "summation of speed" principle suggests that while the taller player relies on the radius of the swing arc, the shorter player relies on the angular velocity of the rotation.

While numerous studies have profiled the physical characteristics of tennis players (Sánchez-Muñoz et al., 2007), most utilize group-based means that obscure individual variances. There is a paucity of literature that directly compares how two athletes of vastly different somatic types achieve similar competitive outcomes. How does the shorter athlete survive in a game increasingly dominated by serving power? What is the physiological cost of their compensation strategies?

The purpose of this case report was to contrast the biomechanical, physiological, and tactical characteristics of two Division I female tennis players representing opposite ends of the anthropometric spectrum (99th vs. 5th percentile). By integrating clinical physical profiling with match-play data derived from computer vision analysis, we aim to define the distinct "Leverage" versus "Power" signatures that allow these contrasting archetypes to achieve elite performance. This analysis seeks to challenge the "one-size-fits-all" approach to coaching and provide evidence for individualized training interventions based on somatic type.

METHODS AND PROCEDURES

Experimental Design

This study utilized a comparative case study design to analyze the distinct physiological and biomechanical profiles of two collegiate athletes. This approach was selected to allow for a granular analysis of how contrasting anthropometric phenotypes navigate the demands of Division I tennis, providing specific insights that are often lost in large-cohort aggregate data.

Subjects

Two female NCAA Division I tennis players from the same university team were selected for this case study. The selection criteria were based on maximizing the anthropometric contrast between teammates who compete at the same level of play.

- Subject A (Height-Dominant): Age 22, 188 cm (6'2") tall, weight 79.4 kg (175 lbs). Subject A represents the ectomorphic/mesomorphic blend typical of the modern "power server." Her playing style is characterized by aggressive first-strike tennis.

- Subject B (Power-Dominant): Age 20, 157 cm (5'2") tall, weight 60 kg (132 lbs). Subject B represents a mesomorphic, compact build. Her playing style is characterized as an "all-court counter-puncher," relying on movement and consistency.

Ethical Considerations

Written informed consent was obtained from both subjects for the publication of this case report and accompanying data. The study protocol adhered to the Declaration of Helsinki and was approved by the university's institutional review board (IRB) for exempt research involving standard athletic performance monitoring.

Physical Examination

A comprehensive battery of physical tests was administered to establish a baseline musculoskeletal profile. Test selection was based on established protocols in tennis medicine literature for assessing risk factors and performance indicators (Ellenbecker & Roetert, 2003; Sanchez-Pay et al., 2021).

- Isometric Strength: Strength was assessed using a Jamar digital handheld dynamometer (Patterson Medical, Warrenville, IL). The "make test" protocol was used, where the examiner holds the dynamometer stationary while the athlete exerts maximal force against it for 3-5 seconds. Three trials were averaged for each position. Key muscle groups tested included the shoulder external rotators (posterior cuff), internal rotators (anterior cuff/pecs), hip abductors (gluteus medius), and hip extensors (gluteus maximus).

- Range of Motion (ROM): Passive ROM was measured using a standard double-arm goniometer. Particular attention was paid to the glenohumeral joint (total arc of motion) and hip internal/external rotation, as these are common sites of adaptation in rotational athletes (Moreno-Pérez et al., 2016).

- Neuromuscular Power: Lower body explosive power was quantified via Countermovement Jump (CMJ) height. Data was collected using the MyJump app (iOS), which utilizes high-speed camera footage to calculate jump height based on flight time. This tool has been validated against force platforms in scientific literature as a reliable field-based measure of vertical power.

Match Analysis

To bridge the gap between clinical metrics and on-court performance, one competitive set of singles match play was analyzed for each subject. The match data was captured using SwingVision (Cupertino, CA), a mobile artificial intelligence platform that utilizes a single camera mounted on the back fence. The software uses computer vision algorithms to track ball trajectories, player positioning, and shot outcomes in real-time.

Key Performance Indicators (KPIs) extracted included:

- Serve Velocity: Peak speed for 1st and 2nd serves (mph).

- Serve Placement: Heat maps distinguishing between "T" (center), Body, and Wide serves.

- Shot Consistency: The percentage of returns landing in the court and the depth of those shots (past the service line).

- Groundstroke Velocity: Average ball speed for forehand and backhand groundstrokes.

RESULTS

The anthropometric disparity between the subjects was substantial. Subject A possesses a 31 cm (12.2 inch) height advantage and a 19.4 kg (43 lb) mass advantage. Despite the mass disadvantage, Subject B demonstrated superior neuromuscular explosive capabilities.

Table 1
Anthropometric and Neuromuscular Profile Comparison.

Variable	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Difference
Anthropometry			
Height	188 cm (6'2")	157 cm (5'2")	+31 cm (Subject A)
Weight	79.4 kg	60.0 kg	+19.4 kg
Experience	3 Years (D1)	2 Years (D1)	+1 Year
Neuromuscular Power			
CMJ Height	26.7 cm	34.9 cm	+8.2 cm (Subject B)

Note: CMJ = Countermovement Jump; D1 = Division 1 collegiate level.

Subject B's CMJ of 34.9 cm was 30% higher than Subject A's 26.7 cm, indicating a reliance on vertical force production to overcome stature limitations.

The match analysis revealed how these physical traits translated into ball mechanics. Subject A dominated the serve velocity metrics, hitting a peak of 74 mph compared to Subject B's 67 mph. However, the return game favored the shorter, more agile athlete.

Table 2
Match Performance and Tactical Analysis (SwingVision Data).

Metric	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Analysis
Serve Velocity			
Peak 1st Serve Speed	74 mph	67 mph	+7 mph (Subject A)
Peak 2nd Serve Speed	69 mph	62 mph	+7 mph (Subject A)
Serve Placement (Deuce)			
"T" / Center	47%	10%	Subject A targets lines.
Body	15%	50%	Subject B jams opponent.
Wide	38%	40%	Comparable usage.
Return Game			
1st Return Consistency	76% In	100% In	Subject B superior consistency.
2nd Return Depth	83% Deep	100% Deep	Subject B superior depth.
Groundstrokes			
Forehand Speed (Avg)	52 mph	52 mph	Equal.
Backhand Speed (Avg)	54 mph	44 mph	Subject A superior drive.

Marked differences were observed in shoulder mechanics and hip strength. Subject B exhibited classic signs of overhead adaptation, including Glenohumeral Internal Rotation Deficit (GIRD), but compensated with superior absolute rotator cuff strength.

Table 3
Musculoskeletal Profile (Dominant Side).

Variable	Subject A (Height-Dominant)	Subject B (Power-Dominant)	Interpretation
Shoulder ROM			
Internal Rotation	77°	47°	Subject B exhibits GIRD.
External Rotation	80°	92°	Subject B has ER Gain.
Total Arc of Motion	157°	139°	Subject A is hypermobile.
Isometric Strength			
Shoulder Internal Rotation	32.5 lbs	37.0 lbs	Subject B is stronger.
Hip Extension	58.3 lbs	66.3 lbs	Subject B stronger deceleration.
Hip Abduction	30.6 lbs	30.0 lbs	Subject B stronger relatively.

DISCUSSION

This case study elucidates two distinct biomechanical pathways to Division I tennis. Subject A utilizes a "Leverage Strategy." Her height provides a high moment of inertia, allowing her to create racquet-head speed through a long swing radius rather than maximal muscular effort. This aligns with findings by Baiget et al. (2023), who identified that height and anthropometry are primary drivers of service velocity in elite populations. Subject A's relatively lower CMJ (26.7 cm) suggests she does not need to generate maximal ground reaction forces to achieve a 74 mph serve because her release point height naturally optimizes the throw. However, this efficiency may lead to a de-emphasis on lower-body loading, potentially limiting her ceiling if she were to integrate more explosive mechanics.

In stark contrast, Subject B employs a "Power Strategy." Every shot requires a near-maximal recruitment of the kinetic chain. Her 34.9 cm vertical jump indicates she uses the ground aggressively to transfer energy up through the trunk and into the racquet. Notably, she matches Subject A's average forehand speed (52 mph) and exceeds it cross-court (54 mph) despite a significant disadvantage in arm length. This finding validates the "summation of speed" principle and correlates with research by Scamardella et al. (2025), which highlights how anthropometric disadvantages in tennis can be offset by superior neuromuscular qualities. She effectively muscles the racquet through the zone, evidenced by her superior shoulder internal rotation strength (37.0 lbs vs. 32.5 lbs).

The serve placement data provides a fascinating window into how anthropometry dictates tactics. Subject A heavily favored the "T" serve on the Deuce side (47%). Because of her height, she can view the service box with a steeper angle, allowing her to target the lines with a flat trajectory (Roetert et al., 2009). Subject B, limited by a flatter release height relative to the net, adopts a "Body Serve Strategy," directing 50% of her Deuce serves into the opponent's body. This is a tactical compensation for a biomechanical limitation, consistent with Fett et al. (2020), who noted that shorter players must often rely on varying location and spin rather than pure velocity.

While Subject A dominates the serve, Subject B dominates the return, posting a 100% consistency rate on 2nd serve returns and a 100% depth rate. This reversal of fortune can be explained by the physics of rotational inertia. Long levers (Subject A) require more torque to initiate movement and more time to change direction. Subject B, with shorter limbs, possesses a lower moment of inertia. She can adjust her racquet face and body position rapidly. This agility advantage makes her significantly more effective at neutralizing the server's advantage.

The most critical finding for sports medicine practitioners is the divergence in physiological "cost" and injury risk. Subject A must stabilize a long spinal column, and her hypermobility suggests a reliance on passive structures. In contrast, Subject B pays a "tax" for her power, exhibiting Glenohumeral Internal Rotation Deficit (GIRD) with a 30-degree deficit compared to Subject A. This adaptation is common in high-velocity overhead athletes (Ellenbecker et al., 2002; Rose & Noonan, 2018). Because Subject B must generate more arm speed to match Subject A's ball velocity, her posterior shoulder musculature and capsule are under higher chronic tension.

Limitations

It is important to acknowledge the limitations of this study to contextualize the findings. First and foremost, this is a case study of only two athletes (n=2). While this allows for deep individual analysis, the results cannot be statistically generalized to the broader tennis population. The findings represent specific phenotypic adaptations rather than universal rules. Second, match analysis was limited to a single competitive set per player. While this provides a snapshot of performance, longitudinal data across a full season would provide a more robust understanding of consistency and fatigue profiles. Finally, while SwingVision is a powerful tool for tactical analysis, it does not offer the same biomechanical precision as 3D motion capture systems regarding joint kinematics. Future research should utilize larger sample sizes stratified by somatotype to validate these observational trends.

Practical Applications

Based on the findings that elite tennis performance is reached through divergent physical pathways, strength and conditioning programs cannot be uniform.

1. Interventions for the Height-Dominant Athlete: Focus on core stability, deceleration control, and end-range strength to protect the long spinal lever.
2. Interventions for the Power-Dominant Athlete: Focus on posterior capsule mobility (GIRD management), power maintenance, and pelvic stability to manage high internal tissue loads.
3. Tactical Coaching: Taller players should leverage "Serve + 1" patterns, while shorter players should utilize body serves to jam opponents and rely on superior conditioning.

CONCLUSION

The comparison of these two athletes demonstrates that there is no single phenotype for Division I tennis success. While anthropometric height provides a distinct advantage in serving velocity and geometry, elite neuromuscular power can bridge the gap. The Height-Dominant athlete succeeds through efficiency and geometry, while the Power-Dominant athlete succeeds through work rate, ground force production, and rotational agility. However, these strategies come with distinct physiological costs. Clinicians and coaches must recognize that the shorter, explosive athlete often bears higher internal tissue loads to produce equivalent external results. Therefore, training and recovery protocols must be individualized based on the athlete's somatic type and specific biomechanical demands.

FUNDING

The authors report no funding sources for this work.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Baiget, E., Corbi, F., & López, J. (2023). Influence of anthropometric, ball impact and landing location parameters on serve velocity in elite tennis competition. Biology of Sport, 40(1), 273-281. https://doi.org/10.5114/biolsport.2023.112095

Ellenbecker, T. S., & Roetert, E. P. (2003). Age specific isokinetic glenohumeral internal and external rotation strength in elite junior tennis players. Journal of Science and Medicine in Sport, 6(1), 63–70. https://doi.org/10.1016/S1440-2440(03)80009-9

Ellenbecker, T. S., Roetert, E. P., Bailie, D. S., Davies, G. J., & Brown, S. W. (2002). Glenohumeral joint total rotation range of motion in elite tennis players and baseball pitchers. American Journal of Sports Medicine, 30(2), 205–210. https://doi.org/10.1177/03635465020300020601

Fernandez-Fernandez, J., Ulbricht, A., & Ferrauti, A. (2014). Fitness testing of tennis players: How valuable is it? British Journal of Sports Medicine, 48(1), 22–31.

Fett, J., Ulbricht, A., & Ferrauti, A. (2020). Impact of physical performance and anthropometric characteristics on serve velocity in elite junior tennis players. The Journal of Strength & Conditioning Research, 34(1), 192-202. https://doi.org/10.1519/jsc.0000000000002641

Germic, A., Filipcic, T., & Filipcic, A. (2025). Anthropometric Characteristics and Somatotype of Young Slovenian Tennis Players. Applied Sciences, 15(15), 8584. https://doi.org/10.3390/app15158584

Kovacs, M. S. (2007). Tennis physiology: training the competitive athlete. Sports Medicine, 37(3), 189–198.

Luna-Villouta, P., Paredes-Arias, M., Flores-Rivera, C., Hernández-Mosqueira, C., Souza de Carvalho, R., Faúndez-Casanova, C., ... & Vargas-Vitoria, R. (2021). Anthropometric characterization and physical performance by age and biological maturation in young tennis players. International Journal of Environmental Research and Public Health, 18(20), 10893. https://doi.org/10.3390/ijerph182010893

Moreno-Pérez, V., Vera-Garcia, F. J., Sanchez-Sanchez, J., & Elvira, J. (2016). Descriptive profile of hip range of motion in elite tennis players. Physical Therapy in Sport, 19, 43–48.

Roetert, E. P., et al. (2009). Biomechanics of the tennis serve: implications for strength training. Strength and Conditioning Journal, 31(4), 35–40.

Rose, M. B., & Noonan, T. (2018). Glenohumeral internal rotation deficit in overhead athletes: An adaptation or a pathological condition? Clinical Journal of Sport Medicine, 28(1), 5–11.

Sánchez-Muñoz, C.; Sanz, D.; Zabala, M. Anthropometric characteristics, body composition and somatotype of elite junior tennis players. Br. J. Sports Med. 2007, 41, 793–799

Sanchez-Pay A, Ramon-Llin J, Martnez-Gallego R, Sanz-Rivas D, Sanchez-Alcaraz BJ, Frutos S (2021) Fitness testing in tennis: Influence of anthropometric characteristics, physical performance, and functional test on serve velocity in professional players. PLoS ONE 16(11).

Scamardella, F., Tafuri, F., Amato, G., Latino, F., & Tafuri, M. G. (2025). Anthropometric Aspects and Athletic Performance in Women's Tennis. Physical Education Theory and Methodology, 25(3), 566–574. https://doi.org/10.17309/tmfv.2025.3.12

RECOMMENDED ITF TENNIS ACADEMY CONTENT (CLICK BELOW)

ITF Academy

International Tennis Federation
COACHING & SPORT SCIENCE REVIEW
International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 21-26
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.755

Shoulder asymmetry in tennis players: functional adaptation or misinterpreted indicator of scoliosis?

Rodolfo Lisi

Ministry of Education and Merit, IMT Varrone, Cassino (FR), Italy

ABSTRACT

Shoulder asymmetry is a frequent finding in tennis players and has often been misinterpreted as a clinical sign of scoliosis. This assumption derives from traditional orthopaedic paradigms in which differences in shoulder height were considered secondary indicators of spinal deformity. However, current biomechanical and sport science evidence suggests that, in tennis players, shoulder asymmetry predominantly reflects a functional, sport-specific adaptation rather than a structural spinal pathology. Tennis is a highly asymmetric overhead sport characterized by repetitive, high-velocity movements of the dominant upper limb, particularly during the serve and forehand. These actions promote selective hypertrophy and strength dominance of the shoulder internal rotators, combined with relative weakness of the external rotators and scapular stabilizers. The resulting muscular imbalance and inertial loading contribute to altered scapular positioning and apparent shoulder depression. This article examines the biomechanical basis of shoulder asymmetry in tennis players and discusses practical implications for screening, prevention, and training.

Key words: Tennis, Shoulder asymmetry, Shoulder biomechanics, Functional adaptation, Scoliosis

Received: 2 February 2026

Accepted: 15 April 2026

Corresponding author: Rodolfo Lisi. Email: rodolfo.lisi@libero.it

INTRODUCTION

Asymmetrical musculoskeletal adaptations are a well-recognized consequence of long-term participation in unilateral and overhead sports. Disciplines such as tennis, baseball, volleyball, and handball require repetitive, high-velocity movements predominantly executed with the same upper limb, leading to sport-specific structural and functional adaptations of the shoulder girdle and trunk (Kibler, 1998; Ellenbecker & Roetert, 2003; Elliott, 2006). In tennis players, these adaptations are particularly evident at the level of the dominant shoulder, where selective hypertrophy, strength imbalances, and changes in scapular positioning are commonly observed across different levels of play.

One of the most visible manifestations of these adaptations is shoulder height asymmetry, often characterized by an apparent lowering of the dominant shoulder. Historically, this clinical sign has generated diagnostic uncertainty and has frequently been interpreted as a possible indicator of spinal pathology, particularly scoliosis. This interpretation originates from traditional orthopedic paradigms in which shoulder asymmetry was considered a secondary sign of structural spinal deformity. However, accumulating evidence from sport science, biomechanics, and clinical sports medicine suggests that, in athletes, shoulder asymmetry more often represents a functional adaptation rather than a manifestation of true scoliosis (Priest, 1988; Kibler, 1995; Negrini et al., 2018).

Recent systematic reviews and narrative syntheses in tennis and overhead athletes have further confirmed that shoulder asymmetries are primarily related to sport-specific loading patterns, strength imbalances, and range-of-motion adaptations rather than structural spinal pathology (Johnson et al., 2018; Moreno-Pérez et al., 2018; Keller et al., 2020). The distinction between structural scoliosis and functional or posture-dependent asymmetries is therefore crucial in the evaluation of athletes. Structural scoliosis is defined as a fixed, three-dimensional deformity of the spine, characterized by vertebral rotation and persistence of the curve irrespective of posture, whereas functional asymmetries are typically flexible, reversible, and strongly influenced by asymmetric loading patterns, muscular imbalances, and neuromuscular adaptations induced by sport-specific training (Nachemson & Lonstein, 1995; Negrini et al., 2018).

Contemporary evidence emphasizes that screening in overhead athletes should focus on modifiable functional factors, including shoulder strength balance, internal-to-external rotator ratios, and range-of-motion adaptations such as glenohumeral internal rotation deficit (GIRD), which have been consistently associated with shoulder injury risk (Johnson et al., 2018; Moreno-Pérez et al., 2018; Keller et al., 2020). Dominant-arm adaptations in tennis players typically include reduced internal rotation range of motion and alterations in total arc, reflecting chronic exposure to asymmetric loading. These features are clinically relevant because deficits in external rotator strength and altered ER/IR ratios have been associated with a history of shoulder pain in elite tennis players (Moreno-Pérez et al., 2018).

Tennis represents a paradigmatic model of asymmetric loading, as match-play analyses have shown that approximately 70–80% of all strokes performed during competitive play consist of the serve and the forehand, both predominantly executed with the dominant arm (Johnson & McHugh, 2006). These strokes are characterized by extremely high angular velocities of shoulder internal rotation, particularly during the acceleration phase of the serve, where peak values exceeding 2,000°/s have been reported in elite players (Elliott et al., 1986; Elliott, 1988). Such biomechanical demands impose substantial mechanical stress on the shoulder girdle musculature, especially on the internal rotators, which play a primary role in power generation.

Isokinetic and electromyographic studies have consistently demonstrated a strength dominance and hypertrophy of the shoulder internal rotators in tennis players, accompanied by relatively lower strength and endurance of the external rotators and scapular stabilizers (Ellenbecker, 1991; Ellenbecker & Roetert, 2003; Kibler et al., 2007). During the serve and forehand, internal rotators act concentrically to accelerate the arm, whereas external rotators are primarily engaged eccentrically during the deceleration and follow-through phases, where they are exposed to high mechanical loads (Ryu et al., 1988; Elliott et al., 2003). This functional imbalance is considered a key factor in both performance enhancement and injury risk.

From a biomechanical perspective, rapid arm rotation generates substantial inertial forces proportional to the moment of inertia of the upper limb and the angular velocity achieved during the stroke (Lisi, 2007). Repeated exposure to these forces promotes adaptive hypertrophy of the muscles primarily involved in acceleration, while the stabilizing and decelerating muscles are subjected to chronic eccentric overload (Bahamonde & Knudson, 2003; Farthing & Chilibeck, 2003). Over time, these neuromuscular adaptations may contribute to altered resting scapular positioning and an apparent depression of the dominant shoulder, without implying any underlying structural spinal abnormality.

Despite early observations reporting the frequent coexistence of shoulder asymmetry and mild spinal deviations in tennis players, no consistent evidence has demonstrated a causal relationship between shoulder height differences and true structural scoliosis (Priest, 1988; Steinbrück & Mauch, 2000). Rather, the available data support the interpretation of shoulder asymmetry as a sport-specific functional adaptation driven by asymmetric muscular development and repetitive biomechanical loading.

The purpose of this article is therefore to analyze the biomechanical and neuromuscular mechanisms underlying shoulder asymmetry in tennis players, to critically re-examine its historical association with scoliosis, and to provide practical implications for screening, prevention, and training. Emphasis is placed on the importance of distinguishing functional adaptations from pathological conditions to avoid misdiagnosis and to guide evidence-based practice in tennis coaching and sports medicine.

The conceptual distinction between functional shoulder asymmetry in tennis players and structural spinal deformity is illustrated in Figure 1.

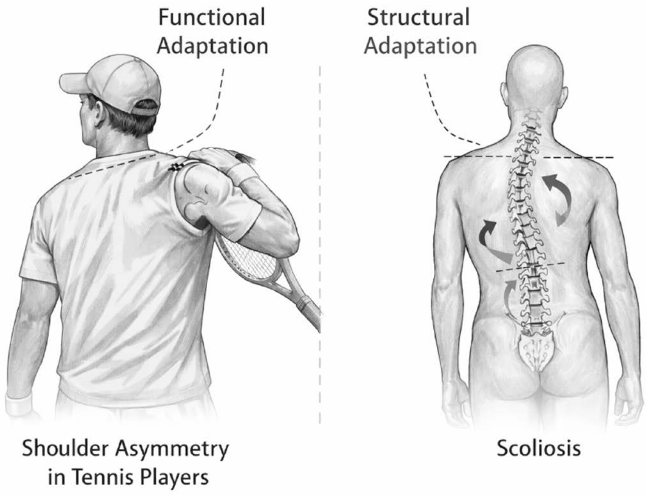


Figure 1. *Comparison between functional shoulder asymmetry in tennis players and structural spinal adaptation. Shoulder asymmetry observed in tennis players represents a sport-specific functional adaptation related to asymmetric loading, whereas scoliosis is characterized by a structural, three-dimensional spinal deformity.*

Shoulder Asymmetry in Tennis Players: Biomechanical Interpretation

The term "tennis player's shoulder" has long been used to describe the characteristic asymmetry observed at the level of the shoulder girdle in tennis players, typically involving an apparent lowering of the dominant shoulder (Rieder et al., 1983; Priest, 1988; Steinbrück & Mauch, 2000). Early observational studies reported a high prevalence of shoulder height asymmetry in competitive players, sometimes associated with mild lateral deviations of the thoracic spine. These findings contributed to the hypothesis that shoulder asymmetry might represent a clinical sign of underlying scoliosis.

However, early critical analyses questioned this interpretation and proposed an alternative explanation based on sport-specific biomechanical adaptations rather than structural spinal pathology (Lisi, 2007). Subsequent investigations failed to demonstrate a statistically significant correlation between shoulder depression and true scoliosis. Although mild thoraco-lumbar deviations were occasionally observed, these deviations were often flexible, posture-dependent, and not consistently oriented toward the dominant arm (Priest, 1988; Steinbrück & Mauch, 2000). Such characteristics are incompatible with the definition of structural scoliosis and instead suggest the presence of functional or apparent spinal adaptations.

Limitations of Early Etiological Hypotheses

Two main mechanisms were originally proposed to explain dominant-side shoulder depression in tennis players (Priest & Nagel, 1976; Priest, 1988). The first attributed the phenomenon to repetitive stretching of the shoulder elevators during the serve, particularly during the acceleration and follow-through phases, leading to progressive elongation and reduced resting tone of these muscles. The second hypothesis suggested that the increased mass of the dominant upper limb, resulting from hypertrophy, would exert a gravitational effect sufficient to lower the shoulder.

A biomechanical critique of these hypotheses highlighted their limitations (Lisi, 2007). During arm elevation, the scapula does not elevate passively but is actively stabilized by coordinated contraction of scapular depressors and rotators, providing a stable base for humeral motion (Boccardi & Lissoni, 1977; 1978; 1984). The modest degree of scapular depression typically observed (approximately 1–2 cm) is unlikely to induce pathological elongation of the elevator muscles, which are subsequently engaged concentrically during arm lowering. This interpretation is further supported by studies on scapular kinematics showing that resting scapular position is maintained primarily by tonic muscular activity rather than by gravitational loading (Ludewig & Cook, 2000). Consequently, the "gravitational mass" hypothesis appears biomechanically implausible.

Role of Inertial Forces and Muscle Imbalance

A more coherent explanation emerges when the dynamic characteristics of tennis strokes are considered (Lisi, 2007). Rapid arm rotation generates inertial forces proportional to the moment of inertia of the upper limb and the angular velocity achieved during the movement. An increase in limb mass or movement speed therefore results in a proportional increase in the mechanical load sustained by the muscles responsible for controlling these motions.

In tennis, both the serve and the forehand rely heavily on high-velocity internal rotation of the shoulder and account for the majority of strokes performed during match play (Johnson & McHugh, 2006). These strokes are characterized by extreme angular velocities, particularly during the acceleration phase of the serve, where peak values exceeding 2,000°/s have been reported in elite players (Elliott et al., 1986; Elliott, 1988). As originally proposed, repeated exposure to such inertial loads promotes selective hypertrophy and strength dominance of the shoulder internal rotators, while placing the external rotators at a relative mechanical disadvantage (Lisi, 2007).

Recent studies and systematic reviews have confirmed that these strength and range-of-motion adaptations persist across different competitive levels and age groups in overhead and racket sports, supporting the concept of long-term functional remodelling rather than pathological alteration (Silva et al., 2025; Madroñal-Sotomayor et al., 2025).

Isokinetic studies have consistently confirmed a functional imbalance between shoulder internal and external rotators in tennis players, demonstrating significantly greater strength of the internal rotators on the dominant side, while external rotator strength often shows minimal side-to-side differences (Ellenbecker, 1991; Ellenbecker & Roetert, 2003; Kibler et al., 2007). The functional imbalance between internal and external rotators in tennis players is schematically illustrated in Figure 2.

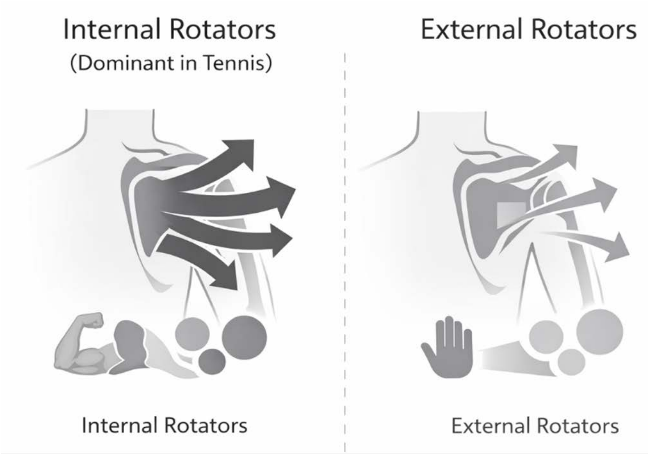


Figure 2. *Conceptual vector model illustrating the functional dominance of shoulder internal rotators compared with external rotators in tennis players. High-velocity strokes generate predominant internal rotation forces, while the external rotators are primarily involved in eccentric control and deceleration.*

This imbalance is further accentuated by biomechanical factors, including thoracic kyphosis and the oblique orientation of the scapula relative to the frontal plane, which reduce the mechanical efficiency of the external rotators during high-velocity movements (Kibler, 1998; Ludewig & Cook, 2000). As a result, the external rotators are required to operate under unfavourable length–tension and moment-arm conditions, particularly during the deceleration phase of the serve. The relationship between angular velocity, inertial forces, and eccentric control demands at the shoulder is central to understanding tennis-related adaptations. High angular velocities generated during the acceleration phase are followed by a rapid deceleration phase, during which substantial eccentric loading is required to dissipate inertial forces and protect the glenohumeral joint (Figure 3) (Bahamonde & Knudson, 2003; Elliott et al., 2003).

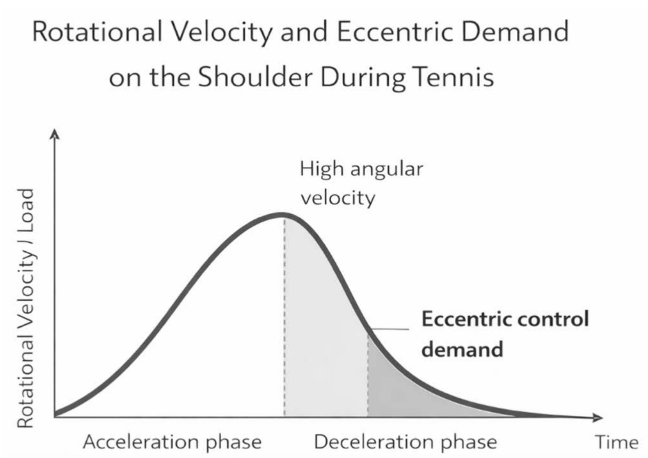


Figure 3. *Conceptual representation of the relationship between rotational velocity and eccentric control demands at the shoulder during tennis strokes. High angular velocities generated during the acceleration phase are followed by a rapid deceleration phase, during which substantial eccentric loading is required to control inertial forces.*

Electromyographic Evidence and Stroke-Specific Loading

Electromyographic analyses of the tennis serve indicate that scapular stabilizers are activated early to position and stabilize the scapula, while rotator cuff activation timing shifts across stroke phases, supporting the need for sequenced scapular–cuff conditioning rather than isolated muscle strengthening (Ryu et al., 1988; Kibler et al., 2007).

Repeated exposure to high-velocity internal rotation during serving and forehand strokes promotes selective hypertrophy and strength dominance of the shoulder internal rotators, including the pectoralis major, latissimus dorsi, teres major, and subscapularis (Ryu et al., 1988; Elliott et al., 2003; Ellenbecker & Roetert, 2003). Over time, this neuromuscular pattern leads to stable, sport-specific adaptations rather than transient functional changes.

These chronic adaptations provide a plausible biomechanical explanation for altered resting scapular positioning and the apparent depression of the dominant shoulder frequently observed in tennis players, without implying any underlying structural spinal abnormality (Kibler, 1998; Lisi, 2007).

Clinical interpretation: functional vs structural asymmetry

Structural scoliosis is defined as a fixed, three-dimensional spinal deformity characterized by vertebral rotation and persistence of curvature irrespective of posture, whereas the asymmetries observed in tennis players are flexible, reversible, and strongly influenced by sport-specific loading patterns (Nachemson & Lonstein, 1995; Negrini et al., 2018). Despite early reports describing the coexistence of shoulder asymmetry and mild spinal deviations in tennis players, no consistent evidence supports a causal relationship between shoulder height differences and true structural scoliosis (Priest, 1988; Steinbrück & Mauch, 2000). Observed spinal deviations are typically mild, posture-dependent, and non-fixed, characteristics incompatible with the definition of structural scoliosis.

DISCUSSION

The present analysis reinforces the interpretation of shoulder asymmetry in tennis players as a functional, sport-specific adaptation rather than a clinical indicator of structural scoliosis. While early observational studies documented a frequent coexistence of shoulder height asymmetry and mild spinal deviations, subsequent biomechanical and clinical investigations have failed to establish a causal relationship between these findings and true scoliosis (Priest, 1988; Steinbrück & Mauch, 2000). Instead, the available evidence consistently supports a model based on asymmetric loading, muscular imbalance, and inertial forces inherent to tennis performance.

A key contribution to this reinterpretation was the biomechanical framework originally proposed by Lisi (2007), which reframed the so-called "tennis player's shoulder" as an adaptive response to repetitive, high-velocity upper limb actions. To the author's knowledge, this interpretation was first explicitly proposed in the context of tennis by Lisi (2007), anticipating concepts that have since been supported by electromyographic, isokinetic, and clinical injury-risk studies in overhead athletes.

This biomechanical model anticipated several concepts now widely accepted in sport science, including the central role of internal rotator dominance, the mechanical disadvantage of the external rotators, and the importance of eccentric capacity during high-velocity deceleration. This aligns with evidence showing that external rotator strength deficits and altered ER/IR ratios are associated with shoulder pain history in elite tennis players (Moreno-Pérez et al., 2018), highlighting the clinical relevance of these functional imbalances.

Electromyographic analyses of the tennis serve demonstrate that scapular stabilizers are activated early to appropriately position the scapula, while rotator cuff activation timing shifts across stroke phases, supporting the need for sequenced scapular–cuff conditioning rather than isolated muscle strengthening (Kibler et al., 2007). During acceleration, internal rotators dominate force production, whereas external rotators are primarily engaged eccentrically during deceleration (Ryu et al., 1988).

Dominant-arm adaptations in tennis players typically include reduced internal rotation range of motion and alterations in total rotational arc. These features are clinically relevant because deficits in external rotator strength and altered ER/IR ratios have been associated with shoulder pain history in elite tennis players (Moreno-Pérez et al., 2018), reinforcing the importance of monitoring functional asymmetries rather than static postural signs alone.

The strength of this functional interpretation lies in its consistency with neuromuscular evidence. Studies examining the tennis serve and forehand consistently report high activation levels of the pectoralis major, latissimus dorsi, and subscapularis during acceleration phases, contrasted with intense eccentric loading of the external rotators during deceleration (Ryu et al., 1988; Kibler et al., 2007; Ellenbecker & Roetert, 2003). Over time, this loading pattern promotes selective hypertrophy and strength dominance of the internal rotators, while exposing the external rotators and scapular stabilizers to chronic overload and fatigue.

Such neuromuscular adaptations provide a plausible explanation for altered scapular positioning and apparent shoulder depression at rest. Rather than reflecting structural deformity, these postural features are consistent with long-term functional remodeling driven by asymmetric loading and repetitive inertial demands, as observed across overhead and racket sports (Kibler, 1998; Silva et al., 2025).

Importantly, this functional perspective also explains why shoulder asymmetry in tennis players is often flexible, posture-dependent, and poorly correlated with the direction or magnitude of spinal deviations. These characteristics are incompatible with the definition of structural scoliosis, which requires fixed vertebral rotation and persistence of curvature independent of posture (Nachemson & Lonstein, 1995; Negrini et al., 2018).

Misinterpreting functional adaptations as pathological deformities may lead to unnecessary diagnostic procedures, inappropriate clinical labelling, and misguided interventions. In athletic populations, particularly young players, such misclassification risks diverting attention away from modifiable performance-related factors toward non-indicated medical management (Negrini et al., 2018).

CONCLUSION

Shoulder asymmetry in tennis players should be interpreted primarily as a functional adaptation resulting from the asymmetric biomechanical demands of the sport rather than as a clinical sign of scoliosis. The repetitive, high-velocity actions of the serve and forehand impose substantial inertial loads on the dominant upper limb, promoting selective hypertrophy and strength dominance of the shoulder internal rotators and altering scapular resting position (Elliott, 1988; Bahamonde & Knudson, 2003).

The biomechanical interpretation originally proposed by Lisi (2007) provides a coherent framework for understanding this phenomenon and remains fully consistent with contemporary findings in electromyography, isokinetic, and movement analysis. Distinguishing functional adaptations from structural pathology is essential to avoid misdiagnosis and to guide appropriate training, prevention, and clinical decision-making in tennis players.

Future research should investigate shoulder asymmetry using integrated biomechanical models that consider the entire kinetic chain, individual playing styles, and modern equipment characteristics. Such approaches may further clarify the boundary between adaptive responses and pathological conditions and support evidence-based practice in tennis coaching and sports medicine.

Practical Implications for Coaches and Practitioners

Shoulder asymmetry in tennis players should be interpreted primarily as a sport-specific functional adaptation rather than as an isolated indicator of spinal pathology. In the absence of pain, neurological signs, or progressive deformity, the presence of a lowered dominant shoulder does not justify automatic suspicion of scoliosis. Instead, it should be understood within the context of asymmetric loading and long-term neuromuscular adaptation inherent to tennis performance (Priest, 1988; Lisi, 2007; Negrini et al., 2018).

Static postural assessment alone is insufficient to evaluate shoulder asymmetry in tennis players. Observation of shoulder height at rest does not capture the dynamic demands imposed by high-velocity strokes and may lead to misinterpretation of normal sport-related adaptations. Therefore, assessment should prioritize functional evaluation, including shoulder range of motion, scapular control during dynamic tasks, and strength balance between internal and external rotators (Kibler, 1998; Ellenbecker & Roetert, 2003; Kibler et al., 2007).

Imbalance between shoulder internal and external rotators represents a key modifiable factor in tennis players. Isokinetic and field-based studies consistently show dominant-side internal rotator strength to exceed that of the external rotators, resulting in altered ER/IR strength ratios (Ellenbecker, 1991; Ellenbecker & Roetert, 2003). Importantly, deficits in external rotator strength and altered ER/IR ratios have been associated with a history of shoulder pain in elite tennis players, underscoring their clinical relevance for injury prevention and monitoring (Moreno-Pérez et al., 2018).

Training programs should systematically include targeted strengthening of the external rotators and scapular stabilizers, with particular emphasis on eccentric loading (Figure 4).

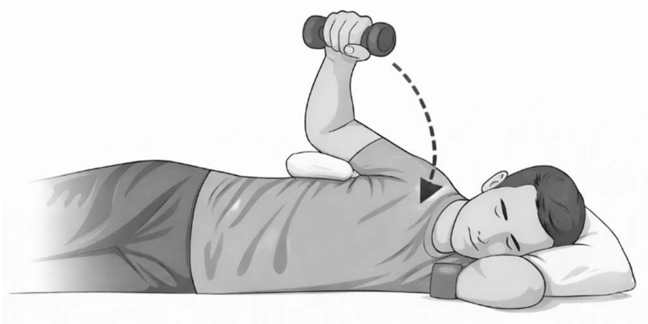


Figure 3. *Example of a side-lying eccentric external rotation exercise performed with the shoulder abducted to 90°. This exercise targets the deceleration function of the external rotators and is recommended to counterbalance internal rotator dominance in tennis players.*

During the deceleration and follow-through phases of the serve and forehand, the external rotators are exposed to substantial eccentric demands required to dissipate inertial forces generated during acceleration (Ryu et al., 1988; Elliott et al., 2003). Enhancing eccentric capacity may improve deceleration control, reduce cumulative overload, and support long-term shoulder health (LaStayo et al., 2003; Farthing & Chilibeck, 2003).

Effective management of shoulder asymmetry requires an integrated approach that prioritizes scapular control within the kinetic chain. Early activation of scapular stabilizers is essential to position the glenoid optimally and to allow efficient force transfer from the trunk to the upper limb during high-velocity strokes (Kibler, 1998; Kibler et al., 2007). Off-court strengthening of the serratus anterior, lower trapezius, and rotator cuff should therefore be combined with stroke-specific on-court drills to reinforce appropriate scapulohumeral sequencing.

Dominant-arm adaptations in tennis players typically include reductions in glenohumeral internal rotation and alterations in total rotational arc. While these changes are recognized as common sport-specific adaptations, excessive or asymmetrical range-of-motion deficits warrant attention, particularly when accompanied by strength imbalance or impaired scapular control (Johnson et al., 2018; Keller et al., 2020). Monitoring shoulder range of motion, especially unilateral internal rotation deficits, may facilitate early identification of maladaptive patterns.

From a preventive standpoint, a function-oriented screening framework is recommended. Rather than relying on static postural signs, clinicians and coaches should integrate assessments of strength balance, eccentric external rotator capacity, scapular control, and sport-specific movement patterns. When shoulder asymmetry is identified, it should prompt functional testing and targeted intervention rather than immediate referral for imaging or spinal evaluation.

Education of players, parents, and coaching staff is essential. Clear communication that certain asymmetries represent normal adaptations to tennis practice may reduce unnecessary concern, discourage premature medicalization, and support more appropriate performance-oriented and preventive strategies.

CONFLICTS OF INTEREST

The author declares the absence of conflicts of interest.

FUNDING

The author declares that no funding was received.

REFERENCES

Bahamonde, R., & Knudson, D. (2003). Kinetics of the upper extremity in the tennis forehand. Journal of Science and Medicine in Sport, 6(1), 88–101.
Boccardi, S., & Lissoni, A. (1977). Cinesiologia (Vol. I). Roma: SEU.
Boccardi, S., & Lissoni, A. (1978). Cinesiologia (Vol. II). Roma: SEU.
Boccardi, S., & Lissoni, A. (1984). Cinesiologia (Vol. III). Roma: SEU.
Ellenbecker, T. S. (1991). A total arm strength isokinetic profile of highly skilled tennis players. Isokinetics and Exercise Science, 1, 9–21.
Ellenbecker, T. S., & Roetert, E. P. (2003). Isokinetic profile of shoulder internal and external rotation strength in elite junior tennis players. Journal of Orthopaedic & Sports Physical Therapy, 33(2), 79–85.
Elliott, B. (1988). Biomechanics of the tennis serve. Australian Journal of Science and Medicine in Sport, 20, 11–16.
Elliott, B. (2006). Biomechanics and tennis. British Journal of Sports Medicine, 40, 392–396.
Elliott, B., Fleisig, G., Nicholls, R., & Escamilla, R. (2003). Technique effects on upper limb loading in the tennis serve. Journal of Science and Medicine in Sport, 6(1), 76–87.
Elliott, B., Marshall, R., & Noffal, G. (1995). Contributions of upper limb segments to racket velocity in the tennis serve. Journal of Applied Biomechanics, 11, 433–442.
Farthing, J. P., & Chilibeck, P. D. (2003). The effect of eccentric and concentric training at different velocities on muscle hypertrophy. European Journal of Applied Physiology, 89, 578–586.
Johnson, C. D., & McHugh, M. P. (2006). Performance demands of professional male tennis players. British Journal of Sports Medicine, 40, 696–699.
Johnson, J. E., et al. (2018). Glenohumeral internal rotation deficit and injuries: a systematic review. Orthopaedic Journal of Sports Medicine, 6(5), 2325967118773322.
Keller, R. A., de Giacomo, A. F., Neumann, J. A., Limpisvasti, O., & Tibone, J. E. (2020). Injury and training history are associated with glenohumeral internal rotation deficit in youth tennis athletes. BMC Musculoskeletal Disorders, 21, 92.
Kibler, W. B. (1995). Biomechanical analysis of the shoulder during tennis activities. Clinics in Sports Medicine, 14(1), 79–85.
Kibler, W. B. (1998). The role of the scapula in athletic shoulder function. The American Journal of Sports Medicine, 26(2), 325–337.
Kibler, W. B., et al. (2007). Muscle activation in coupled scapulohumeral motions in the high performance tennis serve. British Journal of Sports Medicine, 41(11), 745–749.
LaStayo, P. C., Woolf, J. M., Lewek, M. D., Snyder-Mackler, L., Reich, T., & Lindstedt, S. L. (2003). Eccentric muscle contractions: their contribution to injury, prevention, rehabilitation, and sport. Journal of Orthopaedic & Sports Physical Therapy, 33(10), 557–571.
Lisi, R. (2007). Tennis and scoliosis: state of the art. Roma: Lombardo Editore.
Ludewig, P. M., & Cook, T. M. (2000). Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy, 80(3), 276–291.
Madroñal-Sotomayor, Á., Martínez-Aranda, L. M., & Ortega-Becerra, M. (2025). Shoulder rotational and dynamic stability profiles in elite and national-level tennis players. Sensors, 25(10), 3164.
Moreno-Pérez, V., Moreside, J. M., Barbado, D., & Vera-Garcia, F. J. (2018). Comparison of shoulder rotation range of motion in professional tennis players with and without history of shoulder pain. International Journal of Sports Physical Therapy, 13(1), 39–49.
Nachemson, A., & Lonstein, J. (1995). Scoliosis: diagnosis, natural history, and treatment. Spine, 20, 234–241.
Negrini, S., et al. (2018). 2016 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis. Scoliosis and Spinal Disorders, 13, 3.
Priest, J. D. (1988). The shoulder in sports. Orthopedic Clinics of North America, 19, 123–134.
Priest, J. D., & Nagel, D. A. (1976). Tennis shoulder: pathophysiology and treatment. The American Journal of Sports Medicine, 4(1), 28–34.
Rieder, H., et al. (1983). Postural adaptations in competitive tennis players. International Journal of Sports Medicine, 4, 45–50.
Ryu, R. K. N., McCormick, J., Jobe, F. W., Moynes, D. R., & Antonelli, D. J. (1988). An electromyographic analysis of shoulder function in tennis players. The American Journal of Sports Medicine, 16(5), 481–485.
Silva, J. R., et al. (2025). Chronic adaptations of shoulder range of motion and strength in overhead and racket sports: a systematic review. Sports Medicine, 55, 1–18.
Steinbrück, K., & Mauch, F. (2000). Spinal changes in high-level tennis players. International Journal of Sports Medicine, 21, 423–427.

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 27-33
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.750

The impact of rally length on break point saving percentage among male tennis players based on rankings: observations across different professional levels

Andrej Grubisic[1], Nauman Haq[2], Robert Raguz[3] & Rafael Martínez-Gallego[4]

[1]Tennis Club Vierjahreszeiten (TCVJ), Hamburg, Germany. [2]Pakistan Tennis Federation (PTF), TriStar Education. [3]Tennis Association of Bosnia and Herzegovina; International Tennis Federation (ITF), Grand Slam Player Development Programme (GSPDP). [4]Research Group on Sports Technique and Tactics, University of Valencia, Valencia, Spain.

ABSTRACT

This study investigates the tactical role of rally length in saving break points among male professional tennis players, specifically comparing ATP 250 and Challenger Tour levels on hard courts. Based on an analysis of over 500 break point instances from 31 matches played between January 2023 and March 2025, the research explores the correlation between rally duration, point length, and player ranking. Findings reveal a significant negative correlation between player ranking and break point saving percentage, with ATP 250 players saving over 80% of break points compared to approximately 65% for Challenger players. Shorter rallies—specifically those under five shots and lasting less than seven seconds—were consistently associated with higher success rates across both tiers, although ATP 250 players demonstrated superior tactical maturity in effectively shortening points during these critical moments. Challenging the traditional notion of stationarity, these results suggest that elite players proactively alter rally dynamics under pressure, underscoring the critical importance of "first-strike" tennis and the ability to dominate neutral rallies as essential factors for improving break point performance and advancing in professional rankings.

Key words: Rally length, break point performance, tactical decision making, ATP ranking.

Received: 5 January 2026

Accepted: 19 March 2026

Corresponding author: Andrej Grubisic, grubisicandrej@gmail.com

INTRODUCTION

Tennis, as one of the most dynamic sports, demands an intricate blend of physical endurance, mental toughness, and strategic awareness (Sánchez Mencia et al., 2023). The outcome of a tennis match is often decided in pivotal moments, with break points standing out as critical junctures that can drastically shift momentum and determine the winner (O'Donoghue, 2012; Knight & O'Donoghue, 2012). The ability to save break points, defending one's service game under pressure, is widely regarded as a key indicator of a player's mental fortitude, consistency, and composure (Meffert et al., 2021). Indeed, the concept of "big points" underscores that not all points carry equal weight, and success in these high-stakes situations is often what differentiates elite performers (Kovalchik & Reid, 2018; Meffert et al., 2018).

Performance in these critical moments is not solely a function of psychological resilience; tactical decisions, such as the strategic manipulation of rally length, play a significant role (Cui et al., 2019; Conde-Ripoll et al., 2024). The temporal structure of tennis, characterized by intermittent dynamics, short repetitive actions, and varying intensity, inherently involves rally duration as a key component (Torres-Luque et al., 2014). Rally length itself is a multifaceted variable, influenced by factors such as court surface, player level, and specific match situations (Fitzpatrick et al., 2021; Prieto-Lage et al., 2018). For instance, research indicates that shorter points (0-4 shots) are particularly decisive on faster surfaces like grass (Fitzpatrick et al., 2021), and distinct rally patterns emerge during break point situations (Prieto-Lage et al., 2018). However, the conscious strategic use of rally length, specifically on hard courts during break points, and how this varies between different professional tiers, remains an area requiring more detailed exploration.

The cognitive demands of tennis, especially during high-pressure moments, are substantial. Research in cognitive psychology suggests that an overabundance of tactical information or too many variables to consider can lead to cognitive overload, impairing decision-making and performance (Sille, Turner, & Eubank, 2020; Ozsoy et al., 2023). Consequently, adopting a simplified yet effective tactical focus—such as consciously aiming to shorten or extend rallies based on a pre-defined strategy or opponent tendencies—might be a beneficial approach for players. This could reduce cognitive burden, allowing for more decisive action and composure (Raizada et al., 2025). While extensive research has explored various performance indicators in tennis, including serve effectiveness (Meffert et al., 2018), and point-by-point dynamics in Grand Slams (Cui et al., 2019; Escudero-Tena et al., 2020), there is a specific need to understand the nuanced relationship between rally length strategy and break point saving efficacy across the ATP 250 Tour and Challenger Tour levels. These two distinct tiers of professional men's singles tennis present different competitive pressures, skill execution levels, and potentially, tactical proclivities, particularly on hard court surfaces where rally dynamics can vary significantly. Furthermore, match statistics such as serve and return point percentages have shown a significant relationship with professional ranking (Reid, McMurtrie, & Crespo, 2010), underscoring the importance of effective play in these key areas for career progression.

Previous research has highlighted differences in how players approach break points, with higher-ranked players often exhibiting superior strategic skills (O'Donoghue, 2012). For instance, top-ranked ATP 250 players might possess a greater ability to control rally length, employing aggressive play to shorten exchanges (<5 shots), thereby minimizing opponent opportunities. Conversely, Challenger Tour players might engage in longer rallies more frequently, perhaps due to differences in first-strike capabilities or tactical confidence under pressure. Understanding these distinctions is vital, as even marginal advantages gained through optimized rally length strategies during break points can significantly impact match outcomes (Cui et al., 2019).

Therefore, the primary aim of this study is to investigate the impact of rally length on break point saving percentage among professional male tennis players on hard court surfaces. Specifically, this research will focus on comparing performance patterns and tactical approaches between players competing at the ATP 250 Tour level and those at the Challenger Tour level. It is hypothesized that: (a) shorter rally lengths will generally be associated with a higher break point saving percentage across both tiers, and (b) ATP 250 players will exhibit a more pronounced and effective use of specific rally length strategies (particularly shorter rallies) to save break points compared to Challenger Tour players, reflecting greater tactical maturity and execution under pressure. The findings are expected to provide valuable insights for players and coaches in developing targeted training regimens and pre-match strategies.

METHODOLOGY

Research Design

This study employed a comparative, observational, retrospective design to analyse the relationship between rally length, player ranking, and break point saving percentage in professional men's tennis. Data were analysed across two distinct professional tiers, the ATP 250 Tour and the Challenger Tour, with a specific focus on matches played on hard court surfaces.

Sample

Data were collected from a total of 31 official men's singles matches played on hard court surfaces between January 2023 and March 2025. The sample comprised 16 matches from the ATP 250 Tour and 15 matches from the Challenger Tour. These matches were purposively selected to ensure representation from both tournament levels and to obtain a sufficient number of break point situations for robust analysis. Across these matches, over 500 break points were identified and analysed (226 from ATP 250 matches and 276 from Challenger Tour matches). Specific details of the included matches, including tournament, year, and participating players, are provided in Table 1 (Appendix A). This selection strategy aimed to encompass a variety of players and competitive contexts within each tour level. Player rankings (ATP Ranking) at the time of each match were recorded for all participating players. Matches that were not completed due to player retirement or walkover were excluded from the sample.

Data collection and variables

Data were retrospectively collected from publicly available, official match statistics and point-by-point data provided on the ATP Tour (Tennis TV) and Challenger Tour online viewing platforms. These platforms offer comprehensive databases of match events. For each match, match logs and point-by-point summaries were meticulously reviewed to identify every instance where a player faced a break point on their serve. Once a break point was identified, several variables were extracted.

Independent variables included:

• Tournament Level: ATP 250 Tour, Challenger Tour.

• ATP Tennis Ranking: ranking of the serving player at the time of the match.

• Rally Length (shots): total number of successful strokes exchanged by both players within the rally, commencing with the serve and concluding when the point was decided (an ace was recorded as a 1-shot rally, a double fault as a 0-shot rally).

• Point Duration (seconds): time elapsed from the initiation of the serve to the conclusion of the point.

Dependent variable included:

• Break Point Saved Percentage (%): calculated for each match as: (Number of Break Points Saved / Total Number of Break Points Faced) * 100.

Statistical Analysis

Descriptive statistics, including means, standard deviations (SD), ranges, and percentages, were calculated for all variables to summarize the sample characteristics and performance indicators across the two tournament levels. The relationships between player ranking and break point saving percentage, and between rally length/point duration and break point saving percentage, were examined using Pearson correlation coefficients (r), stratified by tournament level.

To further explore these relationships and derived predictive equations, linear regression analyses were conducted. The coefficient of determination (R^2) was reported to indicate the proportion of variance in the dependent variable explained by the independent variable(s). Prior to conducting parametric tests, the assumptions of normality and homogeneity of variances were assessed using Shapiro-Wilk and Levene's tests, respectively. Comparisons of break point saving percentages, rally lengths, and point durations between ATP 250 and Challenger Tour players were performed using independent samples t-tests. In instances where parametric assumptions were violated, non-parametric Mann-Whitney U tests were employed as an alternative.

Graphical representations, such as scatter plots with trendlines, were generated using Microsoft Excel's plotting tools to visualize key relationships. All inferential statistical analyses were conducted using SPSS Statistics Version 28 (IBM Corp., Armonk, NY, USA) and R Version 4.X.X (R Core Team, Vienna, Austria). The alpha level for statistical significance was set at $p < .05$ for all inferential tests.

RESULTS

Statistical analysis of the 31 matches, encompassing over 500 break points, revealed significant relationships between player ranking, rally length, and break point saving percentage, with notable differences between the ATP 250 and Challenger Tours.

Relationship between ATP ranking and break point saved percentage

A statistically significant negative correlation was found between a player's ATP ranking number and their break point saved percentage. As observed in Figure 1, higher-ranked players (a lower ranking number) tend to save a greater percentage of break points.

The linear regression analysis indicates this trend is considerably stronger in ATP 250 tournaments ($R^2 = 0.53$) compared to Challenger tournaments ($R^2 = 0.23$). This suggests that at the ATP 250 level, a player's ranking explains a larger proportion of the variance in performance during critical moments. Descriptively, the analysed ATP 250 Tour players averaged a saving percentage above 80%, whereas Challenger Tour players averaged approximately 65%.

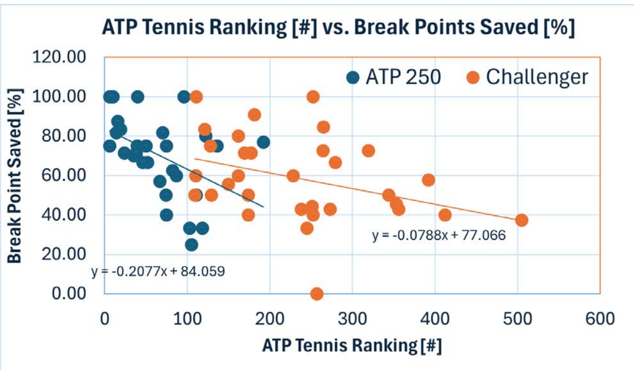


Figure 1. *Relation between player ranking and percentage of break points saved.*

Impact of point duration on performance

The analysis of point duration proved to be a decisive factor in break point outcomes. Figure 2 illustrates a significant negative correlation between point duration (in seconds) and the break point saved percentage across both tournament levels. Notably, the correlation was much more pronounced for ATP 250 players ($R^2 = 0.54$) than for Challenger players ($R^2 = 0.22$). This indicates that the strategy of shortening points has a more consistent and successful impact on the performance of higher-ranked players. Players who saved over 75% of break points predominantly did so in points lasting less than seven seconds. Conversely, a high percentage of lost break points occurred in rallies that exceeded this duration.

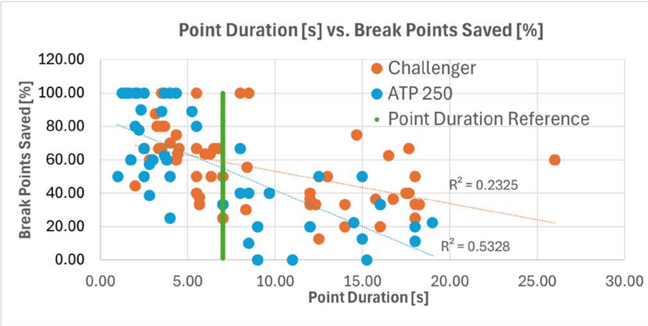


Figure 2. *Break point saved percentage vs. point duration.*

Comparative analysis of rally length

To further investigate tactical strategy, the percentage of break points lost was analysed based on whether the rally lasted fewer than five shots or more than five shots. Figure 3 reveals a drastic performance difference based on this variable.

In short rallies, players of all rankings maintained a low percentage of break points lost, generally below 30%. However, in long rallies, the percentage of break points lost increased significantly, especially for players ranked outside the top 100. This finding suggests that while lower-ranked players can successfully execute short-point tactics, their performance sharply declines as the rally extends—a vulnerability less evident in elite players.

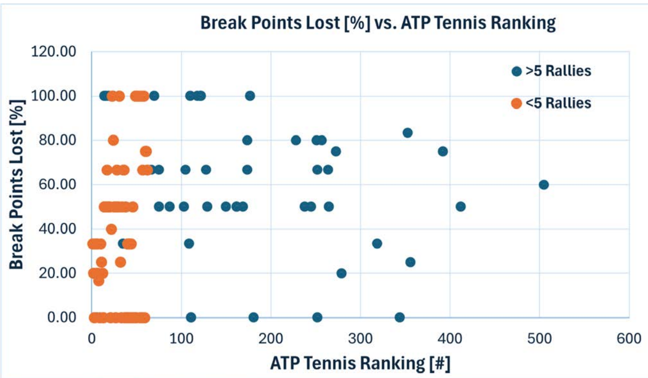


Figure 3. *Visual representation of break point loss [%] compared to players' ranking as analysed from points over and under 5 rallies.*

DISCUSSION

This study provides empirical evidence that the strategic manipulation of rally length is a crucial tactical factor for saving break points in men's professional tennis, particularly on hard courts. The results confirm our hypotheses: shorter rallies are associated with a higher break point saving percentage, and this strategy is employed more effectively by ATP 250 players compared to their Challenger Tour counterparts.

Our central finding challenges the classic assumption of "stationarity" in tennis, the idea that the probability of winning a point remains constant regardless of the score (Knight & O'Donoghue, 2012). Our data strongly support more recent research indicating that player performance is context-dependent and elevates on critical points (O'Donoghue, 2012). The key contribution of our study is to propose why this stationarity fails on break points: higher-ranked players are not merely reacting to pressure but are consciously executing a proactive strategy to shorten exchanges. This aligns with the perspectives of elite players and coaches, who overwhelmingly acknowledge the existence of "big points" like break points, where tactical decisions and mental composure are paramount (Meffert et al., 2021). By simplifying the tactical objective to keep the point short, a strategy designed to conclude the point within the average 5-7 second duration typical of hard-court rallies (Torres-Luque et al., 2014), players can reduce cognitive load and execute with greater confidence.

At first glance, our findings might seem at odds with studies like Conde-Ripoll et al. (2024), which found that break points, on average, feature longer rallies than non-break points. However, this is not a contradiction but rather two sides of the same coin. The findings of Conde-Ripoll et al. represent a descriptive reality of what occurs across all outcomes, whereas our study offers a prescriptive conclusion on how to achieve success. In essence, players who successfully save break points are the ones who manage to defy the trend and end the point quickly. Those who get drawn into longer exchanges, as is common on break points, are the ones who are more likely to lose the point, thus explaining the overall longer average rally length.

Differences between professional levels and strategic approaches

The performance gap between ATP 250 and Challenger players, especially in rallies extending beyond five shots, is a critical insight. While both levels may attempt short-point tactics, the elite players' superior ability to execute their "first-strike" tennis (serve + first shot) under pressure is what differentiates them. This is supported by broad analyses of Grand Slam matches, which consistently find that winners significantly outperform losers in serve quality, return performance, and break point conversion percentage (Raizada et al., 2025).

Crucially, the ability to excel on break points is directly linked to the statistics that define elite players. In a seminal study, Reid, McMurtrie, and Crespo (2010) found that of all the match statistics available, the two most significant predictors of a player's Top 100 ranking were the percentage of second serve points won and the percentage of second serve return points won. These two metrics alone accounted for 52% of the variance in professional ranking. This adds a critical layer to our findings. Success on break points is not merely about hitting an unreturnable first serve (a 1-shot rally); it is about possessing the tactical acumen and baseline solidity to dominate the rally when a second serve brings the point to a more neutral state. Many break points are contested on second serves, making proficiency in these situations, both offensively and defensively, the ultimate differentiator for climbing the rankings.

Furthermore, the mantra "shorter is better" requires nuance. A study on grass court tennis by Fitzpatrick et al. (2021) revealed that while 1-shot (aces/return errors) and 2-shot rallies were critical for winning, the classic "serve plus one" (3-shot rally) was surprisingly not a differentiating factor between winners and losers. This suggests that the most decisive actions are the serve and the return themselves. Similarly, the optimal strategy can be highly dependent on the player and surface. For example, a case study of Nadal and Djokovic on clay courts showed that in that specific context, it was Nadal who won more break points in long rallies (>7 shots), leveraging his unique defensive and attritional capabilities (Prieto-Lage et al., 2018). This highlights that while a short-point strategy is a robust general model for success on hard courts, it is not universally absolute.

Limitations and future lines of investigation

The primary limitation of this study is its focus on a single surface type. Our findings are specific to hard courts. As the comprehensive review by Torres-Luque et al. (2014) details, the temporal structure of tennis, including point duration and work-to-rest ratios, is highly conditioned by the playing surface. Rallies are inherently longer on clay and shorter on grass. Future research should therefore conduct a direct comparative analysis of rally length strategies on break points across all surfaces to build a more complete tactical framework. Additionally, expanding this analysis to the WTA tour would be a valuable step, as rally dynamics and strategic priorities may differ.

CONCLUSION

In conclusion, this study provides strong quantitative evidence that the ability to proactively shorten rallies is a cornerstone of successfully defending break points in elite men's tennis on hard courts. This tactic is a conscious departure from baseline rally patterns, reflecting the heightened importance players place on these moments. The strategic priority of winning the point early aligns with the broader statistical markers of elite performance, particularly the ability to win a high percentage of second serve points, which is a key predictor of professional ranking. For players and coaches, particularly at the Challenger level, the practical implication is clear: developing the technical and tactical capacity for "first-strike" tennis is not just a general goal, but a critical tool for mastering the high-pressure situations that ultimately define career progression.

CONFLICTS OF INTEREST AND FUNDING

The authors declare that they have no conflict of interest, nor have they received any funding related to the development of this study.

APPENDIX

TOURNAMENT	***MATCHUP***	*INDEPENDENT VARIABLE*	*DEPENDENT VARIABLES*		
		RANKING *R* (#)	**BREAK POINTS SAVED (#)**	**NUMBER OF BREAK POINTS (#)**	**BREAK POINTS SAVED (%)**
Challenger Gwangju Open 2024	**Lloyd Harris**	128	9	12	75.00
	Tung-Lin Wu	257	0	5	0.00
Challenger GNP Seguros Open 2024	**Adam Walton**	111	2	2	100.00
	Tristan Schoolkate	252	2	5	40.00
Challenger Hamburg 2024	Ergi Kirkin	251	4	9	44.44
	Yuta Shimizu	264	8	11	72.73
Challenger Chennai 2024	**Dalibor Svrcina**	174	5	10	50.00
	Evgeny Donskoy	353	5	11	45.45
Challenger Chennai 2024	**Sumit Nagal**	121	5	6	83.33
	Dalibor Svrcina	174	2	5	40.00
Challenger Busan 2024	**Blake Ellis**	392	11	19	57.89
	Antonie Escoffier	228	15	25	60.00
Challenger 75 Temuco Chile 2023	**Aleksandar Kovacevic**	110	3	5	60.00
	Gilber Klier Junior	356	3	7	42.86
Challenger Yokkaichi Japan 2023	**Zizou Bergs**	129	2	4	50.00
	Marc Polmans	150	5	9	55.56
Challenger Oeiras 2, Portugal 2024	**Aleksandar Kovacevic**	109	3	6	50.00
	Zsombor Piros	238	3	7	42.86
Challenger Noumea, New Caledonia	**Shintaro Mochizuki**	169	5	7	71.43
	Moerani Bouzige	412	4	10	40.00
Challenger Noumea, New Caledonia	**Constant Lestienne**	177	5	7	71.43
	Jake Delaney	505	3	8	37.50
Challenger Chennai Open 2025	**Shintaro Mochizuki**	181	10	11	90.91
	Enrico Dalla Vale	279	10	15	66.67
Challenger Tenerife 2025	**Henrique Rocha**	162	8	10	80.00
	Abdulah Shelbayh	265	11	13	84.62
Challenger Tenerife 2025	**P. Martin Tiffon**	252	4	4	100.00
	J. Monday	319	8	11	72.73
Challenger Tenerife 2025	**Henrique Rocha**	162	3	5	60.00
	Edas Butvilas	245	2	6	33.33
Challenger Pune 100 2025	**Masamichi Imamura**	344	2	4	50.00
	Jay Clarke	273	3	7	42.86
ATP 250 Los Cabos 2024	**Alexander Zverev**	6	13	13	100.00
	Thanasi Kokkinakis	103	1	3	33.33
ATP 250 Los Cabos 2024	Alexander Zverev	6	9	12	75.00
	Jordan Thompson	35	7	10	70.00
ATP 250 Delray Beach 2024	**Tommy Paul**	14	9	11	81.82
	Alex Michelsen	75	6	8	75.00
ATP 250 Marseille 2024	**Alejandro Davidovich Fokina**	24	5	7	71.43
	Gregoire Barrere	105	1	4	25.00
ATP 250 Doha 2024	**Andy Murray**	50	3	4	75.00
	Alexandre Muller	75	2	5	40.00
ATP 250 Auckland 2024	**Ben Shelton**	16	7	8	87.50
	Roberto Carballes Baena	67	4	7	57.14
ATP 250 Auckland 2024	**Cameron Norrie**	19	5	6	83.33
	Luca Van Assche	87	6	10	60.00
ATP 250 Adelaide 2024	**Daniel Evans**	40	2	2	100.00
	Rinky Hijikata	70	9	11	81.82
ATP 250 Open Occitanie 2025	**Alexander Bublik**	39	3	4	75.00
	Dominik Koepfer	118	2	6	33.33
ATP 250 Open Occitanie 2025	**Andrey Rublev**	10	3	3	100.00
	Christopher Eubanks	111	3	6	50.00
ATP Marseille Open 2025	**Hamad Medjedovic**	96	5	5	100.00
	Raphael Collignon	122	8	10	80.00
ATP Marseille Open 2025	**Zhizhen Zhang**	52	2	3	66.67
	Quentin Halys	74	2	4	50.00
ATP Marseille Open 2025	**Pierre-Hugues Herbert**	192	10	13	76.92
	Harold Mayot	136	9	12	75.00
ATP Marseille Open 2025	**Daniil Medvedev**	8	5	5	100.00
	Jan-Lennard Struff	46	8	12	66.67
ATP Delray Beach 250	**Matteo Arnaldi**	38	10	14	71.43
	Learner Tien	82	5	8	62.50

AVG RALLY LENGTH	B.P. SAVED (%) (< 5 RALLIES)	AVG POINT DURATION(s)	AVG RALLY LENGTH	B.P. SAVED (%) (> 5 RALLIES)	AVG POINT DURATION(s)	B.P. LOST	B.P. LOST (%) (<5 RALLIES)	B.P. LOST (%) (>5 RALLIES)
1.75	44.44	2.00	7.60	55.56	8.4	3	33.33	66.67
3.00	0	2.00	13.25	0.00	17.25	5	20	80
3	50.00	4	4.5	50.00	5.5	0	-	-
3.5	100	5.5	6.33	0.00	7	3	33.33	66.67
4	25.00	7.00	9.33	75	14.67	5	20	80
3	37.50	5.67	10.2	62.5	16.2	3	33.33	66.67
2.67	80.00	3.67	8	20	16.5	5	20	80
3	60.00	4.33	8.5	40	12	6	16.67	83.33
2.40	100.00	8.50	-	0	-	1	0	100
2.5	100.00	8.00	-	0	-	3	33.33	66.67
3.29	63.64	6.00	9	36.364	15.75	8	25.00	75.00
2.83	40.00	8.00	12.44	60	26	10	20.00	80.00
2.5	66.67	3.5	7	33.33	14	2	0	100.00
3	66.67	4.5	7	33.33	16	4	50.00	25.00
4	50.00	7	9	50.00	13	2	50.00	50.00
2.00	40.00	5.50	15.33	40.00	17.67	4	50.00	50.00
3.33	33.33	5.67	9.33	66.67	17.67	3	66.67	33.33
4.50	66.67	6.75	11.33	33.33	12.33	4	50	50
2.50	80.00	3.25	9.00	20.00	16.00	2	50	50
3.33	75.00	4.33	10.00	25.00	18.00	6	50	50
4	80.00	3.5	8.00	20.00	14	2	-	100
3.5	66.60	5.5	10.00	33.40	18	5	40	60
3.43	70.00	4.00	6.67	30.00	8.33	1	100	0
2.9	60.00	2.80	9.8	40.00	12	5	80	20
1.86	87.50	3.17	8	12.50	12.5	2	50.00	50.00
3.57	63.63	4.43	13.50	36.36	16.75	2	50.00	50.00
3.50	100.00	4.00	0	0.00	0	0	0.00	0.00
2.29	63.63	6.29	7.00	36.36	12.00	3	66.66	33.33
1.50	66.66	6.50	6	33.33	12	2	50.00	50.00
2.00	100.00	3.50	0.00	0.00	0.00	4	50.00	50.00
4.33	50.00	6.33	13	50.00	18	2	100.00	0.00
3.33	66.67	3.33	12.75	33.33	18.25	4	25.00	75.00
2.0	38.46	2.8	11.63	61.54	22.88	0	-	-
-	0	-	8	33.33	19.5	2	50	50
1.875	88.89	3.5	8	11.11	18	3	66.67	33.33
2.8	50.00	4	7	20	12	3	66.67	33.33
2.0	77.78	2.21	9	22.22	14.5	2	0	100
2.6	62.5	3.67	7	12.5	15	2	50	50
2.25	57.143	2.8	6	20.00	12	2	0	100
3	25	4	-	0	-	3	33.33	66.67
4,5	66.67	8	9	33.33	16	1	0	100
2	100	2.5	-	0	-	3	33.33	66.67
1.71	100.00	2.14	-	0.00	-	1	0	100
2.5	100.00	4.33	-	0	-	3	33.33	66.67
3.00	80.00	5.50	7	20.00	18	1	0	100
1.75	66.67	2.50	7.5	33.33	16	4	50	50
1.00	50.00	1.00	7	50.00	15	0	-	-
3.29	88.89	5.25	12.5	22.22	19	2	0	100
2	100	1.67		0		1	100	0
1.5	100	1.5	11.75	0	15.25	4	0	100
2.5	66.67	2.50	6	33.33	7	0		
2.5	100.00	2.00	8.5	0	11	3	100	0
2.33	60.00	3.00	7.50	40.00	8.50	0		
2.50	50.00	2.50	10	50.00	12.5	2	0	100
2.67	100.00	3.67	-	0.00	-	1	100	0
1.50	100.00	1.25	-	0.00	-	2	-	-
2.25	60.00	1.75	7	40.00	8.00	3	66.67	33.33
1.92	100.00	1.50	-	0.00	-	3	100.00	0.00
2.50	80.00	2.00	7	20.00	9	0	0.00	0.00
3.55	100.00	4.00	7	0.00	9	4	75.00	25.00
2.58	90.00	2.33	8	10.00	8.5	4	75.00	25.00
4.00	60.00	3.80	7.67	40.00	9.67	3	66.67	33.33

REFERENCES

Conde-Ripoll, R., Martínez-Gallego, R., Esteban-Rodríguez, N., Fanjul-Hevia, A., Genevois, C., & Escudero-Tena, A. (2024). Exploring break point dynamics: A preliminary performance analysis in men's professional tennis. Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 13(3), 76-93.

Cui, Y., Liu, H., Liu, H., & Gómez, M. Á. (2019). Data-driven analysis of point-by-point performance for male tennis player in Grand Slams. Motricidade, 15(1), 49-61. http://dx.doi.org/10.6063/motricidade.16370

Escudero-Tena, A., Castrejon, A., & Ibáñez, S. J. (2020). Indicadores de rendimiento en los Grand Slams de tenis. JUMP, Journal of Movement and Performance, (2), 26-36. https://doi.org/10.17561/jump.n2.3

Fitzpatrick, A., Stone, J. A., Choppin, S., & Kelley, J. (2021). Investigating the most important aspect of elite grass court tennis: Short points. International Journal of Sports Science & Coaching, 16(5), 1178–1186. https://doi.org/10.1177/1747954121999593

Knight, G., & O'Donoghue, P. (2012). The probability of winning break points in Grand Slam men's singles tennis. European Journal of Sport Science, 12(6), 462–468. https://doi.org/10.1080/17461391.2011.577239

Kovalchik, S. A., & Reid, M. (2018). Measuring clutch performance in tennis. Italian Journal of Applied Statistics, 30(2), 255–268. https://doi.org/10.26398/IJAS.0030-011

Meffert, D., Breuer, J., Ohlendorf, L., Born, P., Grambow, R., & Vogt, T. (2021). Towards an understanding of big points in tennis: Perspectives of coaches, professional players, and junior players. Journal of Physical Education and Sport, 21(2), 728-735.

Meffert, D., O'Shannessy, C., Born, P., Grambow, R., & Vogt, T. (2018). Tennis serve performances at break points: Approaching practice patterns for coaching. European Journal of Sport Science, 18(8), 1151–1157. https://doi.org/10.1080/17461391.2018.1490821

O'Donoghue, P. (2012). Break points in Grand Slam men's singles tennis. International Journal of Performance Analysis in Sport, 12(1), 156-165. https://doi.org/10.1080/24748668.2012.11868591

Ozsoy, S., Nash, M., Moffitt, R., Buszard, T., Moreland, A., & Conduit, R. (2023). Cognitive load and fatigue in high performance tennis - Current understanding and training application by Australian tennis coaches. Journal of Science and Medicine in Sport, 26(11), 569-575. https://doi.org/10.1016/j.jsams.2023.08.166

Prieto-Lage, I., Prieto, M. A., Curran, T. P., & Gutiérrez-Santiago, A. (2018). An Accurate and Rapid System to Identify Play Patterns in Tennis Using Video Recording Material: Break Point Situations as a Case Study. Journal of Human Kinetics, 62, 199-212. https://doi.org/10.1515/hukin-2017-0170

Raizada, S., Reddy, A., Biswas, S., & Sharma, R. (2025). Breaking down success: Game-related statistical analysis in tennis grand slams. Journal of Human Sport and Exercise, 20(3), 895-904. https://doi.org/10.55860/qm3vn826

Reid, M., McMurtrie, D., & Crespo, M. (2010). Title: The relationship between match statistics and top 100 ranking in professional men's tennis. International Journal of Performance Analysis in Sport, 10(2), 131-138. https://doi.org/10.1080/24748668.2010.11868509

Sanchez Mencia, E., Campos-Rius, J., González Santamaría, X., & Borrajo Mena, E. (2023). Tactical skills in tennis: A systematic review. International Journal of Sports Science & Coaching, 19(2), 894-907. https://doi.org/10.1177/17479541231216268

Sille, R., Turner, M. J., & Eubank, M. (2020). "Don't Be Stupid, Stupid!" Cognitive-Behavioral Techniques to Reduce Irrational Beliefs and Enhance Focus in a Youth Tennis Player. Case Studies in Sport and Exercise Psychology, 4(1), 40–51. https://doi.org/10.1123/CSSEP.2019-0018

Tennis TV. (n.d.). Live Matches Library. Retrieved March [Fecha de acceso del paper original], 2025, from https://www.tennistv.com/

Torres-Luque, G., Sánchez-Pay, A., Fernández-García, Á. I., & Palao, J. M. (2014). Características de la estructura temporal en tenis. Una revisión. Journal of Sport and Health Research, 6(2), 117-128.

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 34-39
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.464

Creating a tennis culture in the national federation: Practical applications

Ana Piquer Piquer[1], Manrique Rodríguez Campos[1] & Andrés Crespo Dualde[2]
[1]Universitat de Valencia, Spain. [2]Universitat Politécnica de Valencia, Spain.

ABSTRACT

This article is the continuation of an introductory paper of the topic of culture in national tennis federation (NFs). It shares practical examples and guidelines that will assist these organisations in starting a process to embark in a cultural change that can be adapted to the specific characteristics of each organisation. It provides guidelines to all those involved on how to create the appropriate tennis culture in a national tennis federation. Finally, to stimulate the development of sound, practical, and evidence-based cultural practices by NFs, the paper identifies several future applied directions.

Key words: values, management, organisation, national association

Received: 19 March 2025

Accepted: 8 January 2026

Corresponding author: Ana Piquer Piquer - ana.piquer@uv.es

CULTURE GENERATION IN NATIONAL TENNIS FEDERATIONS (NFS)

Culture and strategy of NFs

From an organisational perspective, researchers such as Henriksen (2010a) have indicated that the macro-environment in which tennis organisations and players develop involves various cultural contexts which include the national and regional culture, the industry culture, the organisational culture, the general sporting culture, the tennis specific culture and the youth culture. These have been labelled as levels of culture (Rodriguez et al., 2024).

The relationships between culture and strategy in national NFs are considerably close. Figure 1 shows the main elements of both as related to these organisations.

Figure 1. *Elements of culture and strategy in NFs.*

To develop a sound strategy, cultural considerations should be at the core of the process. In this context, NFs should maintain regular contact with local, regional, and national political and sporting authorities to ensure the alignment with the national policies and strategies to promote tennis as a sport that can be played at all levels of the game (Davies, 2004) as well as with the national culture. When developing the strategy, the people in charge should issue guidance for inclusion of all stakeholders such as players, coaches, officials, clubs and event organizers, spectators, the industry, and tournament staff, including support personnel (Garcia, 2020). Finally, they should strive to promote better coordination between the national government and the regional organisations through a coherent strategy monitored by the NF.

Culture and governance in NFs

An effective system of governance of the national tennis federation is a crucial facilitator to adopt the adequate organizational culture. This involves defining roles and responsibilities, setting policies and procedures, and implementing processes for accountability and transparency.

This system creates an environment that promotes good decision-making and encourages collaboration (Ferkins & Shilbury, 2010).

In this context, effective communication is essential in the adoption of a governance that fosters a strong culture. This includes both internal and external communication. Internally, communication should be effective among staff, board members, and players. Externally, communication should be clear and concise to inform stakeholders, sponsors, and the public about the federation's activities and successes (Rodriguez et al., 2024).

Towards a cultural improvement through change in NFs?

Culture develops daily out of the behaviours and actions of each stakeholder of the organisation and as such it can be changed (Henriksen, 2015). It has been understood as the prevailing attitude in the federation. Therefore, these organisations should adopt a proactive approach towards it.

It has been suggested that the first step to a cultural change in an organisation such as the national tennis federation is to conduct a culture audit to establish the current and desired culture through an aligned combination of informal and formal transformational leadership. By doing so, the NA stakeholders would have to reply to this question: which is the tennis culture of your NA?

In this process, cultural change will be, and must be, improvement and development oriented. Within this purpose, two main streams should emerge, the performance and the participation ones. Key principles such as excellence, sustainability, stability, and collaboration are the ones that guide the leaders in charge of the cultural change of organisations (Whitmore, 2005),

Creating a culture of excellence in NFs

Creating a culture in a national tennis federation can be a difficult but rewarding task. It requires setting up a system that can motivate and inspire players, coaches, and administrators to work together to achieve success. It also involves creating a positive attitude and environment that encourages collaboration and innovation (SIRC& Own the Podium, 2021).

A culture of excellence should be established by setting and enforcing high ethical and behavioural standards. This includes developing a clear mission statement that outlines the purpose of the organisation, its objectives and goals, and the values it will strive to uphold. It should be communicated frequently and reinforced through positive reinforcement and rewards. There should be a clear system of accountability in place, so that all stakeholders in the sport are aware of their roles and responsibilities.

The organisation should also strive to provide a safe and supportive environment for its players, coaches, and administrators, and ensure that everyone is treated with respect and fairness. Finally, a culture of learning should be fostered by providing educational opportunities and resources that allow players, coaches, and administrators to continue to develop and grow. By creating a culture that encourages collaboration, innovation, and learning, a national tennis federation can create a positive and successful environment that will benefit all its stakeholders.

PRACTICAL IMPLICATIONS FOR NATIONAL TENNIS FEDERATIONS

This section includes several examples and proposals for the implementation of an appropriate organisational culture in a NF. Research and practice have provided several key themes that can be used as guiding principles for the structure of an initiative of culture generation. These themes include development, performance, participation, professionality, equality, inclusion, respect, sustainability, and innovation.

Positioning development at the core of the culture

Creating a development culture in a national tennis federation is essential to ensure that the sport continues to grow and thrive. It requires a clear vision and strategy to create a culture of growth and development. This includes setting measurable objectives for improvement and engaging stakeholders in the process (Rahim, 2021).

A collaborative approach should be taken to ensure everyone has a shared understanding of the goals and objectives. The national tennis federation should create an environment that encourages creativity, innovation, and collaboration. This is achieved by providing access to resources, such as education, training, and mentoring, to help players and coaches reach their full potential. (Browers et al., 2015).

Additionally, the national tennis federation should foster an environment that values participation, inclusion, and diversity (Perez et al., 2019). This includes creating opportunities for all levels of players to engage in competition, regardless of their skill level and background.

Finally, a culture of development should be established and sustained through effective communication and marketing strategies. This includes using digital channels to reach out to the public and engaging stakeholders to create a positive and encouraging atmosphere. By creating a development culture in a national tennis federation, the sport will have the potential to grow and reach its full potential (Monegro, 2021).

How can tennis federations create a performance culture?

A performance culture has been defined as high performing cultures prevail when the shared perception and action of elite team environment members: a) supports sustained optimal performance; b) persists across time in the face of variable results (i.e., wins, losses, ties); and, most importantly, c) leads to consistent high performance (Cruikshank & Collins, 2012).

To create a performance culture in NFs, the focus should be on both the individuals and the organisation. According to the means available, the NFs should try to provide a series of services and products that would facilitate the generation of a performance mentality and thus, an increase in the number and quality of high-level players, coaches, events, and facilities.

Players should be at the core of the performance culture. To do so it has been proposed to base it around a sustainable strategy that supports the mental and physical health, safety, and well-being of their players. Organisations such as SIRC & On the Podium (2021) have identified personal dimensions to help federations generate their culture of excellence including mental and physical health and well-being, psychological and physical safety and safe sport, and self-determination.

For instance, the NF can ensure the availability of top-class facilities (i.e., national training centre), quality coaching services, and additional player support services that can be offered compared to any options that the players might have. The NF should attract players with the possibility of superior exposure and the assurance that the advancement of their career as a professional tennis player is the priority. Providing training and competition grants and scholarships, offering wild cards in the appropriate tournaments, and assisting in the access to public or private sponsorship can be some of the means that the federation can provide to generate this performance context (Browers et al., 2015).

Additionally, the relevant business-oriented management processes should be constantly revised and improved to generate the necessary impulse to develop and grow the different areas of the tennis industry at various levels of the game (Botella, 2022). The implementation of the best professional management practices is necessary to ensure that all involved assist in this endeavour. From an operational perspective, the NF should consider implementing organizational processes and activities that include leadership, communication, and motivation to create a performance management cycle.

In this context, NFs should take a proactive approach towards implementing a performance culture. To drive this forward, the following table outlines key programs, target users and the corresponding key message for each programme.

Table 1
Examples of gender equality programmes that a NFs can implement to improve their culture on this crucial aspect.

Programmes	Target Users	Key Message
Introduction of a Performance Management System	Players and Coaches	Use the tool to track performance goals and monitor progress against the goals
Employee Well-Being and Mental Health Support Program	Players and Club Management	Ensure players have access to the resources to help deal with the pressures of performing in high-stress environments.
Organisational Development Programs	Staff and Federation Management	Foster a culture of continuous improvement by providing staff with access to programs that will help them acquire the skills and knowledge to reach their potential.
Leadership Development Programs	Federation Management	Equip federation managers with the right skills and tools to effectively motivate and lead teams.
Fan Engagement and Inclusion Initiatives	Fans and Supporters	Ensure fans and supporters are engaged through activities promoting inclusion and participation
Technology-Driven Initiatives	Federation Management and Fans	Use technology to increase engagement and access to information on performance trends and progress.

By undertaking these initiatives, NFs can create an environment of empowerment, inclusivity, and accountability, all of which will help drive a positive performance culture within its organization.

Additionally, building rapport with players, developing awareness, motivating players, communicating directly and effectively, and providing specific, constructive, and meaningful feedback can help create a "performance culture" and increase their satisfaction with their tennis involvement.

Can a participation culture be generated by NFs?

Creating a participation culture in a nation is a complex mission that requires strong commitment from the NFs (Cortela et al., 2019). To create a participation culture in tennis, the mission should be articulated around the importance of introducing and retaining as many people as possible to the game. This can be achieved by creating the right mix of programmes, such as introductory activities, coaching programmes, competitions and tournaments, court hire, equipment services, and membership benefits. It is also important to adapt tasks to the individual abilities of the players and to generate adequate confidence through a view of realism.

It is in the best interest of tennis federations to have a participation programme that looks at getting more players no matter their characteristics involved in the game of tennis. Through the establishment of the proper structures, this can be achieved (Young et al., 2021). Finally, employing and evaluating creative online strategies using technologies such as Facebook, Twitter or Tik-Tok to ensure that they continue to meet the needs and expectations of all stakeholders can also be helpful.

What about a professional management culture in NFs?

Professionalisation should be a crucial part of the organisational culture of NFs (Ruoranen, 2018). It has been viewed as an attitude on people that arises from the management philosophy. As an example, they need to adapt to the culture of accountability to access to financial resources, especially in nations where funding comes from the government or public institutions. For instance, it has been shown that traditional management approaches and limit financial resources can hinder professionalization, whereas competitiveness and media exposure can promote it.

Adopting a professional management culture means working as a business and change the management philosophy. By doing so, NFs can add a series of proven efficient practices to their organization such as the functional differentiation and specialisation of the staff to be more efficient and generate more funds to improve current programmes or start new ones (Crespo et al., 2021). The constant application, revision and improvement of relevant management processes and tools would generate the necessary impulse to develop and grow the different areas of the tennis industry at the various levels of the game (Van Wyck & Davies, 2009). These areas need to fall under the appropriate scope of the business strategic plan to drive the organizations to a level of service that would make them competitive (Crespo-Dualde, 2021). Tennis federations should be cognisant of and pay particular attention to how they implement cultural processes that include leadership, communication, and motivation (Crespo-Dualde, 2022). These organisational and cultural processes are essential to a tennis federation and should be implemented effectively for gainful results (Lloyd et al., 2022). Therefore, implementing the best professional management practices is necessary to create a professional culture within a tennis federation.

To create a professional culture at all levels of the game in a national tennis federation, it is important to focus on the efficient provision of tennis services and to identify the challenges in the current strategy and define a new one if necessary (Monegro, 2021). Many federations should act as a non-profit organisation, but by working as a business, it would add a considerable level of professionalism to the federation and generate more funds to implement the current strategy in a sustainable way (Crespo-Dualde, 2022). For beginner players, it is in the best interest of the federation to have a participation program that looks at getting more children and adults involved in the game of tennis. Furthermore, at the higher levels of the game, collaboration between all stakeholders is required to produce high-performance national tennis players in a sustainable way (Crespo-Dualde, 2021).

NFs can manage tennis professionally by understanding certain components of business and adapting them to the administration of their tennis organisation. The main objective for tennis clubs and federations is the overall promotion of tennis (Van Wyck & Davies, 2009). The constant revision and improvement of the relevant management processes would generate the necessary impulse to develop and grow the different areas of the tennis industry at the various levels of the game (Crespo-Dualde, 2022). These areas need to fall under the appropriate scope of the business strategic plan to drive the organizations to a level of service that would make them competitive. Additionally, promotion strategies should make existing consumers, but especially non-consumers, aware of the programmes on offer from the federation (Davies & Van Wyck, 2009). In doing this, the manager needs to apply the AIDA principle: Attract attention, create Interest, create a Desire to become involved, and Action by the consumer (Crespo-Dualde, 2021).

The professional culture of the NFs should not replace the existing systems completely but build on them to eventually optimise the performance of the organisation.

The facilitators of the adoption of a professional culture consist of a combination of personnel, processes, and resources. In this context, funding is a key resource for professional management. NFs often have limited budgets and limited access to external funding sources and therefore struggle to hire professional management staff. Additionally, some federations are composed of volunteer board members and staff, who may lack the necessary technical skills and experience to manage a federation efficiently and effectively.

The importance of equality in the generation of the NF culture

NFs should strive to create and implement a gender equality culture to better serve all players. To do this effectively, they should invest in gender-equality focused programming. They have a responsibility to create environments that foster respect and inclusivity for all individuals regardless of their gender (Fuentes & Carmona, 2021).

Through necessary programming, the development of meaningful mentorship opportunities, and the implementation of educational initiatives all stakeholders in tennis, the NFs can create gender equality cultures that create a more positive and equitable environment for all players (Cepeda, 2021).

In this context, NFs have a responsibility to lead and encourage a gender equal culture within their organisations. They should develop programs that work to ensure equal opportunity for all. The following table presents programs that NFs can employ to ensure gender equality and a key message on what they should do to make these programs a reality.

Table 2
Examples of gender equality programmes that a NFs can implement to improve their culture on this crucial aspect.

Programmes	Target Users	Key Message
Establish gender-neutral criteria for selection of teams	All players	Encourage participation in tennis at all levels regardless of gender
Organize gender-sensitive training camps and workshops	Players, coaches, volunteers, administrators, and staff involved in sport organizations	Provide equal opportunities to all genders
Implement an anti-discrimination policy and complaint procedure	All members of the organisation	Be transparent and provide clear rules and codes of conduct for all clubs and regional federations, while also fully enforcing and implementing any policies
Female Leadership Development Program	Female coaches, players, administrators	Empower and support female stakeholders to increase their standing in sport and give them the tools to pursue leadership positions
Mentorship Programs	Male and Female staff	Create meaningful mentorship opportunities that bridge gender gaps and encourage men and women to mentor one another
Educational Programming	All participants in sport	Provide educational sessions and initiatives that focus on fostering respect and understanding between genders and that highlight the importance of equality in tennis.

The implementation of such gender equitability programs will require NFs to create an environment in which gender equality is embraced and supported. This includes making sure that the right resources are in place and that organizational culture is developed and nurtured (Szto, 2015). Additionally, NFs should seek out educational opportunities and resources through sources such as the ITF (Advantage All campaign, 2023), and the International Olympic Committee (IOC) who host various initiatives and workshops regarding gender equality. To ensure that these initiatives are successful, and that gender equitability is established, NFs should ensure that leadership is consulted and that processes such as program evaluation are implemented.

What about values of respect and inclusion? How can NFs create a culture of respect and inclusion?

NFs should enact and adopt programmes to better promote key values such as respect and inclusion among players, coaches, and all those involved in tennis. Generating a culture that emphasizes the adoption of the adequate values based on solid moral attitudes has been shown to positively affect player development (Lucidi et al., 2017). These programmes should target the specific people within the organization and be tailored to ensure individuals are able to develop the skills needed to foster an environment of respect and inclusion (Cahill, 2022). The following table provides a guide for tennis federations to consider when crafting programmes to foster a culture of respect and inclusion:

Table 3
Examples of inclusive programmes that a NFs can implement to improve their culture on this crucial aspect.

Programmes	Target Users	Key Message
Anti-bullying and harassment training	Coaches, players, parents, and other members of the NF	Respect and inclusion should be a given, not an exception. Everyone deserves to feel safe and free from discrimination
Diversity and inclusion policy	Entire organization	Celebrating diversity is a key part of fostering respect and inclusion. By recognizing and honouring individuals' differences, a respectful culture is cultivated.
Sportsmanship workshops	Players and coaches	For players and coaches to successfully practice good sportsmanship and build respectful relationships, they must learn about ethical decision-making and fair play.

A culture of sustainability. The need to act now for the future

Sustainability practices have become a key issue in the culture of NFs that have a modern approach to management and administration. For instance, research has shown that economic factors play a crucial role in tennis associations' operation and economic sustainability (Varmus et al., 2022) and studies have focused on the initiatives of NFs, tournaments (Trendafilova et al., 2021), players (Balliauw et al., 2017) and circuits (Van Hecke, 2022).

Table 4 summarises some practices NFs can adopt to address this key issue that should be an integral component of their organizational culture.

Table 4
Examples of sustainable programmes that a NFs can implement to improve their culture on this crucial aspect.

Programmes	Target Users	Key Message
Outreach Campaigns	Regional federations, tennis clubs and their members	Create awareness of sustainability and encourage everyone to contribute to the relevant initiatives.
Education & Training	Young players	Educate young players, sports authorities, and members of the sports federations about sustainable initiatives and how climate change is affecting sports and players.
Integrating Sustainability	Society at large	Implement sustainability into the NF governance structure, making sure the federation's practices meet all sustainable standards, such as corporate social responsibility, performance management, and sustainable transportation.

Through all these initiatives, National Sports Federations can ensure that sustainability practices become an everyday part of their activities and create a ripple effect to facilitate the uptake of sustainable practices across their organisation.

What about innovation? How can NFs create culture of innovation?

NFs should create a culture of innovation that encourages experimentation and a willingness to embrace change (Crespo et al., 2021a). To do this, they should create a comprehensive strategy that outlines the various programmes, target users, and key messages on how to implement them. Programmes should be tailored to the needs of the stakeholders, such as players, coaches, clubs and other federations (Crespo et al., 2022a).

Examples of programmes that NFs should put into place for effective implementation of a culture of innovation have been studied by authors such as Crespo et al. (2021b) and include, among others, innovation incubators, hackathons, mentor programmes and industry collaborations. Target users for these programmes should include players, coaches, administration personnel, and other relevant staff. These stakeholders should be educated on the benefits of innovation and encouraged to embrace a culture of change and empowered to think creatively and foster a safe environment for the exploration of new ideas (Tennis Australia, 2023).

Finally, the key message that NFs should communicate to promote a culture of innovation is that innovation is essential to allowing tennis to develop and stay competitive. This could include initiatives such as new training procedures, using technology to improve performance, introducing new strategies, and introducing marketing opportunities that will benefit all stakeholders. It is important to emphasize that innovation should be encouraged at all levels, from the administrators to the players, and that everyone should be open to new ideas that can help the sport to grow and succeed (Crespo et al., 2022b).

CONCLUSIONS

As seen through this article, culture is a crucial issue which has many implications and influences. In this complex and changing scenario, the culture of a NF, with which all stakeholders should voluntarily comply is comprised by aspects such as development, excellence, values, ethics and morals, inclusion and respect, sustainability and progress, participation and performance. Its function is instrumental to generate the strategy, inspire the people, educate the staff, construct standards, and meet the demands of the strategy of the NF (Lussier & Kimball, 2009).

Following Maitland et al. (2014) conclusions, we acknowledge that understanding organisational culture is crucial to improve coaching practice, inform stakeholders relationships, increase participation, improve talent identification, boost performance, and ensure inclusion and diversity in organisations such as NFs.

It is hoped that this paper has provided practical and applied guidelines for NF leaders and tennis stakeholders responsible for driving cultural change in their environments.

CONFLICT OF INTEREST AND FUNDING.

The authors declare no conflict of interest and confirm that no funding was received for this study.

RERERENCES

Balliauw, M., Verlinden, T., Van Den Spiegel, T., & Van Hecke, J. (2017). Towards a sustainable financial model for professional tennis players (No. 2017006).
Botella Blanco, H. (2022). The importance of a correct management in a tennis organization. How to create, expand and stay in the business. ITF Coaching & Sport Science Review, 30(87), 48–54. https://doi.org/10.52383/itfcoaching.v30i87.339
Brouwers, J., Sotiriadou, P., & De Bosscher, V. (2015). Sport-specific policies and factors that influence international success: The case of tennis. Sport Management Review, 18(3), 343-358.
Cahill, G. (2021). Coaching philosophy: "Why we do things the way we do?". ITF Coaching & Sport Science Review, 30(86), 7–9. https://doi.org/10.52383/itfcoaching.v30i86.241
Cepeda, I. (2021). Wage inequality of women in professional tennis of the leading international tournaments: Gender equality vs market discrimination?. Journal of International Women's Studies, 22(5), 407-426.
Corrêa Cortela, C., Ginciene, G., Milistetd, M., Pinheiro de Souza, S., & Abaide Balbinotti, C. A. (2019). Challenges for grassroots tennis development in Brazil. ITF Coaching & Sport Science Review, 27(77), 27–29. https://doi.org/10.52383/itfcoaching.v27i77.126
Crespo, M., Botella-Carrubí, D., & Jabaloyes, J. (2021a). Innovation in tennis: an overview of research. ITF Coaching & Sport Science Review, 29(83), 28-30.
Crespo, M., Botella-Carrubi, D., & Jabaloyes, J. (2021b). Coaches' perceptions of innovation programmes of the Royal Spanish Tennis Federation. International Journal of Sports Science & Coaching, 16(6), 1293-1304.
Crespo, M., Botella-Carrubi, D., & Jabaloyes, J. (2022a). Innovation programmes of the Royal Spanish Tennis Federation. Technological Forecasting and Social Change, 175, 121339.
Crespo, M., Botella-Carrubi, D., Jabaloyes, J., & Simón-Moya, V. (2022b). Innovation strategies in sports management: COVID-19 and the Latin American tennis federations. Academia Revista Latinoamericana de Administración, 35(2), 239-256.
Crespo Dualde, A. (2021). Digital marketing strategies for tennis coaches. ITF Coaching & Sport Science Review, 29(84), 34–36. https://doi.org/10.52383/itfcoaching.v29i84.183
Crespo Dualde, A. (2022). Using the balanced score card to improve tennis club management. ITF Coaching & Sport Science Review, 30(87), 34–41. https://doi.org/10.52383/itfcoaching.v30i87.343
Davies, K. (2004). A strategic plan for tennisland tennis, ITF Coaching and Sports Science Review, 33(12), 8-9.
Davies, K., & Van Wyk, J. (2009). The business of tennis: Practical, ITF Coaching and Sports Science Review, 48(16), 14-15.
Ferkins, L., & Shilbury, D. (2010). Developing board strategic capability in sport organisations: The national–regional governing relationship. Sport management review, 13(3), 235-254.
Fuentes-García, J. P., & Carmona Blanco, Á. I. (2021). Transversal competences in primary education through tennis. ITF Coaching & Sport Science Review, 29(85), 22–24. https://doi.org/10.52383/itfcoaching.v29i85.308
García, D. (2020). Let's go back to tennis! Playing tennis safe for everyone's health. ITF Coaching & Sport Science Review, 28(81), 12–15. https://doi.org/10.52383/itfcoaching.v28i81.33
International Olympic Committee (IOC) Gender Equality in Sport. Available online:https://www.olympic.org/gender-equality-in-sport
International tennis Federation (ITF). (2023). ITF Advantage All. Available at: https://www.itftennis.com/en/about-us/governance/advantage-all/ . Accessed May 29.
Lucidi, F., Zelli, A., Mallia, L., Nicolais, G., Lazuras, L., & Hagger, M. S. (2017). Moral attitudes predict cheating and gamesmanship behaviors among competitive tennis players. Frontiers in psychology, 8, 571.
Lussier, R. N., & Kimball, D. C. (2009). Applied sport management skills.
Monegro, M. (2021). Integrated marketing communications in tennis. ITF Coaching & Sport Science Review, 29(83), 7–9. https://doi.org/10.52383/itfcoaching.v29i83.46
Perez, S. E., Watson II, J. C., & Barnicle, S. (2019). Effects of Cross-cultural Communication Competence on Tennis Performance. Journal of Articles in Support of the Null Hypothesis, 15(2).
Rahim, M. R. A., Shapie, M. N. M., Abdullah, N. M., Parnabas, V., Hasan, H., & Khir, Z. M. (2021). Review on the transformation of tennis development in Malaysia. Malaysian Journal of Sport Science and Recreation (MJSSR), 17(1), 73-88.
Rodríguez Campos, M., Piquer Piquer, A., & Crespo Dualde, A. (2024). Creating a tennis culture in the national federation. ITF Coaching & Sport Science Review, 32(93), 29–35. https://doi.org/10.52383/itfcoaching.v32i93.463
SIRC & Own the Podium (2021). Building a culture of excellence in high performance sport. Available at: https://sirc.ca/blog/building-a-culture-of-excellence/. Accessed June 6.
Szto, C. (2015). Serving up change? Gender mainstreaming and the UNESCO–WTA partnership for global gender equality. Sport in Society, 18(8), 895-908.
Tennis Australia (2023). AO Data Slam: Tennis hackathon to predict what players do next. Available at: https://www.tennis.com.au/news/2023/01/29/ao-data-slam-tennis-hackathon-to-predict-what-players-do-next, accessed 27 May.
Trendafilova, S., Pelcher, J., Graham, J., & Ziakas, V. (2021). The ebbs and flows of green waves: environmental sustainability in Grand Slam tennis. Sport, Business and Management: An International Journal, 11(3), 302-320.
Van Hecke, J., Van Den Spiegel, T., Verlinden, T., & Balliauw, M. (2022). How to achieve a sustainable circuit for professional tennis players. International journal of sport management and marketing, 1(1), 10051267.
Van Wyk, J., & Davies, K. (2009). The business of tennis, ITF Coaching and Sports Science Review, 48(16), 12-13.
Varmus, M., Mičiak, M., Kubina, M., & Adámik, R. (2022). Determinants of the tennis players' success and their effect on the sports organizations' sustainability. Entrepreneurship and Sustainability Issues, 10(1), 132.
Whitmore, J. (2010). Coaching for Performance: The Principles and Practice of Coaching and Leadership. Fully Revised 25th Anniversary Edition. Hachette UK.
Young, J. A., Konjarski , L., & Beatson , R. . (2021). Coaching children 10 and under with a disability in a multi-sport program. ITF Coaching & Sport Science Review, 29(85), 15–17. https://doi.org/10.52383/itfcoaching.v29i85.294

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 40-44
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.749

Seven reasons why you should be incorporating time constraints into your coaching

Luke Regan

The Sports Think Thank, United Kingdom.

ABSTRACT

Manipulating time in practice can engage players physically and psychologically and can be used to support skill-learning and transfer to competition. Seven ways in which time pressure influences the behaviour of players are suggested, drawn from existing research in sport science. Practical recommendations for ways in which to implement time pressure are made.

Key words: Skill acquisition, Expertise, Practice, Pressure training

Received: 12 January 2026

Accepted: 10 March 2026

Corresponding author: lwgregan@gmail.com

INTRODUCTION

The ability to manipulate time pressure—by which is meant using a temporal boundary, constraint, or impetus that creates urgency, or necessitates speed—is a powerful and under-appreciated tool at the coach's disposal. The purpose of this article is to draw from extant research to provide a menu of possibilities for how time pressure can be used in the service of improving practice. This article proposes seven ways in which pressure of time may be leveraged to raise the quality of a practice or coaching session. The impact of time pressure on learners encompasses both physical and psychological aspects of behaviour, as well as having potential to impact on the rhythm and intensity of the coaching session as a whole. While seven different ways have been identified in which time pressure can influence, they are overlapping and not entirely discrete or mutually exclusive. Time constraints are versatile and judicious use of them can add an extra layer to an activity and increase the sophistication of practice. There is no doubt coaches reading this will already be employing many of the ideas and suggestions proposed, however it is hoped that the following will bring together some of the varied uses of manipulating time so that coaches may learn new ideas, better exploit techniques already in use, or be stimulated to think of new applications of their existing methods.

WHAT DOES TIME PRESSURE DO?

It Creates More Repetitions

Most simply, the first reason to incorporate time pressure in your coaching is that, with the associated urgency, the number of repetitions players experience will grow. A higher tempo in practice may not always be appropriate as it may mean fewer representative tasks (Pinder, Davids, Renshaw, & Araújo, 2011), or a level of complexity for the learner that renders information for learning of no use (see Guadagnoli & Lee, 2004). However, though greater repetition of a shot, decision, or game situation is not an automatic guarantee of more improvement, if the level of challenge is appropriate, and if quality of practice is present, then a higher volume of points played, decisions made, and balls struck is more likely to be positive than negative, particularly in the earlier stages of learning, when acquiring skill is more of an exploratory process (Button, Seifert, Chow, Araújo, & Davids, 2021).

It Pulls Attention Upstream

The dynamical systems approach to skill acquisition advocates for the education of the attention and intention of a learner in their pursuit of attunement to specifying information in the environment (Jacobs & Michaels 2007). Experts in high-intensity sport do not demonstrate skill simply by moving faster, or reacting quicker, rather they demonstrate perceptual skill characterised by sensitivity to information from all stages of the rally-cycle, while the novice may rely primarily on ball-flight information occurring immediately before her shot. Relying on late-occurring information in the rally cycle, coaches will see a novice "reacting" late to an incoming ball, then perhaps coach them to find a stronger ready-position, execute a split-step, or prepare the racquet earlier. However, it may be a more beneficial strategy to help novices couple their action to different sources of perceptual information. By educating the attention of players through the use of time constraints, we can allow them to better sensitise themselves to this new information. By using time pressure and making the later ball-flight information insufficient for successful performance, we can direct learners' attention to earlier "upstream" information, as they sensitise to what is available to perceive at different stages of the rally-cycle. Gray (2022) argues that practices must be designed by coaches in ways that help learners in this regard, "amplifying" information in ways that make it more apparent to the player, driving their attention towards events in the environment of which they are currently not fully aware. Practising at higher tempo, and with the guidance of an astute coach, places a demand on a learner to look ahead and adjust their behaviour in anticipation of the next repetition or execution, such that they can exploit new perceptual information that will underpin more efficient and adaptive performance.

It Elicits Muscular Co-Contractions

Muscular co-contractions, where both the agonist and antagonist muscles activate simultaneously, serve several purposes in support of efficient movement, according to Bosch (2015). He states that, prior to tensing, muscle-fibres hang between attachment points "like a dangling rope" and managing this muscle-slack is integral to performance. Tensing the muscle and removing the slack takes valuable time, particularly in fast, high intensity sports like tennis. Feedback via the central nervous system is too slow at the tempo required in high intensity movement, and muscles must work together to stabilize and protect joints through self-organising pre-flexes with little or no delay (Bosch, 2020). In other words, performance of skilled movement is a delicate management of tension and slack in the muscles as the body attempts to execute actions in complex environments. Acting as a bodily shock-absorber, protecting joints, muscular co-contractions regulate slack such that movements can be executed efficiently with appropriate muscle-tension. To react without delay the necessary pretension for action removes slack, preventing the body from relying on "passive attractors", and ensuring utilisation of the body's optimal economy and protection mechanisms (Bosch, 2015). Pressure of time is a means of stimulation of muscular co-contractions and removing muscle slack in physical training. To summarise, relative to the ability of a player, a higher tempo of play, faster balls to deal with, and less delay between actions, all naturally facilitate the muscular co-contractions that help train an efficient and effective physical platform for explosive movement and lower response time.

It Leaves No Time To Think

Research into the nature of skilled performance has repeatedly converged on variations of the idea that smooth, automatic, fluid execution of skills can be disrupted by explicit cognitive interference. Common parlance reflects this understanding with terms like "over-thinking" and "paralysis by analysis". Masters (1992) referred to the tendency of explicit, rule-based knowledge held in working memory to upset procedural skills as reinvestment. If explicit information typically acquired during the learning process can be minimised, or bypassed, then the propensity to reinvest can be reduced and procedural skills would be better protected in pressure situations (Masters & Maxwell, 2004). Time pressure can be used as a means of achieving this when training tennis players. Adding time pressure means the learner is more likely to bypass working memory without opportunity to pick up detailed technical information i.e. more likely to self-organise using implicit, perceptual information as described above. By employing an implicit learning approach, cognitive resources are freed up to direct attention to meaningful external information in the environment and perform other tasks such as tactical or situational evaluations to support performance. It has been shown that excessive accumulation of technical information during the learning process leads to an increased likelihood of reinvestment in technique, especially under stressful situations, which has been linked to choking (Beilock & Carr, 2001). Removing time for hypothesis-forming and opportunity to micro-manage techniques during execution, stimulates this adaptive, implicit acquisition of skilled movement.

It Identifies Errors

The Challenge Point Framework (Guadagnoli & Lee, 2004) is an articulation of what coaches already know, that an essential ingredient to learning is an optimal match between the level of challenge of an activity and the current performance level of the learner. To keep someone in this optimal zone for learning, the complexity of a task may need to be adjusted depending on the level of success. While too many errors may indicate a low level of learning, if there are few or no errors at all, learning may also be absent. Adding or increasing time pressure is one of the coach's options for raising the level of task-difficulty if there is insufficient error feedback to stimulate adaptation. Ericsson & Pool (2016) proffer corresponding advice for those faced with the challenge of overcoming learning plateaus. They state that, when an apparent ceiling in performance has been reached, the application of time constraints will help push you over the hump by making sources of error more apparent.

Tennis involves complex skills made up of multiple components, and one of the mechanisms by which practising under time pressure improves performance is by helping identify which aspect of the task requires improvement. Speed things up and see which aspect of a skill tends to break down, this information can then be used to design targeted practice activities to address the weakness.

It Creates Mental Pressure

Pressure training is the deliberate, strategic, and measured application of stressors to help athletes cope with emotional and psychological loads that accompany competition, and research shows that it can benefit athletes across different skill-levels and circumstances (Low, Sandercock, Freeman, Winter, Butt, & Maynard, 2021). Thoughts, emotions, and interoceptive information influence behaviour and can serve the purpose of guiding learners to stable, functional states of organisation. Pressure training research attempts to identify the best ways in which to simulate the emotional and psychological components of the competitive environment and facilitate this adaptation. Time pressure is one means by which to achieve this, acting as a "task stressor" (Stoker, Lindsay, Butt, Bawden, & Maynard, 2016) that can be used to increase the demands of training, to induce adaptation in athletes that will be beneficial for competition.

Resistance to the negative effects of stress is a useful quality to have in matches and time pressure in training has been used effectively as part of a battery of stressors to bolster athletes against the psychological rigours of competition (Kegelaers, Wylleman, Bunigh, Oudejans, 2021). Kegelaers & Oudejans (2024) cite several specific functions of this type of pressure training, including: strengthening psychological characteristics; mastering coping skills; building confidence; reducing choking; and increasing awareness.

Even with those for whom competitive performance is less important, the challenge of learning a new movement pattern nevertheless comes with an underlying uncertainty and excitement that is integral to the learning experience (Headrick, Renshaw, Davids, Pinder, Araújo, 2015). The pressure, urgency and intensity that comes with time constraints is a potential lever that can be pulled to enhance this experience for novice players. Situations that increase cognitive and emotional activation are useful for learning and for skill transfer: "Emotion acts to strengthen memories... and produces greater engagement in ambiguous, unpredictable, or threatening situations" (Headrick et al., 2015). Time pressure in training scenarios can therefore be manipulated to optimise affective learning design. Affective learning design is "... seeking ways to sample the intensity of emotionally charged performance conditions in learning environments and practice situations" (Headrick et al., 2015). Practising with situational fidelity to increase the transfer of learning is not limited to the physical environment and structural qualities of the practice, but simulating an authentic emotional experience helps the learner navigate practice tasks that are faithful to competitive situations on an emotional and psychological level.

It Encourages Smarter Practice

This final point may be the most speculative but is nevertheless based on reasonable assumptions arising from research. Evolution has endowed us with limits to the length of time for which we can continuously concentrate. There is likely individual variation on this limit, depending on the nature of the task; and on factors like the amount of training undertaken, such as after the thousands of hours of music practice completed by the research participants in the deliberate practice study of Ericsson, Krampe, & Tesche-Römer (1993). Though Ericsson et al. (1993) cite the figure of 90 minutes as an approximate maximum, alternative estimates of the attention threshold of the general population in everyday tasks tend to converge at much lower lengths. One piece of electronic tracking research found the most productive employees in an office environment worked, on average, for 52 minutes, followed by a 17-minute break (Thompson, 2014). Another popular time-management technique is based on cycles of 25 minutes concentration followed by a 5-minute break (Cirillo & Borgeaud, 2020). Dr. Noa Kageyama (2009) summarises some research into practice duration for expert musicians and similarly infers that 45-60 minutes may be the maximum for one continuous practice session for a typical adult, significantly less for a junior. A key anecdotal finding that accompanies this conclusion is that the best musicians' practice sessions are often shorter than one would think. What separates them is the process of practice, not the duration. Moreover, there is good reason to think that shorter sessions can improve the process and encourage smarter practice, while practising for too long does the opposite (Kageyama, 2009).

Generalising these findings to tennis, the practical implication is as follows: a standard coaching session in a club setting will likely be scheduled for 1 hour and, considering the above evidence, this may be too long for a single block of continuously focused practice. There is a trope in tennis coaching that the last 10-15 minutes of a one-to-one lesson is often spent in isolated serving practice. This is sometimes attributed to laziness or poor time-management on the part of the coach; however, it could be that this common trend stems from the natural thresholds for concentration described above, i.e. the session naturally winds down and the focus drifts from both player and coach. Then it's natural and easy for the coach (and player) to resort to hitting serves to fill the remaining time.

RECOMMENDATIONS

Some practical suggestions for implementing time pressure when coaching:

- Set time limits and put a clock on it: either at the outset of an exercise, or as the coach decides it's time to move on, e.g. "Whoever's in the lead in 2 minutes will be the winner"; "you have 30 seconds to beat your record so far"
- Make the time limits explicit and use "countdowns" to create urgency

Incorporate a "racing" element into activities:

- 2 pairs competing to achieve a rally challenge the fastest
- Player(s) aim(s) for their best rally (player-player or player-coach), while another player acts as an "egg-timer", racing to complete an individual challenge like a set number of tap-ups, successful serves, or a number of physical exercises (e.g. a squat-thrust or court-sprint). Players then swap roles and try to beat each other's score, or their own personal best

Time pressure can be induced indirectly for groundstroke challenges in 1 vs 1 practice:

- Shortening the distance between players, e.g., through restricting players to rally from inside the baseline or appropriate markers
- Stipulating that all balls must be struck on the rise or at the peak of the bounce
- Switching to a faster ball, or faster court-surface
- Practising groundstrokes against someone at net rather than at the baseline—this effect can similarly be achieved in 1 vs 0 practice by playing against a wall
- Rallying with 2 balls simultaneously
- For coach-player rallies, the coach can increase the tempo and increase time pressure with power, or by taking the ball earlier

Time pressure can be introduced into points situations:

- A serve-clock can be used between points
- By ruling that the serving or feeding player does not have to wait for the returner to be ready at the start of each point
- Time pressure can also be created with a maximum number of total shots, or time limit for each point

Time pressure can be induced when practising serves:

- The server must serve 2 or more balls out of their hand in rapid succession
- The coach can toss the ball for the server, who must meet the ball as it is rising through the contact-point (both the above will induce muscular co-contractions)

...And returns:

- Stipulate an "awkward" ready position for the returner e.g. hands behind back; racquet upside-down, or on the floor until serve is struck
- Have the server deliver the serve from inside the baseline, or have the returner position themselves nearer the service-line to receive

Scheduling and time-management can be used to increase urgency and focus attention in practice sessions:

- Aim for shorter sessions or divide your sessions into short blocks of higher intensity to reflect the limits of effective concentration thresholds and encourage physical, cognitive, and emotional engagement.

CONCLUSION

"Practices at UCLA were nonstop, electric, supercharged, intense, demanding... Games seemed like they happened in a slower gear. I'd think in games 'why is this taking so long,' because everything we did in games happened faster in practice." So describes Bill Walton, student of basketball coach John Wooden, as recorded by Nater & Gallimore (2010). Wooden's students recall the high tempo at which he used to conduct his practices, and how when it came time to compete, matches appeared to take place in slow motion. Wooden's practices were famed for their urgency and intensity, qualities which allowed for a higher volume of repetitions, but additionally placed perceptual & cognitive demands on players, aa well as creating a sense of more available time when competing in matches. Effects like these can be achieved if coaches experiment with manipulating time as part of their task-design, but also by scheduling shorter sessions where possible or, like John Wooden, by dividing their scheduled practice time into shorter, tighter blocks, to test the effect on intensity and continuity of attention from players.

The purpose of this article is to pool various pieces of research from across the skill acquisition literature relating to how time pressure may affect behaviour and support learning. It has been proposed that time pressure can be used to engage players physically, psychologically, and emotionally, for a variety of purposes and intentions. It is hoped that readers will gain some insight into the expansive possibilities of manipulating time and acquire new ideas as to how they might use time to supplement their preferred practice activities, create more enduring learning experiences, and achieve positive transfer to competition.

CONFLICT OF INTEREST AND FUNDING

No conflict of interest is to be declared for this study, which did not receive any funding.

REFERENCES

Beilock, S. L., & Carr, T. H. (2001). On the fragility of skilled performance: What governs choking under pressure? Journal of Experimental Psychology: General, 130(4), 701–725. https://doi.org/10.1037/0096-3445.130.4.701

Bosch, F. (2015). Strength training and coordination: an integrative approach. 20/10 Publishers.

Bosch, F. (2020). Anatomy of agility: Movement analysis in sport. 20/10 Publishers.

Button, C., Seifert, L., Chow, J. Y., Araújo, D., & Davids, K. (2021). Dynamics of skill acquisition: An ecological dynamics approach. Human Kinetics Publishers.

Cirillo, F., & Borgeaud, E. (2020). The Pomodoro Technique. Diateino.

Ericsson, K. A., Krampe, R. T., & Tesch-Römer, C. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review, 100(3), 363-406. https://doi.org/10.1037/0033-295X.100.3.363

Ericsson, A., & Pool, R. (2016). Peak: Secrets from the new science of expertise. Random House.

Gray, R. (2022). Learning to optimize movement: Harnessing the power of the athlete-environment relationship. Rob Gray, Ph. D./Perception Action Consulting & Education.

Guadagnoli, M. A., & Lee, T. D. (2004). Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning. Journal of motor behavior, 36(2), 212-224. https://doi.org/10.3200/JMBR.36.2.212-224

Headrick, J., Renshaw, I., Davids, K., Pinder, R. A., & Araújo, D. (2015). The dynamics of expertise acquisition in sport: The role of affective learning design. Psychology of Sport and Exercise, 16, 83-90. https://doi.org/10.1016/j.psychsport.2014.08.006

Jacobs, D. M., & Michaels, C. F. (2007). Direct learning. Ecological psychology, 19(4), 321-349. https://doi.org/10.1080/10407410701432337

Kageyama, N., PhD (2009, July 30). How Many Hours a Day Should You Practice? Bulletproof Musician. Retrieved December 30, 2025, from https://bulletproofmusician.com/how-many-hours-a-day-should-you-practice/

Kegelaers, J., & Oudejans, R. R. D. (2024). Pressure makes diamonds? A narrative review on the application of pressure training in high-performance sports. International Journal of Sport and Exercise Psychology, 22(1), 141–159. https://doi.org/10.1080/1612197X.2022.2134436

Kegelaers, J., Wylleman, P., Bunigh, A., & Oudejans, R. R. (2021). A mixed methods evaluation of a pressure training intervention to develop resilience in female basketball players. Journal of Applied Sport Psychology, 33(2), 151-172. https://doi.org/10.1080/10413200.2019.1630864

Low, W. R., Sandercock, G. R. H., Freeman, P., Winter, M. E., Butt, J., & Maynard, I. (2021). Pressure training for performance domains: A meta-analysis. Sport, Exercise, and Performance Psychology, 10(1), 149–163. https://doi.org/10.1037/spy0000202

Masters, R. S. (1992). Knowledge, knerves and know-how: The role of explicit versus implicit knowledge in the breakdown of a complex motor skill under pressure. British journal of psychology, 83(3), 343-358. https://doi.org/10.1111/j.2044-8295.1992.tb02446.x

Masters, R. S., & Maxwell, J. P. (2004). Implicit motor learning, reinvestment and movement disruption: What you don't know won't hurt you. In Skill acquisition in sport (pp. 231-252). Routledge.

Nater, S., & Gallimore, R. (2010). You haven't taught until they have learned: John Wooden's teaching principles and practices. Fitness International Technology, Inc.

Pinder, R. A., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative Learning Design and Functionality of Research and Practice in Sport. Journal of Sport and Exercise Psychology, 33(1), 146-155. https://doi.org/10.1123/jsep.33.1.146

Stoker, M., Lindsay, P., Butt, J., Bawden, M., & Maynard, I. (2016). Elite coaches' experiences of creating pressure training environments for performance enhancement. International Journal of Sport Psychology, 47(3), 262-281.

Thompson, D. (2014, September 17). A Formula for Perfect Productivity: Work for 52 Minutes, Break for 17. Retrieved October 11, 2025, from https://www.theatlantic.com/business/archive/2014/09/science-tells-you-how-many-minutes-should-you-take-a-break-for-work-17/380369/

COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 45-48
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v25i73.304

The relationship between one-hand overhead ball throw aimed at target area and maximal ball speed of flat serve in elite junior tennis players: a pilot study

Károly Dobos[1], János Péter Tóth[2], Katalin Orbán-Sebestyén[3], Csaba Ökrös[4]

[1]Saint John Apostle Catholic Elementary School and Kindergarten, Budapest, Hungary. [2]Student of PhD Program, Department of Sport Games, Hungarian University of Sports Science, Budapest, Hungary. [3]Hungarian Tennis Federation, Head of Children's Tennis. [4]Department of Sport Games, Hungarian University of Sports Science, Budapest, Hungary

ABSTRACT

The aim of this study was to investigate the relationship between performance on the one-hand overhead throw speed (OHOTS) aimed at a target area and the post-impact ball speed of the flat serve (PIBS) to promote more effective performance enhancement, and to estimate PIBS using a regression model through this simple field test. The test involved 23 elite junior boy tennis players (14.87±2.47 years). To explore the relationship between performance on the OHOTS and PIBS, we applied Pearson correlation analysis. Furthermore, simple linear regression was used to analyse the effect of the predictor variable (OHOTS) on the dependent variable (PIBS). Performance on the OHOTS test aimed at a target area showed a significant, strong correlation ($r = 0.58$; $p<0.05$) with PIBS. Moreover, the reactive strength exertion on the OHOTS test aimed at a target area accounted for 34% of the variation in PIBS. The result suggests that the motor skill test, which includes a unilateral movement pattern, can be used to monitor reactive strength in tennis players and can also serve as a training tool in the preparation process.

Key words: field test, reactive strength, post-impact ball speed of the flat serve, tennis.

Received: 7 January 2026

Accepted: 23 March 2026

Corresponding author: Károly Dobos, karoly.dobos93@gmail.com

INTRODUCTION

There is a clear consensus among sport professionals and scientists that serving is of extreme importance to the outcome of a match, for age-group tennis players, as well. The effectiveness of serving is influenced by a number of factors (Colomar et al., 2022), of which the post-impact ball speed is one of the most decisive components of performance (Fett, Ulbricht & Ferrauti, 2020).

When planning the athlete's training programs, optimizing effectiveness of training has of utmost importance. Therefore, it is advisable to use targeted training tools that result in measurable improvement in performance even in short term. This is a particularly sensitive issue for junior tennis players in this age group, whose development potential is determined by age-specific and individual characteristics as well as phases of biological maturation. That is why, it is necessary to use training tools that are aiming at the simultaneous development of specific motor skills (reactive strength) and the execution of a given technical element. This supports the improvement of service performance without jeopardizing the athlete's long-term development. Several studies (Dobos & Nagykáldi, 2017; Dobos, 2018; Dobos & Tóth, 2021; Fernandez-Fernandez et al., 2013, 2016; Ulbricht et al., 2013) have pointed to a large correlation between different overhead, unilateral (one-sided) and bilateral (two-sided) throws and serving speed. However, the throwing tests used in the studies were not directed at the target area typical for the serving, so they do not reflect the passing of the ball at a given target area (typical for serve).

It is important to note that serving is not merely a series of movement requiring exertion of reactive strength, but an extremely complex movement pattern, in which each part of the kinetic chain plays a decisive role, and the timing of their interlocking movements is critical in achieving its correct speed (Elliott, Reid & Crespo, 2009). In addition, the placement of the serve (the point of landing of the ball on the target area) also plays a decisive role in the performance of the serve (Colomar et al., 2022). Furthermore, the dynamic balance control and proprioceptive feedback, which are essential components of sport-specific movement coordination, may be more prominent during the execution of movements directed toward a target surface. (Elliott, Reid & Crespo, 2009).

Based on the above, it would be reasonablőe to develop a modern training tool that takes into consideration the specific characteristics of passing the ball to the target area and also provides opportunities for the complex development of technical execution quality, as well as increasing the reactive strength exertion. Therefore, the aim of this study was to examine the relationship between the one-hand overhead target-oriented unilateral throwing form and the post-impact ball speed of the flat serve to promote a more effective performance development. A further aim was to use this simple field test to estimate the post-impact ball speed of the flat serve using a regression model.

METHODS AND PROCEDURES

The study included 23 elite junior boy tennis players with an average chronological age: 14.84 ± 2.47 years; body height: 170.47 ± 16.3 cm, body weight: 59.51 ± 13.83 kg (Table 1.). Subjects were selected through the professional sampling method to select those tennis players who possessed the correct serve technique at the highest level in their age categories. All players were among the top 30 on the Hungarian under 12, 14, 16, and 18 national ranking list in their age categories. As an extra, 26% of the players had a European Tennis Association (ETA) or International Tennis Federation (ITF) ranking.

During the testing sessions two simple field tests were applied. These were the following: a) one-hand overhead ball throw test —to measure the ball speed of the one hand overhead throw, and the unilateral reactive strength of the upper body; b) serve test—to measure the post-impact ball speed of the flat serve and the neuromuscular power ability of the total body. Both tests were performed to the target area (Figure 1.).

Testing sessions were conducted outdoors, in the main competition season. To avoid the effects of tiredness, testing sessions were carried out 48 hours after a heavy training or match. Before each testing the player's age, body height and body mass were recorded. Each testing sessions started with a standardized warm-up of aerobic-type running, general mobilizing, stabilizing exercises and 8 trials on each test. Then the 2 field tests were performed, during which the players had 3 one-hand overhead ball throws and 8 flat serves. Four-minute passive rests were provided after the warm-up and between the tests, and 30 seconds of rest were allowed in the one-hand overhead ball throw test among the trials. In the serve test the resting time was 25 seconds. The best results of the correct trials (the execution is correct and the ball bounces on the valid target area) were considered for later analysis.

The Stalker ATS II" radar instrument (within ±3 km/h of accuracy and operating frequency: 34,7 GHz [Ka-Band] ± 50 MHz) was used for measuring the speed of the ball of one-hand overhead throw and flat serve tests. Furthermore, new 53-56 gram and 6.5 diameter "Slazenger Ultra Vis" balls were used. Before each testing session, the "Stalker ATS II" radar gun was calibrated in accordance with the manufacturer's specifications.

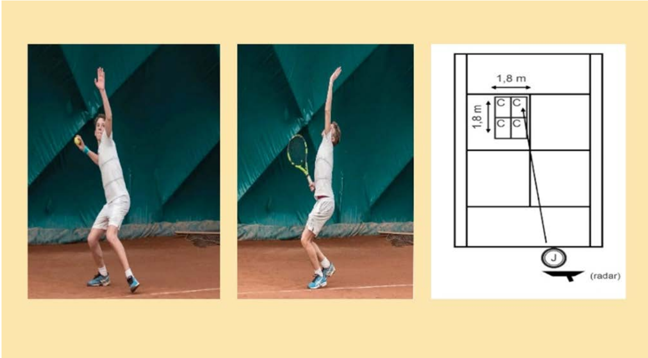


Figure 1. *The selected motor ability tests. C: target area, J: tennis player.*

First, normality of distributions was controlled with using the Shapiro–Wilk-W test. The distribution for each variable was normal (0.17-0.06; p>0.05), therefore the parametric Pearson correlation coefficients (r) were calculated to reveal correlation between the (predictor and dependent) variables. Finally, the simple regression model was used in order to calculate coefficient of determination (R2) and set up regression models. Significance was established at p<0.05 and data analyses were performed with the SPSS 21.0 software.

RESULTS

A significant positive correlation was found (r=0.58; p<0.05) between the ball speed of the one-hand overhead throw aimed at the target area and the post-impact ball speed of the flat serve (Figure 2.). Furthermore, the R2 values indicated that ball speed of the one-hand overhead throw aimed at the target area was 34% of the variance of the post-impact ball speed of the flat serve. Finally, based on simple linear regression analyses the following regression model (equation) was set up (Table 2.):

*PIBS (km/h) =(b0) 53.31+(b1) 1.23 *OHOTS (km/h)*

Where: PIBS=post-impact ball speed of the flat serve = b0: intercept + b1: slope* OHOTS: one-hand overhead throw speed aimed at the target area.

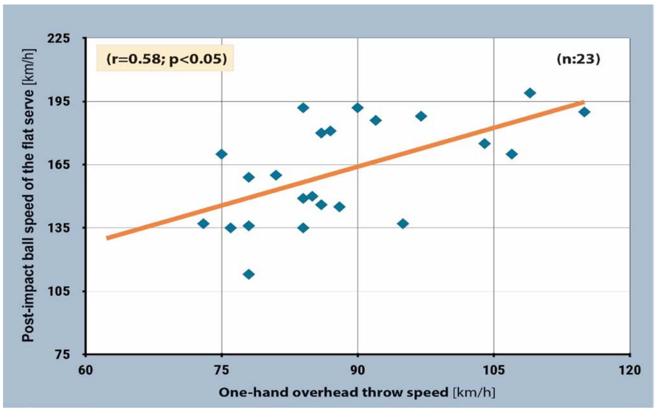


Figure 2. *Correlation between ball speed of the one-hand overhead throw aimed at the target area and the post-impact ball speed of the flat serve (n:23).*

Table 1

Individual characteristics and descriptive statistics of assessed variables in junior boy tennis players (n:23).

Descriptive statistics	Age	Body weight (kg)	Body height (cm)	One-hand overhead throw speed (km/h)	Post-impact ball speed of flat serve (km/h)
Mean±SD	14.87±2.47	59.51±13.83	170.47±16.30	88.34±11.45	161.95±24.16
Min-Max	11.12-18.39	40.0-81.10	145.0±193.40	73-115	113-199

Table 2

Simple linear regression analysis of junior tennis players (n:23)

Group		B	SEM	β	t	p
Junior boy tennis players	Intercept	53.31	33.29		1.60	
	One-hand overhead throw speed (km/h)	1.23	0.37	0.58	3.28	<.004

Dependent variables: the post-impact ball speed of the flat serve
R^2=0.34; adj R^2=0.30; F (1-22) =10.81; p<0.005

DISCUSSION

The fundamental question of the research was to what extent this unilateral movement aimed at the target area affects the post-impact speed of a flat serve and if it can be used to optimize serving performance. The results obtained showed that there is a significant positive correlation between the two variables in tennis players of this age group (r=0.58; p<0.05). Furthermore, the speed of the one-hand overhand throw to the target area explains 34% of the variance in the post-impact ball speed of the flat serve.

The results indicate that in age-group junior tennis players, the throwing motion to the target area may play a role in improving the post-impact ball speed of the flat serve. In other words, the speed of the serve is a complex, multi-component performance parameter that is not solely influenced by the magnitude of reactive strength (Roetert, Reid & Ellenbecker 2009). The level of development of the player's movement coordination, i.e., the precise and well-timed execution of the technical elements of the movement sequence, also plays a key role (Colomar et al., 2022). The integrated functioning of these factors fundamentally determines the dynamics of the entire movement chain and the post-impact speed achieved during the shot (Colomar et al., 2022). As mentioned previously several studies confirm the correlation between unilateral and bilateral throws and the launch speed of the serve (Dobos & Nagykáldi, 2017; Dobos & Tóth, 2021; Dobos, Tóth & Ökrös, 2022; Fernandez-Fernandez et al., 2013, 2016, Ulbricht et al., 2013). Research has revealed that the reactive strength manifested in these throwing movements—especially in the one-hand overhead throw—which collectively involve the lower limbs, torso, and upper body, can be effectively transferred to the serving motion with the right technical knowledge, thereby helping to increase the post-impact ball speed of the flat serve.

Furthermore, this research has highlighted that the throwing movement toward the target area used in the study, i.e., targeted unilateral ball throws, could significantly influence the post-impact ball speed of the flat serve. During the targeted ball transfer, the player throws the ball at a specific target area with conscious motor control. This exercise could help refine the technical movement pattern of the upper limbs and effectively transfer them into the serving motion. It could also support the development of movement coordination and ball control and contribute to increasing the tennis player's reactive strength (Dobos & Tóth, 2021; Fernandez-Fernandez et al., 2013, 2016). Therefore, based on these data, targeted unilateral throwing movements could be an integral part of tennis training, serving to effectively develop sport-specific movement patterns. It is important to mention that the research of Reid, Giblin & Whiteside (2015) and Wagner et al. (2014), which points out numerous mechanical similarities, observed significant mechanical differences between the two movement patterns. Nevertheless, it seems realistic to conclude that a one-hand throwing motion directed at the target area could provide a suitable basis for improving the post impact ball speed of the flat serve in junior boy tennis players.

As a limitation of this research, it would be justified to conduct the study on a larger sample and to expand it to female tennis players to obtain more comprehensive results.

In addition, it would be worth to analyse the correlations between one-hand overhead throws aimed at the target area executed from different starting positions and the post-impact ball speed of the flat serve. During tests performed from prone, seated, and half-kneeling positions, the conscious shortening of the kinetic chain and the exclusion of the lower extremities allow for the isolation of the reactive strength and coordination role of the dominant arm and shoulder girdle in the post-impact ball speed of the flat serve. This allows for more accurate information about individual contribution of each segment to the overall serve performance. In addition, these investigations may pave the way for the development of standardized field tests that enable the precise measurement of performance components of sport-specific movement patterns.

CONCLUSION

During the preparation period one of the most important aspects of training theory is efficiency. This means that training equipment used to prepare athletes must be capable of improving performance in the short term without jeopardizing the athlete's long-term development. Based on the collected data, we believe that unilateral throwing techniques aimed at this type of target area probably increase serving speed and improve movement coordination and ball control. Therefore, it would be worth for age-group junior tennis players to practice different throwing forms on target areas, as in case of tennis we are talking about ball transfer to target surfaces (Rigler, 2004). Furthermore, through the practical application of empirical results, more effective constructive teaching strategies could be developed that emphasize the understanding of tactical elements and the conscious application of specific technical elements (Kovács, 2024).

CONFLICTS OF INTEREST

The authors declared no conflict of interest regarding the publication of this manuscript.

REFERENCES

Colomar, J., Corbi, F., Brich, Q., & Baiget, E. (2022). Determinant physical factors of tennis serve velocity: a brief review. International Journal of Sports Physiology and Performance,8, 1159–1169. https://doi.org/10.1123/ijspp.2022-0091

Dobos, K., & Nagykáldi, Cs. (2017). The relationship between distance of overhead ball throw and maximum ball speed of serve in elite junior tennis players. ITF Coaching and Sport Science Review, 73, 22-23. https://doi.org/10.52383/itfcoaching.v25i73.304

Dobos, K. (2018). Performance-structure analysis of elite junior boy tennis players. Studia Education Artist Gymnasticae, 63, 29-40. https://doi.org/10.24193/subbeag.63(3).21

Dobos, K., & Tóth, P.J. (2021). Within –session reliability and validity of overhand ball throw test to evaluate power ability in junior tennis players. Studia Educatio Artist Gymnasticae, 3, 21-32. https://doi.org/10.24193/subbeag.66(3).22

Dobos, K., Tóth, P.J., & Ökrös, Cs. (2022). Relationship between serve speed and performance of different motor test results. Hungarian Review of Sport Science, 6. 19-26.

Elliott, B., Reid, M., & Crespo, M. (2009). Technique Development in Tennis Stroke Production. International Tennis Federation, London, 2009: 77-88.

Fernandez-Fernandez, J., Ellenbecker, T., Sanz-Rivas, D., Ulbricht, A., & Ferrauti, A. (2013). Effects of a 6-week junior tennis conditioning program on service velocity. Journal of Sports Science and Medicine, 2, 232-239.

Fernandez-Fernandez, J., Villarreal, E.S., Sanz-Rivas, D., & Moya, M. (2016). The Effects of 8-Week Plyometric Training on Physical Performance in Young Tennis Players. Pediatric Exercise Science,1, 77–86. https://doi.org/10.1123/pes. 2015-0019

Fett, J., Ulbricht, A., & Ferrauti, A. (2020) Impact of physical performance and anthropometric characteristics on serve velocity in elite junior tennis players. J Strength Con Research, 34: 192-202. https://doi.org/10.1519/JSC.0000000000002641

Kovács, K. (2024) Challenges of teaching sport games in today's world. Constructive pedagogy in the physical education. Acta Universitatis de Carolo Eszterházy Nominatae: Sectio Sport, 23, 47-69. https://doi.org/10.33040/ActaUnivEszterhazySport.2024.53.47

Reid, M., Giblin, G., & Whiteside, D. (2015). A kinematic comparison of the overhand throw and tennis serve in tennis players: How Similar are they really? Journal of Sport Sciences, 33, 713-723. https://doi.org/10.1080/02640414.2014.962572

Rigler, E. (2004). Sportjátékelmélet. Platin-Print Bt, Budapest, 125-131.

Roetert, P., Reid, M., & Ellenbecker, T. (2009). Biomechanics of the tennis serve: Implications for strength training. Strength Conditioning Journal, 31, 35-40. https://doi.org/10.1519/SSC.0b013e3181af65e1

Ulbricht, A., Fernandez-Fernandez, J. & Ferrauti, A. (2013). Conception for Fitness Testing and individualized training program in the German Tennis Federation. Sports Orthopaedics and Traumatology, 29, 180-192. https://doi.org/10.1016/j.orthtr.2013.07.005

Wagner, H., Pfusterschmied, J., Tilp, M., Landlinger, J., Duvillard von S.P., Müller, E. (2014). Upper body kinematics in team-handball throw, tennis serve and volleyball spike. Scandinavian Journal of Medicine & Science in Sports. 24, 345-354. https://doi.org/10.1111/j.1600-0838.2012.01503.x

ITF International Tennis Federation
COACHING & SPORT SCIENCE REVIEW

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 49-55
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.767

Deception in Tennis: An Ecological Dynamics Perspective

William O'Connell

ITF Coach of High-Performance Players (USA)

ABSTRACT

Deception is ubiquitous and potent in high-level tennis. While this skill is applauded by players and fans, it appears to have garnered limited consideration from coaches and researchers. This paper examines kinematic deception in tennis singles play from an ecological dynamics (ED) perspective, offering definitions, a descriptive taxonomy, and training recommendations for both performing and defending against deception. An understanding of deception would be incomplete without an understanding of its counterpart anticipation — each skill emerging from the players' attempt to gain an advantage in the point/match. ED concepts and frameworks to aid in the training of both anticipation and deception are offered — representative training design (RT), periodization of skill training, (anti)fragility, and action capacity training. Finally, practical activities to develop and defend against deception are provided.

Key words: Kinematic deception, anticipation, ecological dynamics, skill acquisition

Received: 5 March 2026

Accepted: 29 April 2026

Corresponding author: william.oc.92@gmail.com

INTRODUCTION

Deception is an inherently biological phenomenon — octopuses, chameleons, and countless other animals employ it for survival. Twenty-five hundred years ago, Sun Tzu (~500 BCE/2014) observed that "all warfare is based on deception." Sport is no different.

Take a look at any highlight reel from 2025 and compare the quality of points on display with that of decades past. Today's tennis professionals exhibit greater movement complexity than ever before. Often, their amazing shots are executed with intentionally misleading cues, or they delay revealing pertinent information to maximize their shot's impact. These unexpected and effective actions end up on internet highlight reels, but also occur more subtly within the point to create an advantage. While these moments feel more conspicuous now, elite athletes have always tried to reduce the impact and uncertainty concerning their opponent's actions, and increase the impact and uncertainty concerning their own actions. The interplay between anticipation and deception is a foundational feature of high-level dyadic competition in sports with high spatio-temporal demands.

Most research on these interaction skills has focused on anticipation, with comparatively little attention given to deception. Moreover, studies have tended to examine perceptual-cognitive and kinematic aspects in isolation (Panten et al., 2019). This is a meaningful limitation. Farrow and Abernethy (2003) demonstrated that intermediate players' anticipatory abilities were magnified relative to novices under more representative conditions — but not when only a verbal response was required. This is consistent with a broader literature showing that experiments decoupling perception and action diminish the expert advantage (Buszard, 2022). There is also a neuro-anatomical basis for this phenomena. A verbal response engages only the ventral vision-for-perception system, while a movement-based response also recruits the dorsal vision-for-action system (van der Kamp et al., 2008). On a tennis court, deception emerges in response to an opponent's actions across multiple timescales — far more complex than detecting a misleading cue in isolation. A player may establish a pattern of directing forehand approach shots to the opponent's backhand, only to replicate that preparation before redirecting to the forehand side at the last moment. This research tendency to prioritize experimental control over representativeness has been informative but has left our understanding of these interactions incomplete (Ramsey et al., 2022).

Understanding these complex interactions requires a framework for motor control. Two major approaches exist: the cognitivist (C) approach, which has long dominated, and ecological dynamics (ED), which offers an alternative account. For a detailed philosophical comparison, Wilson et al. (2024) is instructive. Araújo et al. (2025) make a compelling case for ED as the dominant paradigm in sport performance analysis. Rob Gray (2021a) examines the two motor-control approaches in baseball hitting, and Carrilho et al. (2025) critique predictive control (rooted in C), before utilizing prospective control (rooted in ED) to explain how soccer defenders anticipate and coordinate to prevent attackers from scoring. This paper adopts an ED lens for its more comprehensive and parsimonious account of motor control.

The purpose of this paper is to define and distinguish different kinematic manifestations of deception, and to explore how players can both perform and defend against it. Contextual factors are inseparable in the execution of the deception skill, but the focus here is on kinematics within singles play, during the point, and within the rules/spirit of the game. Implications for training deception and practical activities are also offered.

DEFINING DECEPTION

A successful deceptive action can be defined as one that coerces an opponent into a movement pattern that is subsequently exploited (Woods et al., 2020). This skill is associated with advanced players because of the increased motor demand — one must supplement veridical action with deceptive actions. Deception is both common and effective at the professional level. Dimic et al. (2023) used frame-by-frame video analysis of the 2019 Wimbledon final to identify incongruencies between shot preparation and post-contact ball trajectory. Deception was employed on 28% of baseline shots, and deceptive shots produced advantageous point dynamics at a higher rate (56%) than non-deceptive shots (38%). Incorrect anticipatory responses were far more frequent on deceptive shots (85%) than veridical ones (23%). These outcomes are consistent with comparable studies in basketball, rugby, netball, and soccer (Güldenpenning et al., 2023).

While exploitation is deception's most obvious purpose, players also use deception to elicit information. We don't just perceive to act — we also act to perceive. From an ED perspective, deception is one aspect of each player's attempt to develop "maximum grip" (gain an advantage) on the interaction by exploiting information across multiple timescales (Ramsey et al., 2022). Present performance is shaped by a player's previous encounters with the performance environment (retrospectively — skill, experience, memories) and oriented toward the future through the perception of affordances (Araújo et al., 2025).

Affordances are the directly perceived opportunities for action relative to a player's capabilities (Araújo et al., 2025). In tennis, affordances evolve relationally — each player's actions shape the other's. Within any given affordance, the player perceives both specifying and non-specifying information. Specifying information consists of ambient energy arrays that lawfully guide action without requiring mental prediction or elaboration (Araújo et al., 2025; Gray, 2021a). Experts are better attuned to specifying information. Rosker and Majcen Rosker (2021) showed that international players adapted their visual search strategy during serve return more effectively than national players, yielding more successful returns. In tennis, specifying information for ball interception becomes increasingly informative as the opponent approaches contact (guiding the player's general positioning for their next shot), and is unambiguously instructive after it (Müller & Abernethy, 2012). Research suggests professional players respond to ball flight information with ~100% accuracy as early as 160ms after the opponent's contact (Triolet et al., 2013). A player's deceptive behavior can impair the opponent's attunement to specifying information, undermining their grip on the point.

Successful anticipation and deception rely on both contextual and kinematic information. Contextual information "reflects the circumstances preceding and surrounding the interaction" (Ramsey et al., 2022; p.3). This could be linked to a particular opponent's preferences on how to act depending on the score, or in a particular game situation. Kinematic information evolves during a given interaction i.e., the current movements of the opponent and/or the flight of the ball (Ramsey et al., 2022). In the ED tradition, it is postulated that anticipation and deception occur prospectively — as opposed to predictively (rooted in C) — through the player's attempt to realize affordances (Araújo et al., 2025, Carrilho et al., 2025; Gray, 2021a).

Anticipation and deception are both employed to gain an advantage, but they operate inversely. Kinematically, anticipation can be understood as one aspect of a system maintaining a negative phase relationship with another — as when a player moves in the direction of a shot before the opponent makes contact (Stepp & Turvey, 2010). Kinematic deception, conversely, can be defined as one aspect of a system causing another to lose that negative phase relationship, or to incur a positive one (Gray, 2021b; Ontañón-García et al., 2021). Put simply: anticipation is an attempt to improve one's own affordances, while deception is an attempt to undermine the opponent's.

DESCRIBING DECEPTION

In this section, vocabulary, perspectives, and parameters will be offered to help discuss deception in the context of a point.

Deception in tennis can be organized into three subcategories. Deceit involves offering a functional but misleading affordance (Panten et al., 2019; Ramsey et al., 2022). Disguise involves concealing specifying information until as late as possible, limiting the opponent's field of affordances (Panten et al., 2019; Ramsey et al., 2022). Finally, "distraction refers to actions that (re-)direct the attention of opponents from task-relevant, specifying information toward less relevant, non-specifying information" (Zheng et al., 2023; p.2). These subcategories can operate alone or in combination, and all function to impair the opponent's perception-action coupling.

As previously mentioned, deception emerges and evolves relationally. Tennis' rules result in varying degrees of influence competitors can have on the interaction. Active influence of the situation is conferred on the player about to strike the ball, with the opponent preparing to receive the ball having less agency (contra-active influence) over the situation (Panten et al., 2019). While most research has focused on the active deceiver, deception occurs in both roles. Contra-active deception takes kinematic form primarily through (1) gestures, and (2) presence (posture and positioning) (Panten et al., 2019).

Deception can also co-occur with anticipation. Often, this collaboration with anticipation is the case in contra-active deception (see figure 2.). Active deception also occurs with anticipation. For instance, a player who knows their opponent likes to offer open court before anticipating to cover it can prepare as if going cross-court, then play behind the opponent instead. Finally, deceptive and veridical information can be combined either sequentially — where the deceptive act terminates before the genuine intention is revealed — or simultaneously, where the two merge within a single action (Panten et al., 2019).

DOING DECEPTION

Active deception places supplementary motor demands on the player toward three distinct ends (Panten et al., 2019; Ramsey et al., 2022; Zheng et al., 2023). Completion deception involves a full termination of the misleading

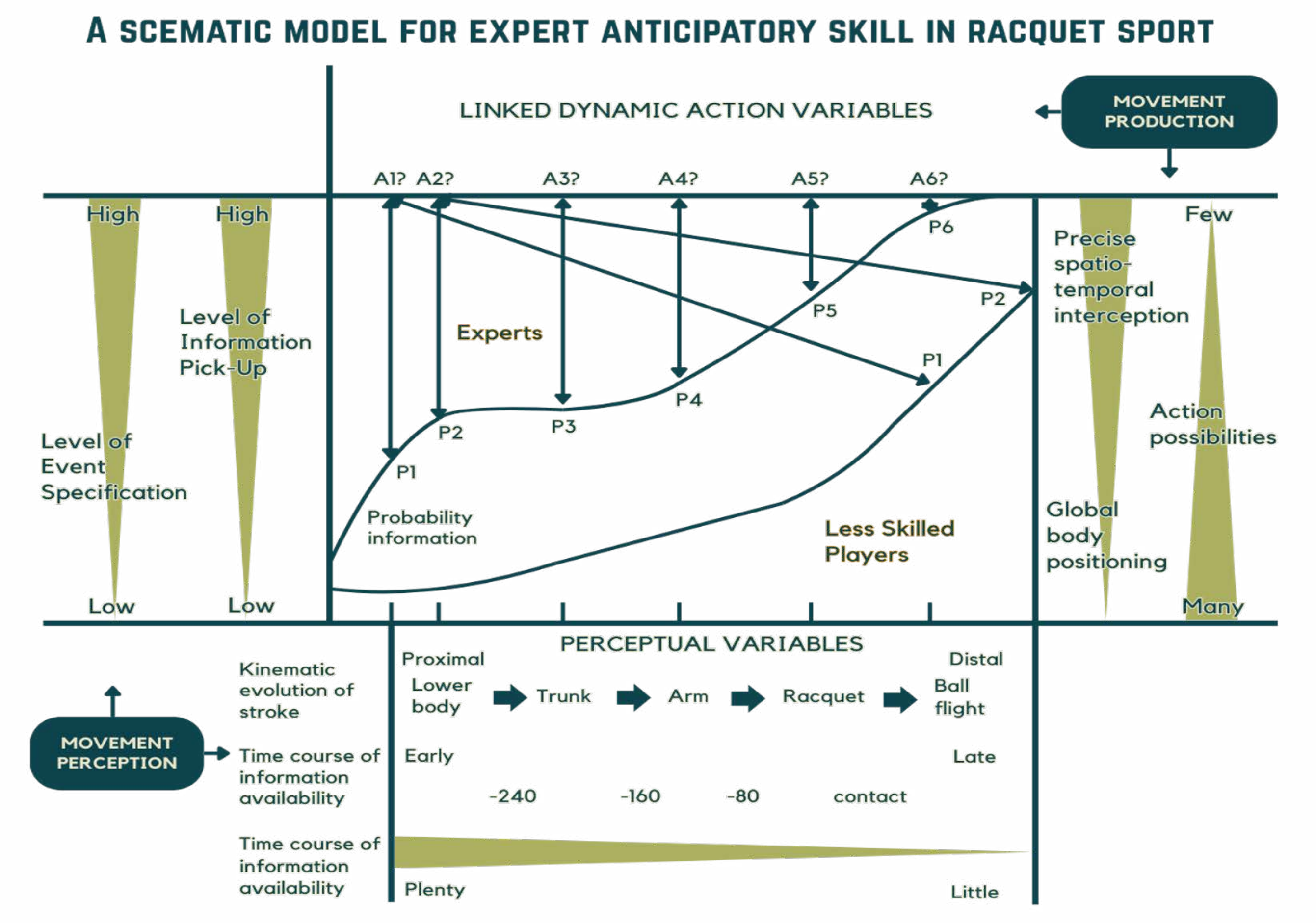


Figure 1. *A schematic model for expert anticipatory skill using a racquet sport as an example. Perceptual variables (P) refer to the key visual information sources available during the proximal-to-distal (early-to-late) evolution of kinematics in an opponent's movement pattern, expressed in regard to the time available for a performer to prepare and respond. Action variables (A) refer to the movement execution phases that need to be coupled to perceptual information to allow successful attainment of the skill goal (i.e., to strike a ball efficiently). The link between perceptual information and action variables may also serve to inhibit action depending on the skill goal. For interception, the model shows that as perceptual information evolves over time, there is an increase in the informational cues that can be used for attainment of the skill goal. Experts (shown in the top trace) are capable of acquiring perceptual information before (P) and during the course of the opposing player's precontact movement pattern (P,-P.), with this early information used to guide global (or gross) positioning of the body. Thereafter, later information from object flight (P) is used to guide and fine-tune interception. Together, acquisition of advance and object flight information guides a progressive reduction in the degrees of freedom of the action system to attain the skill goal. In comparison, less-skilled players (shown in the lower trace) acquire later evolving informative cues (P, and P,) to achieve levels of body positioning and interception comparable to that of experts. With little time remaining to respond, this inevitably results in poorer task performance.*

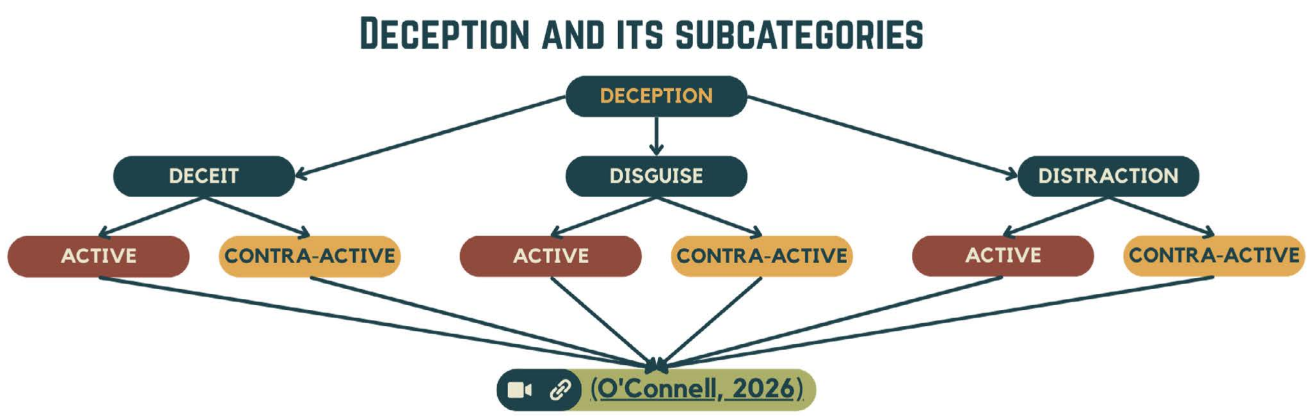
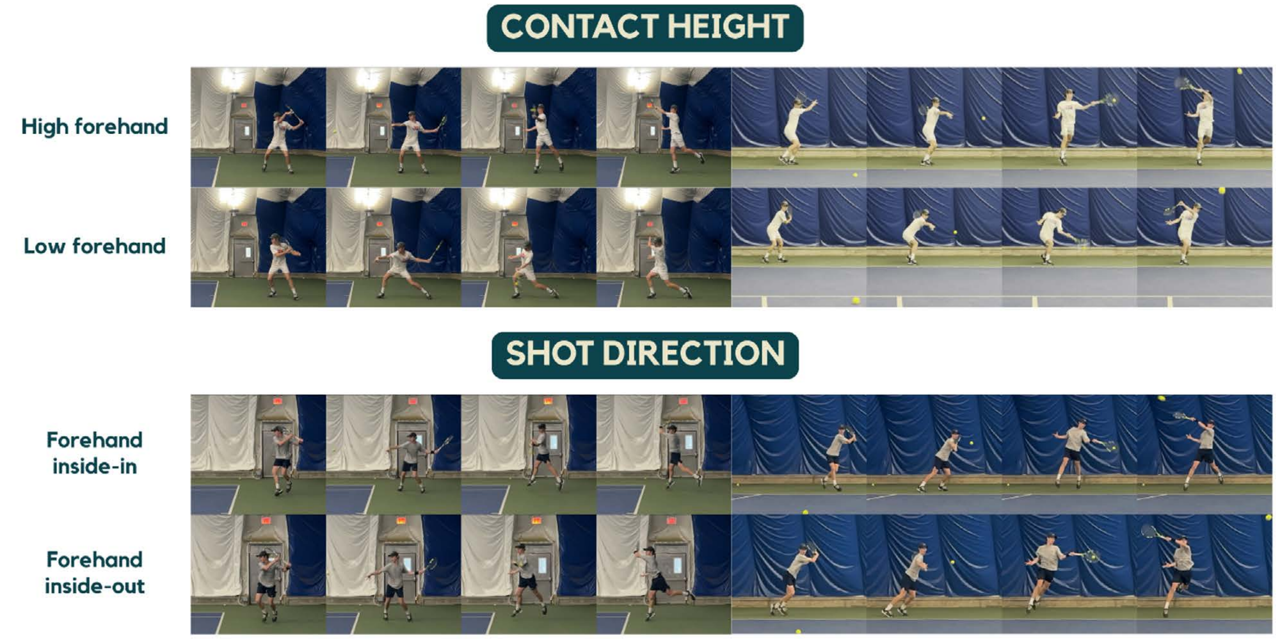
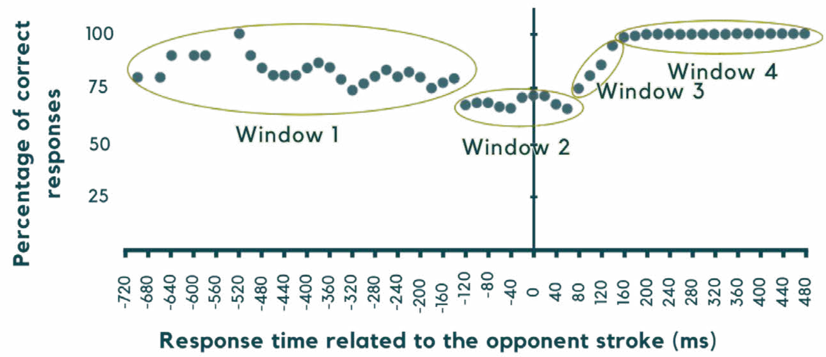


Figure 2. *Examples of the different deceptive contents (deceit, disguise, distraction) across the various roles (active, and contra-active). Adapted from categories offered by Panten et al., (2019), Ramsey et al., (2022), and Zheng et al., (2023) and the degrees of influence offered by (Panten et al., 2019; p.6-7).*



FEELING

	Hit	Jab	Push	Catch	Block
General shot Intention	Used to increase/maintain the speed of the ball.	Used to increase/maintain the speed of the ball.	Used to maximize precision/control.	Used to decrease the speed of the ball.	Used to "maintain" the speed of the ball.
Distinguishing characteristics	Speed before contact.	This is in the hit family, so still speed before contact.	Speed (force) at/after contact.	No racquet speed. Low grip tension.	No racquet speed. High grip tension.
Contact point	Contact well in front allows for acceleration.	Varies based on difficulty of incoming ball.	Contact closer to body to allow for force after contact.	Contact closer to body to allow for passive grip position.	Contact further in front to allow for strong wrist position.



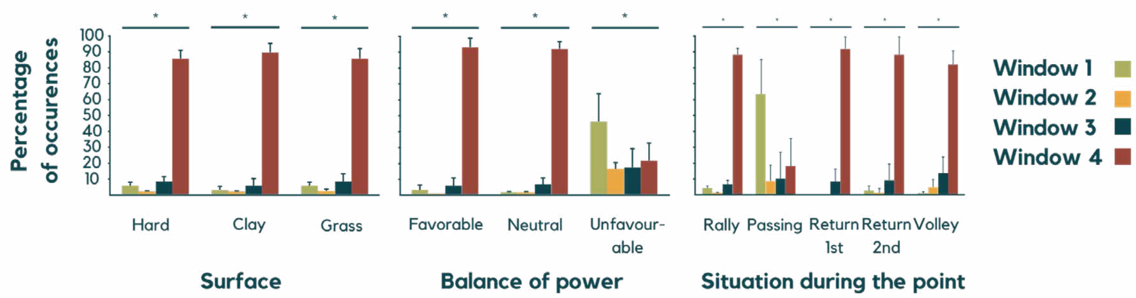


Figure 3. *Top graph: the percentage of correct responses as a function of the response time related to the opponent stroke (t = 0 ms, vertical line) for all surfaces. Bottom graph: the distribution of responses according to the four windows and (A) the three different playing surfaces, (B) the three different balance of power conditions, and (C) the five situations during the point (Triolet et al., 2013).*

movement before executing the genuine intention. Identity deception assimilates sport-specific techniques to create ambiguity. Target deception suggests a target different from the genuine one — typically the opposite. In short, the player exploits where and when they make contact to manipulate where and when the opponent makes contact.

Prerequisites

Active deception requires a player of sufficient skill and a maneuverable racquet, since the time available to transition from deceptive to veridical action is scant. Racquet maneuverability can be improved by developing the player's ability to move the racquet quickly, or by selecting/manipulating racquets to facilitate this. Taraborrelli et al. (2019) note that racquets have trended toward lighter frames with larger heads, making active deception more permissible. It is worth noting that skilled players in racquet sports such as badminton or pickleball, with more maneuverable devices (racquet, paddle, etc) and manageable objects (shuttlecock, ball, etc) employ more frequent and elaborate deception. Beware, if the racquet weight drops too low, the racquet will feel less stable at contact. Task scaling guidelines should be followed for younger athletes to address equipment and environmental constraints appropriately (Buszard, 2022).

Elements of Timing

Effective deception depends on an understanding of timing — defined here as achieving a centered impact, in ideal relation to the body, for the intended shot (according to Larry Jurovich as cited in GBAtennis, 2020a, 2020b). Timing is influenced by three key elements: contact height, intended direction, and the feeling of the swing. Anatomical constraints mean higher contact points occur further away and out in front of the body, while lower contact points occur closer. The direction of a shot is predicated on the body position around the ball, the wrist position at contact, and where in the contact window the player chooses to intercept the ball. The feeling of the swing — whether a hit, jab, push, catch, or block — is also central to timing (see Figure 3).

The active deceiver can create incongruent information using these elements. A player might use a "hit" feeling to execute a drop shot, or contact the ball slightly later in the contact window to disguise direction. In the first example, a swing feeling generally intended to add speed to the ball is used to add spin for a precision attack. The contra-active deceiver can use this same understanding to set traps — for instance, recognizing an opponent preparing a slice with a "hit" feeling and retreating to invite a shorter slice that is difficult to execute with that swing feeling.

Performing Active Kinematic Deception

The player should aim to keep affordances open until as late as possible — delaying the release of specifying information to hold the opponent in suspense. Indicating a higher-percentage option before playing an unlikely one is a reliable application of this principle. The most informative cues an opponent uses to anticipate are precisely the cues worth manipulating. In O'Connell (2026), Bernard Tomic deceives by playing a dropshot with a grip associated with a drive. Ball flight can also be exploited deceptively: movement in the sagittal plane is harder to judge than movement viewed from a different angle. It is trickier to anticipate the opponent's serve if they change their contact points for different serves more parallel to the center line instead of more parallel to the baseline (along the frontal plane). Maintaining similar launch angles across different shot types — analogous to "pitch tunneling" in baseball — can obscure the opponent's perception of the shot. For instance, keeping similar launch angles for a drop shot and a deep slice. Environmental factors such as wind, shadows, and sun can similarly be leveraged deceptively. Finally, the ability to hit closer to lines and the net raises the perceptual challenge for the opponent, particularly under high spatio-temporal demands. Here are examples of deceptive ball flight (ATP Tour, 2021; Australian Open, 2026).

DEFENDING AGAINST DECEPTION

Deception is a powerful disruptor of anticipation (Dimic et al., 2023; Rowe et al., 2009). Understanding where and when it is most likely to occur within a point can help players prepare to counter it. Triolet et al. (2013) found that a player's initial movements to receive the ball was on average 183ms after the opponent's contact and were ~100% successful at 160ms after (opponent's) ball contact (ABC). Movement prior to 160ms ABC (windows 1,2, and 3) was classified as anticipation. Interestingly, anticipation accuracy did not improve linearly as time approached 160ms ABC. Player's movement up to 140ms before (opponent's) ball contact (BBC) was 83% correct and had a higher reliance on contextual information to inform anticipation. Potentially, in this window of time (window 1), the opponent's advantage was so great that the player's anticipation likely would not save them — making the opponent's use of deception redundant. Surprisingly, later anticipation, between 120ms BBC and 60ms ABC (window 2), was characterized by a relatively greater percentage of wrong initial movements by the player (mean = 68% correct). This was largely attributed to the (mis)perception of kinematic/technical information by the player (Triolet et al., 2013), and/or speculatively, deception on the part of the opponent. Notably, this window coincides with what "Schnabel (2007) argued the interval to reorganize movement was 60-100ms" (Panten et al., 2019; p.6). This Window 2 anticipation was most prominent on faster surfaces (grass and hard court), when the player was on defense, and the opponent was approaching/at the net. In this phase of play and game situation, the spatio-temporal demands are greatest on the player and the cost of making a wrong initial movement is offset by their unfavorable odds of winning the point. This could insinuate that professional men are most likely to employ active kinematic deception when they are in control of the point.

In defending against active deception, the player can be certain that the opponent's kinematics must shift from deceptive to genuine intention at contact. The later the opponent makes this shift, and the greater coordinative complexity of the sequential or simultaneous deception to veridical action, the more they are prone to errors. In addition, the player could employ some of their own counter-deception; causing the opponent to take their eye off the ball, resulting in an error or sub-par shot. Finally, assuming the ball is in, until or unless the player is certain it isn't, is a great way to guard against tricky ball kinematics.

While less frequent and less threatening, addressing the contra-active deceiver is important. Recognizing the contra-active deceiver's limited influence on the interaction is a means of avoiding their attempt to disrupt the player's shot. If the player remains sensitive to information over various timescales concurrently they can maximize their grip on the interaction.

Finally, professional players will use the time leading up to the match to become familiar with their opponent – where tactical and technical information is studied by the player and their team. Aspects such as the speculative limitations of a forehand grip to access certain shots, as well as, the probable serving targets on pressure points are noted. Forewarning; relying solely on this offline information that Gibson (1979) calls knowledge about, Stepp & Turvey (2013) call weak anticipation and Zhao and Warren (2014) call heuristics and mapping will not reliably help the player reach the outcomes they desire.

TRAINING CONSIDERATIONS

Critical to the development of deception and anticipation, and their transfer from training to tournaments, is the ED principle of representative training (RT) (Otte et al., 2019). A rote-style practice adhering to an ideal technical template of deception will not develop the tactical awareness of when to apply this skill effectively. Equally, effective deception requires functional variability, since predictable movement patterns are more easily detected. RT is similarly important for anticipation. Buszard (2022; p.2305) asserts that "children can anticipate, but its development is not necessarily a by-product of playing sport and becoming skilled." Without temporal pressure, anticipation is superfluous. Following RT guidelines will elicit and nurture the brinkmanship needed to perform and defend against deception. At minimum, RT will avoid obstructing these skills emergence, as task decomposition and decoupled perception-action training would.

Otte et al. 's (2019) periodization of skill training framework offers practical guidance for scheduling deception and anticipation training relative to the player's stage of learning and competition calendar. Within a session, a coach could look to progress or regress the challenge on the player based upon the dynamical systems concept of (anti)fragility. "A fragile system is one that exhibits more harm than benefits in response to stress whereas an antifragile system is the opposite; the benefits from stress outweigh the harm" (Buszard, 2022; p.2306). The goal of this framework is to keep players in an anti-fragile state by ensuring that they are training under conditions where a slight increase in the challenge produces a greater magnitude of learning than the learning that would occur at an equivalent decrease in challenge.

Another important consideration is improving the player's action capacities so they can better perform and pre-empt deception. While action capacity and skill training go hand-in-hand, developing action capacity is about expanding the affordances available to the player, and skill is about realizing these affordances (Gray, 2022). Factors such as a player's strength relative to their racquet's swing weight is important in their ability to employ active deception. When anticipating, being able to wait longer for more specifying information to become available will more reliably guide action. The option of moving later is partially dependent on the player's agility. Bosch and Cook (2020), and Gray (2022) offer a means of training action capacities in an ED fashion.

TRAINING ACTIVITY

1. One player is approaching the net and the other is passing. Coach feeds in an approach shot. If the approaching player hits a winner they earn a bonus point. If the approaching player hits a winner that bounces three times in the doubles court, they earn two bonus points. Players can switch roles every three points. The approaching player is incentivized to employ deception and the passer attempts to pre-empt it. The coach should modify the feed, incentive structures, and game length so deception and anticipation are intertwined in an anti-fragile state.
2. Finally, a coach could help their player become less susceptible to deception by adequately manipulating the elements of timing outlined in Section C as they play points. The coach could progress and regress the frequency, intensity, and range of deception on their shots so players can learn to combat it while remaining in an anti-fragile state.

CONCLUSION

This paper has defined, described, and offered a means of training to perform and pre-empt kinematic deception in tennis through an ED lens. Kinematic deception – the attempt of one aspect of a system to cause another to lose its negative phase relationship, or incur a positive one – manifests in three subcategories: deceit, disguise, and distraction. Deception can operate actively or contra-actively, and be performed sequentially or simultaneously. Anticipation and deception are best understood together. Anticipation seeks to improve one's own affordances, while deception seeks to undermine the opponent's. Both entail risk, and both become indispensable when competing at the edge of one's ability against a worthy opponent.

Despite the appreciation players and fans have for these skills, coaches need to be both inclined and equipped to teach them – or at least, to avoid obstructing their emergence. The frameworks and evidence presented here offer a foundation for doing so. Further research examining deception and anticipation in singles under representative conditions would meaningfully advance this area. Moreover, research in a doubles setting, or from a more tactical standpoint, or studying the other perceptual forms of deception would provide useful insights on this under-examined, but prevalent skill.

CONFLICT OF INTEREST AND FUNDING.

The authors declares no conflict of interest and confirm that no funding was received for this research.

REFERENCES

Araújo, D., Lopes, H., Farrokh, D., & Davids, K. (2025). The ecological dynamics of cognizant action in sport. Psychology of Sport and Exercise, 80, 102935. https://doi.org/10.1016/j.psychsport.2025.102935

ATP Tour. [@atptour]. (2021, January 5). A point is never over, until it's over [Video]. Instagram. https://www.instagram.com/p/CJqPmUVB2Si/

Australian Open. [@australianopen]. (2026, January 24). What kind of sorcery is this?! [Video]. Instagram. https://www.instagram.com/p/DT4if8yDKtU/

Bosch, F., & Cook, K. (2020). Anatomy of agility: Analysis of movement in sports. 2010 Publishers.

Buszard, T. (2022). On learning to anticipate in youth sport. Sports Medicine, 52(10), 2303–2314. https://doi.org/10.1007/s40279-022-01694-z

Carrilho, D., Lopes, H., Brito, J., & Araújo, D. (2025). A novel action-based model of anticipatory and team synergic behavior using cluster phase analysis. PsyArXiv. https://doi.org/10.31234/osf.io/9a7tj_v1

Dimic, M., Furuya, R., & Kanosue, K. (2023). Importance of disguising groundstrokes in a match between two top tennis players (Federer and Djokovic). International Journal of Sports Science & Coaching, 18(1), 257–269. https://doi.org/10.1177/17479541221075728

Farrow, D., & Abernethy, B. (2003). Do expertise and the degree of perception-action coupling affect natural anticipatory performance? Perception, 32(9), 1127–1139. https://doi.org/10.1068/p3323

GBAtennis. (2020a, January 24). Perception & timing [Video]. YouTube. https://www.youtube.com/watch?v=bWKN6xDfniQ

GBAtennis. (2020b, January 24). Understanding the technical principle of rhythm [Video]. YouTube. https://www.youtube.com/watch?v=f4uMZbr9JlE

Gray, R. (2021a). Approaches to visual-motor control in baseball batting. Optometry and Vision Science, 98(7), 738–749. https://doi.org/10.1097/opx.0000000000001719

Gray, R. [Perception & Action Podcast]. (2021b, January 19). 336 – Strong anticipation: Coordinating with the future without predicting it [Video]. YouTube. https://www.youtube.com/watch?v=fpArGL7oAMM

Gray, R. [Perception & Action Podcast]. (2022, October 25). Action capacity vs skill: Training to expand the field of affordances [Video]. YouTube. https://www.youtube.com/watch?v=RXT5UKKSWzs

Gibson, J. J. (1979). The ecological approach to visual perception. Houghton Mifflin.

Güldenpenning, I., Jackson, R. C., & Cañal-Bruland, R. (2023). The science of deceptive human movement. Human Movement Science, 92, 103147. https://doi.org/10.1016/j.humov.2023.103147

Müller, S., & Abernethy, B. (2012). Expert anticipatory skill in striking sports: A review and a model. Research Quarterly for Exercise and Sport, 83(2), 175–187.

O'Connell, W. [@tennisrecon]. (2026, February 19). Tennis recon: Deception and its forms in tennis [Photograph]. Instagram. https://www.instagram.com/p/DU8k0_ljXM0/?img_index=3

Ontañón-García, L. J., Campos Cantón, I., & Pena Ramirez, J. (2021). Dynamic behavior in a pair of Lorenz systems interacting via positive-negative coupling. Chaos, Solitons & Fractals, 145, 110808. https://doi.org/10.1016/j.chaos.2021.110808

Otte, F. W., Millar, S.-K., & Klatt, S. (2019). Skill training periodization in "specialist" sports coaching — an introduction of the "post" framework for skill development. Frontiers in Sports and Active Living, 1. https://doi.org/10.3389/fspor.2019.00061

Panten, J., Loffing, F., Baker, J., & Schorer, J. (2019). Extending research on deception in sport: Combining perception and kinematic approaches. Frontiers in Psychology, 10. https://doi.org/10.3389/fpsyg.2019.02650

Ramsey, H., Dicks, M., Hope, L., Spence, J., & Reddy, V. (2022). Maximising grip on deception and disguise: Expert sports performance during competitive interactions. Sports Medicine - Open, 8(1), 47. https://doi.org/10.1186/s40798-022-00441-y

Rosker, J., & Majcen Rosker, Z. (2021). Skill level in tennis serve return is related to adaptability in visual search behavior. Frontiers in Psychology, 12. https://doi.org/10.3389/fpsyg.2021.689378

Rowe, R., Horswill, M. S., Kronvall-Parkinson, M., Poulter, D. R., & McKenna, F. P. (2009). The effect of disguise on novice and expert tennis players' anticipation ability. Journal of Applied Sport Psychology, 21(2), 178–185. https://doi.org/10.1080/10413200902785811

Stepp, N., & Turvey, M. T. (2010). On strong anticipation. Cognitive Systems Research, 11(2), 148–164. https://doi.org/10.1016/j.cogsys.2009.03.003

Sun Tzu. (~500 BCE/2014). The art of war. Black & White Classics.

Taraborrelli, L., Grant, R., Sullivan, M., Choppin, S., Spurr, J., Haake, S., & Allen, T. (2019). Materials have driven the historical development of the tennis racket. Applied Sciences, 9(20), 4352. https://doi.org/10.3390/app9204352

Triolet, C., Benguigui, N., Le Runigo, C., & Williams, A. M. (2013). [Full citation needed — journal, volume, issue, and page range required as this is cited heavily throughout the paper but the full reference is absent from your list.]

van der Kamp, J., Rivas, F., van Doorn, H., & Savelsbergh, G. (2008). Ventral and dorsal system contributions to visual anticipation in fast ball sports. International Journal of Sport Psychology, 39(2), 100–130.

Wilson, A. D., Buckingham, G., Dessing, J. C., Lappi, O., Friston, K., Hipolito, I., Ramstead, M. J., Mansell, W., & Gray, R. (2024). Predictive vs. prospective control: Clarifying the terms of the debate. PsyArXiv. https://doi.org/10.31234/osf.io/ce3zb

Woods, C. T., McKeown, I., Rothwell, M., Araújo, D., Robertson, S., & Davids, K. (2020). Sport practitioners as sport ecology designers: How ecological dynamics has progressively changed perceptions of skill "acquisition" in the sporting habitat. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.00654

Zhao, H., & Warren, W. H. (2014). On-line and model-based approaches to the visual control of action. Vision Research, 110, 190–202. https://doi.org/10.1016/j.visres.2014.10.008

Zheng, R., van der Kamp, J., Miller-Dicks, M., Navia, J., & Savelsbergh, G. (2023). The effectiveness of penalty takers' deception: A scoping review. Human Movement Science, 90, 103122. https://doi.org/10.1016/j.humov.2023.103122

International Tennis Federation
www.itfcoachingreview.com
April 2026. 34th Year. Issue 98. 56-60
ISSN 2225-4757
https://doi.org/10.52383/itfcoaching.v34i98.724

Obstacles to female participation in a tennis club: a case study

Yannick Zaputovich

University of Buenos Aires (Argentina)

ABSTRACT

Tennis clubs are spaces where, in addition to practicing a sport, social life takes place, which is an elementary part of them. Along with the benefits considered linked to the healthy outdoor environment, the social experience can work as a stimulus to approach them without having experience in sports. They are also suitable environments for sharing spaces of sociability and the social life that occurs outside the courts has an impact on what happens (or does not happen) inside them. However, it can also lead to exclusions of various kinds. Through ethnographic fieldwork, it was possible to notice the existence of difficulties in accessing the practice of tennis among women members of a club located in the City of Buenos Aires, Argentina. Within the framework of an ongoing attempt by institutional authorities to reach a greater number of players in Argentina and in the world, it is suggested that addressing the social and cultural dimension of tennis clubs is central not only to bring the sport closer to more potential players, but also to enable access and ensure its permanence.

Key words: socialization, clubs, health, exclusion, participation

Received: 30 June 2025

Accepted: 16 March 2026

Corresponding author:
yzaputovich@gmail.com

INTRODUCTION

Cradle of great Grand Slam champions such as Guillermo Vilas and Gabriela Sabatini, tennis is one of the ten most practiced sports in Argentina today. As recent studies have shown (Zaputovich, 2025), in the South American country it was one of the few sports enabled for the practice of women since the beginning of the twentieth century. However, tennis as a sport and tennis clubs as social spaces continue to function as male spaces. This tension between the formal qualification of women to play tennis and their de facto exclusion within club spaces is not new: historical research has documented similar dynamics in elite tennis clubs since the late nineteenth century (Boyle, 2019).

According to data from the 2023 National Survey on Physical Activity and Sport, 5.5% of the Argentine population played tennis (Ministry of Tourism and Sports, 2023, p. 41), a slight drop compared to the results of the same study carried out in 2021, which showed 6.2% of the population (Ministry of Tourism and Sports, 2021, p. 20). According to the results of the 2021 report, there is a mostly male trend towards sports with rackets or paddles (20.2% of men practiced it against 12.5% of women) (p. 21). Other reports (González & Brum, 2024) indicate a 117% growth in the registration of tournaments of the Argentine Tennis Association between 2019 and 2024 and estimate that, at the time of answering the survey, a total of 4.5 million people over the age of 5 played tennis at least once during the last 12 months in Argentina. Research in other contexts has documented that female sex is associated with a higher likelihood of dropping out of tennis, even among young female players (Deelen et al.,

2018), suggesting that barriers to female participation are not limited to initial access, but persist throughout the sporting career. Although statistical data are useful for a diagnosis, we consider it pertinent to implement multiple methodologies for the analysis of the situation.

Jeanes et al. (2021) highlight how certain everyday practices and micro-relationships within a community club exclude and marginalize women and girls, despite institutional efforts to foster a more equitable environment. In a context in which the institutions that regulate the sport seek to promote the practice of tennis at a global and national level (González & Brum, 2024), it is necessary to know first-hand the experiences of real players and partners to know what motivated them to approach the sport and what can keep them close to it or distance them. While previous research has highlighted the role of family and social ties as factors that lead people to choose tennis (Bozkurt, 2022), the present study shows that these same ties can condition the type of participation that women have within the club, initially limiting it to sociability off the court. In this sense, an ethnographic work can offer a novel and fruitful approach to address the issue.

METHODS AND PROCEDURES

The results presented are a survey carried out in a tennis club located in the Autonomous City of Buenos Aires with 650 adult members (in addition to approximately 200 members under 18 years of age). According to the club's own data, between 2016 and 2023, women represented on average 43% of the total number of adult members without major fluctuations (between 45% and 41%). However, the club has two different categories of members: among the "tennis members", who can use the tennis courts, there is a male majority that reaches 62%, while among "social members", those who cannot use the courts, the majority are women (during the indicated period they came to represent 73% of this group, although the latest data indicate that 61% of women are social partners). As in many clubs in the City of Buenos Aires, associating the family offers discounts on the fee, having to meet the requirement that a member be in the category "tennis member", a place generally occupied by a man, which models the places that each member occupies within the club.

During the indicated period there were no significant changes in the club's structure. It can only be observed that, as of 2022, over the total number of female tennis players, there was an increase in those with less than 4 years of seniority in the club (the figure climbed from 16% to 40%). This may indicate that the new members who joined arrived with an explicit interest in playing tennis, unlike what happened previously.

The fieldwork was carried out in two stages. In 2022, the first approach addressed the experience of women members who are players in the interclub tournament, an official team competition organized by the Argentine Tennis Association (AAT). During the second approach, in 2024, the experience of other members could be learned, both male tennis players who competed in the same event and members who played tennis only recreationally. During these periods, the club was accessed as a researcher to carry out participant observation and interviews. 20 interviews were conducted with women members of the club, between 18 and 65 years old. Most of the participants have a university or tertiary education. In terms of seniority as members, the group is heterogeneous: some have been at the club for more than three decades, while others joined in recent years. The selection was made by means of chain sampling (snowball), combining individual and group instances. The names used are fictitious to preserve the anonymity of the participants.

The club under study has characteristics that distinguish it from other local tennis clubs. Unlike the traditional clubs in the northern part of the city, historically linked to British immigration and the upper sectors of Argentine society, this club is in a neighbourhood with a working tradition and had among its founders a prominent presence of people of Italian and Spanish origin. Although the commune in which it is located has the second lowest average family per capita income in the city (IDECBA, 2025), it is clear from the amount of the social contribution (equivalent to 13% of the average of the index) and from the reports about their daily life (vacations abroad, frequent outings to eat, ownership of at least one family car) that their members have a purchasing power higher than the average for the neighbourhood. The club is exclusively for tennis, offers no other sports activities, and has 13 courts. In 2024 it registered 30 adult women's teams, 28 male and 7 mixed teams in the AAT tournaments; In the first half of 2025, the available records show 16 women's, 15 men's and 9 mixed teams, which accounts for a sustained and relatively balanced competitive participation between genders.

CASE STUDY, BACKGROUND AND ANALYSIS

During the first access to the club, a paradoxical reality was found. Despite being in a tennis club and being members of it, playing tennis was not the most accessible activity for many women. The first interviews conducted with women between 40 and 60 years old, who were part of the club's teams, showed an experience of struggle to facilitate the practice for women.

Rosana, a 55-year-old member who had played tennis at another club before joining, highlighted the healthy atmosphere and safety offered in the middle of the city, which makes the club an "oasis". It is worth noting that Rosana appreciates the codes and etiquette of tennis compared to other sports, which reveals a dimension of social distinction linked to practice (Lim et al., 2022). Inés, 54, came to the club because of her husband and has three daughters who also played tennis there. Her testimony clearly summarizes the experience of many: "The issue of tennis here in the club, women's, is difficult. It was always difficult. Now it is less. We had a training session, teacher, and that's when we all started to get to know each other and we started asking the club to really open the doors for us with the issue of women and participation because it was very masculine, very masculine everything." Another member expressed her experience in forceful terms: "I joined the club much earlier, but I was a member... one of those who drink mate and we are in the square. It was waiting for your husband to finish playing millions of games. So, I say 'it can't be that I only come to drink mate, I have to do something else'. So then I said, 'What's there to do?' Tennis". This scene illustrates the two options that many women had: to meet to chat and drink mate – a practice that allows community ties to be strengthened (Maciel, 2022) but that implied staying off the courts – or playing tennis, an alternative that, as we will see, was more complex than it seemed.

The women reported a series of inconveniences within the club linked to the accessibility to the fields, the availability of schedules to play and the possibility of training with a teacher. Generally, most of the courts were occupied by men, which implied an exclusion of women interested in becoming new players, who had to go to the courts with less maintenance. In addition, the schedules offered to them were during midday, when they took care of household chores or taking care of their children. These restrictions coincide with what was documented by Jenkin et al. (2018), who identified time constraints as one of the main barriers to sports practice, frequently aggravated by caregiving responsibilities. In short, the club was not presented as a favourable environment for the practice of tennis among women (Johnston et al., 2022). The question to be asked is: how is it possible that in a tennis club – where there is no other sport to play – the most accessible activity for a part of its members is not to play tennis? The answer must be found in culture. Although there are studies that have addressed the issue of the development of a management culture to increase sports participation (Rodríguez et al., 2024), there are not many that address the problems that tennis culture enables around social exclusion.

As part of a plan to increase the number of players developed by the Lawn Tennis Association, Lake (2011) addressed the issue of social exclusion in a London tennis club. There he warned that the economic incentives were not enough since the new members had severe difficulties to integrate into the "established" members, whose barrier was drawn from the tennis culture of the club: level of play, behaviours on and off the court, clothing and etiquette in general.

In the case presented here, a first barrier is that of entry. The club requires the signature of two previous members to authorize the affiliation form. This restricts the access of potential partners who do not have sufficient "social capital" (Bourdieu, 1986, p. 21). Elizabeth, 62, was able to join thanks to a friend who managed the necessary signatures, despite acknowledging that "I don't have a club life, I'm not a club bug." Her case illustrates that the social capital required for entry can be provided by an informal network, but those who lack such prior ties face a barrier that is not contained in any regulation.

Administrative income is not the only barrier. Patricia, 45, whose husband is also a member but does not play tennis, became associated during her pregnancy because of the green space offered by the club and pointed out that at first it was difficult to bond with established groups, although the bonds "come naturally" over time. It was only years later that he began playing tennis. Carmen, 48, a member since she was 12, recalled: "It's a half-closed club, if they already have a group formed, they don't integrate you much, so it took me several years to meet people to be able to play." After abandoning the practice when she lost her group of friends, she returned around 40 at the invitation of a friend and organized herself with other women to demand better schedules and form teams. It is important to dimension tennis as a group sport: what ensures the permanence of the players is belonging to a team or training group, which discourages abandonment.

The problem of access is structural and exceeds the good or bad intentions of the other partners. On one occasion, a member recalled that "the tennis coordinator grabbed a teacher and told him 'you take care of all these women'", erasing the capacity for agency of the women who had promoted the claim. Once the process was underway, there was a considerable struggle for symbolic spaces, especially the three central courts of the club, the closest to the social headquarters and used in competitions. Originally, when the women trained there, they received expressions of disappointment from many male members who referred to their poor level of play or accused them of leaving the fields in poor condition. In any case, the momentum had effects: in 2018 there were four women's teams, while in 2024 it reached 30 teams. Unlike what was observed by Lim et al. (2022) in tennis clubs in South Korea, where women built their identity around values of respect and distinction within the practice of sport, in the case presented here, women first had to dispute access to the game itself. Tatiana, 39, a member since she was 10 and a competitor since the children's categories, was one of the protagonists of that fight: "For me, women were pleasantly impacted. That today the fields are full of women is spectacular."

For many, the club became a legitimate space to dispute meanings and places. Backed by dozens of women, they managed to organize around a collective claim that also implied putting the body at stake and accessing a dimension that had been forbidden: the practice of sports.

Despite certain favourable results, another aspect to take into account is women's participation in spaces of authority. No woman has presided over the club in its entire history, as is the case in many Buenos Aires clubs and in the AAT itself. Although some members are currently part of the board of directors – such as Carmen, who since the new management is part of the tennis subcommittee and is dedicated to the organization of events aimed at encouraging the participation of members who do not play regularly – women with responsibilities tend to participate only in actions related to the organization of events. The way in which female representation is distributed in the various areas of the club, both at the competitive level and at the level of authorities, is a central aspect to consider.

LIMITATIONS, PRACTICAL APPLICATIONS AND FUTURE LINES OF RESEARCH

This study has some limitations that need to be noted. First, the work focused on a single tennis club located in the City of Buenos Aires, which restricts the possibility of generalizing the findings to other institutions with different social, economic, or geographical characteristics. As it is ethnographic research, the information obtained was based mainly on the observation and testimonies of the participants, which implies a reading situated and crossed by the particular conditions of the context investigated.

Despite these limitations, the results obtained offer relevant contributions for institutional management and the promotion of sport. The case presented here can function as an illustrative example of possible conquests for women in access to sports practice, useful to make visible to the responsible institutions the existence of obstacles that are most likely reproduced in other institutions with similar forms of sociability. From a broader institutional level, the formation of spaces in which women can talk about their experience and a situation that remains imperceptible until the internal dynamics of the clubs are known can be encouraged. In a second instance, incentives could be considered for the presentation of women's teams in competitions as a way to consolidate their participation.

However, it should be noted that the obstacles identified are of a structural and cultural nature and are not resolved through the implementation of formal inclusion programs. The central problem is not one of quotas or formal representation, but of a historically masculine sports culture that has reproduced, within the clubs, the same roles that women occupy in other areas of social life. The training schedules offered to women were incompatible with their domestic responsibilities not because the club had an explicitly discriminatory policy, but because this unequal distribution of care work was never considered an institutional problem.

It is worth comparing the case presented here with the one analysed by Hang (2020) at the Club Gimnasia y Esgrima La Plata, where a group of members formally organized a gender area to introduce this perspective into the institutional structure of the club. The difference between the two cases is significant: while in Gimnasia the transformation was based on the articulation with the feminist movement, in the tennis club studied here the changes took place without the creation of any specific commission, through the sustained impulse of a group of women who faced successive refusals until they consolidated small victories. Both cases illustrate that changes in the conditions of female participation in clubs are possible, but that the ways in which they are produced depend on the institutional context, the political culture of the sport and the historical moment.

In this sense, it should be noted that the current national situation presents different conditions from those of the period in which women's participation in the club studied grew. In a context where policies aimed at gender equality are under public attack by state institutions, it is unrealistic to assume that clubs will spontaneously opt for inclusion programmes on these terms. This does not invalidate the importance of continuing to point out existing obstacles but rather forces us to think about viable interventions within real institutional logics, recognizing that the most lasting changes have historically been those conceived and conquered from within.

While reviewing similar experiences in other research from different parts of the globe may suggest a common cultural root in integration issues, future studies could compare different clubs, regions or institutional profiles, as well as integrate the perspective of other relevant actors such as coaches or managers. It would also be valuable to explore whether the barriers vary according to the age group within the same club, given that in the case presented, female participation is especially active in categories of over 40 years of age (Jenkin et al., 2018). This would contribute to a broader vision of the factors that condition inclusion in sport.

CONCLUSIONS

We suggest that there are issues rooted in the culture of tennis that make it possible to observe it as a sport enabled for women, but in which even within the clubs themselves they can face obstacles to practice. Some may refer to the cost of practicing it, but issues related to the integration of groups and incorporation into those already established should be focused with greater attention. In the attempt to increase the number of players, they should not be sought exclusively away from the field of tennis, but, many times, within the same clubs.

It is worth noting that many times the entry into the culture of tennis is not motivated by starting to practice the sport, but by a set of benefits linked to the clubs: maintenance of social status, a sense of security, physical well-being in the open air, and the comfort of sharing time with previous friends. It should not be lost sight of the fact that in different contexts around the world there has been research that shows difficulties in integration within tennis clubs, expressed in unequal allocation of resources or in the refusal to incorporate new members into already established groups. This dynamic may be motivated, as in the case presented, by gender reasons, but this is not the only aspect to consider.

We see then that the club remains a masculine space, where, as Johnston et al. (2022, p. 32) observe, "it is not surprising that the allocation of important resources often favours men's and boys' teams". However, the possibility of transformation and incorporation of new players has been evident. Even after having established themselves as teams, these groups continue to experience situations of inequality that manifest themselves in displacement in symbolic spaces or decision-making. As we observe at the club, opportunities for women to play tennis remain more limited, in part because their participation continues to be inscribed within an ornamental and subordinate logic. As long as this hierarchy is not questioned, the established order remains undisturbed. When an attempt is made to reverse this logic, tensions emerge that manifest themselves both on the physical level – the dispute over certain fields – and on the symbolic level – access to management positions or certain benefits. This dynamic allows us to understand why, even though tennis seems to offer greater advantages compared to other disciplines, structures of inequality persist in it that limit women's full access to sports.

CONFLICT OF INTEREST AND FUNDING

The author declares that he has no conflict of interest and that he did not receive any funding to carry out the research.

REFERENCES

Bourdieu, P. (1986). The forms of capital. En J. G. Richardson (Ed.), Handbook of theory and research for the sociology of education (pp. 241–258). Greenwood Press.

Boyle, B. M. (2019). Athleticism and the new woman: Lawn tennis at the Staten Island ladies' club. Winterthur Portfolio, 53(4), 231–268.

Bozkurt, T. M. (2022). Examination of the reasons for preferring tennis by the athletes participating in the Eastern League tennis tournament. Revista de Investigaciones Universidad del Quindío, 34(S2), 160–170.

Deelen, I., Ettema, D., & Kamphuis, C. B. (2018). Time-use and environmental determinants of dropout from organized youth football and tennis. BMC Public Health, 18(1), 1022.

Gonzalez, A., & Brum, G. (2024). AAT Community: growing participation based on information. ITF Coaching & Sport Science Review, 32(93), 51–54. https://doi.org/10.52383/itfcoaching.v32i93.600

Hang, J. (2020). Feminists and triperas. Women and politics in the gender area of the Gimnasia y Esgrima La Plata club. Debates in Sociology, (50), 67–90. https://doi.org/10.18800/debatesensociologia.202001.003

Institute of Statistics and Censuses of the Autonomous City of Buenos Aires (IDECBA). (2025). Average per capita household income (CPI) by commune. City of Buenos Aires. https://www.estadisticaciudad.gob.ar/eyc/banco-datos/promedio-del-ingreso-per-capita-familiar-ipcf-de-los-hogares-segun-comuna-ciudad-de-buenos-aires-ano-2017/

Jeanes, R., Spaaij, R., Farquharson, K., McGrath, G., Magee, J., Lusher, D., & Gorman, S. (2021). Gender relations, gender equity, and community sports spaces. Journal of Sport and Social Issues, 45(6), 454–567. https://doi.org/10.1177/0193723520962955

Jenkin, C. R., Eime, R. M., Westerbeek, H., & van Uffelen, J. G. (2018). Sport for adults aged 50+ years: Participation benefits and barriers. Journal of Aging and Physical Activity, 26(3), 363–371.

Johnston, M., Naylor, M., Campbell, A., Fitzmaurice, J., & Ferkins, L. (2022). The female-friendliness of New Zealand's tennis clubs.ITF Coaching & Sport Science Review,30(87), 28–33. https://doi.org/10.52383/itfcoaching.v30i87.342

Lake, R. J. (2011). 'They treat me like I'm scum': Social exclusion and established-outsider relations in a British tennis club. International Review for the Sociology of Sport, 48(1), 112-128. https://doi.org/10.1177/1012690211424523

Lim, S., Kim, H., & Jang, S. (2022). How women's tennis club participants construct identity: 'respect, pride and distinction'. Sport in Society, 25(2), 321–337.

Maciel, M. E. (2022). Chimarrão: Identity, Ritual and Sociability. Flour and Rapadura, 2(1), 5-15. https://www.farinhaerapadura.com.br/docs/FR-E1-V2-Art01-CHIMARRAO.pdf

Ministry of Tourism and Sports. (2021). National Survey of Physical Activity and Sports 2021. Social Observatory of Sport, Ministry of Tourism and Sports. https://www.argentina.gob.ar/sites/default/files/2021/06/encuesta_nacional_1.pdf

Ministry of Tourism and Sports. (2023). National Survey of Physical Activity and Sport 2023. Social Observatory of Sport, Ministry of Tourism and Sports. https://www.argentina.gob.ar/sites/default/files/enafyd_2023_-_digital.pdf

Rodríguez, M., Piquer Piquer, A., & Crespo Dualde, A. (2024). Creating a tennis culture in the national federation. ITF Coaching & Sport Science Review , 32(93), 29–35. https://doi.org/10.52383/itfcoaching.v32i93.463

Zaputovich, Y. (2025). Between Spain and Argentina, tennis as a practice enabled for the female body at the beginning of the twentieth century. Materials for the History of Sport, 29, 72-83. https://doi.org/10.20868/mhd.2025.29.5260