ITF International Tennis Federation

COACHING & SPORT SCIENCE REVIEW

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Editorial

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Welcome to the 97th issue of the ITF Coaching & Sport Science Review, the third and final of 2025, celebrating 33 years of publication. This issue places a strong emphasis on the junior game, offering a collection of research and practical insights aimed at developing the next generation of players. Among the featured topics is an analysis of the predictive validity of the ITF Juniors Tour for professional career outcomes, guidelines on specific approaches for working with GSPDP ITF/TE Touring Teams, the constraints-led approach methodology, and the impact of strength and conditioning on junior footwork. Management, historical and psychological perspectives are also covered, with articles on the ITF World Tennis Number, knowledge management applied to tennis organisations, the history of French tennis and its federation, and research into key skills of champions, resilience in tennis coaching and the effects of coach feedback and motor imagery on junior players.

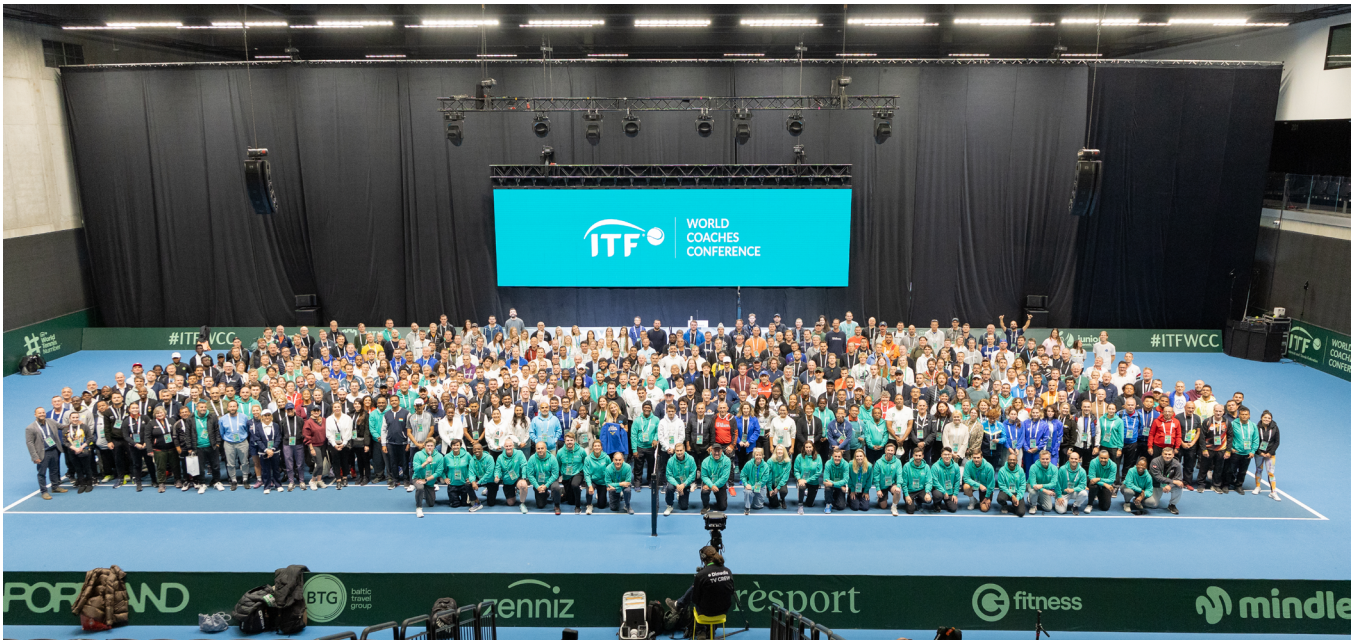
In this editorial, we also spotlight several key ITF initiatives designed to strengthen the global delivery of effective tennis development programmes. These efforts reflect the ITF's commitment to creating inclusive pathways, supporting coaches, and ensuring players at every level have access to the tools they need to succeed. These initiatives are part of the ITF's long-term strategy to make tennis a sport for everyone, from grassroots to elite competition, while embracing innovation and inclusivity.

ITF WORLD COACHES CONFERENCE

The 24th ITF World Coaches Conference in Vilnius concluded with a strong sense of collaboration, innovation, and inspiration, perfectly reflecting its theme: "Future Trends in Tennis: Preparing Today for Tomorrow's Game."

Held at the SEB Arena in partnership with the Lithuanian Tennis Union and Tennis Europe, the event brought together 479 delegates from over 92 countries, showcasing the global reach of the coaching community. Across three days, keynote presentations, interactive workshops, and dynamic discussions highlighted how coaching continues to evolve at the core of tennis.

The conference brought together leading experts in sports medicine, performance analysis, and tennis innovation, alongside ITF leadership, offering diverse and inspiring perspectives on coaching and player development. As the event began, anticipation was high. The programme celebrated the global tennis coaching community and its essential role in shaping the future of the sport. In his opening address, ITF President Dave Haggerty urged coaches to embrace progress through modern methodologies, technological innovation, and player development strategies. His call to leave Vilnius with actionable ideas and practical tools resonated throughout the programme.



With the next generation of talent in focus, the 2025 ITF World Coaches Conference not only reflected on the current state of the game but also outlined a clear vision for its future direction. Experts and speakers explored critical topics shaping the sport's future: inclusivity, sustainability, data-driven decision-making, and the integration of AI and digital tools in coaching. Italy's Billie Jean King Cup captain, Tathiana Garbin, inspired attendees with insights on leadership, team culture, and the importance of people behind success, while advocating for women in tennis and sharing the Italian pathway for talent development.

Dr Brian Hainline reinforced tennis as a lifelong sport, encouraging coaches to leverage research and community networks to support players of all ages and abilities. Former professionals Ernest Gulbis, Kaia Kanepi, and Ričardas Berankis offered personal perspectives on transitioning from junior to professional tennis, emphasizing adaptability and resilience.

Sessions on performance and partnerships added further depth. Jacco Eltingh examined the nuances of doubles development, focusing on communication and trust, while conditioning expert Beni Linder presented modern approaches to physical preparation, recovery, and holistic training.

Equity and empowerment were central themes. Salma Mouehli addressed challenges in coaching female athletes, highlighting confidence-building, communication, and the importance of role models, reinforcing ITF's Advantage All commitment to inclusion.

Breakout sessions encouraged knowledge-sharing and practical application. Mental strategies placed athlete well-being at the forefront, while workshops on tactical analysis showcased how AI, video, and data are transforming player development. Inclusive coaching frameworks demonstrated how tennis can truly be accessible to all.

Global collaboration remained a cornerstone of the event, with federations and coaches exchanging ideas to raise standards worldwide and creating the adequate tennis culture (Nash et al., 2024). Updates on ITF's education and certification frameworks underscored ongoing efforts to strengthen coaching at every level through reflection, learning and development (Martínez-Gallego et al., 2023).

Beyond the court, talent development, sustainability and community engagement were key discussion points, inspiring coaches to use their programmes as platforms for positive change in offering more and better opportunities at a global scale (Crespo et al., 2025). A highlight was the ITF-USTA Red Ball initiative, illustrating innovative adult engagement pathways from red to yellow ball play—a success story since its launch at the US Open.

The conference marked a significant step forward in promoting diversity. It featured 92 speakers from across the globe, including keynote presenters and workshop leaders, with women representing roughly one-third of the overall line-up. Gender representation among the 25 keynote speakers was nearly equal, with 12 women and 13 men, reflecting the ITF's commitment to inclusive leadership in tennis coaching. This progress aligned with the ITF Advantage All programme and broader efforts to advance gender equality in the sport. According to the latest ITF Global Tennis Report, the total female playing population had grown by 8.3%, while the proportion of women coaches increased from 20.6% in 2019 to 24.3% in 2024. Women officials accounted for 31% of the officiating workforce.

As the conference closed, delegates departed Vilnius energized and united in their commitment to advancing coaching and shaping the future of tennis worldwide. The conference explored the technologies and emerging trends that were shaping the next era of player development, offering insights into how innovation continues to transform the future of tennis.

Following the main conference, over 40 National Junior Tennis Initiative (JTI) Coordinators and ITF Tutors participated in the 4th Global JTI Workshop and a dedicated tutor session. These gatherings extended the dialogue, focusing on implementing the new ITF School Tennis Teacher Certification to maximize grassroots development and increase tennis exposure for future generations. They are a practical application of the needs for continuous coach education as concluded by recent studies (Crespo et al., 2024; Hannays, 2020).

As highlighted by tennis-specific research showing the importance coaches place on online education (Mester & Wigger, 2011; Sackey-Addo & Pérez Camarero, 2016) , all presentations from the recent conference have been made available on ITF Academy for those who attended. This ensures that participants can revisit key insights, deepen their understanding of emerging trends, and apply practical knowledge shared during the event at their own pace. By providing on-demand access to expert-led sessions, the ITF continues to support lifelong learning and professional development for coaches worldwide, reinforcing its commitment to innovation and accessibility in coach education.

WORLD TENNIS

The International Tennis Federation (ITF) will adopt the name World Tennis in 2026, following a decisive vote in favour of the proposal by its member national associations at today's ITF Annual General Meeting. Recommended by the ITF Board and Executive, this change aims to better represent the organisation's role as the global governing body and guardian of the sport, as well as its partnership with member nations to grow and develop tennis worldwide.

The name World Tennis was selected after extensive research and stakeholder consultations across the sport, confirming the need for a title that reflects the organisation's scale and significance within the global tennis ecosystem, which spans 213 member associations.

This evolution will create a clearer, more relevant identity for players, fans, partners, and stakeholders, aligning the brand with other leading international sports federations. It also builds on recent brand developments, including the introduction of sub-brands such as World Tennis Tour and World Tennis Number. The rebrand forms part of a long-term strategy to drive greater engagement, recognition, and investment across all levels of tennis—from grassroots participation to elite competition.

After more than a century as the ITF, the organisation is entering an exciting new chapter as World Tennis, continuing to expand its global impact on the sport. The new name reflects its role as the international governing body and guardian of tennis, working closely with member nations to deliver tennis for life.

This evolution follows extensive consultation across the global tennis community and represents a shared ambition to strengthen, unify, and grow the game worldwide. The rebrand is part of a broader strategy to enhance engagement and recognition, and the full identity and plans will be unveiled in the coming months.

Founded in Paris in 1913 as the International Lawn Tennis Federation, the organisation became the International Tennis Federation in 1977. The new trading name will take effect on 1 January 2026, with the World Tennis brand officially launched in summer 2026 as part of a phased rollout.

INTERNATIONAL BLIND TENNIS ASSOCIATION (IBTA)

The International Tennis Federation (ITF) and the International Blind Tennis Association (IBTA) have signed a Memorandum of Understanding (MOU) to strengthen collaboration and drive global development of blind tennis.

This agreement reflects a shared commitment to making tennis inclusive and accessible for all, while creating more opportunities for blind and visually impaired players of all ages and skill levels. Under the MOU, the ITF will gain deeper insight into blind tennis' structure, regulations, classification systems, and long-term development needs. In turn, the IBTA will benefit from the ITF's expertise in governance, programme development, and its experience advancing other disability tennis formats such as wheelchair tennis.

The partnership supports a key pillar of the ITF's 2024+4 strategy – 'Opportunity', which focuses on making tennis a sport for everyone. It reinforces the ITF's ongoing work with organisations representing different tennis variations to expand participation and create new pathways for players. For the IBTA, as the global body for blind and visually impaired tennis, the agreement will help increase worldwide participation, standardise adaptive equipment, and align classification regulations with international standards such as IBSA and IPC.

This collaboration marks an important step in the ITF's commitment to understanding and developing all disability tennis formats. It represents the beginning of a valued partnership aimed at ensuring long-term growth, sustainability, and greater opportunities for blind and visually impaired players worldwide.

For those interested, several articles on blind tennis have already been published in this journal and can be found both in the website and the ITF Academy, including introductory concepts (Bullock, 2007), game analysis (Sato et al., 2010), examples of programmes (Young & Fitz-Gerald, 2015), and equipment related studies (Roth et al., 2023). Other scientific studies conducted on this field are related to practical approaches (Battarel, 2013), and barrier elimination (Polak-Sopinska & Nebelska, 2019). For more details on IBTA, visit: https://www.internationalblindtennis.org/

ITF PLAYER CARE PROGRAMME

The ITF has introduced its Player Care Programme, a comprehensive initiative designed to support athletes' wellbeing both on and off the court. As the global governing body of tennis, the ITF is reinforcing its commitment to players' mental and physical health by offering tailored resources and expert guidance to help athletes navigate the unique challenges of professional tennis.

The programme is available to all players competing on ITF professional tours, including the World Tennis Tour, Wheelchair Tennis Tour, and Beach Tennis Tour.

A key feature is the Wellbeing Tracking app, enabling players to monitor and record their wellbeing and understand its connection to performance.

Additional resources, accessible via the ITF Academy, include:

- Wellbeing Matters: Practical guides on topics such as mood regulation, sleep optimisation, relationship management, and travel fatigue.
- Video-based education on financial literacy, covering budgeting, savings, and sports taxation.
- Expert advice on navigating the digital landscape and managing online abuse.
- Confidential online consultations with wellbeing professionals.
- An online course (developed with International SOS) promoting player safety during travel.
- An IOC-provided course offering guidance on life beyond tennis, skill-building, and career preparation.

Players are recognised as more than just competitors, and achieving peak performance requires a balance of physical health and mental wellbeing. The Player Care Programme reflects this principle, offering a comprehensive package of free resources to support athletes at every stage of their journey—from elite professionals to those preparing for life after competition.

This initiative provides tools and guidance to help players manage wellbeing risks, enabling them to focus on maximising their potential and enhancing their overall experience on tour. By addressing both on-court performance and off-court challenges, the programme ensures that tennis players worldwide have the support they need to thrive.

KEY CHANGES TO ITF WORLD TENNIS TOUR JUNIORS FROM 1 JANUARY 2026

The ITF World Tennis Tour Juniors – a vital stage in the player pathway and a launchpad for future stars – is on track for a record-breaking year, with more than 1,000 tournaments expected for the first time. This milestone reflects the ITF's mission to create opportunities for players everywhere, from playground to podium, while supporting talent from underrepresented nations.

To further strengthen this pathway, several important changes will take effect from 1 January 2026, aimed at enhancing player development and competitive experience.

New Round-Robin Format at J30 and J60 Events

A hybrid approach will be introduced at selected J30 and J60 tournaments, combining a round-robin group stage with an elimination phase.

- Format: 32 players divided into eight groups of four, competing over the first three days. Group winners advance to the quarter-finals.
- Why: The current elimination-only format means half of the players exit after one match. The new system ensures more match play, helping players aged 13–16 reach the recommended 50–70 high-quality matches per year.
- Benefits: Greater competitive experience reduced travel for single-match events, and better value for families.

Players will be informed at entry whether the tournament uses the traditional elimination format or the new hybrid format.

"Introducing round-robin formats at J30 and J60 level will give more players the competitive opportunities they need to develop and gain valuable international experience," said Matt Byford, ITF Executive Director of Juniors, Masters and Beach Tennis.

Expanded Use of ITF World Tennis Number (WTN)

Since 2022, WTN has been a secondary acceptance criterion for junior events. From 2026, its role will grow:

- A portion of direct acceptances into qualifying and main draw singles at J30 and J60 events will be based solely on WTN.
- Example: In a 32-player draw, six direct acceptances will be awarded based on WTN.

This change ensures players progressing through national and regional tours with strong WTNs can access ITF events, even if their junior ranking is lower.

Evolution of the 16&U Regional Reserved Programme

The current programme, which reserves places for players from Europe and South America, will expand globally and adopt WTN as the acceptance measure.

- From 2026, up to two players aged 16-and-under from each region will receive direct acceptance into the main draw based on WTN (if not already accepted via ranking).
- The programme will be renamed the 16&U WTN Regional Reserved Programme, ensuring fair and consistent access for players worldwide.

These changes reflect the ITF's commitment to providing more matches, fairer access, and improved value, strengthening the international player pathway and helping the next generation progress.

We hope this editorial has provided valuable insights and sparked meaningful reflection. Its aim is to showcase some of the significant initiatives the ITF is undertaking to promote tennis worldwide. We also invite new contributions to the ITF CSSR via the designated submission platform. Our heartfelt appreciation goes to all the authors for their contributions and to everyone who shared their work. Detailed guidelines for submissions and publications are available on the platform and in the latest issue section of the ITF Academy. We trust you will enjoy this final edition of the ITF Coaching and Sport Science Review.

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The Predictive Validity of the ITF Juniors Tour for Professional Tennis Career Outcomes

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ABSTRACT

The ITF Juniors Tour represents a key developmental pathway for tennis players aspiring to transition to the professional circuit. This study evaluates its "value" by considering both athletic performance and economic implications, while also exploring alternative routes such as early integration into national adult tournaments or the ITF professional Tour. Using both top-down and bottom-up analyses of ATP and WTA players, we examine the relationship between junior rankings and subsequent professional success. The findings underscore the importance of the ITF Juniors Circuit, with 83% of ATP and 86% of WTA Top 150 players having previously ranked in the ITF Junior Top 100. Participation in high-tier junior tournaments appears instrumental in developing the competitive skills required at the elite level. However, only 30–40% of top junior players advance into ranking regions that enable financial sustainability, highlighting the limitations in the predictive strength of junior success alone.

Key words: Elite athlete development, ATP/WTA career progression, youth tennis, player pathways.

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INTRODUCTION

Professional athletes follow career paths characterized by intense physical demands, limited longevity, and considerable public scrutiny. Unlike most conventional occupations, which offer stable hours and long-term security, athletes must capitalize on a narrow and often unpredictable window of opportunity. These pressures necessitate early specialization and rapid development. Tennis exemplifies this trajectory, where early exposure and competitive success are often critical for reaching the professional level. Within this framework, the ITF Juniors Tour represents a pivotal stage, acting as a gateway to professional tennis. However, the true "value" of the ITF Juniors Tour—both in terms of sporting progression and potential economic return—has not been comprehensively explored in the literature.

According to foundational research by Ericsson, Wylleman, and Sosniak, developing a career in elite sport generally involves approximately ten years of deliberate practice to attain international standards, followed by five to ten years of performance at the highest level (Ericsson et al., 1993; Sosniak, 2006; Wylleman & Lavallee, 2004). In contrast to conventional careers—where retirement age is shaped by personal, health, and socio-economic variables and ranges from 57 (Colombian women) to 67 (men in Denmark and Israel) according to OECD data (OECD, 2023)—professional athletes typically retire by the age of 34 (Wylleman & Reints, 2010). This significantly shorter career span places added importance on the developmental phase, particularly as many elements of athletic progression cannot be postponed or pursued later in life, unlike formal education or job retraining in other professions.

The career lifespan model by Wylleman and Lavallee (2004) shows that athletes are typically between 15 and 20 years old during this critical developmental window—meaning they remain minors for much of this time. In most sports, athlete development occurs centrally through federations, with structured calendars and standardized competition pathways. In contrast, tennis offers diverse and decentralized development routes. Balliauw et al. (2017) identify three common practice environments for tennis development: national federation training centers, private academies, and individualized training with private coaches. In recent years, boarding schools with integrated tennis programs—such as Millfield in the UK—have also gained prominence, offering a structured combination of education and elite training. Competition planning also varies significantly among athletes due to the flexible structure of tennis rankings, allowing for different pathways toward the ultimate goal: a Top 150 position in the ATP or WTA rankings.

Although prior studies have examined the predictive power of junior rankings in professional tennis success (Brouwers et al., 2012; Reid et al., 2009; Casagrande et al., 2018; Perri et al., 2021), these have focused primarily on performance metrics, with limited attention to financial sustainability. Additional contributions by Moreira et al. (2017) and Kovalchik et al. (2016) explore factors such as relative age effects and early

career milestones, but similarly fall short of addressing long-term economic viability. This study seeks to bridge that gap by considering the financial implications of different development strategies. While a comprehensive cost-benefit analysis is constrained by regional variability and lack of consistent data on items like federation subsidies or prize money at national and UTR events, this paper aims to offer stakeholders—coaches, parents, and tennis associations—evidence-based insights for decision-making.

Distinct from earlier works (e.g., Bane et al., 2018; Perri et al., 2021), this study integrates a financial lens by evaluating whether top junior players reach a ranking where tennis becomes economically sustainable. Supported by recent modeling from Schöttl et al. (2025), we add a new dimension to the discussion on the viability of professional tennis careers. This dual perspective—sporting and economic—contributes to a more comprehensive understanding of the ITF Juniors Tour's role in the athlete development pathway.

Effort and Income of the Circuits

Ultimately, the primary goal of aspiring professional tennis players is to attain a top ranking on the WTA or ATP Tour. From a financial standpoint, research indicates that income generally begins to offset expenses at ranking positions between 101 and 250 (Balliauw et al., 2017; Bane et al., 2014). Perri et al. (2021) emphasize that strategic competition scheduling is a crucial factor in the developmental pathway of junior players. Balancing immediate ranking progression with long-term developmental objectives presents an ongoing challenge for both coaches and athletes (Unierzyski, 2003). It can be inferred that players ranked within the Top 150 are more likely to generate sufficient income to support themselves through tennis. Remaining in or above this ranking range for extended periods—and ideally improving upon it—can increase the likelihood of recouping the significant investments made during earlier development phases. However, the actual cost burden depends on numerous variables, including the duration of the development period, federation and sponsor support, doubles participation, and travel logistics (e.g., whether the player travels alone or with a coach and physio).

Balliauw et al. (2017) estimate that players ranked outside the Top 250 experience annual financial deficits ranging from €25,110 to €67,170, contingent upon their training setups and staffing arrangements. These figures, now dated, likely underestimate current expenses due to inflation and the rising costs associated with global travel and coaching. Recent cost-revenue modeling by Schöttl et al. (2024), using career data from junior cohorts, confirms that only 32–34% of players end their careers with a financial surplus. Their findings reinforce ATP/WTA ranking 150 as the practical break-even threshold—below which most careers are financially unsustainable. Although no empirical data currently exist regarding the precise cost of competing on the international ITF Juniors Tour, the global nature of its calendar and the absence of prize money suggest that its financial burden is similarly high—if not comparable to early professional participation.

Consequently, due to the high costs associated with the development phase and the short duration of a professional tennis career, the economic imperative for aspiring professionals is to complete this phase as quickly and efficiently as possible. This allows them to maximize time spent in income-generating ranking positions, improving the chance of financial recovery and long-term viability.

Different Ways to the Top of the professional Rankings? Status Quo of Research on the value of the ITF Juniors Tour

The developmental phase between the ages of 15 and 18 is critical for aspiring tennis professionals. This period is both brief and non-replicable, requiring players to engage in deliberate and strategic competition planning to maximize athletic progression, ranking advancement, and eventual career sustainability. During this phase, players may choose among several developmental pathways, each with specific advantages and limitations. The most prominent options include the ITF Junior Tour, national adult competitions, and early participation in ITF/ATP/WTA professional events. Each route presents unique challenges and opportunities that must be carefully considered when designing individualized development strategies. The ITF Junior Tour offers unmatched opportunities for juniors to compete at the highest international level for their age group, including participation in Junior Grand Slam tournaments. This environment exposes players to intense, high-stakes competition, fostering skill acquisition and psychological resilience. Research by Perri et al. (2021) highlights the importance of this international exposure in facilitating the transition to the professional circuit. Casagrande et al. (2018) likewise underscore the ITF Junior Circuit's role as a critical platform for talent identification and performance benchmarking. High-ranking junior players often receive reserved spots in professional-level tournaments, simplifying entry into the ITF professional tour and increasing their visibility to potential sponsors.

Despite its competitive benefits, participation in the ITF Junior Tour is not without significant challenges. The financial burden is considerable, driven by the extensive travel, accommodation, and staffing expenses required to compete internationally. These costs are further exacerbated by the absence of prize money at junior events. Additionally, the demanding tournament schedule often clashes with academic commitments, leading many players to reduce or abandon formal education during this critical developmental period (AugsburgerAllgemeine, n.d.; ProSieben, n.d.). Research by Otis et al. (2022) emphasizes the importance of incorporating academic education into athletic training programs as a means of promoting long-term career longevity. This supports the growing relevance of dual-career pathways, such as boarding schools and college tennis programs, which seek to balance high-level training with educational continuity.

Moreover, Casagrande et al. (2018) report that players competing on the ITF Junior Circuit exhibit higher levels of burnout and psychological devaluation compared to their peers engaged in regional or national competitions. Compounding these pressures is the expiration of junior rankings at age 18, which compels players to transition abruptly into the professional circuit—often without any direct transfer of points earned as juniors.

As an alternative, some players focus early on adult-level competition through national tournaments and the ITF professional circuit. This route emphasizes the development of match-play skills more reflective of the professional game, which is typically faster-paced and tactically more complex (Filipcic et al., 2021). Early participation in professional tournaments allows players to accumulate ITF ranking points that remain valid for 52 weeks, enabling a potentially more stable trajectory—provided performance is consistent. Research by Reid & Morris (2013) and Perri et al. (2021) shows that many elite players engage in both junior and professional

events during their transition phase, indicating that exclusive reliance on the Junior Tour is not essential.

From an economic standpoint, national tournaments and early engagement in professional circuits offer notable advantages. Reduced travel and accommodation expenses associated with national competitions lead to lower overall costs. Furthermore, prize money—albeit modest—can help offset participation expenses. This pathway also tends to support more consistent training environments and can facilitate better integration with academic schedules. Reid et al. (2007) emphasize the connection between well-structured domestic competition systems and the development of professional-level rankings, thereby underscoring the strategic value of national tournaments in early-stage career planning.

However, this route is not without its drawbacks. Early transition into adult-level competition, especially within the ITF professional circuit, often involves starting in qualifying rounds. These are highly competitive, time-consuming, and may offer limited exposure compared to main draws. Additionally, while national tournaments may be logistically accessible, they can lack the depth and intensity of competition typically found on the international junior circuit. Brouwers et al. (2015) stress the importance of participating in elite-level events to build long-term performance capacity. Zappalà et al. (2024) further support this notion, identifying early success at prestigious tournaments as a reliable predictor of future career achievement. Conversely, excessive competition volume at a young age may compromise long-term athletic development and career longevity, as warned by Otis et al. (2022).

The existing literature generally supports the significance of the ITF Juniors Tour in the development of professional tennis players. Studies by Brouwers et al. (2012) and Reid et al. (2007, 2009) demonstrate a consistent association between strong junior rankings and later professional success. However, they also note that such rankings do not guarantee elite career outcomes. Perri et al. (2021) highlight the critical role of match quality and international exposure in high-level junior tournaments. These findings support the ITF Junior Circuit's role as a high-performance environment but also acknowledge that alternative developmental routes—particularly those grounded in national circuits or early professional transition—may serve as viable options. Nonetheless, further research is required to evaluate the financial sustainability of these paths and their capacity to yield players who reach income-generating professional rankings.

Research Questions

In light of the preceding discussion, the central question is whether participation in the ITF Juniors Tour is essential for progressing to the professional level in tennis, or whether it represents just one of several viable—albeit costly—developmental pathways. Accordingly, the guiding research question is as follows:

> *"What 'value' does the ITF Juniors Tour provide in developing players into professional athletes (specifically, professional tennis players)?"*

On one hand, the study seeks to examine the extent to which the ITF Juniors Circuit has contributed to the careers of current professional players who have reached ranking regions where it is financially feasible to sustain a tennis career. However, this assumption is influenced by numerous contextual factors, including sponsorship availability, federation support, doubles earnings, and the cost structure associated with travel and staffing. Therefore, reaching a particular ranking alone does not guarantee financial sustainability.

On the other hand, this study also aims to identify cases where professional players bypassed the ITF Juniors Circuit and instead followed alternative development routes. These cases may provide insight into different, potentially more cost-effective, pathways to the professional level.

The analysis further considers whether gender-based differences exist in these developmental trajectories—specifically between male and female players—regarding progression from the junior circuit to the professional level. Ultimately, the objective is to assess the extent to which performance on the ITF Juniors Tour can serve as a reliable predictor of future professional success. While many previous studies have focused primarily on the predictive validity of junior rankings, this study also incorporates an economic perspective and explores the feasibility of alternative routes to professional tennis careers.

RESEARCH DESIGN AND METHODOLOGY

In line with Brouwers et al. (2012), this study employs a combined bottom-up and top-down research design to examine the predictive value of ITF Junior rankings in professional tennis outcomes. The top-down analysis investigates how current high-ranking professionals progressed through the junior ranks, while the bottom-up analysis explores the long-term outcomes of top junior players to determine how many ultimately achieved professional success.

Top-down analysis:

For the top-down approach, the sample consists of the Top 150 male and Top 150 female players in the ATP and WTA year-end rankings for 2023. The cut-off point of 150 was chosen based on prior research (Balliauw et al., 2017) indicating that this ranking region marks the approximate threshold at which professional tennis becomes financially sustainable. For each player in this sample, the following variables were collected: 2023 year-end ATP/WTA singles ranking, Date of birth, Career-high ITF Junior ranking, Date of career-high ITF Junior ranking (used to calculate age at junior peak), Best performance in a Junior Grand Slam event

Bottom-up analysis

The bottom-up analysis uses the Top 100 boys and Top 100 girls from the 2008 ITF Junior year-end rankings as its sample. These players, born between 1990 and 1993, are now between 31 and 34 years old—an age range that generally corresponds to the career end of professional tennis players. This allows for retrospective analysis of how many junior players progressed into the professional circuit, what proportion reached income-generating rankings, and how many exited the sport without a return on their developmental investments. The following data were collected for each player in this cohort: 2008 ITF Junior year-end ranking, Career-high ITF Junior ranking, Date of birth, Career-high ATP/WTA singles ranking, Date of career-high professional ranking (used to calculate age at peak), Date of final ATP/WTA singles ranking (used to determine career duration), ITF Junior win/loss record, Number of ITF Junior titles won.

Data Collection

The ITF provides publicly accessible information for all players who have participated in its tournaments. Player profiles include data such as career-high rankings (with corresponding dates), year-end rankings, and performances at Grand Slam events—both at the junior and professional levels. In addition, the official ATP and WTA websites offer biographical data, including date of birth and career prize money. All variables used in both the top-down and bottom-up analyses were gathered through these three official sources. Data collection was conducted between July and August 2024.

Results

The following section presents the findings from both the bottom-up and top-down analyses, structured according to the study's central research questions.

Bottom-up analysis

Analysis of the 2008 ITF Junior Top 100 cohort reveals that 97% of female players and 96% of male players subsequently attained a professional ranking on the WTA or ATP circuits (Figure 2). These rankings spanned a wide range, from World No. 1 to as low as 1491. The average career-high ranking across the sample was 356.21 (SD = 344.05), with a 95% confidence interval of [307.23, 405.18].

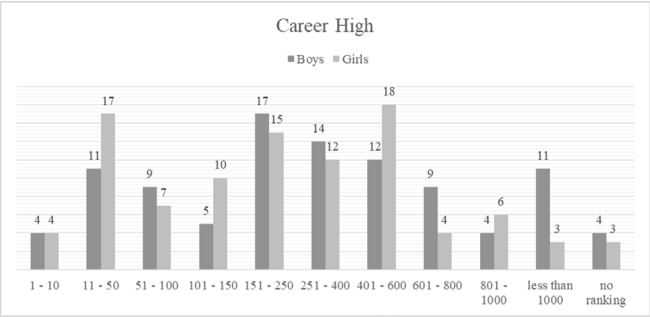

Figure 1. *ATP or WTA career high of the 2008 Top 100 juniors.*

Focusing on critical ranking thresholds, previous sections established that players ranked inside the Top 150 are generally able to finance their careers, while those outside the Top 250 often incur net financial losses. In the 2008 junior cohort, 29% of male players and 38% of female players reached a career-high professional ranking within the Top 150. Conversely, 54% of the boys and 46% of the girls never achieved a Top 250 ranking.

These descriptive findings are supported by a bivariate correlation analysis, which demonstrates a strong and statistically significant relationship between junior win-loss records and professional career-high rankings. Additionally, a significant correlation exists between junior career-high rankings and professional career-high rankings.

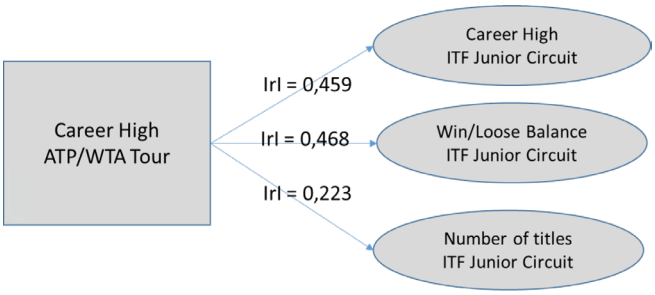

Figure 2. *Correlation analysis professional career high and performance on the ITF Junior Circuit*

A Mann–Whitney U-test was conducted to examine gender-specific differences in professional career-high rankings among Top 100 juniors. The analysis found no statistically significant difference between male and female players (U = 3976.50, Z = −1.640, p = .101), indicating that gender did not influence the highest professional ranking achieved.

The average age at which players reached their professional career-high ranking also differed significantly between genders (Figure 3). Female players reached their peak at an average age of 21.49 years (SD = 3.71), while male players peaked at 22.74 years (SD = 2.96). A Mann–Whitney U-test confirmed this difference as statistically significant (U = 3384.50, Z = −3.195, p = .001), suggesting that female players tend to reach their career peak earlier than their male counterparts.

An analysis of career end age shows that, as of the end of 2023, 26 male players and 20 female players from the original cohort still held active ATP or WTA rankings, while 70 males and 76 females had retired (Figure 4). The average retirement age for female players was 25.81 years (SD = 4.85), compared to 27.21 years (SD = 4.57) for male players. A Mann–Whitney U-test revealed that this difference is statistically significant (U = 3680.50, Z = −2.309, p = .021).

Based on these findings, it is also possible to calculate the average career duration on the professional circuit starting from age 18. Female players spent an average of 7.86 years (SD = 4.68) on tour, while male players averaged 9.24 years (SD = 4.51). This difference was again statistically significant (U = 3691.00, Z = −2.390, p = .017).

Additional correlation analyses revealed significant associations between career-high rankings and key career timeline variables. Specifically, a higher career ranking was significantly correlated with a later age at career peak (r = −0.54, p < .01), a later age at career end (r = 0.691, p < .01), and a longer professional career duration (r = 0.691, p < .01).

Top-down analysis

The results of the top-down analysis show that only four male (2.6%) and four female (2.6%) players in the 2023 ATP and WTA Top 150 rankings did not possess an ITF Junior ranking. Furthermore, 92% of male players and 96% of female players had previously achieved an ITF Junior ranking within the Top 500.

Additional findings reveal that 13% of the 2023 WTA Top 150 players and 14% of their ATP counterparts had previously reached the No. 1 position in the ITF Junior rankings. Moreover, 46% of female players and 49% of male players had achieved a Top 10 Junior ranking, while 77% of females and 74% of males reached at least the Top 50.

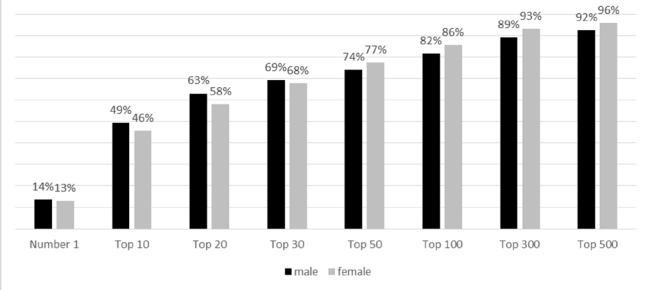

Figure 3. *Top ITF Junior ranking of the 2023 Top 150 ATP and 2023 Top 150 WTA players.*

A Mann–Whitney U-test found no statistically significant difference between male and female Top 150 ATP/WTA players in terms of their junior rankings, indicating that gender did not influence ITF Junior performance among those who reached the professional Top 150.

An examination of the age at which players reached their ITF Junior career-high ranking shows that the majority achieved this between the ages of 17 and 18 (Figure 9). The average age across all players was 17.21 years, with female players averaging 16.92 years and male players averaging 17.50 years. A two-sample t-test confirmed that this difference is statistically significant ($p < .001$), with a medium-to-large effect size ($d = 0.731$).

In summary, most players reached their junior career-high rankings between ages 17 and 18, with female players tending to peak slightly earlier than males. Specifically, 55% of male players attained their junior peak between the ages of 17.5 and 19, suggesting that many male players remained active on the junior circuit until the maximum eligible age.

Regarding Junior Grand Slam participation, over 80% of the sample had competed in at least one such event (Figure 10). Additionally, 16.7% of both male and female players had won at least one Junior Grand Slam title, while another 15–20% reached either the final or semifinal stages.

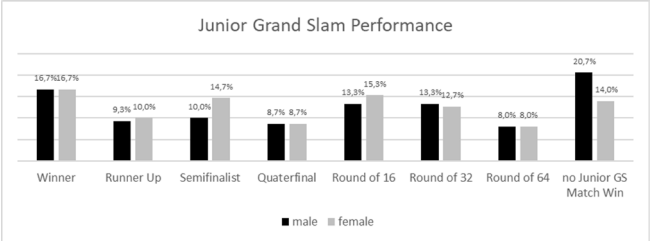

Figure 4. *Junior Grand Slam Performance of the 2023 Top 150 ATP and 2023 Top 150 WTA players.*

Overall, the results indicate that the vast majority of players who reach a financially viable professional ranking—specifically within the Top 150—were previously high-performing players on the ITF Junior Circuit.

Last but not least, we ran a Spearman correlation analysis to evaluate whether there is a connection between the career high ranking on the juniors tour and the one on the professional tour (Table 4).

Table 1
Results of Spearman correlation analysis.

male sample		Junior Career High	Age Junior Career High		**female sample**		Junior Career High	Age Junior Career High
ATP Career High	r	0,197	0,23		WTA Career High	r	0,225	0,118
	p	0,017	0,005			p	0,006	0,157
	N	146	146			N	146	145

CONCLUSION

Summary and Implications

Overall, the results from the top-down analysis highlight the significant role the ITF Juniors Tour seems to play in the development of professional tennis players.

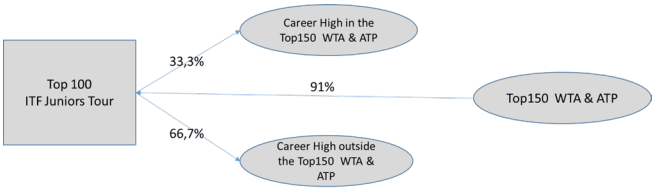

Figure 5. *Top 100 Juniors ranking as mandatory for a professional tennis career.*

Nearly every Top 150 player has been a top junior player on the ITF circuit. While the economic alternatives shown above may make sense, the results indicate that the ITF junior track is the main pathway in the development process of a professional tennis player. However, the results of the bottom-up analysis also show that a top junior ranking does not guarantee reaching a professional ranking region in which income covers current expenses or overcompensates for the expenses incurred during the junior circuit.

Although the majority of top junior players achieve a professional ranking, only about a third reach a ranking region where they can finance their lives from tennis. Even though a top junior ranking does not guarantee future establishment in the professional circuit and certainly not a high probability of being able to refinance your expenses, it seems to be a necessary step for those aspiring to become professional tennis players. The financial expenses, as well as the academic and private sacrifices, required to compete on the ITF Juniors Tour can be viewed as essential for reaching the Top 150 ranking region on the professional circuit. Conversely, there is only about a 30% probability of making the leap from the international top junior level to the professional level.

The investigation shows only a few marginal aspects of gender-specific differences. There are no differences between the men's and women's tours in terms of the importance of the ITF Juniors Tour for later career development, nor in terms of the ranking region required for a career to be economically balanced. The study found male players´ careers tend to last longer than female players´ careers. One possible reason for this could be the higher prize money on the ATP Tour compared to the WTA Tour. Mercer & Edwards (2020) shows this applies especially outside the Grand Slam Tournaments (at smaller ATP and WTA tournaments), where women's prize money is considerably lower than the men´s prize money. Based on data from Schöttl et al. (2025), the average annual cost of competing professionally ranges from $53,000 to $105,000. Using the lower bound, players need to earn at least $53,000 per year to break even. Only around 32–34% of top junior players (ranked in ITF Top 100 in 2008) reached career earnings sufficient to offset these costs. Notably, most players who achieved this were ranked within or above ATP/WTA 150—reinforcing this threshold as the financial tipping point. Coaches and federations should use this insight when advising players on their realistic chances of sustaining a career financially.

This study confirms that most players who reach the ATP/WTA Top 150 have strong junior careers, particularly within the ITF Top 100. However, since only 30–40% of elite juniors reach a financially viable professional level, coaches must carefully assess the risk-reward balance of pursuing this route. For players without major financial backing or elite junior results, alternatives like U.S. college tennis or national leagues may offer better cost-to-benefit outcomes. Additionally, integrating education into tennis development—via boarding schools or academic partnerships—can improve long-term career prospects and life balance.

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A delphi study on the key skills of tennis champions

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ABSTRACT

Research was conducted during an internship program at Tennis Australia headquarters from November 2024 to February 2025, supporting Tennis Australia's goal of developing top-level tennis players. The work analyses the skills and techniques of three of tennis's greatest players, Roger Federer, Rafael Nadal and Novak Djokovic, using the Delphi method. Selected for their exceptional achievements and dominance in the sport, the study uses a structured Delphi survey to assess their skills and identifies the key factors that have contributed to their success. The findings can help enhance tennis coaching programs by integrating key skills essential for developing elite players and future champions. Eventually, producing more top players can strengthen fan engagement and attract greater sponsorship opportunities.

Key words: Delphi Method, systems engineering, high-performance, competencies, coaching.

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INTRODUCTION

Tennis Australia's National Strategy drives the growth and success of tennis across the country. Central to this is the Tennis Australia Vision, which promotes participation, develops elite players and strengthens tennis communities. A key initiative supporting this vision is the Tennis 2020: Facility Development and Management Framework, designed to enhance facility planning, infrastructure and management nationwide. This unified approach aims to produce more active players, world-class champions, passionate fans and stronger communities, reinforcing tennis as a leading sport in Australia (Tennis Australia, 2024).

To support the objective of developing more tennis champions, a summer 2024–2025 internship at Tennis Australia applied the Delphi method to analyse the skills and techniques of Roger Federer, Rafael Nadal and Novak Djokovic. These players were selected for their exceptional records and sustained dominance, having set benchmarks that define success at the sport's highest level. The Delphi method was chosen for its ability to structure expert input, enabling a thorough evaluation of each player's strengths and techniques. By engaging a panel of tennis experts, the study aimed to identify key factors contributing to the players' remarkable careers.

The findings aim to inform a more targeted and effective approach to player training, helping players reach their full potential and compete at the highest level internationally.

RESEARCH METHODS

In the 1970s, Dobrov (1971) identified over 130 distinct methods for scientific decision-making, grouped into three main categories.

1. Trend Interpolation Methods - Predict future conditions using historical trends,
2. Simulation Methods - Model system behaviour under variable conditions, and
3. Convergent Concordance Methods (Intuitive Methods) - Rely on consensus among respondents to forecast outcomes.

The first two methods have limitations in specific scenarios, leading to the development of intuitive methods. These methods combine data, strategic goals and forecasting, emphasising intuition and interdisciplinary approaches in decision-making. Key intuitive methods include (Milosovski et al., 2009):

- Forecasting by Individual Experts, which depends on a single expert's knowledge, but can be limited by the complexity of events;
- Group Forecasting (Brainstorming), which fosters collective expertise and consensus-building, but may be influenced by dominant personalities; and
- Group Forecasting (Individual Opinions), where expert inputs are individually gathered, analysed and synthesised to reach an agreement.

In recent decades, several intuitive methods have been developed, with the Delphi technique being one of the most successful (Quade, 1972). Originally used for forecasting, it is now also applied to group estimation for creating forecasts or setting priorities (Harold & Murray, 1975). The Delphi technique is widely used in fields such as economics, engineering and medicine for technological forecasting and prioritisation (Chorafas, 2002 & Mason et al., 2022).

The Delphi technique has been widely discussed and applied in over 2,600 scholarly papers since its introduction (Flostrand et al., 2020), demonstrating its growing popularity and effectiveness in collecting expert insights. A time series of publications reveals increasing academic acceptance and expansion across various research domains over the past two decades, with a predicted rise in use in the future.

In April 2021, the term 'Delphi method' had 28,200 search hits in Google Scholar from 2016 to 2021, reflecting its importance (Beiderbeck et al., 2021). With rapid technological and social changes creating more uncertainty, collective expert opinions are expected to become even more valuable in addressing complex global challenges.

The following section explains the Delphi technique's definition, procedure and distinctive features, showing its relevance as a strategic decision-making tool.

The Delphi Method: Origins and Applications

The Delphi method, named after the Greek Oracle of Delphi, is a valuable technique for setting priorities to improve and develop complex systems (Kennedy, 2004 & Sandelowski, 2000).

The Delphi technique originated at the RAND Corporation, with its early foundations found in the 1949 article "Prediction for Social and Technological Events" by Kaplan, Skogstad and Girshick, which introduced statistical analysis of individual opinions (Milosovski et al., 2009).

Dalkey and Helmer played a key role in refining and popularising the method. In 1963, they published "An Experimental Application of Delphi Method to the Use of Experts", which helped expand its use. The technique spread from the U.S. to Europe and Asia, becoming widely recognised in various scientific fields. In 1969, Japan's Science and Technology Agency used the Delphi technique to forecast technological advancements by the year 2000, surveying 4,000 individuals (Ferguson, 2000).

Initially, the Delphi technique was used to forecast international events and scientific-technological advancements (Harold & Murray, 1975). Today, the Delphi technique is used not only for forecasting but also for systematically gathering expert opinions to predict developments in technology and other areas (Soobiah et al., 2019 & Strafford et al., 2022).

The Delphi method involves organising expert opinions and requires an interdisciplinary approach to address complex systems. It is also known as the "group estimation method," as it restructures group communication to formulate predictions or priorities (Tooth et al., 2024). The method is crucial for making strategic decisions on technological innovations and developments, as it allows unrestricted expert input, helping to resolve divergent opinions and reach consensus (Gijon-Nogueron et al., 2022 & Mason et al., 2022).

The Delphi method allows experts to share and reconsider their opinions based on group feedback. The process continues through several rounds until consensus or stability is achieved, with all participants contributing to gaining knowledge.

The results of the Delphi technique reflect expert opinions based on current conditions and should be periodically reviewed and updated.

Delphi Method Procedure

The main steps of the Delphi technique are summarised below (Milosovski et al., 2009).

- Designing the Questionnaire: The research team/ working group creates an initial questionnaire with numerical scale-based questions, offering flexibility in choosing the scale size for ranking factors.
- Collecting Responses: Experts complete the questionnaire, and the research team summarises their responses.
- Revising the Questionnaire: Based on the responses, a revised questionnaire is developed and sent back to the experts for further input.
- Iterative Rounds: Experts reassess their responses based on group feedback. This iterative process continues as needed to refine the results.
- Finalising the Results: After typically three rounds, the process concludes with a final report summarising the objectives, methodology and findings of the Delphi exercise.

The Delphi method is defined by three key features (Quade, 1972):

- Anonymity: Experts' responses are independent and anonymous, with no communication between participants. Opinions are presented statistically to ensure anonymity until the process ends.
- Iterative process and feedback: The procedure is repeated multiple times, with feedback refining opinions toward mutual consensus.
- Collective expert opinion: The result represents a collective consensus, with individual opinions not revealed during the process.

The Delphi technique involves teamwork and an interdisciplinary approach. It facilitates expert communication and opinion refinement through multiple rounds of feedback, all managed by the research team. The results are valuable for system improvements, strategic planning and forecasting.

The Delphi Method: Mathematical Models - Criteria of Objectivity

The primary goal of the Delphi technique is to reach a high level of agreement among experts. This is done through multiple rounds of feedback, which help to align and refine the experts' opinions.

To ensure objectivity, the Delphi method typically involves two key phases for analysing expert opinions (Milosovski et al., 2009):

4. Assessing expert competency;
5. Calculating coefficient of concordance (Ck) of expert opinions.

These phases help to ensure that the results of the Delphi process are both reliable and reflective of expert consensus.

Refer to Milosovski et al. (2009) for a detailed discussion of the advantages and limitations of the Delphi method, as well as the mathematical model used to assess expert competency and calculate the coefficient of concordance (Ck) of expert opinions.

DELPHI METHOD APPLICATION

Development of the Delphi Questionnaire

A questionnaire was developed to assess the tennis skills of Roger Federer, Rafael Nadal and Novak Djokovic. A range of books, reports and papers were consulted for input, with the primary source being the book Coaching Tennis: Technical and Tactical Skills (Figure 1), endorsed by the United States Tennis Association (USTA) (Anderson, 2003). This book offers a summary of coaching techniques and provides valuable guidance on evaluating technical and tactical tennis skills, forming the basis for the questionnaire.

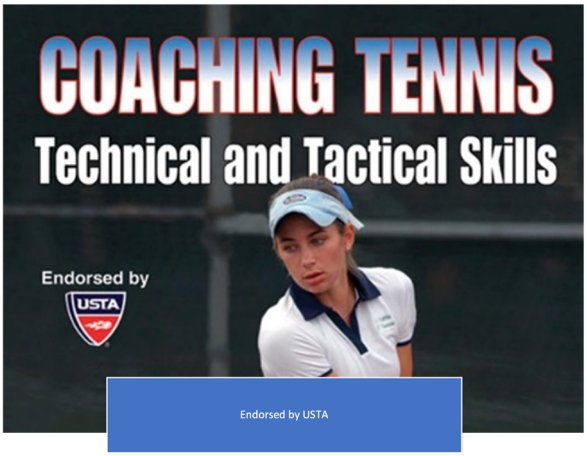

Figure 1. *Primary Source Used for Delphi Questionnaire Development*

The questionnaire has two parts. The first part evaluates the technical, tactical and physical aspects of each player's game through six factor groups, each paired with a question to assess their tennis abilities. These factors provide a detailed breakdown of the skills essential for success in professional tennis, allowing experts to assess each player's strengths and potential weaknesses. The second part includes two open-ended questions on players' integrity and unique qualities, examining their personas and playing styles to define their elite status and global impact.

The credibility of the findings from the Delphi survey is supported by the expertise and professional standing of the participating panel. The respondents were nominated through Tennis Australia's Head Office and comprised ten high-profile coaches and tennis professionals recognised for their contributions to the sport at both national and international levels. The panel included individuals holding senior roles within Tennis Australia's coaching and talent development systems, such as Directors of Coaching, National Program Managers, State Development Coaches and former high-performance coaches with ATP/WTA experience. Collectively, the group brought decades of elite coaching experience and formal coaching accreditations.

Delphi Method Methodology

In the first round, experts provided responses, which were summarised and used to create a revised questionnaire for the second round. The process concluded after two rounds, as the results were sufficiently clear, making a third round unnecessary.

Following the survey, data analysis commenced. Due to strong agreement on many factors, statistical analysis of expert competency was deemed unnecessary. Moreover, the coefficient of concordance was calculated only for the evaluation of Group 1 factors (stroke techniques), as the other groups exhibited similar rankings and consensus, rendering further analysis redundant.

RESULTS

Group 1 Factors: Strokes Evaluation

For the first group of factors, experts evaluated a player's strokes at the peak of their career. The factors were ranked on a scale from 1 to 5:

- Pro Level (1): High professional skill.
- Superior (2): Above-average professional skill.
- Outstanding (3): Exceptional performance.
- One of the Best (4): Among the top players.
- Best Ever (5): The highest level of skill in tennis history.

Table 1 presents the experts' rankings of the players' strokes.

Table 1
Expert group opinions on stroke techniques

#	Strokes	Roger Federer				Rafael Nadal				Novak Djokovic			
		Mean	Max	Min	σ	Mean	Max	Min	σ	Mean	Max	Min	σ
1	First serve	4.1	5	4	0.32	2.7	3	2	0.48	3.1	4	2	0.88
2	Second serve	4.1	5	4	0.32	3.4	4	3	0.52	3.5	4	3	0.53
3	Serve return	3.5	4	3	0.53	3.8	4	3	0.42	5	5	5	0
4	Forehand	4.2	5	4	0.42	4.8	5	4	0.42	3.8	4	3	0.42
5	Backhand	3.7	4	3	0.48	4	4	4	0	5	5	5	0
6	Backspin (slice)	4.7	5	4	0.48	3.4	4	3	0.52	3	4	2	0.67
7	Approach shot	4.2	5	4	0.42	3.5	5	3	0.85	3.5	4	3	0.53
8	Passing shot	3.6	4	3	0.52	4.5	5	4	0.53	4.6	5	4	0.52
9	Drive volley	3.8	4	3	0.42	3.7	4	3	0.48	3.7	4	3	0.48
10	Volley	4.1	5	3	0.74	3.5	4	3	0.53	3	4	2	0.82
11	Half volley	4.2	5	3	0.79	3.4	4	3	0.52	3	4	2	0.67
12	Overhead/smash	4.4	5	4	0.52	3.9	5	3	0.88	3.2	4	2	0.92
13	Drop shot	3.7	4	3	0.48	3.8	4	3	0.42	3.9	5	3	0.88
14	Lob	3.4	4	3	0.52	3.8	4	3	0.42	4.1	5	3	0.88
15	Groundstroke from deep in the court	3.3	4	3	0.48	5	5	5	0	4.5	5	4	0.53

Table 2 presents the coefficient of concordance (Ck) for each player's stroke technique, calculated per Milosovski et al. (2009) with a 95% confidence interval for reliability.

Table 2
Testing non-randomness of the coefficient of concordance (Ck)

Roger Federer			Rafael Nadal			Novak Djokovic		
C_k	χ^2	$\chi^2_{critical}$	C_k	χ^2	$\chi^2_{critical}$	C_k	χ^2	$\chi^2_{critical}$
0.452	**63.32**	**23.69**	**0.632**	**88.48**	**23.69**	**0.678**	**94.89**	**23.69**

For each player, the condition |χ^2 |>χ_critical^2 confirms the rejection of the null hypothesis, indicating that the coefficient of concordance (Ck) is not random and reflects strong expert consensus.

Figure 2 further illustrates the distribution of average ranks assigned by experts for each of the 15 strokes of Federer, Nadal and Djokovic. The vertical axis shows the rank (from 1 to 5) assigned to a tennis stroke by experts, while the horizontal axis shows how many times each rank was selected. The results indicate that their stroke skills consistently fall within the top three categories: Outstanding (3), One of the Best (4) and Best Ever (5). This suggests that none of the three players exhibit average strokes or technical weaknesses, highlighting their exceptional proficiency across all aspects of stroke play.

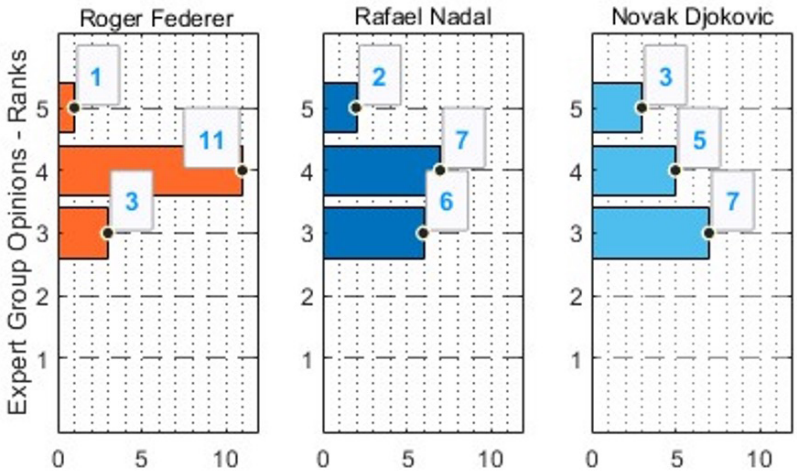

Figure 2. *Average Rank Distribution for Tennis Strokes. (1 - Pro level, 2 – Superior, 3 – Outstanding, 4 – One of the Best, 5 – Best Ever)*

In addition, Figure 3 displays the mean values for each stroke per player in a three-dimensional chart, with the rankings of Federer, Nadal, and Djokovic on the axes, showing that all strokes rank highly, confirming their exceptional technical performance.

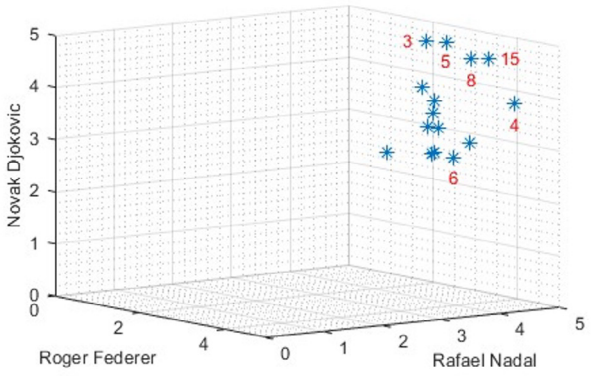

Figure 3. *Expert Opinions on Tennis Strokes of Federer, Nadal and Djokovic. (1 - Pro level, 2 – Superior, 3 – Outstanding, 4 – One of the Best, 5 – Best Ever).*

Figure 4 summarises the top average ranks assigned by experts for each of the 15 evaluated strokes. The analysis reveals that for every stroke, at least one player, Federer, Nadal or Djokovic, is rated in the highest range (One of the Best to Best Ever, ranks 4-5).

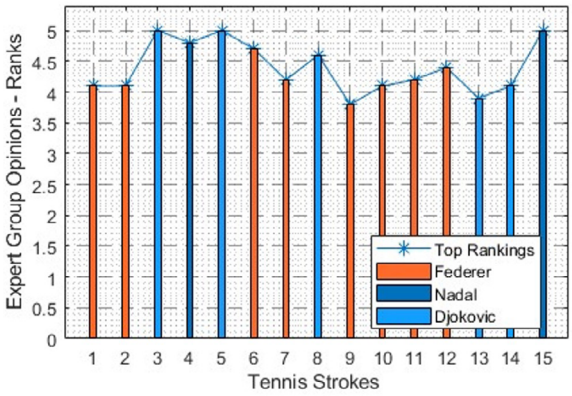

Figure 4. *Expert Ratings of Top Strokes.*

As detailed above in Table 1 and Figure 3, expert evaluations identified several strokes as exceptionally strong, particularly:

- Djokovic's passing shot (stroke No. 8) – Average rank: 4.6
- Federer's backspin/slice (stroke No. 6) – Average rank: 4.7
- Nadal's forehand (stroke No. 4) – Average rank: 4.8

Additionally, perfect scores of 5 (Best Ever) were awarded to:

- Nadal's groundstroke from deep in the court (stroke No. 15)
- Djokovic's serve return (stroke No. 3)
- Djokovic's backhand (stroke No. 5).

Group 1 Factors: Strokes Evaluation – Cluster Analysis

Additionally, a cluster analysis of expert stroke evaluations was conducted for each player using the 3-means algorithm as a partition-based method (King, 2015), based on Table 1 results.

Table 3 presents the clustering outcomes, categorising stroke techniques into three groups, with the Top-Ranked Cluster containing the highest-ranked and most effective strokes.

Table 3
Clustering Results of Stroke Techniques for Each Player.

	Lower-Ranked Cluster	Mid-Ranked Cluster	Top-Ranked Cluster
Roger Federer	15. Groundstroke from deep in the court (3.3) 14. Lob (3.4) 3. Serve return (3.5)	8. Passing shot (3.6) 5. Backhand (3.7) 9. Drive volley (3.8) 13. Drop shot (3.7)	1. First serve (4.1) 2. Second serve (4.1) 10. Volley (4.1) 4. Forehand 4.2) 7. Approach shot (4.2) 11. Half volley (4.2) 12. Overhead (smash) (4.4) 6. Backspin (slice) (4.7)
Rafael Nadal	1. First serve (2.7) 2. Second serve (3.4) 6. Backspin (slice) (3.4) 11. Half volley (3.4) 7. Approach shot (3.5) 10. Volley (3.5)	9. Drive volley (3.7) 3. Serve return (3.8) 13. Drop shot (3.8) 14. Lob (3.8) 12. Overhead (smash) (3.9) 5. Backhand (4)	8. Passing shot (4.5) 4. Forehand (4.8) 15. Groundstroke from deep in the court (5)
Novak Djokovic	6. Backspin (slice) (3) 10. Volley (3) 11. Half volley (3) 1. First serve (3.1) 12. Overhead (smash) (3.2)	2. Second serve (3.5) 7. Approach shot (3.5) 9. Drive volley (3.7) 4. Forehand (3.8) 13. Drop shot (3.9) 14. Lob (4.1)	15. Groundstroke from deep in the court (4.5) 8. Passing shot (4.6) 3. Serve return (5) 5. Backhand (5)

Federer's top-ranked cluster included the first serve, second serve, volley, forehand, approach shot, half volley, overhead (smash) and backspin (slice). This collection of strokes emphasised Federer's focus on offensive techniques, reflecting his aggressive playing style and ability to dominate at the net and in fast rallies.

Nadal's top-ranked cluster included passing shots, forehand and deep groundstrokes, which showed his strategy of controlling rallies and countering opponents effectively. The emphasis on passing shots and deep groundstrokes highlighted his defensive skills and ability to outlast opponents in extended rallies, while his forehand was a powerful weapon that strengthens both his attack and defence.

Djokovic's top-ranked cluster included the serve return, passing shot, backhand and deep groundstroke. These strokes reflected Djokovic's strategy of maintaining control and consistency in rallies, while also showing his ability to counter opponents effectively. His proficiency in serve returns and passing shots, combined with his strong backhand and deep groundstrokes, emphasised his consistent and reliable game in different situations.

Group II Factors: Technical/Tactical Skills Evaluation

For the second group of factors, experts evaluated a player's technical/tactical skills, at the peak of their career. The factors were ranked on a reduced scale from Pro Level (1) to Outstanding (3), using the same definitions as for the first group.

As shown in Table 4, Federer, Nadal and Djokovic all received a perfect score of 3 for 'Outstanding,' reflecting their mastery of shot selection, footwork and recovery, key elements of their long-term dominance in the sport.

Table 4
Expert Group Mean Opinions on Technical/Tactical Skills Evaluation.

#	Technical / Tactical skills	Federer		Nadal		Djokovic	
		Mean	σ	Mean	σ	Mean	σ
16	Shot selection	3	0	3	0	3	0
17	Footwork	3	0	3	0	3	0
18	Recovery	3	0	3	0	3	0

Group III Factors: Tactical Skills Evaluation

For the third group of factors, experts evaluated a player's tactical skills across eleven shots at the peak of their career. The factors were ranked on a scale from Pro Level (1) to Outstanding (3), using the same definitions as for the first group.

Table 5 presents the experts' evaluations of players' tactical skills.

The results show that all three players demonstrate strong tactical skills, with Nadal and Djokovic consistently earning the highest ratings (a perfect score of 3) in most categories. Federer also scores highly, but has slightly lower ratings in certain areas, such as defending against aggressive baseline players (2.6) and keeping the ball in play (2.3).

Notable differences include:

- Aggressive serve-and-volley: Federer (2.7) scores higher than Nadal (1.6) and Djokovic (1.4), suggesting a greater emphasis on this tactic in his playstyle.
- Keeping the ball in play: Nadal and Djokovic (3.0) outperform Federer (2.3), reflecting their strong defensive capabilities.
- Defensive play: Nadal and Djokovic score higher in defending against aggressive baseline players and serve-and-volley tactics.

Overall, Nadal and Djokovic appear to have a more consistent tactical approach across different play styles, while Federer shows a distinct preference for attacking tactics.

Group IV Factors: Spin Application Evaluation

For the fourth group of factors, experts assessed the level of spin a player applied to their shots at the peak of their career. The factors were ranked on a scale from Pro Level (1) to Outstanding (3), using the same definitions as for the first group.

Table 6 presents the expert group's opinions on the spin levels applied to players' shots. The table shows that Nadal and Djokovic are highly proficient in topspin, both scoring 3.0, while Federer demonstrates more versatility with backspin and sidespin, also scoring 3.0.

Group V Factors: Shot Control Evaluation

For the fifth group of factors, experts assessed the level of control a player applied to their shots at the peak of their career. The factors were ranked on a scale from Pro Level (1) to Outstanding (3), using the same definitions as for the first group.

Table 7 presents the expert group's evaluations of the control applied by players to their shots across four key areas.

All three players received high ratings in shot angles (2.9), with Nadal leading in shot height (3.0). Nadal ranked higher in shot speed, while Djokovic performed best in shot depth with a perfect score. Overall, Nadal leads in height, Djokovic in depth and Federer remains consistent.

Group VI Factors: Physical Skills Evaluation

For the sixth group of factors, experts assessed the level of physical skills a player demonstrated at the peak of their career. The factors were ranked on a scale from 1 to 3:

- Competent (1): Demonstrates reliable physical skill.
- Advanced (2): Displays high-level physical skill.
- Exceptional (3): Exhibits elite physical skill.

Table 8 provides the expert group's evaluations of players' physical skills across five key areas.

Table 8 highlights the players' strong physical attributes, with Nadal and Djokovic leading in strength, power and flexibility. Nadal achieved near-perfect scores, while Djokovic received three perfect ratings. Federer remained consistent across all aspects.

Open ended questions

The questionnaire included two open-ended questions asking experts why tennis fans might admire some players more than others.

Experts expressed admiration for Federer, Nadal and Djokovic for their grace, talent and ability to make tennis look effortless. They praised their humility, fairness and sportsmanship, alongside their fierce competitiveness, work ethic and determination. Despite their differences in personality, experts emphasised that the players remained gracious in defeat and developed into thoughtful, classy figures. Off the court, they contributed significantly through exhibition matches and charity work, using their platforms to support various causes and promote the sport.

Experts noted that their passion for tennis, ability to handle pressure and strong self-belief set them apart. Their willingness to give everything on the court, combined with exceptional shot-making, defence and effort on every point, defined their success and legacy.

On the other hand, experts note that some behaviours of the three players, such as repetitive on-court habits and slow pace of play, can be seen as unappealing to the public. Additionally, political stances, match volatility and outbursts toward their players' boxes have drawn mixed reactions. While these behaviours reflect their competitive spirit, they can sometimes overshadow their exceptional skill and contributions to the sport.

Experts Final Comments

Final comments and expert discussions emphasised the challenges of assessing tennis skills, often due to their subjective nature. Experts noted that while the exceptional abilities of Federer, Nadal and Djokovic offer valuable insights, coaching other players based on their superior skills remains a complex task.

Table 5
Expert Group Mean Opinions on Tactical Skills Evaluation.

#	Tactical Skills	Federer		Nadal		Djokovic	
		Mean	σ	Mean	σ	Mean	σ
19	Hitting every shot with purpose	2.8	0.42	3	0	3	0
20	Playing to his strength	3	0	3	0	3	0
21	Aggressive baseline play	2.7	0.52	2.9	0.32	2.8	0.42
22	Aggressive serve-and-volley	2.7	0.48	1.6	0.52	1.4	0.52
23	Hitting to the open court	3	0	3	0	3	0
24	Attacking weak serves	2.7	0.48	2.7	0.48	3	0
25	Keeping the ball in play	2.3	0.48	3	0	3	0
26	Deal with the strengths, weaknesses and idiosyncrasies of opponents	2.8	0.42	3	0	3	0
27	Defending against aggressive baseline players	2.6	0.48	3	0	3	0
28	Defending against the serve-and-volley	2.6	0.48	2.9	0.32	3	0
29	Understands physical playing conditions and reacts appropriately	3	0	3	0	3	0

Table 6
Expert Group Mean Opinions on Spin Applied to Players' Shots.

#	Spin Applied	Federer		Nadal		Djokovic	
		Mean	σ	Mean	σ	Mean	σ
30	Topspin	2.6	0.52	3	0	3	0
31	Backspin	3	0	2.5	0.53	2.5	0.53
32	Sidespin	3	0	2.6	0.52	2.3	0.82

Table 7
Expert Group Mean Opinions on Control Applied to Players' Shots.

#	Shot Control	Federer		Nadal		Djokovic	
		Mean	σ	Mean	σ	Mean	σ
33	Shot angle	2.9	0.32	2.9	0.32	2.9	0.32
34	Shot height	2.6	0.52	3	0	2.8	0.42
35	Shot speed	2.7	0.48	2.8	0.42	2.7	0.48
36	Shot depth	2.7	0.48	2.8	0.42	3	0

Table 8
Expert Group Mean Opinions on Physical Skills Evaluation.

#	Physical Skills	Federer		Nadal		Djokovic	
		Mean	σ	Mean	σ	Mean	σ
37	Strength	2.6	0.52	3	0	2.8	0.42
38	Speed	3	0	3	0	3	0
39	Agility	3	0	3	0	3	0
40	Power	2.8	0.42	3	0	2.9	0.32
41	Flexibility	2.7	0.48	2.9	0.32	3	0

Additionally, the Delphi exercise identified the need for a Comprehensive Tennis Skills Training Manual. This Manual would serve as the primary reference for teaching the technical, tactical, physical and non-physical skills essential for developing top-level tennis players.

The Manual shall include "functional" requirements detailing player actions and performance requirements setting measurable outcomes to ensure systematic skill development and assessment. It shall categorise tennis skills with detailed clauses for each, classified as Essential, Important, Desirable or Advice and assign standard verification methods such as Test, Demonstration, Analysis or Inspection.

In summary, the Manual shall provide the technical guidelines and verification methods needed to develop advanced tennis skills, enhancing coaching and shaping future champions.

The need for a Comprehensive Tennis Skills Training Manual aligns with a Functional Performance Specification, commonly used in Systems Engineering. Systems Engineering plays a critical role in the successful execution of complex projects such as building an aircraft, robotics, computer chip design or city-wide infrastructure. It provides a structured process that covers the entire project lifecycle, from the initial concept and design to development, implementation and maintenance.

CONCLUSIONS

The Delphi exercise identified key skills and tactics for integrating into coaching programs to develop top-level tennis players. While the study focused on male players, many of its findings are also applicable to female tennis, particularly in areas such as physical and non-physical skills, as these are fundamental and universally required in high-level competition. However, future research is necessary to examine the extent to which the specific technical and tactical insights identified in this study are relevant to the women's game, considering potential differences in playing style, match dynamics and physical demands.

Conclusions: The Tennis Skills of Federer, Nadal and Djokovic

The tennis skills of Federer, Nadal and Djokovic were consistently ranked among the best, with perfect scores achieved in multiple areas.

- Strokes Evaluation: Federer, Nadal and Djokovic were ranked highly in all strokes, reflecting exceptional technical performance. For each of the 15 main strokes, at least one player was rated as "One of the Best" or "Best Ever". Perfect scores of 5 ("Best Ever") were awarded to Nadal's deep groundstroke, Djokovic's serve return and Djokovic's backhand.
- Technical/Tactical Skills: Each player received a perfect score of 3 ("Outstanding"), reflecting their mastery of shot selection, footwork and recovery.
- Tactical Skills: Tactical skills were evaluated across eleven components, with all players ranked highly. Nadal and Djokovic displayed a balanced approach, while Federer's style was more aggressive.
- Spin Application: All three players were highly ranked in topspin, backspin and sidespin, with Nadal and Djokovic particularly dominant in topspin, while Federer was recognised for his versatility.
- Shot Control: Each player was highly ranked for shot control, with Nadal dominant in height, Djokovic in depth and Federer maintaining consistency across categories.
- Physical Skills: Physical skills were assessed across five aspects. Nadal and Djokovic were highly ranked in strength, power and flexibility, while Federer maintained a strong overall performance.

Conclusions: The Legacy and Perception of Tennis Legend

Experts have recognised Federer, Nadal and Djokovic for their elegance, talent and sportsmanship. Their competitive spirit has set new standards, making them iconic figures. While their game styles and personalities inspire admiration, occasional on-court behaviour has drawn mixed reactions. Despite this, their legacy is defined by exceptional skills, discipline and a lasting impact on the sport.

Conclusions: Experts' Final Comments

Experts stressed the challenge of assessing tennis skills due to their subjective nature. While Federer, Nadal and Djokovic's abilities offer valuable insights, applying them to coaching others remains difficult. They emphasised the need for a Comprehensive Tennis Skills Training Manual to provide a structured reference for teaching technical, tactical, physical and non-physical skills. The Manual would include functional and performance requirements with standardised verification methods, ensuring systematic skill development and assessment, aligned with Systems Engineering principles for developing future champions.

Conclusions: Enhancing Tennis Coaching for Champions

Enhancing tennis coaching to develop more champions should focus on eliminating weaknesses in technical and tactical tennis skills. Prospective major champions must show strong performance across all evaluated techniques, ensuring their stroke skills consistently rank within the top three categories: Outstanding, One of the Best and Best Ever.

Mastery in shot selection, footwork, recovery and spin control suggests that coaching should prioritise these skills, aiming for near-perfect execution.

Physical and non-physical skills are equally important. Comprehensive conditioning and on-court creativity are essential, while character skills such as sportsmanship, resilience and composure under pressure should be integrated into coaching. By focusing on these areas, coaches can develop well-rounded, championship-calibre players.

As a key outcome, the Delphi exercise emphasised the need for a Comprehensive Tennis Skills Training Manual. This manual would serve as a structured guide, not only for coaching but also for assessing the technical, tactical, physical and non-physical skills necessary for developing elite players and future champions.

To demonstrate the practical implications of this finding, Annex A provides a brief outline of the proposed Comprehensive Tennis Skills Training Manual, including its structure, format and potential application in player development and coaching environments.

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CONFLICT OF INTEREST AND FUNDING.

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Specific approach in working with GSPDP ITF/TE Touring Teams

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ABSTRACT

Tennis is an individual sport with a highly competitive environment in which players display their strongest character traits. They must be able to fight in all circumstances, stand up for themselves, be brave, persevere, rely on themselves and make independent decisions throughout the match. In this way, sport itself contributes to the development of strong, responsible and independent personalities. This is why junior team competitions are an extraordinary experience for both players and coaches. Bringing together the strongest players, creating a positive, friendly atmosphere and helping each one to realise their potential is a challenging task for a coach. Each year the ITF invites talented players, mostly from less developed tennis countries, to join the Grand Slam Player Development Programme/ITF Touring Teams. These teams, made up of players from different countries, are an extremely interesting and valuable project. In this article we describe the specifics of working with such teams, highlight the importance of communication skills and define the focus of work in different types of player training during the tour.

Key words: GSPDP ITF/TE Touring Teams, communication, psychological tools, technique and tactic drills.

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INTRODUCTION

One of the main goals of the International Tennis Federation is to promote the global standard of tennis, to help prepare players from beginner level to high professional level, and to increase the number of countries capable of competing at the international level. The International Tennis Federation's Development Department has several programmes and projects that it has been running successfully for many years. One of these projects is the Grand Slam Player Development Programme ITF/TE Touring Teams (GSPDP ITF/TE Touring Teams). These teams exist in different age categories: under 14, under 16 and under 18. Through this programme of support for promising players, the ITF has been able to contribute to the development such well-known players as Eleni Daniilidou (GRE), Hubert Hurkacz (POL), Jarkko Nieminen (FIN), Marcos Baghdatis (CYP), Kateryna Bondarenko (UKR), Anhelina Kalinina (UKR), Simona Halep (ROU), Jelena Ostapenko (LAT) and others (https://www.tenniseurope.org/page/15945/Development).

One of the main objectives of the International Tennis Federation's work with teams is to give players the opportunity to gain valuable experience in tournaments at the highest level, where they can compete against the best players in their age group. The GSPDP 14&Under European Touring Team, for example, will take part in the TE Junior Tour category 1 and Super Category tournaments during the tour. The winners and finalists of the junior tournaments have included such famous tennis players as Jelena Ostapenko (WTA best 5 as of 19.03.2018); Damir Dzumhur (ATP best 23 as of 2.07.2018); Anhelina Kalinina (WTA best 25 as of 22.05.2023); Marta Kostyuk (WTA best 16 as of 17.06.2024); Sebastian Baez (ATP best 18 as of 24.06.2024);

Alexandra Eala (WTA best 75 as for 31.03.2025). This indicates that the 14&Under category 1 and Super Category feature the leading players of this age group, who are playing at a high level and have the potential to achieve significant results at professional level in the future. Competing and winning in such an environment is a valuable experience and motivation for the development of ITF/TE Touring Team players.

It is worth noting that the ITF and TE are constantly working hard to improve the tour, considering current trends in tennis development and the needs of players at this stage of their development. This is particularly true for the ITF/TE Touring Team 16&under. For example, when planning tournaments for this team, which includes players under 15, their age is considered, which helps with the transition to the 18& under age group. Just 7 years ago, for this team were planned two Tennis Europe Junior Tour 16&Under tournaments and two ITF 18&Under tournaments. In 2024, only ITF 18&under, J30 and J60 tournaments will be played. In 2025 there will be two ITF J60 tournaments and 2 ITF J100 tournaments. Such tournament scheduling will allow players to gain more experience, develop their game, and improve ranking positions. The GSPDP ITF/TE Touring Team 18&under has several tours throughout the year and one of its main tasks is to facilitate the preparation and participation of players in the U18 Grand Slam tournaments, which is an extremely important and necessary experience for young players.

Thus, the ITF helps to support players in their transition from one age category to another, to gain important and necessary experience at high-category tournaments, as well as to obtain points, providing a good basis for further development of players.

RESEARCH OBJECTIVES

1. To reveal the characteristics and importance of developing the communication skills of ITF/TE Touring Teams players;
2. To specify the peculiarities of psychological, physical, technical and tactical training of players of ITF/TE Touring Teams 16&under:
3. To study the effectiveness of approaches in working with ITF/TE Touring Teams 16&under.

METHODS

To achieve our objectives, we used the following methods: the analysis of academic and methodical literature, the theory analysis and synthesis, the teaching observation; psychological state assessment, art therapy method.

Observations were conducted across multiple teams, each consisting of four male and four female players. While general player behaviour and training responses have been recorded since 2017, the use of specific tools such as art therapy and board games were introduced between 2023 and 2025 and applied across three distinct touring teams.

Daily written observations were maintained throughout each tour, covering both on-court performance (e.g., match play, training responsiveness) and off-court behaviour (e.g., emotional regulation, team interaction). These notes served both documentation and reflective coaching purposes, allowing for continuous adaptation of strategies based on player needs.

RESULTS

Gender-specific observation and coaching implication

As we know, the ITF/TE teams are made up of players from different countries, speaking different languages and, of course, belonging to different religions and cultures. For example, the 16&Under team in 2024 included players from Hungary, Greece, Lithuania, Poland, Serbia, Turkey, and Norway. The coaches of this team were from Estonia and Ukraine. As we can see, the diversity of countries, languages and cultures is extremely wide. That is why finding a common language with the players, helping them adapt to unusual conditions, and even more so, opening and promoting their development during the tour is one of the main tasks of coaches. Creating a friendly and welcoming atmosphere in the team allows you to positively influence the players and give them a sense of security.

Given that our tour spans 4–5 weeks, we can observe players both on and off the court. This extended period allows us to identify notable patterns in behaviour and interpersonal dynamics between male and female players. Based on these observations, we would like to highlight several key considerations in our work:

- Female players often express emotions more openly, which can influence their preparation, match performance, and interactions with coaches. Coaches should consider these emotional dynamics carefully, providing supportive communication and targeted strategies to enhance emotional regulation. Encouraging and guiding emotional control throughout the tour significantly contributes to their overall development and performance.
- Creating a trusting professional relationship requires clear explanations about training objectives, methods, their purposes, and expected outcomes. Female players demonstrate heightened motivation, increased task focus, and greater willingness to commit fully when training goals are communicated transparently. Moreover, female players are typically more open to discussing their emotions, fears, and feelings when they feel safe and trust their coaches, directly linking these conversations to their performance. Boys, on the other hand, often need more time to feel comfortable sharing their emotions and typically attribute fluctuations in their performance more readily to technical, tactical, or physical factors rather than emotional aspects.
- Female players especially value a safe, supportive environment and prefer democratic communication that respects individual perspectives. Establishing this atmosphere significantly enhances their sense of security, encouraging openness and emotional honesty, which in turn positively impacts their confidence and performance on the court. Male players may initially appear more reserved, requiring patience and consistent effort from coaches to foster openness about emotional factors impacting their game.

COMMUNICATION

Since communication is the process of exchanging information, views, ideas between two or more people, it is not a simple process to establish. As a rule, the players communicate with each other in English and their knowledge of the language may be at different levels. To remove communication barriers, we use the following tools:

- Developing listening skills.
- Ability to ask open and relevant questions.
- Questions during the lunch break.
- Board games.

Among the latter, we use games of different orientation (Figure 1):

- Alias – verbal explanation.
- Crocodile – non-verbal communication.
- What am I – the ability to ask relevant questions.
- Say it in 10 seconds – development of the fast thinking and the ability to make timely decision.

Figure 1. *Board games used for enhancing Team communication.*

"Alias" is a board game where you must explain the given words to your team as quickly as possible and avoid using the same root. The more words are guessed, the faster the team moves to victory.

"Crocodile game". The main goal is to guess the word that the other player demonstrates with gestures. The participant or team that guesses the word first wins. Then the person who showed the word guesses the next word to the winner of the previous round. The game continues until the participants want to finish.

"Who am I?" The point of the game is to guess the word from a card that a player has drawn without seeing what is on it. Players must ask questions to their opponents, and they can only answer 'yes' or 'no'.

Board game 'Say it in 10 seconds'. In this game, you must name, for example, 5 seas, 5 rivers, 5 kitchen items, etc. in 10 seconds. These are very simple questions, but we are constantly adapting this game for players. For example, we allow them to name the items in their native language, but then they need to translate them into English. The game is quite a challenge for the players, although it is quite simple and has simple questions, but the time limit makes it interesting even for players aged 14-15 years old, as they must name the required things quite quickly.

These games consistently generate positive emotions and engagement. This has an overall impact on the players' mood and well-being. Thanks to these games, we create a favourable and friendly atmosphere for the players on tour and help them to reach their potential. Board and card games are also employed to limit social media use and overall screen time, contributing to higher-quality rest both physically and emotionally.

PRACTICAL COMMUNICATION STRATEGIES

The touring team environment requires coaches to apply flexible and sensitive communication strategies to support players' development and emotional well-being. Several methods have proven effective:

- Clarity and Transparency: Clearly explaining training objectives, methods, and goals helps players—especially female athletes—engage more fully with the process and feel in control of their development.
- Emotionally Safe Environment: Female players tend to open up when trust is established. "Walk and talk" conversations, art therapy, and democratic communication styles are used to encourage self-expression.
- Observation-Based Adjustment: Male players often communicate indirectly through body language or humour. Coaches monitor social interactions and off-court behaviour to assess emotional states.
- Group Dynamics Management: Coaches prevent cliques—especially among female players—by rotating roommates weekly and ensuring all team communication is conducted in a common language.
- Cultural and Family Considerations: Communication styles are adapted based on players' cultural norms and family structures, recognizing that some respond more positively to authority figures of a particular gender.

These strategies contribute significantly to building mutual respect, emotional resilience, and player-coach trust throughout the tour.

PSYCHOLOGICAL PREPARATION

By creating a positive and welcoming atmosphere within the team, by improving the quality of communication and understanding between players and coaches, we actively use psychological tools such as walk and talk technique, art therapy and match analyses. We would like to note that the walk and talk technique was used by the WISH programme participants during the residential week in Hertfordshire and art therapy was offered by the mentor to stabilise their emotional state. These approaches are modern, effective, and most importantly, easy to use (Khaniukova & Ibraimova, 2024).

Walk and talk. This technique is a type of therapy that involves walking while talking. It is a relatively new form of therapy that has gained popularity due to its effectiveness and convenience. Players in tournaments often experience excessive excitement, tension and stress (Martinez-Gallego, R., et all, 2022). After difficult matches, whether won or lost, there is a certain emotional devastation. By walking and talking in nature, we can help the players to recover psychologically, to find peace and balance, which is extremely important during a long competitive tour. In addition, this type of physical activity releases endorphins, natural chemicals that improve mood and promote happiness and well-being. We use the Walk and Talk technique not only to communicate between coach and player, but also to encourage the players to choose topics to talk about during their walks, which not only has a positive effect on their psychological state but also improves their communication skills.

We use Art therapy extensively in our work with the players in our teams. It is a form of psychological correction and psychotherapy based on art and creativity (Tararina, 2019, 2023). One of the forms of art therapy is drawing tests. Thanks to them, we can get to know the players better, understand them and help them to feel comfortable and safe during the tour. The advantage of these tests is that the players express their feelings, wishes, fears, experiences, expectations, etc. non-verbally. After all, it is not always possible to be brave enough to discuss difficult issues with a coach you do not know well. Therefore, these drawings allow us to motivate, support and create a safe environment for our players.

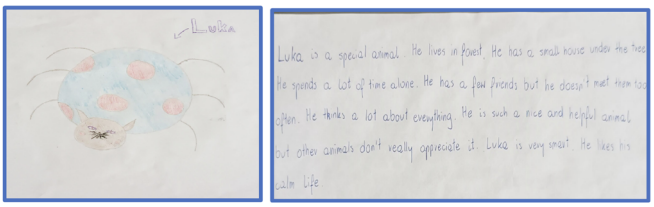

Figure 2. *"Unreal Animal" — player's drawing and description from art therapy exercise.*

In Figure 2 it can be seen an example of an unreal animal drawing. Alongside the drawing is a short story the player created about his non-existent animal. The player subconsciously tells a story about herself, her preferences and feelings. This helps us to understand the player better and find a way to help them feel good and confident during the tour. From the story you can see that the player is a rather calm, kind person and likes to help others, but does not always feel that she is appreciated. On the other hand, she likes to be alone. During the tour, this player always asked to go back to the hotel to be alone, and we allowed her to do so, as we understood from her drawings that this was important to her and that this is how she felt comfortable, safe and recovered physically and mentally. Although in the team, we always encourage players to support each other during matches and spend time together.

PHYSICAL PREPARATION

The structure of ITF/TE Touring Team events—typically four tournament weeks in a row—places high physical and mental demands on players. While the competition phase is not ideal for building new physical qualities, physical preparation remains a key focus throughout the tour, with emphasis shifting between injury prevention, movement quality, and post-match recovery.

Importantly, each touring team includes both male and female players. This necessitates careful consideration of gender-specific physiological and morphological differences when planning training. Female athletes generally have lower absolute muscle mass (30–35% vs. 40–45% of body weight in males), smaller skeletal structures, reduced hemoglobin levels (affecting oxygen transport), higher body fat percentage, and greater ligament laxity—all of which influence physical performance and recovery needs (Ivkovic et al., 2007; Murphy, 2014). In extreme conditions, thermoregulation may also differ. As a result, female players may need to exert relatively greater effort to perform the same tasks as their male counterparts. These differences are fully considered when designing training loads, recovery strategies, and performance goals for each athlete.

Physical training is integrated into daily routines through structured warm-ups, cooldowns, and targeted off-court sessions. On match days, physical work is brief and focused primarily on joint mobility, dynamic activation, and muscle maintenance. Between tournaments or on days without matches, sessions are slightly longer, targeting movement mechanics, agility, and speed using low-load, high-control exercises.

The training often includes:

- Resistance band and bodyweight routines for scapular and hip stability.
- Dynamic mobility drills to support serve mechanics and lateral movement.
- Low-impact functional strength using medicine balls or coordination-based footwork ladders.
- Breathing and core engagement exercises to enhance postural control.

Coaches share responsibility for physical preparation, coordinating to ensure that each player receives individualized attention while maintaining group flow. This collaborative structure helps monitor workload and spot fatigue or asymmetries, especially when matches are long or emotionally demanding.

TECHNICAL AND TACTICAL DRILLS USED DURING THE TOUR

Technical and tactical training during the tour is structured around practical drills that simulate match conditions and help players understand the game's demands. The exercises are designed to support long-term development by building match-intensity habits, improving decision-making, and refining tactical patterns without overloading players with instruction.

Racquet acceleration and shot control:

These exercises are designed to improve the player's ability to hit with high intensity while maintaining control and shot depth.

- Drill 1: Baseline Depth vs Power
  - Setup: Player 1 stands 1 meter inside the baseline; Player 2 on the baseline.
  - Task: Player 1 hits with maximum pace; Player 2 must keep the ball deep and consistent.
  - Purpose: Encourages racquet head acceleration while training the receiving player to absorb and redirect pace with depth.
- Drill 2: Drive Volley Decision-Making
  - Setup: Same as Drill 1.
  - Task: Player 1 executes a drive volley if the incoming shot is deep enough.
  - Purpose: Improves decision-making and aggressive court positioning, encouraging explosive racquet speed under pressure.

Court Awareness and Space Creation:

These drills teach players how to use the full width and depth of the court to create space and find attacking opportunities.

- Drill 3: Controlled Power with Tactical Finishing
  - Setup: Players play with 50% power. Court is marked with additional lines: 2 meters from the baseline and extended alleys.
  - Task: Players can only finish the point after "opening the court" and creating an angle.
  - Purpose: Develops tactical patience, court vision, and understanding of when and how to attack without coach guidance.

TACTICAL TRAINING BASED ON JUNIOR PERFORMANCE INSIGHTS

From match analysis and comparative studies between top and intermediate-level juniors, several patterns emerge that influence how training is shaped:

- Top players:
  - Serve with intention and consistency (high first-serve percentage, clear plan for the third shot).

- Value returns and pressure the opponent without gambling.
- Maintain intensity from the baseline, stepping in whenever possible.
- Sustain momentum and know how to manage "big points."

On-Court Warm-Up Drills (30–45 min)

These routines simulate match tempo and help players prepare mentally and physically for high intensity play.

- Drill 1: Rally from the baseline for 1 minute, 30 seconds break. Repeat 5 sets. Count strokes per set.
- Drill 2: Same as Drill 1, but forehand and backhand crosscourt.
- Drill 3: Repeat with net game exchanges.
- Goal: Maintain a pace of around 40–42 strokes per minute for U14–U15 players, simulating match intensity from the first ball.

BASELINE TACTICAL DRILLS

These games reinforce offensive thinking, depth, variation, and understanding of critical match moments.

- Drill 1: Depth Recognition Game
  - Rule: If the opponent's shot lacks depth (won't reach backdrop with second bounce), player may let it bounce and win the point.
  - Goal: Teaches recognition of weak balls and rewards aggressive depth.
- Drill 2: Avoiding the Middle
  - Rule: If a player returns a middle ball back to the middle zone (see Figure 3), they lose the point.
  - Goal: Encourages angle creation and aggressive targeting when central shots arrive.

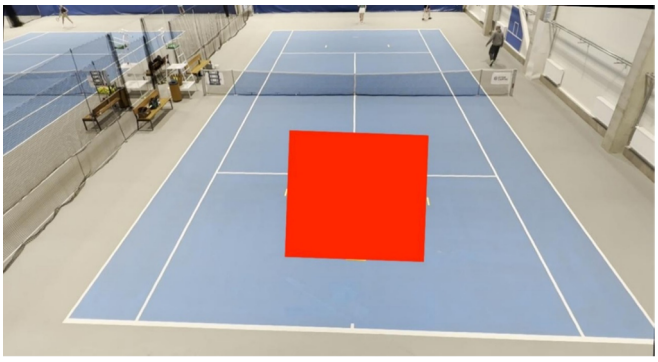

Figure 3. *Visual representation of the middle zone to avoid during attacking shots.*

- Drill 3: Angle Creation Bonus
  - Rule: Winning a point with an angled shot (that passes the sideline before reaching the baseline) grants an extra point.
  - Goal: Promotes tactical creativity and early pressure.
- Drill 4: Momentum Points
  - Rule: Points increase in value based on consecutive wins (e.g., 3rd point in a row = 3 points).
  - Goal: Builds awareness of momentum and teaches players to raise focus during streaks.
- Drill 5: "Go" Call for Attack
  - Rule: If the player feels ready to attack, they call "go" and receive double points if they win the rally. Female players may use the doubles alley for this.
  - Goal: Develops confidence in identifying attacking opportunities and committing to execution.
- Drill 6: First Serve Focus
  - Rule: Same as Drill 4 but only points won on the first serve count for multipliers.
  - Goal: Reinforces consistency under pressure and encourages structured first-serve planning.

EFFECTIVENESS OF THE APPROACH

One of the core objectives of the ITF/TE Touring Teams initiative is not only to provide international competition experience but also to observe measurable player development within a short but intensive period. From 2017 to 2025, notable progress has been consistently documented in players during and after the tour, especially in areas of emotional regulation, tactical discipline, and professional habits.

Observed improvements include:

- Changes in tactical patterns and decision-making under pressure (e.g., higher use of serve + 1 and return + 1 combinations).
- Enhanced emotional awareness and self-management, leading to reduced frustration and more stable performances in competitive environments.
- Improved pre- and post-match routines, including structured warm-up and cool-down habits adapted from team training blocks.

These developmental gains frequently translate into improved on-court performance. In most cases, players display stronger match results during the latter stages of the tour and report higher motivation and confidence. Several team alumni have significantly improved their rankings in the months following the tour, and in some cases, achieved standout international results such as winning junior Grand Slam titles or reaching the semifinals of the European Championships.

Coaches evaluate player development using a mix of match charting, video analysis, and structured observation. Key metrics that indicate successful progression include:

- Increased percentage of points and games won on serve.
- Improved performance in the 0–4 shot rally segment, indicating more effective serving and return strategies.
- Higher number of winners and forced errors, reflecting better shot selection and tactical application.
- Behavioural markers such as improved composure during high-pressure points, longer periods of focused concentration, and increased verbal self-encouragement during matches.

Notably, players who are more open-minded, receptive to feedback, and who internalize the changes achieved during the tour tend to show more consistent improvement in the following months. This highlights the long-term developmental value of the touring team approach beyond short-term results.

CONCLUSIONS

This study set out to explore the communication strategies, training specifics, and overall effectiveness of the ITF/TE Touring Teams 16&Under programme based on structured observations between 2017 and 2025.

1. Communication Development. The findings highlight the importance of cultivating emotionally intelligent, culturally sensitive communication to support young athletes in a high-performance setting. Trust-building methods—such as daily informal conversations, transparent feedback, and walk-and-talk sessions—help players open about their emotional states and link those emotions to performance. Gender-specific tendencies were also observed: female players were generally more open to discussing fears and linking feelings to outcomes, while male players often required more time and subtle observation to communicate emotionally. These insights allow coaches to adjust their communication style, accordingly, increasing engagement and responsiveness.

2. Psychological, Physical, Technical, and Tactical Training Specifics. The holistic nature of the touring team programme allows coaches to monitor and support players across all performance domains. Art therapy and board games supported emotional awareness and team cohesion while reducing screen time. Physical sessions emphasized injury prevention, movement quality, and learning professional habits rather than physical transformation. Tactical preparation was individualized and adaptive, using drills that developed serve-return quality, intensity in baseline play, and point construction awareness. Players were encouraged to self-reflect and take ownership of their game identity.

3. Effectiveness of the Approach. Despite the short tour period (4–5 weeks), players showed measurable improvements: better emotional regulation, more purposeful match play, and enhanced pre- and post-match routines. Coaches reported changes in tactical choices, improved serve efficiency, and increased match confidence. These gains often extended beyond the tour for players who internalized the experience.

Feedback from former participants reinforces the programme's long-term value.

Kateryna Bondarenko (WTA Singles #29, Doubles #9, Australian Open Doubles Champion 2008) shared: "It was really tough, but at the same time it was fun, because we worked all together in the team."

Anhelina Kalinina (WTA Singles #25, Doubles #100) reflected: "It was an invaluable opportunity… I appreciate the team coaches for their professional work and for making the experience a pleasant memory."

By combining clear structure, consistent observation, and emotionally aware coaching, the ITF/TE Touring Team programme offers a strong model for developing junior athletes in multicultural, international settings. It is a practical reference for coaches seeking to balance competitive performance with long-term player development.

CONFLICT OF INTEREST AND FUNDING

The authors declare that they do not have any conflict of interest and that they did not receive any funding to conduct the research.

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Resilience in Tennis Coaching – Strategies for Mental Strength and Professional Sustainability

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Swiss Tennis

ABSTRACT

Tennis coaches face numerous challenges, including high workloads, job insecurity, and mental strain. The ability to manage stress and maintain long-term performance is crucial for a sustainable career. This study examines resilience strategies for tennis coaches based on a qualitative analysis of seven expert interviews, additional interviews with club board members and parents of junior players, and relevant scientific literature. A model with four key resilience strategies is presented, aimed at helping coaches navigate the demands of their profession.

Key words: Resilience, coaching, tennis, mental strength

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INTRODUCTION

Tennis coaching has evolved into a highly demanding profession, requiring not only technical and tactical expertise but also emotional stability, pedagogical skills, and business acumen. The daily pressures of planning, coaching, competition preparation, and customer expectations create a work environment that is vulnerable to burnout and turnover. Against this background, the concept of resilience has emerged as a critical factor in ensuring long-term effectiveness and well-being in the coaching profession.

While much attention has been paid to the psychological resilience of athletes, comparatively little focus has been given to the resilience of coaches – especially in individual sports such as tennis. Unlike athletes, coaches are often responsible for a wide range of simultaneous demands: planning, execution, communication, administration, and client retention. The profession is marked by emotional labor, blurred work-life boundaries, and limited institutional support, leading to high dropout rates and burnout. Recent studies (e.g. Gould & Mallett, 2021) emphasize the need for sustainable career strategies in coaching. This article positions resilience not just as a personal trait, but as a set of strategies and structures that can be intentionally developed.

METHODS AND PROCEDURES

This article builds on a combination of theoretical groundwork, a self-developed resilience model, and empirical data collected through qualitative interviews. A total of 17 semi-structured interviews were conducted: 7 with tennis coaches, 5 with club board members (employers or partners), and 5 with parents of junior players (representing key clients). The interviews with coaches were longer and more in-depth, focusing on personal stressors, coping mechanisms, and definitions of professional success. The additional interviews

provided external perspectives on coach expectations and working conditions.

LITERATURE REVIEW

Resilience has been widely examined in sport psychology, but most studies have focused on athletes rather than coaches. Athletes' resilience has been conceptualized as the ability to "bounce back" from adversity (Galli & Vealey, 2008) or as a dynamic process that integrates protective factors such as confidence, focus, and social support (Fletcher & Sarkar, 2012). These models emphasize individual adaptation to high-pressure environments, yet they are not directly transferable to coaches, who face qualitatively different demands. Unlike athletes, coaches operate at the intersection of pedagogy, management, and service provision, often without the structured institutional support that athletes receive.

Coach-specific research has mainly highlighted stress and burnout. Early studies on tennis coaches reported high levels

of emotional exhaustion and role conflict, pointing to income insecurity and long working hours as major risks (Duda, Balaguer, & Crespo, 2003; Kelley, Eklund, & Ritter-Taylor, 1999). Young (2006) similarly warned that professional tennis coaches are particularly vulnerable to burnout due to the combination of performance pressure and precarious employment. More recent scholarship has broadened the perspective to include personality, recovery, and organizational factors (Coulter, Mallett, Singer, & Gucciardi, 2016), yet empirical models of coach resilience remain scarce.

At the same time, the literature on coaching careers has drawn attention to high dropout rates and the difficulty of sustaining long-term engagement in the profession (Gould & Mallett, 2021). Emotional labor, blurred work-life boundaries, and the absence of systematic mentoring structures exacerbate these risks. While psychological hardiness and adaptive coping strategies are repeatedly identified as relevant, little is known about how these can be systematically developed in tennis coaching.

This gap justifies the development of a practice-oriented model specifically tailored to coaches. By integrating findings from both resilience theory and coach-specific stress research, the present article seeks to extend existing frameworks. It positions resilience not merely as an individual trait but as a set of strategies and structures—self-reflection, boundary setting, social support, and adaptability—that address the unique challenges of tennis coaching.

RESULTS

Interview results revealed a strong overlap with stressors documented in the coaching literature. Across all target groups—coaches, club board members, and parents—certain stress patterns emerged consistently. Freelance coaches struggled with income insecurity and a lack of work-life boundaries. Several emphasized long days, insufficient breaks, and emotional exhaustion due to conflicting client expectations, confirming prior findings by Duda et al. (2003) and Kelley et al. (1999).

"Sometimes I feel like I'm just rushing from one session to the next without ever catching up. I don't even remember what I told the last player." – Coach, age 42

Club representatives highlighted the need for "reliability and communication" and noted challenges with innovation, unclear responsibilities, and an overload of digital tools—adding structural pressures that go beyond personal resilience.

"Communication is key. If coaches are not transparent about their availability or goals, it creates tension in the team." – Club president

Parents valued pedagogical empathy and consistency yet sometimes created additional stress through unrealistic expectations. The combination of emotional labor, systemic complexity, and blurred role boundaries across stakeholders highlighted the necessity of a multi-faceted resilience model.

"*We expect the coach to be a role model, but also flexible with timing and spontaneous. That's not always realistic.*" – Parent of 13-year-old

A MODEL OF RESILIENCE FOR TENNIS COACHES

The development of the resilience model was directly informed by the converging insights from the literature and interview data. For example, the factor "Self-Reflection and Values Orientation" responds to coaches' struggles with alignment between their own philosophy and external demands (Stein & Grant, 2014). Several interviewees expressed a sense of "drift" in their work, especially when revenue pressures conflicted with pedagogical intent.

"*Boundary Setting and Time Management*" emerged as a response to recurring mentions of exhaustion, digital overload, and administrative spillover. These themes were especially clear in the interviews with club coaches and were also emphasized by club presidents who noted that effective delegation and clearer task division were lacking.

"*Social Support and Collegial Exchange*" was included after coaches described their work as emotionally isolating and competitive. Positive mentions of mentoring and peer exchange—as well as unmet needs for such structures—confirmed the importance of building community support, echoing Coulter et al. (2016).

Finally, "*Lifelong Learning and Adaptability*" reflected both literature and interview input: Coaches are regularly challenged by changing client groups, shifting expectations from clubs and parents, and their own evolving career goals. Adaptability, rather than rigid expertise, was seen as the key to sustainability.

The decision to combine certain topics – such as 'Boundary Setting & Time Management' or 'Social Support & Collegial Exchange' – was based on how these elements were described by interview participants. Rather than being experienced as separate categories, they were often intertwined in daily practice. For example, the lack of time management was often related to unclear delegation structures or an absence of collegial support. Thus, the grouping reflects the applied nature of the model rather than strict theoretical separation.

Figure 1. *Four-factor model of resilience in tennis coaching: Self-reflection, Boundary setting, Social support, and Lifelong learning.*

PROPOSALS – DRILLS – EXERCISES

Based on the model presented, coaches can incorporate the following practical tools and exercises into their routines:

- Values Clarification Worksheet – Identifying personal coaching values and aligning them with daily work.

Coaches might identify values such as 'fairness', 'development over results', or 'long-term motivation'. The worksheet encourages them to reflect on whether their current practices reflect those values.

- Weekly Time Audit – Monitoring and adjusting time spent on different coaching and admin tasks.
- Peer Coaching Circles – Regular exchanges with trusted colleagues for support and idea-sharing.
- Feedback Journals – After each lesson, reflect briefly on what worked and what can be improved.
- Scenario-Based Resilience Training – Role-playing typical stress situations and exploring adaptive responses.

A typical scenario might involve a parent confronting the coach about their child's lack of progress. The coach must practice maintaining boundaries, empathizing, and reasserting realistic expectations.

- Goal Laddering – Structuring short-, medium-, and long-term career goals for better orientation.

CONCLUSION

Resilience is not a luxury but a necessity in modern tennis coaching. Strengthening it requires both individual development and systemic support. With targeted strategies and shared responsibility, the profession can become more sustainable and attractive in the long term.

This model is not intended as a universal solution, but as a practical framework to help tennis coaches reflect, adapt, and sustain their professional commitment. Its strength lies in integrating personal strategies with structural considerations. The combination of self-reflection, boundaries, social support, and adaptability can also inform resilience training in other individual sports. Future studies could further explore how these factors interact over the course of a coach's career and how organizations can build environments that reinforce resilience.

AUTHOR STATEMENT

This article is an original submission that has not been published previously and is not under consideration for publication elsewhere. All research involving human participants (i.e. qualitative interviews) was conducted in accordance with ethical guidelines, with informed consent obtained from all participants. No funding was received for this study, and the author declares no conflict of interest. The author agrees to the terms of the Creative Commons Attribution License 4.0 as outlined by the ITF Coaching and Sport Science Review journal.

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A constraints-led approach to coaching the serve

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ABSTRACT

The purpose of this article is to build on previous work in this publication and make recommendations to coaches for developing the serve, based on the principles of an ecological dynamics approach to skill acquisition. The article outlines the theory of the ecological view of motor learning, the most prominent methodology arising from which is the constraints-led approach (CLA). Evidence-informed recommendations for coaches wishing to apply these principles to coaching the serve are provided, along with an overview of some of the most important practical tenets of an ecological approach.

Key words: Skill acquisition, constraints, serving, self-organisation, coaching.

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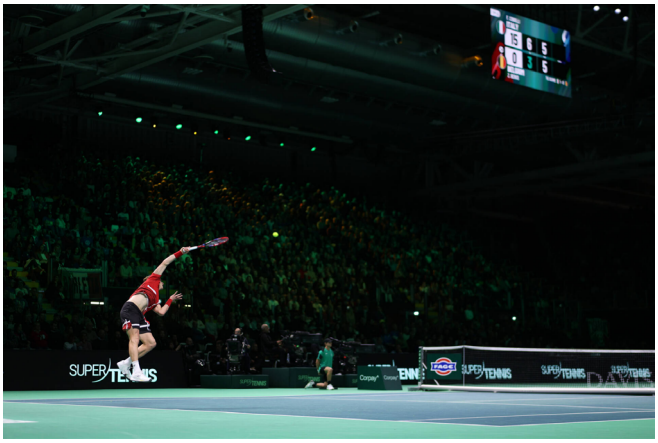
INTRODUCTION

There are two main theoretical positions that currently dominate the study of skill acquisition. The cognitive approach is sometimes referred to as information processing, and commonly as the 'traditional' approach, though perhaps somewhat pejoratively (Collins & Taylor, 2025). It can be contrasted with the ecological dynamics approach, which draws on the science of complex systems and psychological theories of direct perception. Predictive processing, a burgeoning explanatory framework across many branches of psychology, seems a likely candidate for a third approach, but yet has little published research in the sport domain (for examples see Cappuccio, Kirchnoff, Alnajjar, & Tani, 2019; and Harris, Arthur, Broadbent, Wilson, Vine, & Runswick, 2022). For the purposes of the current article, and for the benefit of coaches, the principles of the ecological approach to coaching will be contrasted to the cognitive approach for description and clarity. Any comments or reflections from a predictive processing perspective are beyond the scope of this paper and will be omitted.

The cognitive account of motor learning is founded on the strengthening of mental representations, or schemas, of movements through practice and repetition, and is greatly attributed to the work of Schmidt (1975). In contrast to the cognitive approach, which recommends high volumes of rote repetition based on an 'expert' model of technique, alternative methods have drawn on complex systems theory and ecological psychology to give rise to the constraints-led approach to coaching (CLA). Critical to this methodology, and in contrast to the fundamental role of mental representations in a cognitive approach, self-organisation is the basis for skilled movement. Self-organisation refers to the inherent tendency in complex adaptive systems to adhere to stable, patterned behaviours (Button, Seifert, Chow, Araujo, & Davids, 2021). In the case of sport coaching, a learner is considered part of an athlete-environment system. Information flowing between the environment and the learner acts as a confluence of constraints that drive the system towards coherent movement



solutions that exploit the fit between the performer and their surroundings, often in nonlinear and unpredictable ways. The coach as learning designer is able to manipulate and modify this environment in innumerable ways to influence this self-organisation process. This implies a greatly diminished role for technical instruction and augmented feedback for correcting "errors". An emphasis on self-organisation is contrasted with the traditional coaching approach of using prescribed movements to pursue ideal form or postures based on the templates of the most successful athletes in a sport. However, this association between targeting a singular "correct" technique and the cognitive approach has been misrepresented according to Taylor, Taylor, Ashford, & Collins (2023).

In the CLA, the term 'constraints' refers to "influential factors within the learning environment" (Davids, 2010). Understanding the player as a complex adaptive system, constraints serve as boundaries that guide self-organisation and are categorised as either "task", "environmental", or "individual", according to a model developed by Newell (1986). An example list of constraints available to be manipulated by a tennis coach can be found in Figure 1 below.

Individual	Environment	Task
Intentions: • Competitive/Co-operative • Gain advantage • Apply Pressure • Make it harder/easier for yourself/opponent • Cause/avoid/get out of trouble Fatigue Emotion Confidence Motivation Personality Physical including coaching aids: • Handcuffs • Resistance bands • Occlusion/Sunglasses • Weights Speed/agility Ability Experience Genetics incl. handedness Sociocultural Injury	Weather: • Temperature • Humidity • Wind • Precipitation Visibility: • Sunlight (or lack of) • Floodlights Other players: • Stronger/weaker • Older/younger • Same/opp. gender Spectators • Hostile/friendly • Camera/video Court surface: • Indoor/outdoor • Clay • Grass • Hard • Fast/Slow • Wet/dry • Altitude Sound: • Crowd noise, cheering/jeering • Music: headphones/speaker	Court dimensions: • Length, Width; Areas in/out: for balls & players; Areas for 2nd bounce Net/barriers: • Min & max heights; 'Low ceilings'; Rope/tape above net; Height ratio (e.g. lower at middle); Draped/opaque net; 2nd net for height/depth Ball type: • Compression; Size; Other e.g. taped, stripped Racquet type: • Length; Weight; Balance; Head-size; Strings Instructions/feedback: • Educate ATTENTION & INTENTION Time-limits: • Racing (e.g. rally-race); Win in a certain # of shots; Objective measures i.e. mins/secs Starting court position Ball feed position Ball feed type: • Spin • Speed • Distance • Direction • Height Sound: • Noisy vs. quiet footwork/shots • Listen to sound of contact

Figure 1. *An Example List of Constraints available to a Tennis Coach.*

Unlike in the cognitive approach, in the CLA prescriptive instruction is minimised to harness the self-organising tendencies of the athlete-learner. The value of massed, isolated, and part-whole practice is considered subordinate to the concepts of: representative learning design, where the constituent elements of competition are recreated as much as possible in the practice environment (Button et al., 2021); and the maxim of "repetition without repetition", attributed to Bernstein (1967) who used the phrase to capture how no two movements are ever precisely the same, even when produced to achieve the same outcome. The role of the coach is therefore to guide intention, awareness, and focus the attention of the player so that he or she may become better attuned to relevant feedback and information in the environment (Renshaw, Davids, Newcombe, & Roberts, 2019). For developing technique, this means that the coach should work to manipulate constraints in a way that guides the player away from undesirable movement patterns, allows exploration of the perceptual-motor search space, and facilitates discovery of alternative movement solutions that satisfy the task demands.

The CLA and the wider ecological dynamics approach have been criticised for theoretical inconsistencies, ignoring the role of mental representations in sporting expertise, and failing to offer an expansive set of tools across the entire coaching process (Carson & Taylor, 2025). Despite this, the success of the CLA has been demonstrated in tennis, for instance by Lee, Chow, Komar, Tan, & Button (2014); using task constraints such as ball-compression (Hammond & Smith, 2006); and the scaling of equipment (e.g. Beak, Davids, & Bennett, 2002), which was found to promote functional movement variability (Buszard, Garofolini, Reid, Farrow, Oppici, & Whiteside, 2020).

The purpose of this article is to build on previous work in this publication guiding coaches in how learning might be designed from an ecological perspective in the application of skill acquisition for tennis (see Carvalho, Correia, & Araújo, 2013; Martinez, 2015; Morales, & Martinez-Gallego, 2021; Parry, & O'Rourke, 2023; Parry, O'Callaghan, & Strawsma, 2025). More specifically, the following will contain evidence-informed ideas and guidance for coaches wishing to use the CLA to help players improve their serving. There is no intended implication of any objective superiority of this approach over any other method. The intention is to outline examples of evidence-informed practice stemming from a theoretical foundation rooted in the ecological dynamics view of the performer as a self-organising, complex adaptive system. While it is beyond the scope of this article to test these proposals experimentally or quantify their value in comparison to any other method, the following exercises consist of logical progressions from the tenets of an ecological approach to coaching, progressions that have led to anecdotal success in building adaptive serving techniques.

RECOMMENDATIONS FOR COACHING THE SERVE

Task Simplification Versus Task Decomposition

Firstly, it is strongly suggested that however the serve is practised it should be done so in such a way that the integrity of the serving action is preserved, as opposed to being broken down into constituent parts to be practised in isolation and then re-assembled. The ecological model emphasises the importance of perception-action couplings, which form in a cyclical relationship whereby environmental information guides movement, which in turn allows further perception in an ongoing interdependency (Davids, Button, & Bennett, 2008). The implication is that perception and action should not be separated in training, e.g. rather than practising the ball placement separately, the toss and racket-swing should be practised together to maximise skill transfer. In the instance of serving, this is important because connecting information and movement allows the individual to better perceive opportunities for action in the serve, e.g. swinging the racket fast (Button et al., 2021). Also, the server's intrinsic dynamics mean that adaptive ball placements are unique to them and not dictated by a coach or expert; and thirdly because actions are nested (Gray & Sullivan, 2023), or in other words the act of performing a ball-toss without a swing, changes the very motion of tossing itself, resulting in a loss of practice specificity.

It is therefore recommended that, when practising the serve, players are encouraged to swing and attempt to hit the ball on every toss, regardless of whether the toss is deemed "good enough" to hit. To aid beginners, rather than deconstructing the serve, it can be made easier by modifying task constraints, such as by scaling the equipment or enlarging the target area. For example, an abbreviated service action, starting in the 'trophy' position; a shorter racket, or a wider-diameter ball, could be used to simplify the challenge of serving without resorting to part-practice (Farrow & Reid, 2010).

Representative Learning Design

Building on the aforementioned importance of representative learning design and the faithful sampling of key informational sources in the environment, several principles follow from which coaches and players can optimise learning environments (Parry et al., 2024). One key element of competitive tennis, for example, is that a player is always serving to an opponent. Without this key information source, behaviour has found to differ when serving to an active returner, raising questions about the value and purpose of prolonged serving practice into an empty court when an opponent or practice partner is available (Krause, Farrow, Buszard, Pinder, & Reid, 2019).

Serving in tennis is however a skill that can readily be practised alone and unopposed, something which can be a gainful activity when coaches and practice partners are unavailable. One of the criticisms of the ecological dynamics approach is that it does not fully recognise the role of embedding skills with high volumes of this kind of "non-representative" practice, the kind commonly found in the developmental histories of many successful athletes (Carson and Taylor, 2025). However, it is recognised that this type of unopposed practice can be profitable for skill development, and fun. The goal however should not be to achieve some technical ideal through rote repetition. Rather, unopposed practice is an opportunity for exploring ways to do things differently and find effective solutions, not to adhere to a prescribed technique (Parry, Myszka, Yearby, O Sullivan, & Otte, 2024). Therefore, in one-to-one sessions, coaches should carefully weigh up the relative value of standing next to the player while they serve, for closer observation and ease of instruction; versus playing the role of the returner and fulfilling the role of a key source of external feedback and perceptual information.

Velocity

A critical task constraint for serving is velocity. When serving, whatever constraints are employed, it is crucial that the learner practises with the goal of sending a ball at speed or to distance. A powerful serve requires a qualitatively different action from a soft or gentle one because, with the intention of creating velocity, it is more likely that, through self-organisation, a greater range of motion will be explored, and range of different body parts and muscle groups will be recruited. This will ultimately lead to more effective projection of the ball. Velocity acts as a control parameter that, at a critical value, precipitates a phase transition from one movement to another (Southard, 2002). This is akin to changing gait from a walk to a jog as speed increases: i.e. both walking and jogging are means of upright locomotion, but fundamentally different movements (jogging is more than just fast walking). This is not to say that velocity is a critical objective element of a functional serving technique, but the intention to increase velocity and the associated forces through the body as control parameters are an essential part of the search for an adaptive movement. Soliciting physical effort in the quest for racket-speed will allow the player to self-organise around the task to achieve a serving action that satisfies the current task constraints. Therefore, any task or exercise involving practising the serve should invite the intention of sending the ball to distance or with power. Celebrated anecdotal evidence of this can be found in the developmental history of Andre Agassi (2009), whose father imposed a high-volume practice regime where he encouraged young Andre to maximise his power on groundstrokes, "Hit harder, my father yells. Hit harder."

According to Bosch (2020), building functional movement attractors that optimise efficiency and protect against injury is a key goal for training physical skills. He states that, at the intermuscular level, when training motor skills, forces are more important than body positions for movement specificity. In other words, learners in tennis should be encouraged to hit the ball as hard as they can as early as possible.

"If it is true that information about the force landscape is more important than information about body posture… it makes sense to provide exercises early in the motor learning process that include large and emphatically changing forces" (Bosch, 2020).

The implication for coaching therefore is that serving practise should incorporate the goal of propelling the ball to distance or at speed as early in development as possible.

To supplement serving practices and exercises variability could be used through switching among different balls and rackets for varying combinations of force and inertia to promote effective adaptations (Gray & Sullivan, 2023). With these guiding principles in mind, some practical ideas for encouraging racket-speed based on Newell's (1986) model of constraints are included below to help players develop functional movements when serving.

Modifying the Task

Goal: To encourage the learner to explore the use of a range of muscle-groups and different movements solutions to propel the ball further.

Skill Level: Beginner – Intermediate

Exercises:

- Serving to an expanded target area: e.g. a larger service box, or anywhere into the court.
- Serving from an increased distance to the target area e.g. further behind the baseline, or into an adjacent court.
- Serving from inside baseline (e.g. from the service line) to the regular service area, but with the goal of maximising distance between 1st and 2nd bounce (this can also help develop wrist flexion (Farrow & Reid, 2010)).

Variations: these exercises can be employed for an isolated serving practice (for greater volume of repetition), or as part of match-play or a conditioned game (for greater emphasis on representative learning design).

Exploiting the Environment

Manipulating environmental constraints is more difficult for most—few coaches have the option of switching between the court-surfaces and climates in which they can train, however there are some options to take by utilising changing conditions in an opportunistic way.

Goal: To develop a faster, flatter serve

Skill Level: Intermediate – Advanced

Exercises:

- Serving into a head-wind
- Practising the serve on cold and damp days
- Serving from an unstable base (e.g. standing in a sandpit or on a beach) invites use of the lower body and recruitment of the leg muscles (Farrow & Reid, 2010).

Variations: Schedule practices for evenings or early mornings; or watering a clay court before practice, are further means of creating slower environmental conditions.

Manipulating Individual Constraints

Emotional, physical and psychological states act as individual constraints. For example, to facilitate the biomechanical efficiency necessary to serve at speed, mental and physical relaxation are beneficial—fear of failure can increase physical tension and inhibit freedom to 'go for it' on the serve. Confidence could be increased in the short-term by a coach through an implicit learning paradigm such as an 'errorless learning' task. Such practice has been shown to improve skill when performing without any knowledge of the outcome (Maxwell, Masters, Kerr & Weedon, 2001).

Goal: To reduce error-anxiety and guide attention away from the outcome and towards intrinsic sources of information and feedback

Skill level: All

Exercise:

- An "errorless learning" task: serving at speed from close proximity into a wire fence or partition of the kind commonly found on tennis courts, with no specific target or aiming instructions. A task such as this builds skill and reduces anxiety about mistakes that might otherwise hinder a learner from serving at speed.

Physical tension is a barrier to serving at speed. Highly activated mental states and physical arousal can create tightness and overthinking. Beyond the beginner level, when a basic serving action has been established, manipulating these states is a possible avenue through which a coach could allow a player to play more freely and just "let it happen".

Goal: Facilitate racket-speed and an external focus through decreased muscle tension and a relaxed mental state

Skill level: Intermediate – Advanced

Exercises:

- Precede serves with a task to fatigue the wrist. This can usually be achieved with ~60 seconds of continuous tap-downs of a ball. This reduces muscular tension and inhibition of the kinetic chain through the forearm.
- Practising serving while when sleep-deprived, or jetlagged (as some Olympic skiers have successfully tried; Blumberg, 2018).

CONCLUSION

The CLA is a skill acquisition methodology that is not reliant on direct provision of copious amounts of prescriptive information based on the fallacy of a single, universally optimal technique. The above ideas are examples of how using an ecological approach may be applied to tennis in order to encourage players' search of the perceptual-motor workspace in order to satisfy constraints, with the coach as a guide for educating intention and attention. It is natural for coaches to be apprehensive of working without continuous resort to prescriptive instructions, but an ecological approach does not preclude verbal input. However, rather than aspiration to a model of technique, the emphasis is on providing a base from which a player can search for an individually appropriate movement solution. As Passos, Araújo, Davids, & Shuttleworth (2008) state, coaches can use verbal feedback as a task constraint which; "...should aim to get players into a 'ball park' area of movement solutions from which they need to practise finding a functional 'emergent' action...".

To restate the purpose of this paper, the intention is to provide some practical examples of using an ecological dynamics approach to help build adaptive movement solutions among players when coaching the tennis serve. As a final thought, it is recommended that coaches aspiring to use an ecological approach in their coaching should appreciate the value of conveying the associated benefits to the athlete-client and promoting performer understanding (Cruickshank, 2025). Among the potential drawbacks of the CLA is the resistance that may be experienced from players who express a desire for technical information and have expectations of movement prescription when attending a coaching session. This presents a challenge for the coach, and delicate management of the coach-player relationship to satisfy clients' wishes but also create buy-in that leads to enthusiasm for tasks and exercises, optimising the potential for improvement.

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The Impact of Strength and Conditioning on Footwork Development in Youth Tennis

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ABSTRACT

Footwork is a foundational element in tennis performance, directly impacting a player's ability to move efficiently, react quickly, and execute strokes with power and precision. Despite its importance, footwork remains a neglected area in many strength and conditioning programs focused on developing youth tennis. Traditional strength and conditioning programs often emphasize general physical qualities such as speed, strength, and power, under the assumption that these will naturally enhance movement on the tennis court. However, this approach overlooks the need for targeted, tennis-specific footwork training. Hesitation to address specific skills and uncertainty over whether responsibility lies with the strength and conditioning coach or the tennis coach contribute to this gap. This article explores the important role that strength and conditioning can play in developing effective tennis footwork patterns for youth athletes. By integrating sport-specific footwork training with foundational physical development, coaches can better support long-term athletic success and improve on-court performance.

Key words: Tennis-specific footwork, Tennis Strength and conditioning, Athletic development, Youth tennis

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INTRODUCTION

Footwork is frequently highlighted as a crucial element in tennis, with many coaches and players arguing that it is the foundation of success in the sport (International Tennis Performance Association [ITPA], n.d.; Roetert et al., 2016). Proper footwork is widely believed to account for a significant percentage of a player's success on the court due to the fact that most tennis players' mistakes result from a lack of ability to move efficiently (Broudy, 1997; Feingold, 2017; Roetert et al., 2016). Good footwork enables players to move effectively, ensuring they are in the optimal position to execute each stroke with both power and precision. Additionally, it allows them to react quickly, set up properly, and hit their shots with control and accuracy (Elliott et al., 2009; Kovacs et al., 2007; Ogunmah, 2024).

Despite its importance, footwork is often overlooked in many training programs and discussions about athletic performance (Kovacs, 2006; Ogunmah, 2024). When developing youth athletes, many strength and conditioning (S&C) coaches focus on speed, strength, and power, assuming that training these qualities will naturally translate to improved movement on the court. While speed, strength, and power are essential for improving athletic performance in tennis and should remain central components of every training program, prioritizing only these qualities neglects the specific footwork skills needed to move efficiently and effectively during a match (Kovacs, 2007).

Neglecting sport-specific footwork in training is common for multiple reasons, including concerns about specificity, as well as confusion about responsibilities. Many S&C coaches, particularly those working with youth athletes, emphasize general physical development over strict specificity in programming, as early specialization may lead to a narrow focus on immediate performance outcomes and potentially limit long-term athletic development (Lloyd & Oliver, 2012). Focusing on specific movements may result in overlooking foundational physical elements, such as foundational movement patterns and overall strength, which are crucial for long-term development (Lloyd et al., 2015). In addition to hesitancy with specificity, another factor contributing to the lack of structured tennis-specific footwork training is the ongoing debate about whether responsibility for that training lies with the S&C coach or the tennis coach. This division often results in fragmented or inconsistent development, despite the fact that both roles are critical to optimizing player movement (Kovacs, 2006; Reid et al., 2013).

Given these discrepancies regarding tennis-specific footwork training, the aim of this article is to identify the unique need for tennis footwork training and clarify the role that strength and conditioning coaches can play in supporting and enhancing footwork development and overall performance during the youth phase in tennis. By doing so, this discussion aims to promote an integrated approach where sport-specific footwork training is combined with foundational physical development to better support long-term athletic success and enhance on-court performance in young athletes.

THE IMPORTANCE OF FOOTWORK IN TENNIS

In tennis, a player's ability to hit the ball with power is often the most visible and celebrated aspect of performance, leading many to believe it is the key to success. However, what is less obvious, but equally critical, is the footwork that allows players to be in a position to strike the ball effectively (Kovacs et al., 2007; Ogunmah, 2024). Footwork forms the foundation of positioning, enabling athletes to cover the court efficiently, maintain balance, and prepare each stroke with optimal alignment and timing (Ogunmah, 2024; Roetert et al., 2016). Whether returning to a serve, transitioning from baseline to net, or recovering between shots, every movement on the court is governed by the quality of a player's footwork. Theoretically, if a player could reach every ball and return it successfully, they would never lose, underscoring the importance of training effective footwork.

Understanding crucial footwork in tennis is essential to knowing why athletes need to perform it properly and how to improve those movements. The split step (a quick jump from the ready position) enables athletes to position their legs and load weight effectively for an explosive takeoff (Ogunmah, 2024). Through recent high-speed video analyses, Kovacs (2009) revealed that elite tennis players do not land both feet simultaneously during the split step. Instead, they begin their reaction while still airborne, typically landing first on the foot opposite their intended direction, followed closely by the other foot. This staggered landing pattern facilitates quicker directional changes and improved balance, enhancing a player's ability to respond rapidly to the ball (Kovacs, 2009). The asymmetrical split-step landing is a movement strategy unique to tennis, allowing players to initiate quicker directional changes on larger courts and harder surfaces, even when compared to other racquet sports (Shepherd & Sandercock, 2017), and requires deliberate attention in training.

Immediately following the split step, tennis players choose how to approach the ball based on the situation after taking an explosive first step in the direction of the ball. The average tennis player sprints 3 meters each shot and changes direction 3–4 times per point throughout a match (Fernandez-Fernandez et al., 2014). Because of the size of the tennis court, first-step explosiveness is an essential element of tennis movement and also requires intentional development in context.

After the split step and explosive step in the direction of the ball, tennis players will then engage in one of four stances to prepare them for making contact with the ball. There are four primary stances used in tennis when executing a groundstroke: open (Figure 1), semi-open (Figure 2), closed (Figure 3), and neutral (Figure 4). Open stance is a widely adopted footwork pattern in modern tennis and has become increasingly common across all court surfaces due to the rising pace of the game (ITPA, n.d.). Under time pressure, players often cannot step across with the opposite leg. Instead, they slide the outside leg toward the ball, which helps maintain balance and enables efficient recovery for the next shot (Adamthwaite, 2021). The semi-open stance involves positioning the back foot diagonally behind the front foot, creating a stable base to load force and transfer explosive energy into the stroke (Gaby, 2020). Closed and neutral stances are often grouped together, as both position the front leg closer to the net. The closed stance is commonly used on the backhand side, helping players transfer their body weight into the shot for added control and power (ITPA, n.d.). The neutral stance is typically used when moving forward to attack an easier or shorter ball (Gaby, 2020).

Figure 1. *Open Stance.*

Figure 2. *Semi Open Stance.*

Figure 3. *Closed Stance.*

Figure 4. *Neutral Stance.*

Once the players have completed their groundstroke, they will then engage in a recovery movement. In the recovery movement of tennis, players typically use two movement positions after hitting a groundstroke: the lateral shuffle and the lateral crossover. Kovacs (2009) asserts that the lateral crossover is more effective for covering greater distances and making quick directional changes. The lateral crossover is often used when a player is forced wide off the court and needs to cover more distance quickly to recover in the middle of the court (Reynolds, 2021). By pushing the ground explosively with the outside foot, tennis players can initiate a quick recovery movement. Conversely, the lateral shuffle is typically used when players have more time to recover and reposition before the next movement (Kovacs, 2009). Tennis players use a lateral shuffle to recover instead of running back because it is similar to the ready position, which allows them to transition to the split step immediately when their opponent returns the ball. If they run back to the middle, their opponent can easily hit the ball behind them, and it will be difficult for them to change direction to the back.

Learning effective footwork is essential not only for optimal positioning on the court but also for improving energy efficiency and reducing the risk of injury (WTA Staff, 2019). In a fast-paced sport like tennis, players are required to make constant adjustments in direction, speed, and balance. By learning proper footwork technique, athletes can minimize the steps to cover the court, which enables them to conserve energy and maintain performance throughout a long match. Athletes with proper footwork technique and who keep their weight on the ball of their foot are better able to absorb and redirect forces during sudden stops, starts, and directional changes (Kovacs, 2009; WTA Staff, 2019). This control reduces the strain placed on joints and soft tissues, thereby

lowering the risk of common overuse injuries such as ankle sprains, patellar tendinopathy, or knee ligament stress (Martin et al., 2023). Implementing footwork drills that develop foot control, movement efficiency, and proper landing mechanics can help athletes move more effectively while reducing stress on the body (Zhou et al., 2025).

Strength and conditioning coaches can be a valuable resource for developing and training tennis-specific footwork.

It is important to note the impact S&C coaches have on the overall development of youth tennis players to fully understand the critical role they can play in maximizing the effectiveness of footwork training. Their impact is evident in several areas such as improving physical qualities, minimizing the risk of injuries, building resilient athletes, and enhancing movement efficiency, among others (Baechle & Earle, 2021; Weldon et al., 2022).

The development of speed, strength, and power plays a critical role in supporting effective footwork. Research has shown a strong correlation between muscular strength and both speed and power in youth athletes, which are qualities that directly translate to sport performance (Lloyd & Oliver, 2012; Suchomel et al., 2016). While any physical activity carries inherent injury risk, structured strength training in youth has been associated with a reduced risk of injury by up to 50%, largely due to improvements in biomechanics, muscle strength, and functional movement (Lloyd et al., 2016). When implemented with proper periodization and adequate rest, strength and conditioning training provides a wide array of physical benefits that prepare young athletes for the demands of their sport.

When designing a strength and conditioning program for tennis, it is essential to consider the sport's physical demands, particularly the high volume of lateral and multidirectional movement (ITPA, n.d). Strength development is an essential component for effective change of direction (COD) performance. Strength contributes directly to the three phases of COD: eccentric strength for deceleration, isometric strength for planting, and concentric strength for re-acceleration (Spiteri et al., 2014). These qualities serve as the foundation for efficient footwork, which is crucial across many sports, including tennis. Long-term training appears especially effective. A 12-week randomized controlled trial involving skilled male youth tennis players who performed functional resistance training three times per week demonstrated significant improvements in movement quality and technical skill performance (Xiao et al., 2025). The researchers noted that this type of structured training enhanced neuromuscular coordination and functional strength, which are essential for efficient force application during tennis-specific movements. These findings support the idea that implementing resistance early in an athlete's development not only contributes to general health and injury prevention but also improves movement efficiency and enhances sport-specific performance outcomes.

In addition to strength, power and speed are critical for optimizing COD. Tennis, for instance, involves lateral movements approximately 48% of the time (Parsons & Jones, 1998), making first-step quickness, acceleration, and lateral movement key determinants of performance (Salonikidis & Zafeiridis, 2008). Plyometric training, through enhancement of the stretch-shortening cycle, has been shown to significantly improve COD ability by increasing neuromuscular efficiency, rate of force development (RFD), and power output. A meta-analysis by Asadi et al. (2016) recommends plyometric programs lasting seven weeks, performed twice weekly with 100 jumps per session and 72 hours of rest, to yield measurable gains in COD. Furthermore, speed itself is a strong predictor of COD performance. Jones et al. (2009) found that linear sprint speed accounted for 58% of the variance in COD ability among university athletes. Similarly, Sinković et al. (2023) investigated young competitive tennis players and found that linear sprint performance over short distances was significantly correlated with COD speed and reactive agility, especially for reactive agility. These findings highlight that quicker acceleration over short sprints is associated with more effective directional changes in tennis. While speed is a key factor, COD training is also essential for developing technical movement patterns, such as deceleration mechanics, re-acceleration angles, and proper foot placement, that underline successful directional changes (Nimphius et al., 2016). These findings suggest that, particularly for developing athletes, a combination of targeted strength, speed, plyometric, and COD training can significantly enhance movement quality and performance by improving both physical capacity and skill execution.

While strength and conditioning programs build a solid movement foundation, due to the unique emphasis in tennis on body positioning to strike the ball with optimal timing, it must be acknowledged that the patterns of COD and foot placement are distinct from those in other sports, and should be addressed accordingly (ITPA, n.d.; Kovacs, 2009; Shepherd & Sandercock, 2017). For example, a tennis player may need to decelerate rapidly in an open stance to reach a wide ball or continually reposition their shoulders, hips, and feet to achieve proper alignment for hitting or initiating movement. This contrasts with traditional COD training approaches, where athletes are typically taught to keep the hips square and toes facing forward to promote efficient transitions through braking, planting, and re-acceleration phases (Dos'Santos et al., 2019).

While traditional COD principles and drills can improve general movement efficiency, not all of them fully transfer to tennis performance due to the sport's unique demands on footwork and body positioning. Therefore, incorporating tennis-specific footwork patterns, movement strategies, and stances into strength and conditioning speed sessions adds significant value, particularly when introduced early in an athlete's development (Reid et al., 2013). This aligns with long-term athletic development (LTAD) models, which emphasize the importance of early exposure to sport-specific movement competencies (Lloyd et al., 2016). By applying training that reflects the principle of transfer, coaches can better ensure that athletic gains translate to actual on-court performance (Baechle & Earle, 2021). This approach not only enhances movement efficiency but also lays the foundation for long-term competitive success through improved sport-specific movement skills.

In addition, when youth tennis players work on footwork with their S&C coach, they can focus exclusively on movement mechanics without the distraction of other tennis elements, demonstrating the benefits when S&C coaches incorporate this responsibility into their training. While tennis coaches inherently incorporate footwork into their sessions, the primary focus often shifts to stroke technique, timing, ball contact, and targeting. As a result, footwork may not receive the full attention it requires. Dedicated footwork sessions with an S&C coach may help isolate and refine movement

patterns, leading to more efficient court coverage, improved movement, and a reduced risk of injury (Kovacs, 2009). These sessions also help bridge the gap between general speed training and tennis-specific movement, reinforcing how these elements complement one another to enhance overall performance.

Footwork training in tennis: A shared responsibility

With the understanding that S&C professionals are essential not only for improving qualities that support overall athletic development but also valuable in enhancing tennis-specific footwork training, a recurring question emerges: Who should be responsible for training footwork, the tennis coach or the S&C coach? The answer is both. But it is the collaboration and clarity of roles that truly elevate an athlete's movement to a world-class level. (Kovacs, 2006; United States Tennis Association [USTA], 2024, p.5).

Footwork in tennis is a multifaceted skill. It blends technical execution, tactical awareness, and physical capacity. To build athletes who move efficiently and explosively, tennis coaches and S&C coaches must work together, bringing their unique expertise and aligning under a shared vision (Gambetta, 2007; ITPA, n.d).

The tennis coach is responsible for teaching footwork as both a technical and tactical tool. This involves training movement patterns within tactical contexts, as footwork is never performed in isolation during a match, and it must be integrated with shot selection, court positioning, and strategic decision-making (ITPA, n.d.). For example, teaching recovery after a wide forehand should also include when and where to reposition based on the opponent's possible responses. Footwork must also be embedded into drills and live play consistently reinforcing technical cues like split step, unit turn, and push-off as well as during basket-fed drills to open-point scenarios, so that movement becomes an ingrained part of the athlete's rhythm and match identity (USTA, 2025). Once a solid foundation is built, coaches must adapt footwork to align with each player's strengths, biomechanics, and playing style (Kovacs, 2006). Whether an athlete is an aggressive baseliner or a counterpuncher, their movement patterns should support how they plan to win points.

The S&C coach supports and enhances on-court movement by developing the physical qualities that underpin footwork. This includes training tennis-specific footwork mechanics such as lateral shuffles, first step, crossover steps, stances, and reactive split steps, all performed efficiently and under game-like conditions, reinforcing the principle of specificity (NSCA, 2016). They also focus on developing the physical qualities that drive the elite movement, including acceleration, deceleration, coordination, and COD, through targeted speed and agility training focused on tennis mechanics (NSCA, 2016; Yessis, 2006), helping to bridge general speed and COD drills with tennis-specific footwork. Additionally, the S&C coach targets the muscular structures that power movement, emphasizing the strength and reactivity of key muscles, not just for performance, but for durability throughout long matches and tournaments (Bompa & Haff, 2009; Yessis, 2006).

While both tennis and S&C coaches provide significant value to the development of tennis players and their footwork, collaboration is often the missing link in many tennis programs to maximize athlete development. The most effective programs are built on seamless integration between tennis and S&C coaches, going beyond basic communication to embrace a unified approach to language, timing, and goals (Gambetta, 2007). Shadow footwork drills serve as a powerful bridge between mechanics and match play, allowing players to rehearse technical patterns such as the split step, load, and recovery, without the distraction of the ball, thereby enhancing neuromuscular precision and body awareness (Elliott et al., 2009; Kovacs, 2009; Schöllhorn et al., 2009). On-court hybrid drills further this integration by combining physical and tactical elements; for instance, a medicine ball rotational throw followed by a cross-court forehand replicates the demands of explosive power into shot execution (Kovacs, 2006). A shared vocabulary and consistent cueing across both departments, such as reinforcing a "low split and push-off," creates clarity and reinforces movement habits (USTA, 2025). To maintain this alignment, weekly coaching meetings are essential for coordinating footwork themes, addressing player-specific needs, and ensuring that key movement skills are reinforced consistently across all practice environments (Gambetta, 2007). Additionally, it is vital for the S&C coach to develop a deep understanding of tennis-specific movement patterns through ongoing education. This knowledge enables more effective support of the technical aspects of footwork. With consistent messaging and unified efforts, every repetition becomes a step toward more efficient and effective movement.

Implementing footwork in a strength and conditioning session

While components like plyometrics, strength, speed, and endurance must be carefully tailored to an individual's age and developmental stage to provide adequate preparation, specific tennis footwork training has more flexibility, as it focuses more on coordination, agility, and movement patterns (Behm et al., 2008; Lloyd & Oliver, 2012; Kovacs, 2009). Since advanced players, regardless of age, tend to outperform novices in both tennis skill and tactical knowledge (McPherson & Thomas, 1989), it is important to consider a youth athlete's skill level, not just age, when designing footwork programs as part of a strength and conditioning regimen. Tailoring footwork to the player's experience ensures appropriate challenge and transfer to on-court performance. Advanced players typically have a better grasp of the game and can understand more advanced tennis movements, allowing their footwork training to be more detailed (McPherson & Thomas, 1989; Reid et al., 2016). The progression from beginner to advanced tennis footwork training should follow a structured path designed to develop athletic foundations, enhance footwork efficiency, and ultimately improve on-court movement.

At the beginner level, the emphasis is placed on building a strong foundation of general athletic movement. Most of the training should focus on fundamental athletic movements such as running mechanics, shuffling, acceleration, deceleration, and COD, prioritizing the development of agility, coordination, and reaction time (Lloyd & Oliver, 2012). In addition to these core athletic components, beginner training introduces tennis-specific footwork, including split-steps, first steps, recovery steps, and stance drills, with a focus on proper technique and execution to lay the groundwork for efficient movement and performance on the court (Kovacs, 2009). The volume of repetition remains low for specific footwork to ensure mastery of movement patterns and to maintain quality of the movement, consistent with recommendations for youth training emphasizing lower volume for technique focus (Behm et al., 2008; Faigenbaum et al., 2009). See Table 1.

Table 1
Guidelines for Implementing footwork in a Strength and Conditioning session of Beginner Tennis Players.

Beginner Level	Drill Example	Instructions
General Athletic Movement (Main Focus at this level)	Zig-Zag Shuffle drill + sprint back	Start in an athletic stance and shuffle in a zig-zag pattern through the cones, then pivot and sprint backward to the start.
Tennis-Specific Footwork (Introduction at this level)	Split step to multi-direction sprint to the cone with deceleration in any tennis stance to a lateral crossover step	Perform a split step, and sprint to a cone, decelerate into a stable tennis stance (open, semi-open, closed, or neutral), and execute a single lateral crossover as a recovery step.
Training Volume	Low repetition volume for tennis-specific footwork drills to maintain quality execution and technical development, while keeping effort intensity high.	Example: 6 sets 1 rep for Tennis-Specific Footwork

Table 2
Guidelines for Implementing footwork in a Strength and Conditioning session of Intermediate Tennis Players.

Intermediate Level	Drill Example	Instructions
General Athletic Movement (Main Focus at this level)	Zig-Zag Shuffle drill + sprint to 1 lateral crossover to shuffle back (sprint 10 yards – lateral crossover to shuffle 5 yards)	Start in an athletic stance and shuffle in a zig-zag pattern through the cones, then sprint 10 yards, focusing on acceleration, and transition into a lateral crossover to shuffle back for 5 yards
Tennis-Specific Footwork (Main Focus at this level)	Medicine Ball or Shadow forehand or backhand stroke Drill	Start in an athletic stance with a medicine ball or racquet for shadow strokes, perform a split step, and move into a forehand or backhand motion, decelerating into a stable tennis stance (open, semi-open, closed, or neutral), and recover with a lateral crossover to shuffle back to the starting position.
Training Volume	Moderate repetition volume for tennis-specific footwork drills prioritizing precision and speed without sacrificing technique, while keeping effort intensity high	Example: 6 sets of 3-4 reps for Tennis-Specific Footwork. *Collaboration drills, like medicine ball/ shadow strokes followed by live feeding, are effective at this stage.

As players progress to the intermediate level, the focus shifts more evenly between general athletic fundamentals and tennis-specific footwork. Athletes begin to refine their COD skills and quickness while continuing to enhance movement efficiency and reduce wasted motion on the court (Lloyd & Oliver, 2012; Kovacs, 2009). Footwork-specific drills can be performed at moderate volume but high intensity, prioritizing precision and speed without sacrificing technique, in line with recommendations for progressive overload and skill refinement in youth athletic development (Behm et al., 2008; Faigenbaum et al., 2009). See Table 2.

Finally, at an advanced level, the goal is to maximize movement efficiency and sustain high-speed performance throughout matches. A greater portion of training can be devoted to tennis-specific movement drills, focusing on multi-directional movement patterns applied in high-intensity, game-like scenarios (Kovacs, 2009; Reid et al., 2016). This stage continues to reinforce general athletic fundamentals such as acceleration, deceleration, and COD to maintain a well-rounded physical profile (Lloyd & Oliver, 2012). Because athletes are highly skilled in these movements, footwork can be performed at high volumes and intensities, which sharpens court coverage and prepares players to move explosively and efficiently under the demands of competitive play (Behm et al., 2008; Faigenbaum et al., 2009). See Table 3.

Table 3
Guidelines for Implementing footwork in a Strength and Conditioning session of Advanced Tennis Players.

Advanced Level	Drill Example	Instructions
General Athletic Movement (Maintenance at this level)	Zig-Zag Shuffle drill + sprint to 1 cross-over to shuffle back (sprint 10 yards – Lateral crossover to shuffle 5 yards) *Add Shadow strokes	Start in an athletic stance and shuffle in a zig-zag pattern through the cones, performing a shadow forehand or backhand at each cone, then sprint 10 yards, focusing on acceleration and transition into a lateral crossover to shuffle back for 5 yards
Tennis-Specific Footwork (Main Focus at this level)	Medicine Ball or Shadow forehand or backhand stroke Drill - with resistance bungee band	Start in an athletic stance with a medicine ball or racquet for shadow strokes and a resistance bungee band for added intensity. Perform a split step, and move into a forehand or backhand motion, decelerating into a stable tennis stance (open, semi-open, closed, or neutral), and recover with a lateral crossover to shuffle back to the starting position.
Training Volume	High repetition volume for tennis-specific footwork drills to improve court coverage and prepare players to move explosively and efficiently under the demands of competitive play, while keeping effort intensity high	Example: 6 sets 6-8 reps for Tennis-Specific Footwork *Collaboration drills like medicine ball/ shadow strokes, followed by live feeding, are effective at this stage.

It is relevant to note that both speed and specific tennis footwork are consistently included in the strength and conditioning program from beginner to advanced levels. What differs is the proportion of each and the intensity, depending on the athlete's skill level. The more advanced the player, the greater the emphasis on specific footwork training to match the demands of high-level play (Lloyd & Oliver, 2012; Kovacs, 2009; Reid et al., 2016).

CONCLUSION

Footwork is not just a technical component of tennis; it is a physical skill that supports every aspect of performance on the court. Ignoring it in strength and conditioning programs leaves a critical gap in the athletic development of youth tennis players. Both tennis and strength and conditioning professionals share responsibility for developing efficient, sport-specific movement patterns, and collaboration between the two is essential. S&C coaches must embrace footwork as a core element of their programming, integrating with speed, strength, and power training. When footwork is treated as a foundational aspect of physical development, athletes are better prepared to move efficiently, react faster, and execute with greater precision. By building sport-specific movement literacy early on, specificity becomes the foundation that allows players to gain the agility, coordination, adaptability, and understanding needed to succeed on court. Specific footwork is not just a technical necessity; it is a strategic investment in a player's future.

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Making the history of french tennis and its federation

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ABSTRACT

Imported to Dinard in 1875 and played by the elites of the Belle Époque, tennis became a national passion in the 1920s. The press, radio, and cinematographic newsreels magnify the exploits of Suzanne Lenglen and the Musketeers. During the 1950s and 1960s, French tennis seemed to be falling asleep, but new clubs were already appearing. The conversion of the middle classes to the practice of tennis then accelerated, reaching its peak with the victory of Yannick Noah at Roland-Garros in 1983, and France in the Davis Cup in 1991. One of the first sports federations to become independent in 1920, the lawn-tennis federation was for a long time content to legislate and organize competitions at the regional and national level. But, with the transition to the Open era (1968), the French Tennis Federation (FFT) created a unique model for the development of its sport by drawing on the profits generated by the Roland-Garros tournament it owns. Clubs that are more than a hundred years old, old federal magazines and bulletins, the pedagogies of the master-teachers of yesteryear and the coaches of today, federal politics, the trajectories of its fourteen presidents, heritage and sponsors, exchanges beyond borders, here is an invitation to revisit 150 years of France's history with a racket in hand.

Key words: French Tennis Federation; history; governance; Centenary Clubs

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INTRODUCTION

In 2025, the French Tennis Federation (FFT) celebrated both the centenary of the France Open and the 150th anniversary of the first tennis balls exchanged on French soil in 1875. While there are many histories of tennis in France that focus on the Roland-Garros tournament, its champions, and the epics of the Davis Cup, it failed to take the measure of the role played by the federation and its leaders in the expansion of this sport, which has become the second largest in France in terms of the number of its licenses (behind football) and the first in terms of individual and mixed sports.

This book is not a federal novel but the result of the work of historians, to whom the FFT has opened its archives and provided a large iconographic collection. In France, the FFT is indeed the first single-sport federation to entrust the writing of its history, not to communicators, but to academics. The result is a constructed, distanced and useful narrative for those who want to understand the complex contexts in which federal policies have been deployed since the establishment of tennis in France. Beyond the collection of facts and events, the proposed narrative is fully social, cultural, economic and even political. While it focuses on the emergence of tennis at the end of the nineteenth century to its modern organization, it is open to all the dynamics of French society from the 1870s to the present day.

This book is written in five parts (5 sets) with 32 chapters, the first four progressing chronologically, the last one being devoted to the heritage of French tennis and the pioneer clubs. Its backbone is articulated around federal policies in France and beyond, portraits of presidents, official bulletins placed in the publishing economy of tennis, exchanges beyond borders, forms taken by tennis teaching and high-level production, partners and sponsors. The periodization adopted was punctuated by the establishment of seaside tennis in 1875, the creation of the federation in 1920, the arrival in 1953 of a series of leaders who, for the first time, were not former champions, and the seizure of power in 1968 by Marcel Bernard and Philippe Chatrier who would carry the Open revolution.

Figure 1. *Aerial view of the Philippe-Chatrier court and the Roland-Garros stadium, 2024*

FIRST SET: FRENCH TENNIS BEFORE ITS FEDERATION (1875-1920)

The first part of the book allows us to analyze the prerequisites for the creation of the French Lawn Tennis Federation (FFLT) in 1920.

In chapter 1, Serge Vaucelle places the history of tennis in the long term of racquet sports from the short palm of the Renaissance princes to the recent arrival of padel. This is all the more useful because, on the one hand, short palm players were among the first "tennis players" (Émile Broquedis and Martin Plaa) and, on the other hand, this "game of kings" has bequeathed to modern tennis several of its characteristics: the counting of points from 15 to 15 which inspired the handicap ranking system, naming of the shots played (forehand, backhand, serve), vocabulary, layout of the playing field, although initially asymmetrical, expressions from the French language ("amuser la galerie", "faire faux bond", "qui va à la chasse perd sa place" to illustrate). The author does not spare the history of all the other games of long palm, ball in hand, pelota, sieve and tambourine that have survived to the present day in conservatories of practices that correspond to the former royal provinces. These traditional games were even formed into multiple French federations between the 1900s and 1930s and continue their existence until today.

Readers are then immersed in the atmosphere of the Belle Époque when tennis came to the beaches (Chapter 2, Jean-Michel Peter). Tennis as a physical and cultural novelty allows the racing elites to distinguish themselves and recognize themselves, from the seaside resorts of the North Sea and the Normandy or Aquitaine coasts to the palaces of the Côte d'Azur via the western districts of Paris. The establishment of the first tennis courts in Dinard, Dinan, Paris and Nice and, by extension, seaside tennis, was determined primarily by the development of sports and tourist leisure activities. In the middle of the nineteenth century, a new market was created at the intersection of industrial boom, improved transport (railways), the island's tradition of outdoor activities and the appetite of the British upper classes for physical, recreational and hygienic practices. With their well-known role as ambassadors of modern sports, English expatriates and tourists are the leading exporters of new sports and leisure activities, including yachting, tennis and golf. It was also the French law on freedom of association of 1901 that contributed to the development of tennis, even if the beginnings were to be credited to the "leisure class". In the end, the spread of tennis in France during the Belle Époque was at the interface of recreational tennis, sports shows that attracted crowds after the war, and the proliferation of clubs. But before 1914, tennis also developed in the French colonies, a privileged space for its expansion among the colonial elites who admired the British model (Chapter 4, Claude Boli).

Figure 2. *Seaside tennis in Pornichet*

Business magazines at the heart of federal tennis

Taking the tennis press and official bulletins as a focus is a good introduction to understanding the evolution of the federal administration. Also, one of the innovative contributions of this book concerns the close relations forged between the owners of the tennis trade magazines and the federal leaders (Chapters 5, 12 and 15, Patrick Clastres). This cohabitation between magazines sold on newsstands and federal bulletins results in a creative tension where the control of information is essential, sometimes to conquer and retain a clientele of readers and advertisers, sometimes to ensure hegemony over the organization of French tennis.

In 1910, Max Decugis launched the first magazine of its kind sold on newsstands and entitled Tennis Organe du lawn-tennis en France. Many federal leaders break into the specialized magazines created by champions and enthusiasts to impose their discourse and their power, while editors-in-chief, often also very good players, use their newspaper as a platform to try to conquer federal power. The magazines Tennis by Max Decugis and Tennis et Golf by Marcel Daninos (1914 and 1920) not only initiated the promotion of professional tennis against amateur doctrine, they also played a role in the genesis of the FFLT.

After the Revue du Tennis et du Badminton launched in 1929 by Quiry, other commercial magazines were created during the interwar period: Tennis-Sports, which was carried at arm's length by the master-teachers from December 1929 to February 1930, or Smash by René Mathieu, which had the misfortune to be launched in June 1939. This editorial golden age reflects the enthusiasm of the media and the French for the exploits of Suzanne Lenglen and then the Musketeers. However, it does not mean that the practice of tennis became more democratic at the time.

SECOND SET: THE MUSKETEERS' FOOTPRINT (1920-1953)

Until the end of the Great War, there were no real sports federations in France (Chapter 3, Patrick Clastres): the different sports were organized into separate committees that made up the Union of French Athletic Sports Societies (USFSA). The FFLT broke away from the USFSA to become a fully independent sports federation with the filing of the statutes on 9 November 1920 and a declaration in the Official Journal of the French Republic on 26 November 1920 (Chapter 6, Patrick Clastres and Lionel Crognier). On December 17, 1920, the constitutive meeting of the FFLT council also validated the elections of the delegates of the regional committees, which are the ancestors of the leagues. It is one of the challenges of the FFLT's operation to represent the provinces and their involvement in decision-making.

Another issue that spanned the century until the 1980s was the definitions of amateur and professional. Suzanne Lenglen's conversion to professionalism in 1926 put the FFLT's positions in tension. Bitter debates took place again during the 1950s and 1960s, and they faded with the opening of Roland-Garros to professionals in 1968 (Open era). This revolution was largely due to the tenacious commitment of Philippe Chatrier, who secured the return of tennis to the Olympic Games in 1988 and became a member of the International Olympic Committee (IOC).

The construction of a large stadium dedicated to tennis was the essential starting point to be able to welcome a large audience and switch to spectator sport. This was due to the advent of a men's team made up of four players called "The Musketeers" by the press (Brugnon, Borotra, Cochet and Lacoste). The latter won the silver bowl six times from 1927 to 1932 in the wake of Suzanne Lenglen's exploits and made the Roland-Garros stadium the place of memory of French tennis. After their first victory in 1927 in Philadelphia, the FFLT acquired a new stadium located at the Porte d'Auteuil to host the Davis Cup final the following year, to the point of opening up new perspectives for the development of French tennis (Chapters 6 and 8). In addition to this architectural inscription in the Parisian landscape with the centre court enclosure as we still know it today, the Davis Cup victory was in many ways decisive for the history of the federation. The influence exerted by the Musketeers on the history of the FFLT and French tennis would continue in the decades that followed. If their career was somewhat mythologized - most often they played with an incomplete team, with 3 more than 4 - the fact remains that the choice of the stadium, which is the property of the federation, proved to be wise to conquer greater legitimacy in French sport and vis-à-vis the public authorities.

The rediscovery of former presidents and master-professors

Several major players in the institutionalization of French tennis were still unknown, especially those before 1968. The biographical notes of the fourteen presidents, which are scattered throughout the pages (Chapters 7, 9, 14, 16, 18, 20), are particularly unpublished and enlightening. These portraits not only include their careers as players and managers, they also consider their social origins and professional destinies. Their profiles, spread over a century and a half, bear witness to the sociological shift from the eminent elites of the capital to the bourgeoisie and middle classes of the southern regions. Moreover, it is not insignificant for the balance of power that is at stake, at the national and international levels, that half of the fourteen presidents are players who have reached the first French series, i.e. the best national level (Albert Canet, Pierre Gillou, René Lacoste, Raymond Rödel, Marcel Bernard, Philippe Chatrier, Gilles Moretton). Several of these biographies deal with the proximity of the federation to certain governments, during the dark years of the Vichy regime as well as during the Glorious Thirty. Françoise Taliano-des Garets (Chapter 8) notes a great continuity of the federation's policy and the stability of the leaders of the Musketeers' generation beyond the Vichy regime. But the federation also has its war heroes, Simonne Mathieu and Bernard Destremeau, in particular. The years 1920 to 1950 were those of a sustained development of competitive tennis in North Africa, from which a number of champions emerged (Chapter 10, Claude Boli). The benefit of the growth of tournaments in North Africa allowed the emergence of local players including Robert Abdesselam, Gilbert Naccache, the brothers Pierre and Maurice Darmon, and Françoise Dürr, the winner of Roland-Garros in 1967.

The teaching of tennis was a concern that continued to progress in the minds of the leaders of the FFLT from the beginning of the 1920s (Chapter 11, Lionel Crognier). Henri Wallet, the first president (1920-1924) was thus imbued with the need to train young people to compete with the English and the Americans. Very early on, the progressiveness of the teaching was based on three levels (initiation, improvement, training) before being enriched by an initial stage in 1990: mini-tennis. The profession was organized in 1925 in connection with the rise of professional tennis. Initially, the elite of the trade, the famous master teachers, were the holders of the secrets of the moves and gave primacy to style and technique in individual lessons. However, group initiations developed after the launch in 1935 of the first tennis school, then in 1942 of the school tennis initiation centres, and finally with the dissemination of Suzanne Lenglen's Method (1942). Henri Cochet is fully involved, both in France and in North Africa, to transmit knowledge born of his practice at the highest level. However, it was not until the 1960s that the idea of being able to "learn tennis" took hold, going beyond the beautiful style taught to a privileged audience.

THIRD SET: A FEDERATION IN TRANSITION (1953-1968)

Guy de Bazillac's presidential decade (1953-1963) and the shorter terms of his two successors, Robert Soisbault (1963-1966) and Roger Cirotteau (1966-1968), were forgotten, if not discredited. This oversight can be explained by the prestige of their predecessor Pierre Gillou (1931-1941 and 1947-1953), the captain of the Musketeers, and by the exceptional transformations that French tennis underwent under their successor Philippe Chatrier (1973-1993). Moreover, itis commonly accepted that the latter carried out a "revolution in French tennis" from his conquest of the federation in December 1968 alongside Marcel Bernard. Without questioning this reality, the third set (Patrick Clastres, Chapters 13 to 16) rehabilitates these three presidencies as years of transition where conservatism and reforms are intertwined. The author returns to this discredit, which can be compared to that of the regime of the Fourth Republic orchestrated by General de Gaulle.

These fifteen years were punctuated by the attacks launched by Philippe Chatrier's magazine Tennis de France against the rule of amateurism maintained by the International Federation with the support of the French leaders. The monthly created in 1953 made it possible to build a group

of editors and contributors who would ensure the success of the journal and would be able to familiarize readers with new ideas carried by a dream team that would take power in 1968 (Chapter 15). Thus, Philippe Chatrier embodies a liberal and entrepreneurial vision against leaders who have been in place for a quarter of a century and are presented as backward-looking. In these years 1953-1968, however, we note the growth in the number of players, the increase in licenses, a boom in tennis schools, the emergence of champions such as Pierre Darmon, Pierre Barthès, Annie Soisbault, and Françoise Dürr. Who remembers that Ginette Bucaille was a finalist at Roland-Garros in 1954? Under the presidencies of General de Gaulle (1958-1969), the French Ministry of Youth and Sports, then in gestation, did not remain completely passive in supporting equipment projects and in making Gil de Kermadec in 1963 the first National Technical Director (DTN) of French sport, i.e. the first official in charge of high level sport.

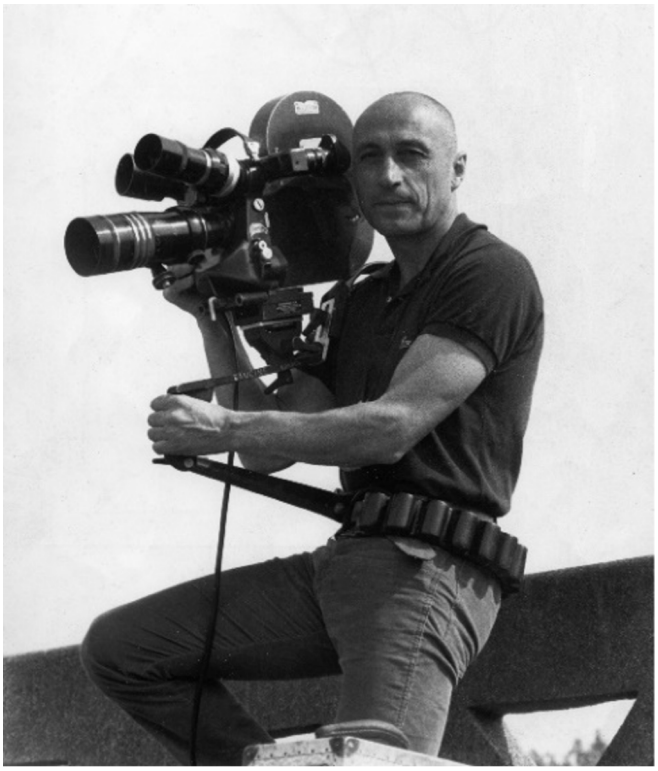

Figure 3. *Gil de Kermadec on camera*

FOURTH SET: THE MODERNIZATIONS OF FRENCH TENNIS (1968-2025)

The fourth set opens with Emmanuel Bayle's analysis (Chapter 17) of the profound reforms on the sporting, commercial and managerial levels led by presidents Marcel Bernard (1968-1972) and Philippe Chatrier (1973-1993). This chapter is pivotal in understanding the continuity of federal policy over the past half century, as the following 4 presidencies (Christian Bîmes, Jean Gachassin, Bernard Giudicelli, Gilles Moretton) have not fundamentally modified or renounced the line defined in 1968.

Marcel Bernard, winner of the France Open in 1946, and Philippe Chatrier, former French number 6, arrived at the presidency of the FFLT in an extremely favourable economic and social context with a development of tennis already launched by their predecessors and beginning to benefit from State aid. Tennis then became a social phenomenon widely broadcast on television (from 1972) and whose practice became commonplace throughout France.

The "Chatrier revolution" was based on four key points set out in 1968: to increase the number of courts and players by paying attention to the development of school tennis, to provide the federation with a modern management structure, to give more autonomy to the leagues and to prepare future champions by taking the example of Australian tennis. In order to make an impression on public opinion, Philippe Chatrier is betting on both the France Davis Cup team and the profound transformation of the Roland-Garros stadium into a "large national centre with covered courts, accommodation for trainees or national teams, federal offices". A clear management principle was adopted for this federation, which until then had been very unprofessional: a collective and united management that associated the league presidents and delegated the technical and operational management of files to salaried executives. The policy of decentralization of resources found its full effectiveness with the creation of the leagues in the 1970s, including in Corsica and in the French overseas departments (Claude Boli, Chapter 21).

The Porte d'Auteuil tournament became a first-rate promotional and financial tool. The FFLT, renamed FFT in 1976, was then the only French individual sports federation to own and organise a major media event. Since the early 1980s, its economic model has been based almost exclusively on Roland-Garros, which generates between 80% and 85% of federal resources. The continuously increasing results gave the FFT a particularly stable and comfortable financial situation, which allowed it to renovate its stadium, which was in a pitiful state at the end of the 1970s, and then to gradually extend the site above and below ground.

Fifty years later, in the age of globalisation and digitalisation, four major challenges await the federation (Chapter 19, Emmanuel Bayle): to continue to optimise the profitability of the new Roland-Garros during and outside the tournament, to maintain the density of the high-level while bringing out exemplary and inspiring champions, to succeed in the new territorial organisation for a better overall governance of tennis, and finally to strengthen the attractiveness of tennis and the new associated disciplines (beach tennis, padel, pickleball, etc.) to the population by boosting the life of the clubs.

A French originality: the federation's manufacture of champions

The "Chatrier revolution" could not be completely achieved without a high-level sporting policy that would make it possible to rediscover the lost golden age of the Musketeers and to reconquer the silver bowl of the Davis Cup. The FFT is counting on the creation of a federal network to manufacture champions in tennis-studies whereas, in most other countries, the courses are most often made outside the federation, relying on family, sponsors or private academies.

It was from the appointment in 1963 of the first DTN that the strategies for structuring the training sector were set (Chapter 22, Lionel Crognier). The DTNs who succeed Gil de Kermadec (Jean-Paul Loth, Patrice Dominguez, Jean-Claude Massias, in particular), continue to implement a model of access to the elite that makes France a successful nation to lead young people into the Top 100. Federal pedagogy was then considered both as a prescription from above through the teaching method of 1972 but also as the result

of teachings built empirically by master teachers, champions and all the new players in the clubs. DTN until 1976, Gil de Kermadec brilliantly revealed this knowledge through the kinograms he published in Tennis de France and the making of educational films. He benefits from his travels abroad as well as from the contributions of sports science and training. His large-scale project is to combine cinema and tennis, around the style, technique and personality of the champions. Gil de Kermadec's plethoric work constitutes a true memory of international tennis, with a brilliant filmic writing from the silent film of 1966 presenting the elementary technical basics from slow-motion gestures, to the match between McEnroe and Lendl in 1984 at Roland-Garros.

Finally, by combining State aid (new diplomas, State staff made available, development of sports-study classes in middle and high schools, public tennis facilities and courts) and the financial resources emanating from the Roland-Garros tournament, the FFT has set up a training course with convincing results from the 1980s to the present day. The brilliant careers of Yannick Noah and Amélie Mauresmo, as well as the victories in the Davis Cup and Fed Cup attest to this (Chapter 23).

Figure 4. *Yannick Noah, 1991 Davis Cup*

Bertrand Pulman (Chapter 24) then addresses an essential issue for the development of federal tennis, in connection with the internationalisation of the Roland-Garros brand, that of advertisements, advertisements and other commercial sponsorships to demonstrate both its age and its importance. He recalls that the founder of Tennis de France has chosen to recruit professionals to set up a global commercial partnership strategy whose challenge is to satisfy and retain partners. None of his successors will lose sight of these objectives, when bringing a partnership to life all year round - and not only during the peak of Roland-Garros - will be a more topical issue.

FIFTH SET: HERITAGE AND PIONEER CLUBS

Heritage and pioneer clubs are in the spotlight in the 5th set. In the space of a century, the FFT has acquired a cultural, artistic and architectural heritage made up of remarkable movable and immovable property. Françoise Germaix-Wasserman and Henri Wasserman (Chapter 25) take hold of one of the most beautiful collections, the posters of the Tournament, to retrace a whole section of the history of art and sport. The Federation has indeed pictorial works of first value: paintings, engravings, and drawings ranging from the nineteenth century to the present day such as The Palm Players in the Jardin du Luxembourg by Gustave Doré (1866) or The Portrait of Chris Evert made in 1977 by Andy Warhol in the same spirit as the portraits of Marilyn Monroe and Liz Taylor. Under the aegis of its president Christian Bîmes, a vast acquisition policy was launched by the FFT for the opening of the Tenniseum, the federal museum which was inaugurated on 25 May 2003. The 2017 museographic inventory lists nearly 12,976 items listed.

Tennis clubs and leagues also have their own collections and history. This is what Patrick Clastres reminds us (Chapter 26) by offering advice to enthusiasts wishing to do historical research and promote their finds. Serge Vaucelle (Chapter 27) then evokes the last short palm clubs still active in France (Fontainebleau, Paris, Bordeaux, Pau, Bayonne) whose activity is coordinated by a Committee that has been part of the FFLT since its creation in 1920. Finally, and this is an essential and promising contribution, twelve researchers have joined forces to tell the story of the birth and first developments of 34 century-old clubs, some of which have disappeared. While the capital and the seafronts are particularly represented because they were the gateways to tennis in France during the Belle Époque, the inland cities are not forgotten, whether they are spa resorts or regional metropolises. Even if so many local stories remain to be written, the return of clubs to the center of the game is eminently welcome (Chapters 28 to 32).

CONCLUSION

With the end of false amateurism and the transition to the Open era in 1968, the French Tennis Federation created a unique model for the development of its sport by drawing on the profits generated by the Roland-Garros tournament that it owns and that it can redistribute to the regional leagues. The continued success of the tournament and its commercialisation have made it possible to continue the professionalisation of the FFT and its decentralised bodies, but also to renovate and build a new, modernised Roland-Garros stadium. Despite a turbulent and sometimes conflictual governance since 1993, competition from a large number of sports and leisure activities and the evolution of the leisure practices of French youth, the FFT remains one of the major French sports federations and a major player in international tennis. Despite many ups and downs and power struggles, the FFT has played a decisive and positive role in the evolution of the game and the democratisation of its practice.

Because it manages to articulate, in the long term, the national, regional and local levels, this book is already a reference for tennis lovers and enthusiasts as well as for researchers and all those who wish to better understand the trajectories and developments of sports federations. Even if the history of champions was not part of the project of this book, it is probably the most complete ever published on the history of tennis in France and its federation. Last but not least, the reader will enjoy consulting this beautiful large format book of 335 pages, with cardboard cover and glossy paper, embellished with more than 200 often unpublished photographs and a very extensive index of more than 1200 names of people and names of clubs, committees and leagues which facilitates reading and encourages future studies.

CONFLICT OF INTEREST AND FUNDING

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

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View of the new Centre Court with the Musketeers' Garden. Philippe Montigny-FFT

Pornichet tennis on the square. All rights reserved. Jean-Michel Peter Collection.

Gil de Kermadec on camera. 1960. Gil de Kermadec-FFT.

Yannick Noah carried in triumph, Davis Cup final, December 1, 1991. Christophe Guibbaud-FFT

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Effects of coach feedback and motor imagery on baseline game performance in regional junior tennis players

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ABSTRACT

The objective of this study was to evaluate the effects of coach feedback, combined or not with imagery practice, on the performance of the baseline game in tennis. Thirty young tennis players (M = 11.54) at the regional level, were willing to participate in this study. The players were divided, by random draw, into 3 groups: Control, Feedback and Feedback+Imaging. They carried out 3 experimental phases: Pre-test (30 long balls with ball launcher and super tie-break), acquisition (12 training sessions) and post-test (identical to the pre-test). While during the sessions of the acquisition phase the participants in the Control group received no other instructions than to play at the back of the class, those in the Feedback group received feedback from the coach after each unprovoked foul and the players in the Feedback+Imaging group also had to visualize (according to an internal visual imagery modality) the success of the previous shot by taking into account the feedback given by the coach. The results of this study show that supplementing the coach's feedback with motor imagery improves its effects. We recommend that coaches use the visualization integrated into the training.

Key words: feedback, visualization, forehand, backhand.

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INTRODUCTION

According to Martin (2018), tennis is a racquet sport that consists of hitting a ball in order to send it onto the court once more than your opponent. It involves the performance of various complex motor skills, such as forehands and backhands, the efficiency of which requires a large number of repetitions and training sessions (Akpinar et al., 2012). In order to facilitate or accelerate learning and promote performance optimization, coaches and players use strategies (Reid et al., 2007) such as feedback (Schmidt & Lee, 1999) or motor imagery, which consists of internally simulating a movement in the absence of actual execution (Robin et al., 2023). Feedback from the coach, including feedback from poor gesture execution that is used to correct the internal model or mental representation of a technical gesture (Dhawale et al., 2017), but also motor imagery (Robin & Dominique, 2025) that is performed on the basis of this same internal model, are strategies that can have a positive impact on motor performance in tennis (Martin, 2018). While a recent study has shown beneficial effects of the combination of these two strategies on performance in a precision task (i.e., passing towards a target) in football (Robin et al., 2020), we thought it would be interesting to assess whether receiving feedback from the coach about unprovoked fouls, forehands or backhands from the back of the court, and then visualizing the success of these same movements would improve the performance of young tennis players.

The objective of the project was to evaluate the effects of the coach's feedback, combined or not with motor imagery, relating to the visualization of a corrected and successful gesture, on the performance of the baseline game in a precision test with a ball thrower but also in match conditions (i.e., super tie-break).

METHOD

Thirty male players (M = 11.54 years old; SD = 1.47) playing tennis at a regional level for more than 4 years, playing at least 5 tournaments per year and training between 2 and 3 times a week (for a weekly duration of 4 and 5 hours), were volunteers to participate in this study. After the parents and participants signed a consent form, they were randomly assigned to 3 groups: Control (N = 10), Feedback (N = 10) and Feedback+Imaging (N = 10). This study, carried out in accordance with the latest version of the Helsinki Declaration, was approved by the ethics committee of the ACTES laboratory (Urp5-4-2024-03) of the *Université des Antilles*.

PROCEDURE

This study took place at the Amicale Tennis Club in Le Gosier (France). Before the start of the experimental phase, the players made the latest French version of the Movement Imagery Questionnaire (MIQ-3f; Robin et al., 2020) to verify that none of them had difficulty doing motor imagery. Then, the participants carried out 3 experimental phases: Pre-test (6 sets of 5 balls from the bottom of the course with a lobster elite 2 type ball launcher and a super tie-break), Acquisition (12 training sessions with or without feedback and imaging) and Post-test (identical to the pre-test). While during the sessions of the acquisition phase, the participants in the Control group were only instructed to play at the back of the course, those in the Feedback group benefited from the coach's feedback (see Table 1) after each unprovoked foul, and the players in the Feedback+Imaging group also had to imagine, according to an internal visual imagery modality, succeed in the forehand or backhand by integrating the correction feedback given by the coach (State Tennis Graduate, 20 years of experience, full-time coach).

Table 1

Feedback used by the coach.

Number	Correction
1	You must go through the ball and finish your swing
2	You must move in order to hit the ball at hip height
3	You must center the ball on your racket strings
4	You must recover your position, make a split step, then adjustment steps to hit the ball in the best possible conditions
5	You must lower the racket head
6	You must use this grip and hold your handle better

In the pre-test and post-test, the test performed with the ball launcher consisted of returning 30 baseline balls to the baseline area on the opposite side (see Figure 1) in order to obtain the highest possible score. The velocity of the bullets was measured with a radar gun (cordless R1000) and the performance (i.e., accuracy scores and number of errors) was recorded by the experimenters and by means of the Swingvision software (i.e., speed of keystrokes, number of rallies, number of errors) during the super-tie-breaks.

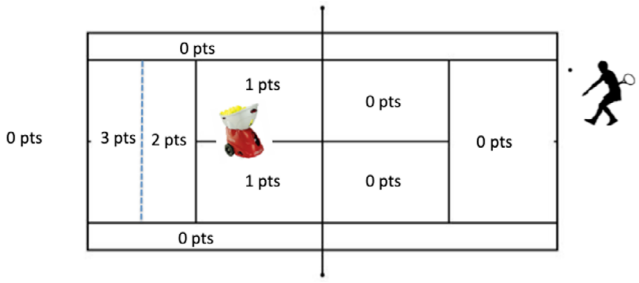

Figure 1. *Accuracy scores with the ball launcher during pre-tests and post-tests.*

Dependent variables (hitting speeds, accuracy scores and number of errors at the pitcher; percentage of rallies between 5 and 8 balls, percentage of balls from baseline and percentage of unforced errors in super-tie-breaks) were normally distributed (Kolmogorov-Smirnov tests). These variables were subjected to repeated measures ANOVAS (Pre-test versus Post-test) with independent groups (Control versus Feedback versus Feedback+Imaging), calculated with the Statistica software. Post-hoc analyses (Newman–Keuls test) and an alpha cut-off of .05 were used.

RESULTS

The ANOVA performed on the pitcher's strike speeds did not reveal any significant differences between groups or between tests (all p >.05).

The ANOVA on pitcher accuracy scores showed on the one hand that players in the Feedback and Feedback+Imaging groups improved their performance between pre-test and post-test (p <.05), and that the performance of the Feedback+Imaging group was superior to that of the other groups at the post-test (p <.05 ; see Figure 2A).

The ANOVA on the number of fouls, on the ball thrower, revealed that players in the Feedback+Imagery and Feedback groups decreased their number of fouls between pre-test and post-test (p <.01), and that players who benefited from motor imagery in addition to feedback (i.e., Feedback+Imaging group) made fewer mistakes, post-test, than those in the Control group (p <.05) as shown in Figure 2B.

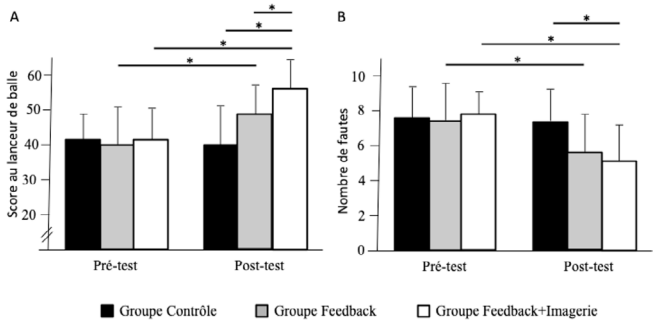

Figure 2. *Ball pitcher performance scores (A) and number of fouls (B) for participants in the Control (black) and Feedback (gray) and Feedback+Imaging (black) groups, during pre- and post-tests (* p <.05).*

The ANOVA made on the percentages of rallies between 5 and 8 balls, during the super-tie-breaks, did not show any significant difference between the tests or between the groups (all the p >.05), knowing that players obtained the following percentages: Control (M=14%), Feedback (M=18%) and Feedback+Imaging (M=20%), in the post-test.

The ANOVA on the percentages of baseline shots, during super-tie-breaks, showed that players in the Feedback and Feedback+Imaging groups improved their performance between the pre-test and the post-test (p < .05). In addition, the Feedbacks group performed better than the Control group (p <.05), and finally those of the Feedback+Imaging group were superior to the performance of the other two groups at the post-test (see Figure 3A).

The ANOVA carried out on the percentages of unprovoked fouls during the super-tie-breaks showed that the players in the Feedback and Feedback+Imaging groups improved their performance between the pre-test and the post-test (p <.05), and that their percentage of mistakes was lower than that of the Control group at post-test (p <.05), as shown in Figure 3B.

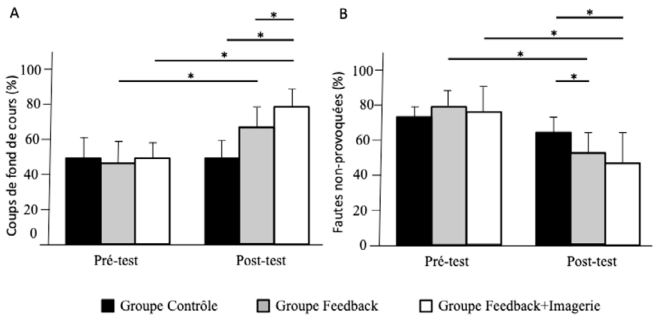

Figure 3. *Percentages of strokes at the bottom of the court (A) and percentages of unprovoked fouls (B) during super-tie-breaks for players in the Control (in black) and Feedback (in grey) and Feedback+Imaging (in black) groups, during pre-tests and post-tests (* p < .05).*

DISCUSSION

The objective of this original study was to evaluate the effects of coach feedback, combined or not with motor imagery practice, consisting of visualizing a corrected forehand or backhand, on the performance of the baseline game in a precision task performed with a ball thrower and during a super-tie-break.

First, the results of this study show beneficial effects of the coach's feedback on the performance of the game from the back of the course to the ball thrower and in match conditions. Indeed, the players in the Feedback group obtained better scores and made fewer fouls on the ball thrower, but also made more baseline shots and made fewer unforced fouls, than the participants in the Control group during the post-test. These results confirm the data in the literature showing the importance of coach feedback in improving motor learning and sports performance (Smith & Ward, 2006; Schmidt & Lee, 1999; Tsetzis & Votsis, 2006), particularly in racquet sports (Tzetzis et al., 2008) and more specifically in tennis (Morales & Martinez-Gallego, 2022). As mentioned by Robin et al. (2020), feedback can guide players by helping them to reinforce or correct their mental representations of the actions they perform. Providing verbal cues about corrections to their movements for subsequent trials is particularly beneficial for non-experts (Kernodle & Carlton, 1992), as was the case for the young players who participated in this study. In tennis, the coaches' "eye" and expertise are essential to analyse performance, identify mistakes and provide appropriate feedback allowing players to progress by correcting their mistakes (Schönborn, 2000).

Secondly, the results of this study showed that motor imagery made it possible to optimize the performance of the baseline game in tennis. These results confirm the interest of motor imagery in improving sports performance (Toth et al., 2020), particularly in tennis (for review see Robin & Dominique, 2025) and more specifically with regard to the baseline game (Robin et al., 2025). On the other hand, these results confirm the interest of supplementing the coach's feedback with the visualization of a successful action (Robin et al., 2020). Indeed, the results of this study showed that the players in the Feedback+Imaging group obtained higher scores than the post-test with the ball launcher and sent more balls to the back of the court during the super-tie-break than those in the Control group but also those in the Feedback group. These results confirm the results of previous studies that have observed beneficial effects of a combination of feedback and motor imagery on accuracy in a passing task in football (Robin et al., 2020) or during the plunged start in swimming (Robin et al., 2023). The authors mentioned that benefiting from feedback from an expert such as the tennis coach, before visualization, allowed players to perform motor imagery based on mental representations of corrected gestures, thus optimizing the athletes' performance.

It is necessary to emphasize that this study is not without limitations. Indeed, although equivalent to that of previous research that has used similar protocols (e.g., Cherappurath et al., 2020; Guillot et al., 2013; Robin et al., 2025), the number of participants could be considered to be relatively small. For this reason, the results of this study must be confirmed with larger samples of participants before any generalization. In addition, it is also possible that the players in the Control group were less motivated than those in the Feedback and Feedback+Imaging groups due to the experimental conditions (Robin et al., 2020) and instructions involving a passive attitude towards the baseline fouls committed during training sessions.

CONCLUSION

The results of this study showed on the one hand that tennis players who benefited from the coach's feedback improved their baseline game performance in a precision event with the ball thrower but also in a match situation (i.e., super-tie-break), and on the other hand that visualization increased the positive effects. Although this research needs to be confirmed by studies with larger sample sizes, we recommend that coaches use motor imagery integrated into training, in addition to the feedback they give to players, in order to improve the performance of the baseline game.

CONFLICT OF INTEREST AND FUNDING

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

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An updated assessment of the predictive accuracy of World Tennis Number and Universal Tennis Ratings

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ABSTRACT

In 2024, the World Tennis Number (WTN) algorithm was updated to enhance its predictive accuracy. This study analyzes 3,727 matches involving elite-level junior development players in the 12-and-under (12U) and 14-and-under (14U) categories, as well as Intercollegiate Division 1 players, from tournaments sanctioned by the United States Tennis Association (USTA), United Kingdom Lawn Tennis Association (LTA), Tennis Europe (TE), and the Intercollegiate Tennis Association (ITA). We compare the updated WTN and Universal Tennis Rating (UTR) classification accuracy in predicting match winners across these competitions. Our findings reveal no consistent evidence that WTN outperforms UTR in any category. UTR exhibits superior predictive accuracy in junior tournaments and in prequalifying rounds at the collegiate level, which highlights rating differences when players transition into new competitive environments. This study provides new evidence on the predictive accuracy of WTN and UTR in the context of young elite junior players and top collegiate talent.

Key words: World Tennis Number (WTN), Universal Tennis Rating (UTR), Junior Tennis, Match Forecasting

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INTRODUCTION

On September 11, 2024, the International Tennis Federation (ITF) introduced enhancements to the World Tennis Number (WTN). This WTN update incorporated match results from over 80 nations, drawing on more than 30 million recorded matches, alongside feedback from players, coaches, and national federations (ITF, 2024). The purpose of this paper is to evaluate the ability of the newly updated WTN to predict match outcomes relative to the Universal Tennis Rating (UTR) for elite level tournaments in junior categories and at the ITA All American Championships.

Prior research investigating the ability of WTN and UTR to predict match outcomes has generally documented that WTN and UTR are equivalent predictors of match outcomes (Im & Lee, 2023; Krall et al., 2024; Mayew & Mayew, 2023). However, these studies focus exclusively on matches from the United States Tennis Association (USTA) Junior National Championships prior to the 2024 WTN algorithm change, making it unclear whether existing insights regarding match prediction are generalizable. The USTA Junior National Championships is the premier junior tournament for players in the United States, spanning ages 16U and 18U for both boys and girls. To increase external validity, we analyze premier non-professional tournaments beyond the USTA Junior National Championships to assess WTN and UTR predictive accuracy in samples that are not confined to U.S. players and in age ranges that come both before and after the age ranges of the USTA Junior National Championship.

For players older than the USTA Junior National Championship sample, we study the 2024 Intercollegiate Tennis Association (ITA) Division 1 Men's and Women's All-American Championships. For players younger than the USTA Junior National Championships sample, we study elite tournaments across USTA, Lawn Tennis Association (LTA), and Tennis Europe (TE) sanctioned events including the 2024 Lexus British Indoor National Championships, 2024 Junior Orange Bowl, 2025 Les Petits As Mondial Wilson, and 2025 Open Super 12 Auray. These tournaments are highly selective which helps ensure the players have extensive match histories upon which a WTN or UTR could be based.

Updating the academic record regarding the predictive accuracy of WTN and UTR is important as tennis organizations around the world debate whether to adopt WTN or UTR as the preferred rating system and as WTN becomes more widely used for tournament entry and seeding criteria. Whether WTN or UTR will predict match outcomes differentially in our sample is an open empirical question. Given the ITF's stated expectation that WTN algorithm change effects should be most pronounced in junior divisions (ITF, 2024), we may observe superior WTN classification accuracy in 12U and 14U events. At the collegiate level, the Intercollegiate Tennis Association (ITA) adopted WTN as its official rating system in 2023 from UTR (ITA, 2023). This may imply that WTN is superior at the college level.

METHODS

Sample

We obtain match and player information by reviewing publicly displayed match draws on the ITA, USTA, LTA and TE websites for the tournaments summarized in Table 1.

Table 1
List of categories and subcategories.

Federation	Age Group	Tournament	Category	Gender
ITA	College	2024 ITA All-American Championships	NCAA Div. 1	M / F
USTA	12U, 14U	2024 Junior Orange Bowl	Level 2	M / F
USTA	12U, 14U	2024 IMG Academy International Championships	Level 2	M / F
LTA	12U*, 14U	2024 Lexus Junior Indoor National Championships	Grade 1	M / F
LTA	12U*	2024 Lexus Junior National Tour	Grade 2	M / F
LTA	14U	National Age Group Matchplay	N/A	M
LTA	12U*, 14U	2025 Lexus Junior National Tour	Grade 2	M / F
LTA	14U	2025 Lexus Clay Court Championships	Grade 1	M / F
TE	14U	2025 Lexus Junior International Bolton	Cat 1	M / F
TE	14U	2025 Les Petits As Mondial Wilson	Super Cat	M / F
TE	14U	Kungens Kanna & Drottningens Pris	Super Cat	M / F
TE	14U	Tim Essonne	Cat 1	M / F
TE	14U	Lexus Junior International Liverpool	Cat 3	M / F
TE	12U	Open Super 12 Auray	Cat 1	M / F
TE	12U	Lexus Junior International Nottingham	Cat 2	M / F

*Table 1 presents information about the tournaments analyzed. ITA is the Intercollegiate Tennis Association. USTA is the United States Tennis Association. LTA is the Lawn Tennis Association. TE is Tennis Europe. M (F) is male (female) gender. 12U (14U) indicates 12 (14) years old or younger. Collegiate competition is not based on age but rather eligibility. College players are typically aged between 18-23 years old. *This tournament also has an 11U division which is combined with 12U for analysis.*

These tournaments result in a sample of 4,174 potential matches, including main draw, qualifying, and consolation events for both male and female players, where applicable. After excluding matches affected by byes, pre-match withdrawals, retirements, missing UTR or WTN values for either player, and matches where both players had identical WTN or UTR ratings, the final sample consisted of 3,727 matches involving 3,020 players.

Player WTN and UTR ratings were recorded on the day before the tournament began. UTR values were sourced through a power subscription to the UTR Sports App (UTR, 2023), while WTN ratings were obtained from the ITF WTN rating website (ITF, 2023) or official tournament federation websites. The collected WTN values reflect the updated 2024 algorithm.

Statistical Analysis

For each match played, we follow Im & Lee (2023) and randomly choose one player from the match as the reference player. We then regress an indicator variable for whether the randomly chosen reference player won the match on the difference between the reference player's rating versus the rating of the other player. Separate bivariate logistic regressions are estimated for UTR and WTN ratings using STATA/SE 18.5 statistical software. From each logistic regression we obtain two measures of classification accuracy utilized in the tennis match forecasting literature: the area under the receiver operator characteristic curve (AUC) (Im & Lee 2023; Krall et al 2024; Mayew and Mayew 2023), and the Brier score (Boulier and Stekler, 1999; del Corral and Prieto-Rodriguez, 2010; Krall et al 2024; Mayew and Mayew 2023). An AUC (Brier score) value of 0.50 (0.25) represents random chance levels of classification accuracy, and an AUC (Brier score) of 1.00 (0.00) represents perfect classification accuracy. We statistically test for equality between WTN AUC (AUC_{WTN}) and UTR AUC (AUC_{UTR}), as well as WTN Brier score ($BRIER_{WTN}$) and UTR Brier score ($BRIER_{UTR}$). We consider p-values < 0.05 to be statistically significant.

RESULTS

In Panel A of Table 2, we provide WTN and UTR values for players in the 2024 ITA All-American Championships overall, followed by a decomposition by both gender and draw stage. Consistent with prior research for similarly aged players, males have higher (lower) UTR (WTN) values than females (Krall et al. 2024; Mayew and Mayew 2023). Additionally, the main draw players have higher (lower) UTR (WTN) than the pre-qualifying and qualifying draw, consistent with higher quality players making it further in the tournament than lower quality players.

In Panel B we tabulate how often the favored player wins the match. Overall, we find the favored player based on WTN wins 59.83% of the time. This is statistically smaller than what is observed for UTR, where the favored player wins between 66.50% of the time. These proportions differ from the existing literature examining the USTA Junior National Championships, where the favored player won about 75% of the time regardless of whether WTN or UTR was used (Im & Lee, 2023; Krall et al. 2024; Mayew and Mayew 2023). These proportions are also smaller than the proportions ranging from 71.2% and 81.8% in Grand Slam professional tournaments (Boulier and Stekler, 1999; del Corral and Prieto-Rodriguez, 2010). We note that these accuracy rates at the professional level were derived using player rankings to determine the favored player, not UTR or WTN ratings. These studies predated the availability of UTR and WTN ratings and as a result accuracy rates are not perfectly comparable.

We observe similar inferences as the overall sample when we consider matches by gender. The favored player based on UTR wins more often than the favored player based on WTN, suggesting the overall sample proportion differences do not appear to be driven by gender. However, when we partition by draw stage, we find the overall difference in predictive accuracy is driven by the pre-qualifying and qualifying matches, not main draw matches. In the main draw, the favored player based on WTN and UTR wins 61.95% and 62.44% of the time respectively and these proportions do not statistically differ (p-value = 1.00). However, in the pre-qualifying and qualifying draw, the favored player based on WTN wins the match 58.68% of the time, which is statistically smaller than the 68.68% based on UTR (p-value < 0.0001).

Proportions only consider the sign of the rating difference between players, not the magnitude. To ascertain whether these patterns hold when we formally consider the magnitude of the difference between player ratings, we perform two different analyses. First, we sort the entire sample by the absolute difference in UTR and partition the sorted sample into quintiles from smallest differences to largest differences and report the percentage of the time the favored player wins. We repeat the exercise using WTN and display the results in Figure 1. Each quintile therefore is comprised of approximately 117 matches. We find that in four of the five quintiles, UTR outperforms WTN, suggesting that the overall outperformance of UTR over WTN is consistent across most quintiles, with UTR outperforming WTN in the first, second, fourth, and fifth quintiles, while WTN slightly outperforms UTR in the third quintiles.

Table 2
Analysis of 2024 ITA All-American Championships.

Panel A. Player Level Descriptive Statistics

	Overall (N=438)		Men (n=220)		Women (n=218)		Main Draw (n=125)		Pre-Qual/Qual (n=346)	
VARIABLE	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**
WTN	9.97	3.80	6.62	1.91	13.35	1.61	8.28	3.75	10.49	3.66
UTR	11.51	1.45	12.88	0.44	10.12	0.45	11.94	1.42	11.38	1.43

Panel B. How Often Favored Players Win Matches

	Overall (N=585)		Men (n=298)		Women (n=287)		Main Draw (n=205)		Pre-Qual/Qual (n=380)	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**	**#**	**%**
FAVORED PLAYER WINS$_{WTN}$	350	59.83%	175	58.72%	175	60.98%	127	61.95%	223	58.68%
FAVORED PLAYER WINS$_{UTR}$	389	66.50%	193	64.77%	196	68.29%	128	62.44%	261	68.68%
P-value test of equal proportions+	0.0003		0.0133		0.0125		1.0000		<0.0001	

Panel C. Match Outcome Prediction Analysis Based on Logistic Regression Results

	Overall (N=585)		Men (n=298)		Women (n=287)		Main Draw (n=205)		Pre-Qual/Qual (n=380)	
VARIABLE	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**
AUC$_{WTN}$	0.6362	0.5917 0.6807	0.6346	0.5718 0.6975	0.6380	0.5749 0.7012	0.6554	0.5805 0.7303	0.6282	0.5714 0.6849
AUC$_{UTR}$	0.7038	0.6633 0.7444	0.6901	0.6281 0.7520	0.7150	0.6575 0.7725	0.6688	0.5938 0.7438	0.7272	0.6769 0.7776
P-value of test++: AUC$_{WTN}$ =AUC$_{UTR}$	<0.0001		0.0053		0.0008		0.5218		<0.0001	
BRIER$_{WTN}$	0.2361	0.2273 0.2449	0.2352	0.2225 0.2478	2364	0.2239 0.2489	0.2316	0.2154 0.2479	0.2382	0.2277 0.2487
BRIER$_{UTR}$	0.2183	0.2062 0.2305	0.2180	0.2001 0.2359	0.2183	0.2010 0.2355	0.2265	0.2078 0.2453	0.2106	0.1940 0.2272
P-value of test+++: BRIER$_{WTN}$=BRIER$_{UTR}$	<0.0001		0.0019		0.0028		0.3267		<0.0001	

Table 2 presents data for 438 sample players in Panel A and 585 sample matches in Panels B and C from the 2024 ITA All-American Championships. UTR is the UTR value as of the start of the tournament, which ranges from 1.00 (lowest skill) to 16.50 (highest skill). WTN is the WTN value as of the start of the tournament and ranges from 40.00 (lowest skill) to 1.00 (highest skill). FAVORED PLAYER WINS$_{WTN(UTR)}$ indicates the player with the lower (higher) WTN (UTR) won the match. AUC$_{WTN}$ and BRIER$_{WTN}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player WTN minus the WTN of the other player. AUC$_{UTR}$ and BRIER$_{UTR}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player UTR minus the UTR of the other player. AUC (Brier score) values of 0.50 (0.25) represent chance levels of classification accuracy and 1.00 (0.00) represent perfect classification accuracy. EST is the derived estimate, and 95% CI indicates the 95% confidence interval using bootstrap method. All reported p-values are two tailed. +McNemar test of equal proportions; ++DeLong et al. (1998) test of equal areas called via the roccomp command in STATA; +++Paired t-test.

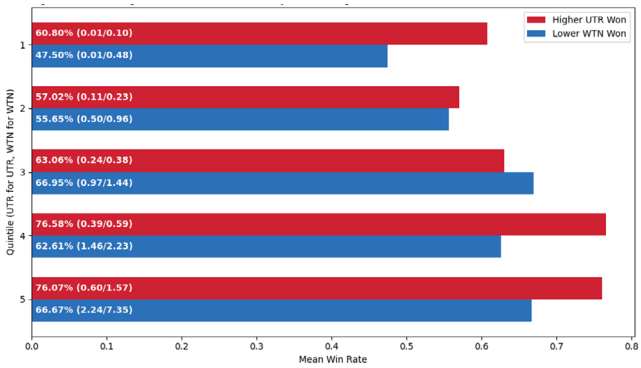

Figure 1. *Favored Player Win Percentage at the 2024 ITA All-American Championships.*

Figure 1 shows the percentage of the time the favored player won based on UTR and WTN for 585 matches examined in Table 1. The x-axis shows the proportion of matches won by the player with the higher (lower) UTR (WTN). Each quintile of the absolute difference in rating between players is displayed from lowest (quintile 1) to highest (quintile 5) on the y-axis, with the minimum and maximum values of the absolute rating difference range indicated on each bar.

A second method to consider the magnitude of the difference in rating is to estimate logistic regressions where the dependent variable equals 1 if a randomly chosen player from the pair wins the match as a function of the magnitude of the rating difference between that randomly chosen player and the opponent. Such regressions allow for the derivation of AUC and Brier scores to assess classification accuracy. In Panel C, overall, we observe AUC values (AUC_{UTR} = 0.704 versus AUC_{WTN} = 0.636, p-value = <0.001) and Brier scores ($BRIER_{UTR}$ = 0.218 versus $BRIER_{WTN}$ = 0.236 p-value = <0.001) that statistically differ in a manner consistent with UTR offering better classification accuracy than WTN. As with the proportions in Panel B, both AUC and Brier scores show statistically stronger classification accuracy for UTR over WTN for both males and females. Also consistent with the proportions in Panel B, we find WTN and UTR exhibit statistically equivalent classification accuracy in the main draw using either AUC (AUC_{UTR} = 0. 669 versus AUC_{WTN} = 0.655, p-value = 0.522) or Brier scores ($BRIER_{UTR}$ = 0.227 versus $BRIER_{WTN}$ = 0.232, p-value = 0.327). In pre-qualifying and qualifying matches, however, UTR exhibits superior classification accuracy over WTN using both AUC (AUC_{UTR} = 0.727 versus AUC_{WTN} = 0.628, p-value = <0.001) and Brier scores ($BRIER_{UTR}$ = 0.211 versus $BRIER_{WTN}$ = 0.238, p-value = <0.001).

Thus far, we have only considered gender and draw stage separately. To ascertain whether there are interactive effects we examine subsamples conditioned by both draw stage and gender in Table 3. Panel B reveals that the proportion of matches won by the favored player based on WTN and UTR is statistically identical for both men and women in the main draw but statistically differs in the pre-qualifying and qualifying draw. The difference in proportions is similar in magnitude at 9.23% for men and 10.81% for women. Similar inferences are obtained using AUC and Brier Scores in Panel C. We therefore conclude that for the ITA sample, draw stage but not gender is responsible for the overall superiority of UTR over WTN for predicting match outcomes.

Table 4 extends this ITA analysis to elite junior development tournaments (LTA, USTA and TE). Similarly to the ITA data and consistent with prior research for similarly aged players, panel A shows that males have higher (lower) UTR (WTN) values than females (Krall et al. 2024; Mayew and Mayew 2023). We find in Panel B that across 3,142 junior matches, the WTN favored player wins 74.57% of the time, while UTR favored players win 78.87% (p-value < 0.001). The magnitudes of these proportions are in a range similar to the USTA Junior National Championships and to professional tennis results (Mayew & Mayew 2023).

Figure 2 displays the percentage of the time the favored player wins by quintile of the absolute difference ratings between opponents. Each quintile contains approximately 628 matches. In all quintiles, UTR outperforms WTN, suggesting the overall superiority of UTR is not concentrated in any particular part of the rating difference distribution. Moreover, the proportion of the time the favored player wins generally decreases as the magnitude of the difference in rating decreases, similar to the results documented in Im & Lee (2023).

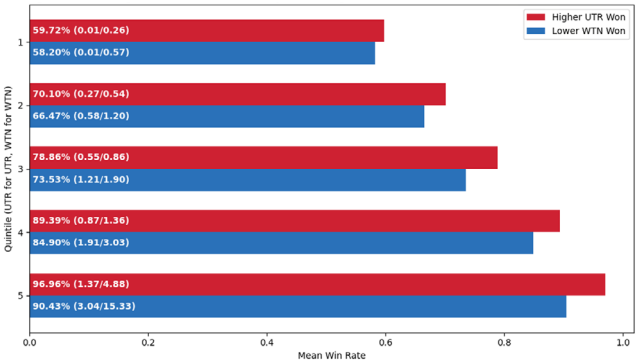

Figure 2. *Favored Player Win Percentage in 2024/25 World Junior Development Tournaments*

Figure 2 shows the percentage of the time the favored player won based on UTR and WTN for 3,142 examined in Table 4. In Figure 2, the x-axis shows the proportion of matches won by the player with the higher (lower) UTR (WTN). Each quintile of the absolute difference in rating between players is displayed from lowest (quintile 1) to highest (quintile 5) on the y-axis, with the minimum and maximum values of the absolute rating difference range indicated on each bar.

Considering the magnitude of rating differences via logistic regression (Table 4, Panel C) also suggests UTR superiority. UTR significantly outperforms WTN overall (AUC: 0.868 vs. 0.817, p-value < 0.001; Brier Score: 0.148 vs. 0.175, p-value < 0.001). We also find UTR statistically outperforms WTN in each subsample, regardless of whether we partition by gender or by age.

In Panel C of Table 5 we further decompose the sample by both age and gender, revealing that UTR consistently outperforms WTN in all categories. The largest disparity also emerges in 14U Boys, where UTR provides significantly higher classification accuracy (AUC: 0.858 vs. 0.785, p-value < 0.001; Brier Score: 0.154 vs. 0.189, p-value < 0.001), whereas 12U Girls (AUC: 0.900 vs. 0.849, p-value < 0.001; Brier Score: 0.128 vs. 0.157, p-value < 0.001) and 14U Girls (AUC: 0.844 vs. 0.807, p-value < 0.001; Brier Score: 0.161 vs. 0.180, p-value < 0.001) show smaller magnitude but still statistically significant differences.

Table 3
Analysis of 2024 ITA All-American Championships (Draw Stage x Gender).

Panel A. Player Level Descriptive Statistics

	MD Men (n=63)		MD Women (n=62)		PQQ Men (n=174)		PQQ Women (n=172)	
VARIABLE	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**
WTN	4.89	1.68	11.72	1.35	7.16	1.62	13.86	1.29
UTR	13.30	0.37	10.56	0.35	12.76	0.36	9.99	0.38

Panel B. How Often Favored Players Win Matches

	MD Men (n=103)		MD Women (n=102)		PQQ Men (n=195)		PQQ Women (n=185)	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**
FAVORED PLAYER WINS$_{WTN}$	63	61.17%	64	62.75%	112	57.44%	111	60.00%
FAVORED PLAYER WINS$_{UTR}$	63	61.17%	65	63.73%	130	66.67%	131	70.81%
P-value test of equal proportions+	1.0000		1.0000		0.0039		0.0045	

Panel C. Match Outcome Prediction Analysis Based on Logistic Regression Results

	MD Men (n=103)		MD Women (n=102)		PQQ Men (n=195)		PQQ Women (n=185)	
VARIABLE	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**
AUC$_{WTN}$	0.6538	0.5412 0.7663	0.6576	0.5504 0.7648	0.6272	0.5486 0.7058	0.6301	0.5484 0.7118
AUC$_{UTR}$	0.6701	0.5625 0.7777	0.6502	0.5434 0.7570	0.7036	0.6304 0.7767	0.7506	0.6809 0.8203
P-value of test++: AUC$_{WTN}$ =AUC$_{UTR}$	0.5795		0.799		0.0048		0.0003	
BRIER$_{WTN}$	0.2331	0.2094 0.2569	0.2302	0.2055 0.2548	0.2363	0.2207 0.2518	0.2391	0.2245 0.2536
BRIER$_{UTR}$	0.2205	0.1907 0.2503	0.2317	0.2081 0.2553	0.2153	0.1929 0.2376	0.2048	0.1799 0.2296
P-value of test+++: BRIER$_{WTN}$=BRIER$_{UTR}$	0.1506		0.7963		0.0045		0.0006	

Table 3 presents data for 438 sample players in Panel A and 585 sample matches in Panels B and C from the 2024 ITA All-American Championships. UTR is the UTR value as of the start of the tournament, which ranges from 1.00 (lowest skill) to 16.50 (highest skill). WTN is the WTN value as of the start of the tournament and ranges from 40.00 (lowest skill) to 1.00 (highest skill). FAVORED PLAYER WINS$_{WTN(UTR)}$ indicates the player with the lower (higher) WTN (UTR) won the match. AUC$_{WTN}$ and BRIER$_{WTN}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player WTN minus the WTN of the other player. AUC$_{UTR}$ and BRIER$_{UTR}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player UTR minus the UTR of the other player. AUC (Brier score) values of 0.50 (0.25) represent chance levels of classification accuracy and 1.00 (0.00) represent perfect classification accuracy. EST is the derived estimate, and 95% CI indicates the 95% confidence interval using bootstrap method. All reported p-values are two tailed. +McNemar test of equal proportions; ++DeLong et al. (1998) test of equal areas called via the roccomp command in STATA; +++Paired t-test.

Table 4
Analysis of 2024/25 World Junior Development Tournaments.

Panel A. Player Level Descriptive Statistics

	Overall		Boys		Girls		12U		14U	
	(N=2,582)		(n=1,329)		(n=1,253)		(n=1,045)		(n=1,537)	
VARIABLE	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**
WTN	28.52	3.17	28.01	2.90	29.05	3.36	30.79	2.34	26.97	2.70
UTR	7.03	1.74	7.56	1.66	6.46	1.65	5.72	1.44	7.91	1.32

Panel B. How Often Favored Players Win Matches

	Overall		Boys		Girls		12U		14U	
	(N=3,142)		(n=1,615)		(n=1,527)		(n=1,357)		(n=1,785)	
	#	%	#	%	#	#	#	%	#	%
FAVORED PLAYER WINS$_{WTN}$	2,343	74.57%	1,188	73.56%	1,155	75.64%	1,050	77.38%	1,293	72.44%
FAVORED PLAYER WINS$_{UTR}$	2,478	78.87%	1,279	79.20%	1,199	78.52%	1,096	80.77%	1,382	77.42%
P-value test of equal proportions+	<0.0001		<0.0001		0.0028		0.0021		<0.0001	

Panel C. Match Outcome Prediction Analysis Based on Logistic Regression Results

	Overall		Boys		Girls		12U		14U	
	(N=3,142)		(n=1,615)		(n=1,527)		(n=1,357)		(n=1,785)	
VARIABLE	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**
AUC$_{WTN}$	0.8167	0.8019 0.8315	0.8096	0.7896 0.8295	0.8243	0.8044 0.8442	0.8467	0.8263 0.8671	0.7953	0.7753 0.8153
AUC$_{UTR}$	0.8677	0.8552 0.8803	0.8669	0.8498 0.8840	0.8687	0.8520 0.8855	0.8882	0.8710 0.9054	0.8510	0.8339 0.8681
P-value of test++: AUC$_{WTN}$ =AUC$_{UTR}$	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	
BRIER$_{WTN}$	0.1748	0.1679 0.1817	0.1780	0.1690 0.1871	0.1713	0.1617 0.1808	0.1591	0.1485 0.1698	0.1845	0.1760 0.1931
BRIER$_{UTR}$	0.1481	0.1409 0.1554	0.1487	0.1389 0.1586	0.1474	0.1377 0.1571	0.1353	0.1245 0.1461	0.1575	0.1483 0.1667
P-value of test+++: BRIER$_{WTN}$=BRIER$_{UTR}$	<0.0001		<0.0001		<0.0001		<0.0001		<0.0001	

Table 4 presents data for 2,582 sample players in Panel A and 3,142 sample matches in Panels B and C from the Junior Development tournaments. UTR is the UTR value as of the start of the tournament, which ranges from 1.00 (lowest skill) to 16.50 (highest skill). WTN is the WTN value as of the start of the tournament and ranges from 40.00 (lowest skill) to 1.00 (highest skill). FAVORED PLAYER WINS$_{WTN(UTR)}$ indicates the player with the lower (higher) WTN (UTR) won the match. AUC$_{WTN}$ and BRIER$_{WTN}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player WTN minus the WTN of the other player. AUC$_{UTR}$ and BRIER$_{UTR}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player UTR minus the UTR of the other player. AUC (Brier score) values of 0.50 (0.25) represent chance levels of classification accuracy and 1.00 (0.00) represent perfect classification accuracy. EST is the derived estimate, and 95% CI indicates the 95% confidence interval using bootstrap method. All reported p-values are two-tailed. +McNemar test of equal proportions; ++DeLong et al. (1998) test of equal areas; +++Paired t-test.

Table 5
Analysis of 2024/25 World Junior Development Tournaments (Age Group + Gender).

Panel A. Player Level Descriptive Statistics

	12U Boys (n=536)		12U Girls (n=509)		14U Boys (n=793)		14U Girls (n=744)	
VARIABLE	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**	**MEAN**	**STD**
WTN	30.09	2.04	31.53	2.40	26.61	2.53	27.35	2.82
UTR	6.23	1.31	5.19	1.37	8.45	1.21	7.34	1.19

Panel B. How Often Favored Players Win Matches

	12U Boys (n=694)		12U Girls (n=663)		14U Boys (n=921)		14U Girls (n=864)	
	#	**%**	**#**	**%**	**#**	**%**	**#**	**%**
FAVORED PLAYER WINS$_{WTN}$	530	76.37%	520	78.43%	658	71.44%	635	73.50%
FAVORED PLAYER WINS$_{UTR}$	556	80.12%	540	81.45%	723	78.50%	659	76.27%
P-value test of equal proportions+	0.0178		0.0619		<0.0001		0.0236	

Panel C. Match Outcome Prediction Analysis Based on Logistic Regression Results

	12U Boys (n=694)		12U Girls (n=663)		14U Boys (n=921)		14U Girls (n=864)	
VARIABLE	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**	**EST**	**95% CI**
AUC$_{WTN}$	0.8436	0.8159 0.8713	0.8494	0.8201 0.8788	0.7850	0.7544 0.8147	0.8069	0.7780 0.8358
AUC$_{UTR}$	0.8779	0.8530 0.9029	0.8998	0.8772 0.9224	0.8581	0.8347 0.8816	0.8438	0.8177 0.8700
P-value of test++: AUC$_{WTN}$ =AUC$_{UTR}$	0.0037		<0.0001		<0.0001		<0.0001	
BRIER$_{WTN}$	0.1612	0.1467 0.1756	0.1570	0.1417 0.1724	0.1890	0.1768 0.2012	0.1796	0.1665 0.1926
BRIER$_{UTR}$	0.1420	0.1269 0.1570	0.1280	0.1130 0.1430	0.1537	0.1407 0.1667	0.1611	0.1474 0.1748
P-value of test+++: BRIER$_{WTN}$=BRIER$_{UTR}$	0.0034		<0.0001		<0.0001		<0.0001	

Table 5 presents data for 2,582 sample players in Panel A and 3,142 sample matches in Panels B and C from the Junior Development tournaments. UTR is the UTR value as of the start of the tournament, which ranges from 1.00 (lowest skill) to 16.50 (highest skill). WTN is the WTN value as of the start of the tournament and ranges from 40.00 (lowest skill) to 1.00 (highest skill). FAVORED PLAYER WINS$_{WTN(UTR)}$ indicates the player with the lower (higher) WTN (UTR) won the match. AUC$_{WTN}$ and BRIER$_{WTN}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player WTN minus the WTN of the other player. AUC$_{UTR}$ and BRIER$_{UTR}$ represent the area under the receiver operator curve and Brier score, respectively, derived from a bivariate logistic regression where the dependent variable is an indicator for whether a randomly chosen reference player from the pair wins the match and the independent variable is the reference player UTR minus the UTR of the other player. AUC (Brier score) values of 0.50 (0.25) represent chance levels of classification accuracy and 1.00 (0.00) represent perfect classification accuracy. EST is the derived estimate, and 95% CI indicates the 95% confidence interval using bootstrap method. All reported p-values are two-tailed. +McNemar test of equal proportions; ++DeLong et al. (1998) test of equal areas; +++Paired t-test.

DISCUSSION

This study evaluates the predictive accuracy of the WTN following its 2024 algorithm update versus UTR, using match data from the ITA All-American Championships and elite junior development tournaments across USTA, LTA, and Tennis Europe circuits. Our findings indicate that WTN does not significantly outperform UTR in predicting match outcomes at either the collegiate or junior development levels. Instead, except for the main draw stage at the collegiate level, UTR exhibits higher predictive accuracy than WTN.

We can only put forward conjectures as to why WTN ratings exhibit less ability to predict match outcomes versus UTR. The results from the ITA All-American Championships may be driven by variation in the players country of origin. Collegiate tennis is comprised of a substantial fraction of international players (Grabb, 2023). The differential predictive accuracy may, therefore, be driven by collegiate players from countries that are not fully onboarded to WTN and may experience inferior WTN performance relative to UTR. Any such effects may also be exacerbated by class standing, whereby, underclassmen have more of their prior record tied to their historical origin country record, which dissipates as the player engages in more and more matches at the college level over time. Future research might therefore consider player country of origin and the role of collegiate class standing in explaining the predictive accuracy differences we observe at the collegiate level.

At the junior level, since the oldest age group we analyze is 14U, one possible explanation for the inferiority of WTN relative to UTR in all of our analysis is the extent of match histories. UTR analyzes matches on a rolling one-year basis. WTN, on the other hand, considers full match histories, and so for young players, it may be that enough time has not passed to accumulate a sufficient match history. This potential problem is, of course, exacerbated if a junior player is from a geographic location not onboarded fully to WTN.

The largest discrepancy occurs in the 14U boys' division, where UTR classification accuracy superiority is 7.4% based on AUC. WTN may underperform particularly in this setting as this is the age elite boys increasingly transition from national to international competition, facing a broader range of opponents outside their domestic circuits. This change in player network may inhibit the ability of WTN to predict match outcomes much like new collegiate players entering the ITA setting. Moreover, puberty begins to play a role with larger serve speed changes for boys versus girls around this age (Fernndez-Fernndez et al., 2019). If puberty also plays a role in transitioning a player to a new player network due to increased size and skill, WTN may take longer to adapt because of the longer match histories it considers relative to UTR. Future research might begin to consider whether differences in competitor physical attributes that occur during puberty explain the UTR and WTN predictive accuracy differential we observe, as has been considered at the professional level (del Corral and Prieto-Rodriguez, 2010). To date public data on physical characteristics of junior players is, unfortunately, not readily available.

While we find evidence that UTR outperforms WTN in predictive accuracy in the sample of elite tournaments we analyze, we cannot ascertain how UTR and WTN will perform in other settings. For example, UTR and WTN have repeatedly performed equivalently well in the USTA Junior National Championship two years in row (Im & Lee, 2023; Krall et al, 2024; Mayew & Mayew 2023). If the reason for this equivalent predictive accuracy is the homogenous nature of the players analyzed, it may well be the case that ITF tournaments containing players primarily from the same country will also exhibit UTR and WTN predictive accuracy that does not differ. Future research should extend our analysis to other settings. Moreover, we acknowledge that WTN has been in existence for a shorter period of time relative to UTR. As future algorithm enhancements occur and more countries onboard the accuracy differences we observe may dissipate.

CONCLUSION

We provide insights on whether the classification accuracy of WTN improved after the 2024 algorithm change using 3,727 matches from elite tennis events primarily comprised of 12U and 14U players. We find UTR generally outperforms WTN in predicting match outcomes, potentially due to our elite level tournaments containing players that are integrating into new competitive structures and due to players from countries who have not fully onboarded to WTN.

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Knowledge management in tennis as a collaborative process: a strategic approach to innovation in sports organizations

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ABSTRACT

This proposal, developed as a strategic article based on a theoretical review and the author's applied experience, assumes knowledge management not only as a set of technical tools, but as a dynamic, social and collaborative process that allows for the preservation, sharing and transformation of organizational knowledge. In the field of sports, where experiential learning is constant and often informal, this perspective highlights the need to systematize and collectivize this knowledge as a strategic asset. The collaborative approach enhances the participation of all the institution's actors (coaches, managers, athletes, technical staff), generating a culture of continuous learning. In this way, innovation is not imposed from the outside, but emerges from within, the result of an articulated management of collective knowledge, which ensures sustainability, institutional identity and continuous improvement.

Key words: Knowledge Management, Innovation, Sports Management, Organizational Learning.

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INTRODUCTION

In the world of sport, where results are visible and measurable, knowledge management is still an aspect that is often invisible, but decisive. While resources are invested in facilities, technology or competitions, few sports organizations spend time asking: what do we do with the knowledge we generate?

The experience accumulated by coaches, physical trainers, sports psychologists and different actors involved in sports development, represents an asset that, if not properly managed, is lost over time. Development plans, player evaluations, institutional decisions, learning after tournaments or even projects that have not materialized, often remain only in the memory of those who lived them. And when that person leaves the institution, a large part of that knowledge also leaves.

This article analyses the reasons why knowledge management should be consolidated as a strategic tool for clubs, academies and sports federations, and proposes concrete strategies to facilitate its implementation. It is framed in a theoretical-practical approach that combines contributions from specialized literature with the author's professional experience in consulting processes and organizational development in the sports field.

What is knowledge management?

Knowledge management can be defined as the structured process by which an organization creates, organizes, shares, and applies relevant knowledge to improve its performance, generate innovation, and sustain its competitive advantage over time (Davenport & Prusak, 1998; Holsapple, 2005).

This approach has evolved from its origin in the business field, to its application in complex organizations, including sports institutions, where technical, methodological and experiential knowledge represents a strategic asset. Indeed, several authors agree that adequate knowledge management allows organizations to adapt more quickly to change, consolidate learning, and avoid the loss of critical knowledge when a key member leaves the institution (Araujo de la Mata, 2008; Malhotra, 1998; Scarbrough, 2003).

In the context of sports organizations, knowledge manifests itself in two main forms:

1. Explicit knowledge: This type of knowledge is easily articulated and can be documented in manuals, protocols, training plans, evaluations, and statistical records. Their encoding and storage facilitate transfer and reuse within the organization (Manev & Jakimovski, 2017).
2. Empirical knowledge: More difficult to formalize, this knowledge resides in the practical experience, intuition, and personal skills of individuals. In the sports field, it is reflected in situational decision-making, reading the game and understanding team dynamics. The effective management of this knowledge requires strategies that encourage its externalization and sharing, such as communities of practice and mentoring (Martínez-Salinas, 2023).

Managing knowledge, therefore, is not limited to accumulating documents or creating databases, but involves fostering an organizational culture that values continuous learning, intergenerational transfer, and collaborative work. As Trillo Holgado and Sánchez Cañizares (2006) point out, the

success of these programs depends not only on the technical structure, but also on factors such as institutional culture and motivational practices. This reinforces the idea that knowledge management should not fall to a specific person but should be assumed as a strategic organizational initiative (Davenport & Prusak, 1998).

Why is it key in sport?

In the sports context, characterized by its dynamism, high staff turnover and constant pressure for results, knowledge management acquires strategic relevance.

Organizations that fail to preserve, transfer, and evolve their knowledge run the risk of repeating mistakes, interrupting training processes, and wasting hard-earned learning over time.

Photos 1 and 2. *Images of a knowledge transfer session in different tennis academies, integrating group discussions, visual materials and collaborative spaces to strengthen collective learning.*

A common example in clubs and academies is the departure of a coach who, after several years of work, takes with him evaluation criteria, training methodologies, competition strategies and a deep knowledge of the context and the players. When there are no mechanisms for documentation and transfer, the organization is devoid of this knowledge. What should be an ongoing process, turns into a series of improvised reboots.

Knowledge management allows to:

3. Safeguard the intellectual capital of the organization: ensure that key knowledge does not depend exclusively on people but is institutionalized.
4. Increase the quality of training processes: by having protocols, records, indicators and feedback systems.
5. Promote innovation and continuous improvement: because it allows learning from practice and evolving from collective experience.
6. Develop a culture of shared learning: that promotes dialogue between areas (technical, physical, medical, psychological), between coaches of different categories, and between generations of professionals.

From a sustainability perspective, knowledge management also allows a sports entity to consolidate its methodological identity, which is essential to build a coherent training proposal in the long term. As Trillo Holgado (2006) points out, knowledge should not be seen as a static resource, but as a living process of collective creation and evolution.

In this sense, sports institutions that develop internal mechanisms to systematize good practices, share learning between technical teams, generate databases on athlete development and facilitate access to this information, have a clear competitive advantage. Not only do they improve their performance, but they strengthen their organizational culture.

In the words of Wenger (1998), creator of the concept of communities of practice, "learning organizations are those that manage to convert experience into shared and applied knowledge." In sports, this implies that knowledge should not be encapsulated on the field or in the mind of the coach but become an active part of the institution's capital.

Knowledge management, innovation and technology: a strategic triad

The interaction between these three components can be represented schematically (see Figure 1), highlighting how each one empowers the others and contributes to consolidating a process of continuous improvement in sports organizations. In today's sports ecosystem, characterized by complexity, volatility and constant evolution, innovation cannot depend solely on individual initiatives or the sporadic incorporation of new tools. It must arise from a structured management of knowledge that allows organizations to learn from themselves, share what they have learned and generate new ways of acting. In this framework, technology emerges as a key facilitator of these processes.

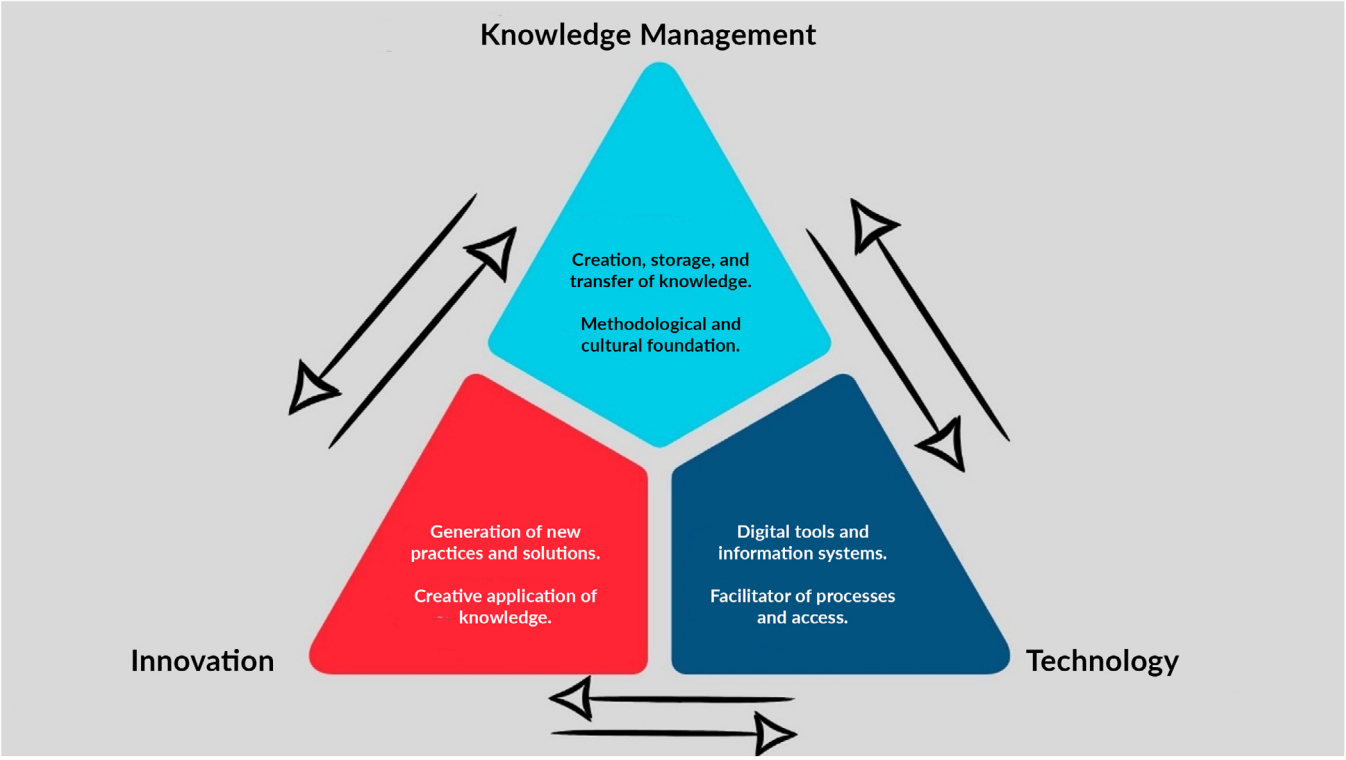

Figure 1. *The interaction between knowledge management, innovation and technology enhances organizational learning and sustainable development in sports entities.*

As Hislop, Bosua, and Helms (2018) argue, innovative organizations are those that not only preserve existing knowledge but also create conditions to transform it into unprecedented solutions. In sport, this transformation is enhanced when knowledge is captured, analysed and communicated using appropriate technological tools.

The relationship between knowledge management, innovation and technology materializes, for example, in:

- The use of digital platforms to systematize technical information and facilitate collaborative work between coaches.
- The creation of multimedia repositories (videos, internal podcasts, digital reports) that allow experiences to be converted into reusable content.
- The incorporation of performance analysis and data management software that allows you to visualize patterns and make more informed decisions.
- The development of virtual communities of practice, where professionals from different areas and locations can share good practices in real time.
- The use of artificial intelligence to identify trends in training, competition, or player development data.

León & Martínez (2022) highlight that, in sports contexts, innovation does not arise only from the adoption of new technologies, but from the intelligent articulation between existing knowledge, organizational culture, and technological tools. When this articulation takes place in an environment that values knowledge as an institutional asset, the innovative potential is multiplied.

In short, technology enhances the scope of knowledge management, making it more agile, accessible and sustainable. And at the same time, knowledge management provides meaningful content to innovation, preventing it from being reduced to a mere incorporation of fashions or tools without purpose.

Strategies to implement knowledge management in sports entities

Implementing knowledge management in a sports organization does not require large technological investments or complex structures. It requires, above all, an institutional decision to prioritize organizational learning and to develop simple, but sustained, mechanisms that allow the capture, sharing, and reuse of the knowledge generated day by day in the different areas of a club, academy, or federation.

Table 1 presents some key strategies and their corresponding examples.

These strategies do not necessarily require large structures, but they do require an institutional will to assume that knowledge should be treated as an organizational resource and not as individual property. The accumulated experience of coaches, physical trainers, psychologists or coordinators can become a differential if it is managed collaboratively, continuously and strategically.

Table 1
Strategies and examples for implementing knowledge management in tennis organizations.

Strategy	Key actions	Example
1. Systematize the practice	- Document training plans, methodological progressions, evaluation protocols, competency reports, and feedback sessions. - Use common templates for data recording and reuse.	A tennis academy that documents training plans monthly and shares them in a common digital folder, making it easy to consult and update.
2. Create transfer spaces	- Organize regular meetings of the technical team to share experiences and learnings. - Stimulate internal mentoring between coaches with different levels of experience.	A sports club that organises quarterly meetings where coaches and physical trainers present success stories and key learnings.
3. Fostering communities of practice	- Follow Wenger's (1998) approach to creating collaborative groups. - Use categories by age, functional areas or projects as exchange nuclei.	A group of coaches from different areas that meets virtually once a month to exchange methodological resources and solve common problems.
4. Digitize knowledge	- Create an internal database with documents, videos, reports, and analytics. - Use collaborative platforms for remote access and constant updating.	Use of a cloud platform where training videos, technical reports and training materials accessible to all staff are stored.
5. Evaluate and provide feedback on processes	- Design quality indicators on training processes and skills development. - Use feedback to improve methodological processes and not only the athlete's performance.	Design a system of indicators that allows measuring the quality parameters of a tennis school.
6. Strengthen the culture of learning	- Include observation, reflection, recording and communication skills in the coach's profile. - Reinforce the idea that sharing knowledge enriches the role of the coach and the organization.	Preparation of good practice manuals, methodological protocols or induction guides for new coaches, consolidating a culture of shared learning and continuity in training processes.

CONCLUSIONS

Knowledge management is an essential component for institutional strengthening in the field of sport. Far from being an exclusive practice of large corporations, its implementation in clubs, academies and federations represents a concrete opportunity to optimize processes, preserve significant learning and build organizational cultures based on continuous improvement.

In many sports organizations, technical, methodological and contextual knowledge remains dispersed, tacitly stored in the individual experience of coaches, coordinators or specialists. This type of knowledge, if not properly managed, is easily lost, generating discontinuities, unnecessary repetitions and even setbacks in institutional evolution.

In this sense, promoting knowledge management strategies makes it possible to transform accumulated knowledge into a valuable institutional asset, capable of prioritizing training systems, standardizing pedagogical criteria, facilitating the induction of new professionals and guaranteeing long-term coherence in sports projects.

Likewise, its incorporation strengthens the professionalization of internal structures, improves evidence-based decision-making, and promotes a more reflective, collaborative, and resilient organizational culture in the face of change.

In short, knowledge management not only provides operational value, but also acts as a catalyst for sustainable institutional development. Recognizing it as a strategic dimension implies assuming the commitment to institutionalize learning, systematize the experience and build a solid base from which sports projects can grow with meaning and continuity.

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