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Age-Related Characteristics and Training Methods for Enhancing Technical Formation in Child and Adolescent Tennis Players

Çocuk ve Genç Tenisçilerde Teknik Formasyonun Geliştirilmesinde Yaş Dönemi Özellikleri ve Antrenman Yöntemleri

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Abstract

This narrative review examines the development of technical formation in child and adolescent tennis players in relation to age-specific physiological, neuromotor, and cognitive characteristics, and discusses corresponding training methods. Peer-reviewed studies focusing on technical skill development in youth tennis players were identified through searches in PubMed, Web of Science, Scopus, and Google Scholar. The findings indicate that technical learning should not be viewed solely as motor skill acquisition, but rather as a multidimensional process shaped by growth and maturation, equipment and court scaling, attentional focus, feedback strategies, and game-based pedagogical approaches. Game-based, variable, and age-appropriate training models are more effective than traditional blocked practice in enhancing technical accuracy, retention, and transfer to match play. Furthermore, external focus instructions, self-regulated feedback, and functional neuromuscular training are reported to support technical stability, movement quality, and postural control. Overall, the evidence suggests that age- and maturation-sensitive, individualised and multidisciplinary training approaches are essential for the sustainable and healthy development of technical formation in young tennis players.

Keywords: Child, Tennis, Technical formation, Motor learning, Training

Öz

Bu çalışma çocuk ve genç tenisçilerde teknik formasyonun gelişimini yaşa özgü fizyolojik, nöromotor ve bilişsel özellikler bağlamında incelemekte ve bu doğrultuda kullanılan antrenman yöntemlerini tartışmaktadır. PubMed, Web of Science, Scopus ve Google Scholar veri tabanlarında yürütülen literatür taramasında, genç tenisçilere yönelik teknik beceri gelişimini ele alan ve hakemli dergilerde yayımlanmış çalışmalar değerlendirmeye alınmıştır. Bulgular, teknik öğrenmenin yalnızca motor beceri kazanımıyla sınırlı olmadığını; büyüme ve maturasyon süreçleri, ekipman ve kort ölçeklemesi, dikkat odağı, geri bildirim türleri ve oyun-temelli pedagojik yaklaşımlarla bütüncül biçimde ele alınması gerektiğini ortaya koymaktadır. Özellikle oyun-temelli, değişken ve yaşa uygun antrenman modellerinin, teknik doğruluk, öğrenmenin kalıcılığı ve oyun içi transfer üzerinde geleneksel blok tekrar yöntemlerine kıyasla daha etkili olduğu görülmektedir. Ayrıca, dışsal dikkat odaklı yönergeler, öz-yönelimli geri bildirimler, fonksiyonel ve nöromüsküler antrenman uygulamalarının teknik stabiliteyi, hareket kalitesini ve postüral kontrolü desteklediği vurgulanmaktadır. Sonuç olarak, yaşa ve biyolojik olgunluk düzeyine duyarlı, bireyselleştirilmiş ve çok disiplinli antrenman yaklaşımları, çocuk ve genç tenisçilerin teknik formasyonunun sürdürülebilir ve sağlıklı biçimde geliştirilmesi için kritik öneme sahiptir.

Anahtar Kelimeler: Çocuk, Tenis, Teknik formasyon, Motor öğrenme, Antrenman

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Introduction

This review aims to summarise the age-related characteristics that shape the development of technical formation in child and adolescent tennis players and to present age-specific training methods, equipment adaptations, neuromotor- and cognitive-aligned practices, and contemporary assessment and monitoring approaches. Translating current scientific evidence into coaching practice not only improves performance outcomes but also supports a healthy and sustainable developmental trajectory. In line with this purpose, this review provides a detailed examination of physical, neuromotor, and psychocognitive characteristics together with training practices tailored to these developmental features.

Tennis is a highly complex sport that demands the simultaneous integration of technical precision, rapid decision-making, motor coordination, and periodised physical development (Liu et al., 2024; Coşkuntürk et al., 2023a). Therefore, training programs designed to develop technical formation in children and adolescents must move beyond teaching correct stroke mechanics alone. They should also incorporate age-specific neuromotor sensitivities, learning strategies, appropriate equipment adaptations, and principles of long-term athlete development. Such an integrative approach aims to enhance performance while mitigating the injury risks associated with early specialisation and excessive training loads (Ford et al., 2011).

Importantly, motor learning capacity during childhood and adolescence is far from uniform. Each developmental stage presents distinct sensitive periods, coordination trajectories, and cognitive competencies. For instance, specific age ranges—such as 10 to 12 years—are characterised by accelerated improvements in motor coordination and specific tennis skills, highlighting the necessity of age-adapted training design (Coşkuntürk, et al., 2023b; Çalık & Öktem, 2024). As a result, technical training should progress from simple to complex in accordance with children's neuromotor capacities. It should incorporate variable, dynamic, and game-like conditions rather than relying solely on static technique drills (Waldziński et al., 2024).

Training methodology itself plays a decisive role in technical development. The literature consistently demonstrates that variable and random practice formats outperform traditional repetitive (blocked) practice in promoting long-term retention and transfer of skills to match play (Hebert et al., 1996). Moreover, integrating motor learning principles—such as providing appropriate feedback, progressively increasing task difficulty, and employing problem-based learning—further enhances the durability and contextual applicability of skills (Çalık, 2024; Yel et al., 2024). Consequently, coaches are encouraged to develop training frameworks that combine foundational motor learning research with effective on-court pedagogical strategies (Reid, 2007).

Additionally, environmental and equipment-related conditions are essential components of technical development. Age-appropriate scaling of racket size, ball type, court dimensions, and rule structures has been shown to improve technical control, accuracy, and self-confidence. Complementarily, neuromuscular and physical development programs reinforce technique acquisition by enhancing movement quality and injury resilience. This multidisciplinary approach strengthens technical proficiency not only at the mechanical level but also by supporting physical capacity, endurance, and decision-making skills (Wang et al., 2022).

Assessment and monitoring are equally indispensable for ensuring individualised progression. Systematic evaluation of technical criteria in young athletes enables the identification of current competencies and the prediction of long-term performance

trajectories. Therefore, training programs should be continuously updated using objective, measurement-based feedback. Furthermore, adequate management of training load and the training–competition balance supports sustainable learning and reduces the risk of injury (Kolman et al., 2021).

Taken together, these considerations underscore the importance of supporting technical formation at the correct developmental period and with appropriately tailored methods. Early childhood represents a particularly advantageous window for the development of coordinative skills, allowing technical learning to occur more rapidly and with greater permanence. Nevertheless, training content must remain aligned with the child's cognitive capacity, motivation, and psychosocial needs; otherwise, pressures associated with early specialisation may increase the risk of injury and premature dropout. Thus, an age-sensitive, progressive, and individualised training approach serves as a foundational determinant for the healthy and effective development of technical formation in young tennis athletes.

Method

This study is a narrative review examining the existing literature on the development of technical formation in child and adolescent tennis players. Relevant publications were identified through searches conducted in PubMed, Web of Science, Scopus, and Google Scholar using the keywords “youth tennis,” “skill acquisition,” “motor development,” “technical training,” “long-term athlete development,” and “junior tennis performance.” The inclusion criteria required that studies be conducted with child or adolescent tennis players, focus on technical skill development, and be published in peer-reviewed journals. Only studies for which full texts were available in Turkish or English were considered.

Research Design

The research design follows a descriptive, non-systematic review approach. Studies identified through the literature search were examined for content relevance and thematic alignment, and subsequently categorised according to age-related motor development characteristics, technical skill acquisition, and training methodologies. Within this thematic framework, each study was analysed in terms of its purpose, sample characteristics, training protocols, and reported technical performance outcomes, with an emphasis on factors that may influence technical formation at different developmental stages (e.g., coordination, neuromuscular control, cognitive development, equipment adaptation, and coach feedback).

During the synthesis process, the findings were not subjected to statistical meta-analysis. Instead, a narrative synthesis approach was adopted to describe patterns of similarity and divergence across studies. This method allowed the identification of key factors influencing technical development across age groups and supported the formulation of practice-oriented recommendations for training design. The overall aim of the review is to integrate current evidence and provide a theoretical and practical framework for supporting technical formation in child and adolescent tennis players in a systematic and developmentally appropriate manner.

Technical learning in young tennis athletes encompasses more than the acquisition of motor skills alone; it reflects the interaction of growth and maturation processes, cognitive development, equipment and court scaling, and pedagogical variables (e.g., task structure, types of feedback). Each of these factors directly influences the content,

intensity, and timing of training interventions; therefore, the methods applied must be sensitive to age and maturation-related differences.

Findings

Technical learning in child and adolescent tennis players encompasses more than the acquisition of motor skills; it reflects the interaction of growth, cognitive development, equipment scaling, and pedagogical variables such as task structure and types of feedback. Each of these factors directly shapes the content, intensity, and timing of training interventions; therefore, training strategies must be sensitive to both chronological age and biological maturation (Lloyd et al., 2015). Growth and maturation influence musculoskeletal structure, strength capacity, balance, coordination, and neuromotor control, defining optimal periods—or sensitive windows—for technical development. During early adolescence, rapid changes in physical capacity may lead to temporary fluctuations in technical performance, making it preferable to monitor markers of maturation rather than relying solely on chronological age when planning training (Myburgh et al., 2016).

Research consistently demonstrates strong associations between motor coordination, fundamental movement patterns (such as running, jumping, and balancing), and technical performance in young tennis players. Consequently, developing fundamental motor skills alongside technical work enhances training efficiency (Söğüt, 2016). The benefits of equipment and play-area scaling for children—such as smaller courts, low-compression balls, and age-appropriate racket length and weight—are robustly supported in the literature. Scaling modifies movement time, the amount and type of feedback received, and the nature of technical errors, enabling children to discover more functional movement solutions while increasing motivation and perceived competence. Numerous controlled studies have reported longer rally durations and higher accuracy rates when scaled equipment is used (Buszard et al., 2016). These findings highlight the necessity of tailoring the learning environment to children's anthropometrics.

Motor learning research has also highlighted the importance of attentional focus in skill acquisition. Studies in tennis indicate that instructions promoting an external focus of attention enhance learning by supporting more efficient motor control in children. Moreover, considering children's cognitive characteristics, visual and tactile cues—such as marked racket surfaces or colored target zones—have been shown to facilitate learning, particularly among younger players who may struggle with processing verbal explanations (Tapan et al., 2023). Feedback frequency and type (e.g., self-controlled feedback, positive reinforcement, knowledge-of-results vs. knowledge-of-performance) directly influence the rate of learning, with the literature recommending simple, guiding, externally oriented cues during the early stages of skill acquisition.

Biomechanical analyses in tennis, especially regarding the forehand stroke, provide detailed descriptions of mechanical components and learning phases. Studies examining forehand mechanics have documented changes in rotation, weight transfer, and racket-head speed across various age and maturation stages, as well as which components can be effectively modified through training. These biomechanical insights inform which technical elements should be prioritised in different stages of development. Recently, practical on-court assessment tools for preadolescent tennis players—such as portable groundstroke evaluation instruments—have been developed and validated, supporting more objective coaching decisions (Diler et al., 2024).

Technical development is not restricted to motor programs alone; age-appropriate progressions in strength, speed, agility, and flexibility must be integrated with technical training. Controlled studies demonstrate that functional training models (e.g., core and kinetic chain–based programs) enhance performance in youth tennis players (Yıldız et al., 2019). Static and dynamic balance—respectively referring to the ability to maintain stability in stationary and moving conditions—are fundamental components of sport performance and can be trained individually or in groups (Dilican et al., 2023).

Skill acquisition research further shows that variable practice, task variations, and game-based training (e.g., modified-court matches, constraint-led games) effectively enhance transfer and decision-making skills. These approaches cultivate not only technical repetitions but also tactical cognition, enabling more functional application of technical skills during play. When paired with scaled equipment, game-based methods are particularly effective for developing youth sports.

Wilson (2009) argues that technical and tactical skills in children and adolescents are acquired more effectively through game-like environments and task variability than through traditional repetition-based approaches. Within this framework, the coach's role shifts from directing athletes toward repetitive technical drills to designing tasks that activate "in-situ decision-making, problem-solving, and adaptive responses." Wilson further notes that game-based methodologies increase motivation, enhance learning engagement, and support skill transfer. This perspective is especially relevant for sustaining technical development in young tennis players, as game-based training activates both motor and cognitive components simultaneously. Integrating such approaches into training settings offers a more dynamic and engaging learning environment compared with conventional repetition-based sessions.

Technical development in youth athletes is not exclusive to tennis; findings from similar racket sports, such as badminton, table tennis, and squash, contribute to understanding skill acquisition, particularly regarding hand–eye coordination, anticipatory processing, reaction time, and stroke stability. For example, one study reported that combining coordination training with technical stroke training yielded greater improvement in 9–13-year-old badminton players compared with isolated technical repetition (Prajongjai et al., 2021). Additional evidence suggests that the ability to interpret visual cues before stroke execution is a key determinant of performance in competitive settings (Phomsoupha & Laffaye, 2015). Such findings support the strong transfer observed in tennis when using game-based and decision-making–oriented technical instruction.

Table tennis research further illustrates age-related development in motor quickness, reaction speed, segmental movement control, and racket-face orientation. One study found that the ability to process environmental cues rapidly was strongly associated with technical success in youth table tennis players (Akpınar et al., 2012). Similarly, squash—due to its constrained space and fast tempo—provides extensive evidence on anticipation and positional play, with studies showing that training protocols designed to improve early recognition of opponent movements directly enhance stroke performance (Ramos et al., 2021).

Correctly guiding technical development in tennis has also been linked to long-term performance outcomes. Research on talent identification indicates that early-observed technical stability, movement economy, and anticipation skills are significantly associated with future performance, suggesting that technical formation should be firmly established during the highly receptive ages of 8–14 rather than waiting until players "appear skilled" (Kramer et al., 2017). In table tennis, studies comparing performance levels have shown that expert athletes display more rhythmic and energy-efficient

segmental coordination during strokes (Malagoli Lanzoni et al., 2012). These findings underscore the importance of technical training models that reduce unnecessary muscular tension and promote fluid, economical movement patterns in children. Supporting this, a recent study found that a 12-week functional training program produced greater improvements in technical performance and movement quality than traditional resistance training among young male tennis players (Xiao et al., 2025).

Discussion

This review demonstrates that the development of technical formation in child and adolescent tennis players is closely linked to age-specific physiological, neuromotor, and cognitive characteristics. The literature emphasizes that acknowledging sensitive periods—during which technical skills are most effectively acquired—is critical not only for optimizing performance development but also for reducing injury risk. The age range of approximately 8–14 years is consistently identified as a phase in which neuromotor coordination develops rapidly and the window for technical learning remains open. During this period, game-based and variable training models significantly enhance technical accuracy, motor adaptability, and decision-making speed.

The findings also indicate that equipment and court scaling—such as modifying ball compression, racket length, or court dimensions—improves accuracy, reduces error types, and supports the development of self-efficacy in young athletes. Moreover, the type of attentional cues and instructional strategies used by coaches plays a central role in learning quality. Approaches that promote external attentional focus and problem-based engagement facilitate the automatization of motor control in children. Addressing technical formation not solely through repetitive practice but through the integration of cognitive and tactical processes strengthens the transfer of skills to match play. Accordingly, variable and task-based training methods appear more effective than traditional block practice.

The literature also aligns in showing that neuromuscular and functional training models support technical stability, enhance movement quality, and contribute to the early development of postural control. Furthermore, monitoring maturational differences and basing training design on biological rather than chronological age helps minimize temporary performance fluctuations. This perspective reinforces the importance of individualized training approaches during periods of rapid growth and maturation.

Conclusion

In conclusion, establishing technical formation in child and adolescent tennis players in a healthy and sustainable manner requires age-sensitive, individualized, and multidisciplinary training approaches. An integrated training system that combines pedagogical, biomechanical, and neuromotor components supports both performance sustainability and long-term engagement in the sport. Based on the collective evidence, coaches are encouraged to conceptualize technical instruction not merely as the teaching of specific skills, but as a comprehensive developmental process shaped by maturation, cognitive growth, and motor learning principles.

Beyanlar / Declarations

Etik Onay ve Katılım Onayı / Ethics approval and consent to participate

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During the preparation and writing of this study, scientific, ethical and citation rules were followed in accordance with the 'Higher Education Institutions Scientific Research and Publication Ethics Guidelines'; no alterations were made to the collected data, and this study has not been submitted for evaluation to any other academic publication medium. The author is solely responsible for any violations that may arise in connection with this article.

Veri Ve Materyal Erişilebilirliği / Availability of data and material

Bu çalışmanın bulgularını destekleyen veriler, makul talepler üzerine sorumlu yazardan temin edilebilir. Veri seti yalnızca akademik amaçlar için erişilebilir olacak ve verilerin herhangi bir kullanımı, orijinal çalışmayı referans gösterecek ve katılımcıların gizliliğini koruyacaktır.

The data that support the findings of this study are available from the corresponding author upon reasonable request. The dataset will be accessible only for academic purposes, and any use of the data will recognize the original study and maintain the confdentiality of the participants.

Çıkar Çatışması / Competing interests

Yazarlar, bu makalede sunulan çalışmayı etkileyebilecek herhangi bir çıkar çatışması veya kişisel ilişkiye sahip olmadıklarını beyan etmektedirler.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Yazar Katkıları / Authors' Contribution Statement

Tüm çalışma ve yazım sürecinden tek yazar (T.D.) sorumludur.

The entire study and manuscript preparation were solely conducted by the author (T.D.).

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