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CONTENTS

Chapter 1

BODY IMAGE AND EATING DISORDERS IN ATHLETES

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Body image plays a crucial role in shaping self-esteem among athletes, with positive perceptions often fueling confidence and overall well-being. When athletes see their bodies in a favorable light, they are more likely to have stable and positive self-esteem, which in turn supports their motivation and mental resilience in competitive sports. Conversely, negative body image can erode self-worth, making athletes more susceptible to self-doubt and psychological stress. This dynamic highlights the importance of fostering healthy self-perceptions, as body image not only affects how athletes feel about themselves but also influences their approach to training, competition, and personal growth (Hausenblas & Fallon, 2006).

Athletes are uniquely impacted by both societal beauty standards and sport-specific body ideals, which can create conflicting pressures. In many sports, there is a prevailing expectation for athletes to maintain certain body shapes or weights, often dictated by coaches, peers, and the broader sporting culture. For example, aesthetic sports such as gymnastics or figure skating may emphasize leanness and appearance, whereas sports like weightlifting may focus on muscularity and strength. These pressures can be outlined as follows:

- Societal standards emphasize thinness or muscularity based on gender.
- Coaches and teammates may reinforce sport-specific body ideals
- Media portrayal of athletes often sets unrealistic expectations
- Family and peers can inadvertently contribute to these ideals (Schaefer et al., 2015).

Such influences can lead athletes to internalize narrow definitions of the "ideal" athletic body, increasing vulnerability to negative body image and unhealthy behaviors (Baceviciene et al., 2023).

Prevalence of Eating Disorders Among Athletes

A statistical overview of eating disorders among athletes reveals significant variability across different sports, with prevalence rates ranging widely depending on the type of sport, gender, and level of competition. For instance, research has found that the prevalence of disordered eating and clinical eating disorders ranges from 0–19% in male athletes and 6–45% in female athletes, indicating that certain sports environments may present higher risks (Reardon et al., 2019). These statistics underscore the heightened vulnerability of athletes, particularly those engaged in sports emphasizing leanness or weight categories (Sundgot-Borgen & Torstveit, 2004). Notably, subclinical disordered eating behaviors are even more widespread, affecting a considerable proportion of both male and female athletes (Pope et al., 2020). This data highlights the

importance of considering both clinical and subclinical manifestations when assessing the true scope of the issue within athletic populations.

Gender differences play a crucial role in the prevalence of eating disorders among athletes, with females consistently exhibiting higher rates of both clinical and subclinical conditions compared to their male counterparts (Ghazzawi et al., 2024; Rosinska et al., 2025). Studies indicate that females are up to ten times more likely to develop an eating disorder, and female athletes specifically report more significant concerns regarding eating, shape, and weight (Qian et al., 2022; Krebs et al., 2019). This disparity not only reflects societal and sport-specific pressures that disproportionately affect women but also suggests that female athletes may internalize ideals related to thinness and performance more intensely (Borowiec et al., 2023; Ghazzawi et al., 2024). As a result, targeted interventions and support systems for female athletes are essential in mitigating these risks and promoting healthier attitudes toward body image and nutrition (Rosinska et al., 2025; Ghazzawi et al., 2024).

When comparing athletes to non-athlete populations, the relationship between athletic participation and eating disorder rates is complex and not always straightforward. While some research suggests that certain athlete groups may exhibit eating disorder rates comparable to non-athlete populations (Ghazzawi et al., 2024), other findings point to an increased risk due to unique sport-related pressures (Rosinska et al., 2025). This complexity can be attributed to the interplay of factors such as sport type, competitive level, and the presence of protective elements like team support or access to nutrition education (Borowiec et al., 2023). Nevertheless, the existence of elevated or comparable rates of disordered eating among athletes compared to non-athletes highlights the need for ongoing research and prevention efforts within both groups (Qian et al., 2022).

Types of Eating Disorders Common in Athletes

Anorexia nervosa is one of the eating disorders observed among athletes, particularly in sports that emphasize leanness or weight categories such as gymnastics, endurance running, and wrestling (Borowiec et al., 2023). Characterized by an intense fear of gaining weight, a distorted body image, and persistent behaviors that interfere with weight gain, athletes may manifest anorexia through extreme dietary restriction, excessive training, and even denial of their underweight status (Rosinska et al., 2025). This disorder can be especially insidious in competitive environments where low body fat or low energy availability is often prized, potentially leading to a dangerous cycle of energy deficiency, physical deterioration, and impaired performance (Mountjoy et al., 2018). Moreover, athletes with anorexia nervosa may refuse to maintain a minimally normal body weight and engage in rigid eating rituals,

which can negatively affect both their physical health and athletic performance (Ghazzawi et al., 2024).

Bulimia nervosa is an eating disorder that can also be observed among athletes and is characterized by recurrent episodes of binge eating followed by compensatory behaviors intended to prevent weight gain (Ghazzawi et al., 2024). These compensatory behaviors often include self-induced vomiting, misuse of laxatives or diuretics, excessive exercise, and fasting. Individuals with bulimia nervosa may maintain a normal body weight, which can make the disorder more difficult to detect in athletic settings (Nitsch et al., 2021). Sports that emphasize appearance, weight control, or endurance may contribute to pressures that increase the likelihood of such disordered eating behaviors (Borowiec et al., 2023). Bulimia nervosa can also lead to serious medical complications, including electrolyte imbalances, gastrointestinal problems, and dental erosion, which can negatively affect athletes' health and performance (Nitsch et al., 2021).

In addition to anorexia nervosa and bulimia nervosa, athletes may also present with Other Specified Feeding or Eating Disorders (OSFED); however, athlete-specific prevalence estimates for OSFED are limited in the literature, because most studies report overall disordered-eating prevalence rather than DSM-5 diagnostic subtypes (Ghazzawi et al., 2024).

Risk Factors for Disordered Eating in Athletic Populations

The pressure athletes face from coaches, peers, and family members has been identified as a significant psychosocial risk factor for the development of disordered eating behaviors. Research shows that athletes may internalize appearance- or weight-related feedback, which can increase body dissatisfaction and contribute to unhealthy eating patterns. Weight-focused comments from coaches, including emphasizing leanness or critiquing body shape, have been associated with higher levels of disordered eating symptoms among athletes. Similarly, peer and family reinforcement of appearance ideals—such as comparisons, encouragement to lose weight, or comments about physique—may intensify perceived pressure to modify eating behaviors, thereby heightening overall risk. Collectively, these interpersonal influences can create an environment in which athletes feel compelled to meet unrealistic body expectations, increasing vulnerability to both physical and psychological health consequences (Voelker et al., 2015).

The type of sport an athlete participates in can also significantly influence their susceptibility to disordered eating. Athletes engaged in aesthetic sports (e.g., gymnastics, figure skating) or in weight-class and endurance sports consistently show higher risk for disordered eating compared to other sport

types (Borowiec et al., 2023). Such elevated risk is thought to stem from the unique pressures these sports impose — namely the demand to maintain a specific body composition or meet strict weight or performance/appearance criteria (Ghazzawi et al., 2024). For example, aesthetic sports emphasize appearance and grace, often rewarding leaner physiques (Borowiec et al., 2023). Weight-class sports, like wrestling or boxing, require athletes to meet strict weight thresholds, which can promote hazardous weight-cutting and disordered eating behaviors (Ghazzawi et al., 2024). Endurance sports, such as long-distance running, frequently foster the belief that lighter body weight enhances performance, possibly increasing vulnerability to restrictive eating or excessive exercise (Rosinska et al., 2025). These sport-specific demands may thus create an environment where restrictive dieting, excessive training, or other harmful behaviors become normalized in pursuit of athletic success (Borowiec et al., 2023).

Personality traits, particularly perfectionism, are recognized as important risk factors for disordered eating in both general and athletic populations. Individuals with highly perfectionistic tendencies often set unrealistically high standards for themselves, striving not only for athletic excellence but also for an ideal appearance, which may lead to rigid control over eating and exercise. Because perfectionism has been shown to function as a transdiagnostic risk factor — contributing to a range of mental health issues including eating disorders — athletes with pronounced perfectionistic traits may be especially vulnerable. The competitive nature of sports combined with such personality traits can therefore foster a relentless drive for improvement, potentially at the expense of psychological and physical well-being (Somasundaram & Burgess, 2018).

Warning Signs and Symptoms of Eating Disorders in Athletes

Physical warning signs of disordered eating in athletes can include reduced bone health and increased risk of overuse injuries. In cases of inadequate nutrition or low energy availability, athletes may suffer from decreased bone density and a higher incidence of stress fractures, which can significantly impair performance and long-term health (Tenforde et al., 2015). Early recognition of such signs is crucial to enable timely intervention and prevent more severe complications (Mountjoy et al., 2018).

Psychological symptoms are another critical set of warning signs, often preceding or accompanying physical changes in athletes with eating disorders. These symptoms typically include an intense preoccupation with food choices, calorie counts, and body image, as well as persistent dissatisfaction with their physique. Athletes may also demonstrate heightened anxiety or guilt related to eating or missing a workout, and their self-esteem may become increasingly

tied to weight or appearance. Such patterns align with research showing that athletes with disordered eating frequently exhibit obsessive concerns about weight and food, elevated anxiety, and rigid attitudes toward training (Plateau et al., 2017). These intrusive thoughts can disrupt daily life, hinder social interactions, and may even contribute to depressive symptoms, as athletes become overwhelmed by pressure to meet unrealistic body or performance standards. Recognizing these psychological indicators early is essential for identifying athletes at risk and initiating timely intervention (Kong & Harris, 2015).

Behavioral changes provide further insight into the presence of eating disorders among athletes, often revealing patterns that might otherwise go unnoticed. These may include deliberately avoiding team meals or social eating situations, frequently skipping meals, or adhering to rigid eating rituals. Additionally, athletes may engage in excessive exercise or overtraining beyond what is recommended by coaches or required by their sport, as a means of controlling weight or compensating for perceived dietary lapses. Research shows that such compensatory behaviors, including compulsive training and restrictive eating routines, are common among athletes experiencing disordered eating and significantly increase both physical and psychological strain (Martinsen & Sundgot-Borgen, 2013). These behaviors not only isolate the athlete from their peers but also intensify the negative health consequences of inadequate nutrition and overtraining. By observing these shifts in behavior, coaches and teammates can help identify at-risk individuals and encourage them to seek appropriate support (Karrer et al., 2020).

The role of coaches and athletic staff is crucial in detecting and addressing early warning signs of eating disorders among athletes. By remaining attentive to physical indicators such as sudden weight loss, recurring fatigue, or frequent injuries, coaches may identify at-risk individuals before conditions worsen. Observing behavioral changes — like avoiding team meals or engaging in excessive exercise — can also serve as red flags. Early detection becomes even more important because athletes may conceal symptoms due to fear of stigma or losing their spot on the team. To support prevention and early intervention efforts, staff should: monitor performance, energy, and mood; notice sudden behavioral shifts; and foster an environment that encourages open, nonjudgmental communication. Recognizing such red flags promptly and offering support can make a meaningful difference in an athlete's recovery and long-term well-being (Mountjoy et al., 2018).

Creating a supportive, body-positive team culture is an important preventative strategy for reducing body image concerns and disordered eating risk among athletes (Matheson et al., 2023). When coaches consistently promote an environment that values diverse body types and emphasizes

health and function over appearance, athletes report improved body esteem and related outcomes in trial settings. (Bickmore et al., 2025). Practical steps that have been used in intervention programs include refraining from negative comments about weight or appearance, celebrating effort and skill development rather than physique, and encouraging balanced eating and training schedules (Matheson et al., 2023). While evidence is promising—showing small but meaningful short-term improvements in body image from coach-led, team-based interventions—longer-term and larger multisite trials are still needed to confirm sustained reductions in disordered eating incidence (Li et al., 2024).

Training and education on eating disorder prevention are increasingly recognized as vital for coaches and athletic staff to support the health and well-being of athletes. Education initiatives that inform staff about the complex interactions between nutrition, energy availability, mental health, and performance can improve awareness of risk factors and early warning signs. When staff are knowledgeable about eating disorder risk and red flags — such as unexplained weight loss, restrictive behaviors, or disordered eating attitudes — they are more likely to identify at-risk athletes and facilitate timely referral to professionals. Effective training programs generally include instruction on how to approach sensitive conversations about body image and nutrition, guidance on referral pathways to dietitians or mental-health professionals, and up-to-date information on best practices in athlete health and energy balance (Mountjoy et al., 2018). By prioritizing ongoing education of coaches and support staff, sports organizations can foster safer environments where athletes' physical and psychological health is safeguarded.

Media Influence and Social Pressures

The impact of social media and advertising on athletes' body image cannot be understated, as these platforms often promote filtered and idealized portrayals of physical perfection. Athletes—particularly adolescents—are frequently exposed to online content that reinforces narrow appearance standards, contributing to body dissatisfaction and increasing vulnerability to disordered eating behaviors (Holland & Tiggemann, 2016). Research also indicates that social media use is associated with a greater likelihood of dietary supplement misuse and performance-enhancing substance interest, driven by pressure to emulate the physiques showcased online (Backhouse et al., 2013). Consequently, the constant comparison to curated images can distort perceptions of what is healthy or attainable, negatively affecting both mental well-being and athletic performance.

The portrayal of ideal bodies in sports media further compounds the issue for athletes striving to meet often unattainable standards. Sports coverage and advertising campaigns frequently highlight physiques that align with narrow

and highly selective definitions of athleticism, conflating appearance with performance and reinforcing the belief that success depends on achieving a specific body type (Bernstein et al., 2023). This dynamic not only fuels insecurity among athletes but also perpetuates stereotypes that marginalize individuals who do not fit these media-constructed ideals. Female athletes, in particular, may experience intensified pressure to demonstrate both physical attractiveness and athletic excellence, placing them at heightened risk for body image disturbances and disordered eating behaviors (Feng & Duncan, 2024).

To counteract negative media messages, athletes, coaches, and organizations must adopt proactive strategies that foster resilience and critical thinking. Evidence from recent studies in general adolescent and young adult populations shows that media literacy programs effectively reduce body dissatisfaction and disordered eating risk by helping individuals critically evaluate unrealistic body portrayals (McLean et al., 2017). Encouraging open discussions about body diversity and the dangers of social comparison is also supported by research demonstrating that social media–driven comparison processes significantly contribute to body dissatisfaction and disordered eating behaviors (Holland & Tiggemann, 2016; Butkowski et al., 2019). Additionally, workshops and educational resources focused on body image and healthy media engagement can strengthen athletes' ability to challenge idealized images and minimize harmful internalization of appearance-based standards (Tiggemann et al., 2020). By integrating these strategies into athletic environments, it becomes possible to mitigate the negative influence of media and support athletes in developing a healthier, more realistic relationship with their bodies.

Health Consequences of Disordered Eating in Athletes

Athletes who engage in disordered eating behaviors often face serious health consequences that can undermine their performance capabilities. In the short term, inadequate caloric and fluid intake may result in dehydration and electrolyte disturbances, conditions that are particularly hazardous during high-intensity training or competition (Sawka et al., 2015). Even modest dehydration has been associated with impaired endurance, decreased cognitive and reaction time, and reduced thermoregulatory capacity — all of which can significantly compromise athletic performance (Nuccio et al., 2017). This physiological stress not only hampers training adaptations, but also increases the risk of acute injuries and heat- or exertion-related illnesses. Athletes may experience symptoms such as muscle cramps, dizziness, premature fatigue, and impaired recovery — clear indicators that their bodies are not receiving the necessary support to compete safely and effectively (Sawka et al., 2015).

Beyond the immediate dangers, prolonged disordered eating can have serious long-term health implications for athletes, particularly in relation to

bone health and hormonal function. When energy availability remains chronically low, athletes—especially females—are at heightened risk for developing the Female Athlete Triad, defined by low energy availability, menstrual dysfunction, and decreased bone mineral density (De Souza et al., 2014). Over time, this condition can progress to osteoporosis, increased susceptibility to stress fractures, and potentially irreversible bone loss. Additionally, irregular or absent menstrual cycles are common among female athletes experiencing chronic energy deficiency, further compounding the risk of long-term reproductive and cardiovascular complications (Mountjoy et al., 2018). These health issues not only jeopardize an athlete's current performance but may also have enduring effects long after their competitive careers have ended.

The psychological impacts of disordered eating in athletes are substantial and often occur alongside physical symptoms. Research shows that athletes struggling with disordered eating frequently report elevated levels of anxiety, depressive symptoms, and body dissatisfaction compared to non-affected peers (Bratland-Sanda & Sundgot-Borgen, 2013). The ongoing pressure to achieve an idealized athletic body can intensify negative self-evaluation and foster obsessive thoughts related to food, training, and appearance (Kirsch et al., 2016). These psychological difficulties may present as reduced motivation, impaired concentration, and social withdrawal, all of which negatively affect both athletic performance and daily functioning (Bratland-Sanda & Sundgot-Borgen, 2013). Importantly, evidence suggests that even after physical symptoms improve, psychological distress may persist, highlighting the need for comprehensive treatment approaches that address both mental health and nutritional rehabilitation (Kirsch et al., 2016).

Prevention and Intervention Strategies

Nutritional education and counseling play a critical role in preventing and addressing disordered eating among athletes. Providing athletes with evidence-based information about their energy needs and the risks associated with restrictive dieting helps counteract common misconceptions that link extreme leanness to improved performance (Mountjoy et al., 2018). Individualized nutritional counseling further supports athletes by promoting healthier relationships with food, enhancing body awareness, and addressing sport-specific challenges related to fueling and recovery (Boidin et al., 2021). Athletes who engage in such programs are more likely to recognize early indicators of disordered eating and seek timely support, reducing the likelihood of escalation. Effective components of nutrition-focused prevention efforts include teaching balanced, sport-tailored meal planning, emphasizing the importance of adequate energy availability, and correcting misunderstandings about body composition and performance (Mountjoy et al., 2018). Making nutrition counseling accessible within athletic environments can substantially lower the

risk of eating disorders while fostering both physical and psychological well-being.

Implementing screening programs and robust support systems is an essential strategy for identifying and assisting athletes at risk for disordered eating. Regular screenings delivered by trained professionals can detect early indicators of problematic behaviors, enabling timely and effective intervention. These programs commonly include confidential questionnaires, structured interviews, and continuous monitoring across the competitive season. Moreover, fostering a supportive environment in which athletes feel comfortable discussing concerns without fear of judgment or negative consequences encourages openness and early help-seeking (Bratland-Sanda & Sundgot-Borgen, 2013).

The role of multidisciplinary teams in the treatment of eating disorders among athletes is fundamental, as effective care requires integrated support across multiple domains. Collaborative intervention involving physicians, sports dietitians, psychologists, and when appropriate, coaches, has been shown to improve treatment outcomes by simultaneously addressing the medical, nutritional, and psychological components of disordered eating (Melin et al., 2014). Multidisciplinary teams develop individualized treatment plans, closely monitor progress, and adjust interventions to meet the athlete's evolving needs. This coordinated, holistic approach not only supports medical stabilization and nutritional rehabilitation but also promotes long-term psychological recovery and return-to-play readiness (Mountjoy et al., 2018). By bringing together expertise from various specialties, multidisciplinary teams provide comprehensive care that significantly enhances athletes' chances of successful and sustained recovery.

Recovery and Support Resources for Athletes

Rehabilitation and return-to-play protocols for athletes recovering from eating disorders are designed to ensure a safe balance between physical health and psychological readiness. These protocols typically involve a gradual progression of training intensity, continuous medical monitoring, and close collaboration among healthcare providers, coaches, and the athlete. Current consensus guidelines highlight the importance of individualized plans that prioritize restoration of adequate energy availability, stabilization of mental health, and careful physical reconditioning before an athlete is cleared to resume full participation (Mountjoy et al., 2018). Such structured, multidisciplinary approaches help reduce the risk of premature return, prevent relapse, and promote long-term athletic and personal well-being (Melin et al., 2014).

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Chapter 2

EFFECTS OF EDUCATIONAL GAMES FOR CHILDREN WITH INTELLECTUAL DISABILITY

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INTRODUCTION

Children with intellectual disabilities require greater support than their peers in cognitive, academic, social, and adaptive skill domains. The limitations encountered during the learning process necessitate the use of individualized instructional approaches and the implementation of multidimensional support strategies in educational settings (American Psychiatric Association [APA], 2013). Difficulties in understanding abstract concepts, sustaining attention, and transferring learned skills to daily life are particularly prominent among children with intellectual disabilities. Consequently, there is a growing need for alternative instructional approaches that actively engage learners and render learning experiences more meaningful.

Educational games represent an effective instructional tool that transforms the learning process into an enjoyable, interactive, and learner-centered experience. Game-based learning approaches have been shown to enhance students' motivation, extend attention spans, and promote the retention of learned content (Ginsburg, 2007). For children with intellectual disabilities, educational games not only support academic achievement but also contribute to the development of social interaction, communication, problem-solving, and self-regulation skills (Piaget, 1962; Vygotsky, 1978). In this respect, educational games can be regarded as a holistic learning tool that supports psychosocial development alongside cognitive growth.

The multidimensional nature of educational games closely aligns with the principles of therapeutic recreation. Therapeutic recreation is defined as a structured and goal-oriented intervention that employs planned recreational activities to enhance individuals' physical, cognitive, emotional, and social functioning (Austin & Crawford, 2016). For children with intellectual disabilities, therapeutic recreation practices have been found to promote social adaptation, strengthen self-confidence, reduce stress, and improve overall quality of life. Within this framework, educational games emerge as a fundamental component of therapeutic recreation, facilitating the integration of educational objectives with therapeutic goals.

A review of the literature examining the effects of educational games and therapeutic recreation-based interventions on the educational and developmental outcomes of children with intellectual disabilities reveals an increasing emphasis on qualitative research in recent years. Qualitative studies enable researchers to examine educational games and recreational activities not only through measurable outcomes but also through participants' lived experiences, interactional processes, and contextual dynamics (Merriam & Tisdell, 2016).

International research consistently demonstrates that educational games enhance engagement in learning processes and strengthen classroom interactions among children with intellectual disabilities. For example, a case study conducted by Schleien and Ray (2015) reported that structured recreational game activities positively influenced children's levels of social acceptance and peer interaction. Findings based on teacher and observer perspectives indicated that game-based activities facilitated self-expression and encouraged participation in group-based learning tasks.

Similarly, Dattilo (2018) employed qualitative methods to examine the effects of game-based activities implemented within the framework of therapeutic recreation on self-efficacy perceptions and emotional regulation skills among children with intellectual disabilities. Data collected through semi-structured interviews and systematic observations revealed that educational games functioned not merely as sources of enjoyment but also as safe and supportive environments for learning and experimentation. These findings underscore the importance of integrating therapeutic recreation principles with educational objectives.

Another qualitative study addressing the therapeutic dimension of game-based learning was conducted by Goodwin and Staples (2005), who investigated the impact of recreational games on the behavioral adjustment of children with intellectual disabilities. The results indicated that purposefully designed game activities contributed to a reduction in problem behaviors and an increase in positive social behaviors. Teacher reports further suggested that participation in game-based activities positively influenced children's attitudes toward the learning environment.

Furthermore, qualitative studies grounded in Vygotsky's social interactionist framework emphasize the role of educational games as powerful mediational tools within the zone of proximal development (Vygotsky, 1978). Game-based activities implemented with teacher guidance have been shown to support both cognitive and social skill development simultaneously, while allowing therapeutic recreation principles to be naturally embedded within instructional contexts.

Overall, the existing body of literature suggests that educational games and therapeutic recreation-based interventions yield multidimensional benefits for children with intellectual disabilities. However, many studies are characterized by limited sample sizes and context-specific implementations, highlighting the need for further qualitative research across diverse educational settings and age groups. Addressing this gap, the present study aims to explore the effects of educational games on children with intellectual disabilities from a qualitative perspective within the framework of therapeutic recreation.

Specifically, the study seeks to examine the contributions of educational games to learning processes, social interactions, emotional responses, and attitudes toward instruction, drawing on the perspectives of teachers and practitioners. The findings are expected to inform the development of more effective, purposeful, and sustainable game-based practices in special education and therapeutic recreation contexts.

METHODS

Research Design

This study was designed based on educational game applications conducted by third-year Sports Science students as part of their Therapeutic Recreation course. Over six weeks, these students gained theoretical knowledge about disability and learned how to communicate with individuals with intellectual disabilities. They also acquired theoretical knowledge about preparing educational games and materials. Subsequently, they used this knowledge to prepare and implement educational games with 21 children with intellectual disabilities over eight weeks. Data for the study were collected during these applications.

Participants

The study included 21 children with intellectual disabilities who were attending special education and whose ages ranged from 7 to 19 (X=11.5). The children's disability status was: Autism (7), Down syndrome (9), Other intellectual disabilities (5).

Data Collection

Data were collected through participant observation, a qualitative research method that enables the researcher to gain an in-depth understanding of participants' behaviors, interactions, and experiences within their natural settings (Merriam & Tisdell, 2016). Participant observation allows the researcher to become directly involved in the research context while systematically observing and documenting social processes as they unfold, thereby providing rich and contextualized data (Creswell & Poth, 2018).

In the present study, the researcher assumed an active participant-observer role during educational game activities implemented within the framework of therapeutic recreation. This role involved engaging in the instructional environment while maintaining a reflective and analytical stance toward the observed behaviors and interactions (Spradley, 1980). The educational games were purposefully designed to align with both instructional objectives and therapeutic recreation principles, and were implemented in small-group

settings to facilitate social interaction and engagement among children with intellectual disabilities.

Observations were conducted over a predetermined period during regularly scheduled instructional sessions. Particular attention was given to students' levels of engagement, social interaction patterns, communication behaviors, emotional responses, and participation in game-based tasks. Field notes were recorded systematically during and immediately following each observation session to ensure the accuracy and completeness of the data (Angrosino, 2007). Descriptive notes were used to document observable behaviors and contextual factors, while reflective notes captured the researcher's interpretations, emerging insights, and methodological reflections.

To enhance the credibility and trustworthiness of the observational data, multiple observation sessions were conducted across different instructional contexts. Prolonged engagement in the field enabled the researcher to develop rapport with participants and to gain a deeper understanding of routine behaviors and interactional dynamics (Lincoln & Guba, 1985). Additionally, observation protocols were used to guide data collection and to maintain consistency across sessions, while allowing flexibility to capture unanticipated but relevant behaviors related to the educational game activities.

Ethical considerations were carefully addressed throughout the data collection process. Prior to data collection, informed consent was obtained from school administrators and legal guardians, and assent was sought from the participating children. To protect confidentiality, all participants were assigned pseudonyms, and observational data were recorded and stored securely. The researcher remained attentive to ethical principles of respect, non-intrusion, and beneficence during all observation sessions.

Data Analysis

The data obtained through participant observation were analyzed using thematic analysis, a flexible and systematic qualitative data analysis method that allows for the identification, analysis, and interpretation of patterns within qualitative data (Braun & Clarke, 2006). Thematic analysis was selected because of its suitability for examining complex social interactions, behaviors, and experiences within educational and therapeutic contexts, particularly when rich observational data are collected (Guest, MacQueen, & Namey, 2012).

Initially, all field notes were transcribed and reviewed repeatedly to achieve data familiarization and to gain an overall understanding of the observed educational game activities (Braun & Clarke, 2006). During this

phase, the researcher engaged in reflexive reading to become immersed in the data and to identify preliminary patterns related to students' engagement, social interaction, emotional responses, and participation behaviors.

In the second phase, open coding was conducted by systematically examining the observational data line by line. Meaningful units of data were labeled with descriptive codes that captured observable behaviors, interactional dynamics, and contextual features of the educational game sessions (Saldaña, 2016).

Following initial coding, related codes were compared and clustered into potential categories based on conceptual similarities. These categories were then reviewed and refined to form broader themes that represented recurring patterns across observation sessions (Braun & Clarke, 2006). Theme development focused on capturing both explicit behaviors (e.g., participation levels, peer interaction) and underlying processes (e.g., emotional regulation, engagement through play) associated with educational games implemented within a therapeutic recreation framework.

To enhance the trustworthiness of the analysis, constant comparison was employed throughout the coding and theme development stages, allowing themes to be continuously examined across different observation contexts and time points (Lincoln & Guba, 1985).

Finally, themes were defined, named, and supported with thick descriptions drawn directly from the observational data. Detailed excerpts from field notes were used to illustrate each theme and to ensure transparency between the data and the analytical interpretations (Merriam & Tisdell, 2016). The analysis process was iterative and recursive, with movement back and forth between data, codes, and themes until analytical saturation was achieved.

FINDINGS

The findings derived from participant observations were organized under three main themes: physical development, sociability, and cognitive development. These themes reflect observable changes in participants' behaviors, skills, and interactions throughout the intervention process.

Physical Development

Observations revealed a gradual improvement in participants' physical performance, motor confidence, and willingness to engage in movement-based activities. During the first two weeks, many participants avoided specific physical actions such as throwing a medicine ball, walking on a balance board, or rolling. As noted in the field notes,

> *"In the first two weeks, they abstained from doing some acts (e.g., throwing the medicine ball, walking on the balance board, rolling)."*

After approximately three weeks, participants began to attempt activities they had previously refused. Although fear and hesitation were still evident, rejection behaviors decreased. This change was documented as follows:

> *"After three weeks, they started to try to do some acts which they did not want to attempt before. They were fearful, but at least they did not reject trying."*

Individual progress was particularly noticeable. One participant, M., who initially required assistance to walk, demonstrated increased independence over time. The researcher noted,

> *"M., who cannot walk without help, wanted to do some acts without help with his own desire and achieved this after four weeks."*

Additionally, observable improvements in motor control were recorded:

> *"There is obvious development in the angle of the arm."*

By the fourth week, participants became familiar with the routine physical activities implemented each session. Their movements appeared calmer, more controlled, and of higher quality. According to field observations,

> *"After four weeks, it was obvious that they became familiar with routine acts applied every week. They were quieter while doing these acts, and the quality of their performance increased."*

Motivation was further enhanced through immediate feedback and reinforcement:

> *"They became motivated by instant feedback and reinforcements and tried to do better."*

When new activities were introduced, participants demonstrated greater openness than in the initial weeks. As recorded in the field notes,

> *"When a new act was instructed, they did not reject it as they did in the initial weeks and were willing to try, but they preferred to perform the acts in the way they learned in the first weeks."*

Motivational changes were also evident in relation to body awareness and self-perception. One participant, H., a 16-year-old overweight student, showed increased engagement after four weeks. The researcher documented,

> *"H., who is sixteen years old and overweight, started to join the course actively after four weeks, asking himself, 'Did I lose weight? I will lose weight,' and attempted to achieve more than the other children."*

Teacher feedback confirmed that,

> *"he lost 2–3 kg after seven weeks, and this motivated him."*

Balance skills showed significant improvement across sessions. Initially, nearly all participants requested physical support during balance board activities. As noted,

> *"Almost every child wanted to be supported by holding their hands while walking on the balance board."*

However, progress was observed over time:

> *"After four weeks, some of them did not want help, and in the last week almost every participant could walk on the balance board without help."*

Sociability

Findings related to sociability indicated positive changes in social participation, peer interaction, and group adjustment. On the first day, participation levels varied. Field notes indicated that

> *"On the first day, 14 children out of 21 responded positively immediately, five joined after insistence and hand-holding, and two rejected participation."*

Dependence on teacher support decreased over time. One participant, N., initially required continuous physical contact with the teacher to participate. This change was documented as follows:

> *"N., who joined activities by holding the teacher's hand during the first three weeks, started to join without holding the teacher after four weeks, although she constantly looked toward the teacher."*

Social conflicts were more frequent during the early sessions, particularly related to turn-taking. The researcher noted,

> *"In the initial weeks, they sometimes fought about the line of activity." Over time, these conflicts diminished: "In the last weeks, this behavior was reduced."*

A notable change was observed among two participants who frequently conflicted, as documented:

> *"Two children who fought each other permanently started to support each other when they raced on the same team."*

Increased social responsibility was also evident. Participants who initially arrived with inappropriate clothing or footwear showed improvement over time. As recorded,

> *"Participants who came to the course with inappropriate clothes and shoes in the initial days started to care about dressing properly in the last weeks."*

Teacher feedback further illustrated strong intrinsic motivation. One teacher reported,

> *"During one week, M. came to the course with a fever of 38°C and said, 'I came because today I will do sports.'"*

Although the group appeared generally friendly during the first week, engagement levels were low due to shyness. This changed noticeably over time:

> *"Especially in the first week, although the group was friendly, participation was low because of shyness."*

Emotional attachment became evident by the end of the program:

> *"In the last weeks, university students and participants separated from each other crying."*

Both teacher feedback and observational data confirmed that participants developed strong emotional bonds with the activities and instructors. As noted,

> *"Every week they came to the course with increasing eagerness and participated with increasing desire."*

In the final week, participants independently expressed appreciation:

> "*The participants brought gifts to us in the last week, and this idea did not belong to the teachers; it belonged to the participants."*

Cognitive Development

Due to differences in levels of intellectual disability, participants were supported individually during cognitive skill activities. The researcher noted,

> *"Because of the differences in disability levels, we worked with each participant one-on-one, especially during cognitive skill activities, and avoided frequent changes."*

As the weeks progressed, improvements in cognitive engagement were observed through verbal stimulation and visual familiarity. Field notes indicated that

> *"As weeks passed, advancement in cognitive skills was observed through verbal stimulation and visual familiarity."*

Cognitive development included both reinforcement of existing concepts and acquisition of new ones:

> *"Through cognitive activities, not only previously known concepts were reinforced, but many new concepts were also taught."*

Inattention, which was frequently observed during rule explanations in the initial weeks, decreased over time. As documented,

> "*The inattention seen in the first weeks while game rules were explained was no longer observed in the last week."*

Additionally, frequent verbal cues and short instructions provided by assisting university students facilitated clearer understanding:

> *"Short and loud verbal cues provided by assisting students helped participants perform tasks with fewer errors and supported cognitive processing."*

RESULTS AND DISCUSSION

The qualitative analysis of participant observation data revealed three overarching themes reflecting the effects of educational games implemented within a therapeutic recreation framework: physical development, sociability, and cognitive development.

Findings related to physical development indicated progressive improvements in motor performance, balance, and movement confidence. Initial avoidance and hesitation toward physical tasks decreased over time, while participants demonstrated increased willingness to attempt new activities and greater independence in movement-based tasks.

Regarding sociability, observations showed enhanced social participation, reduced dependence on adult support, and improved peer interactions. Conflicts related to turn-taking diminished across sessions, and cooperative behaviors within group activities increased. Emotional engagement and motivation toward participation were also notably strengthened.

In terms of cognitive development, participants exhibited improvements in attention, rule comprehension, and task execution. Familiarity with game routines, individualized support, and the use of short verbal cues contributed to clearer understanding and reduced inattentive behaviors during activities.

Overall, the results suggest that educational games, when structured within a therapeutic recreation framework, produce multidimensional benefits that support the physical, social, and cognitive development of children with intellectual disabilities.

This study examined the effects of educational games implemented within a therapeutic recreation framework on children with intellectual disabilities. Overall, the findings indicate that structured, repetitive, and feedback-oriented game-based activities positively influenced participants' physical development, sociability, and cognitive functioning. These results support previous research highlighting the multidimensional benefits of play-based and therapeutic recreation interventions for individuals with intellectual disabilities.

Regarding physical development, participants demonstrated increased willingness to engage in movement tasks, reduced avoidance behaviors, and improved motor performance over time. Familiarity with activities, routine practice, and immediate feedback appeared to enhance motor confidence and task persistence. These findings are consistent with motor learning theories emphasizing repetition and reinforcement in skill acquisition (Schmidt & Lee, 2019) and with studies reporting improvements in balance, coordination,

and physical engagement through structured recreational activities (Sherrill, 2004).

Improvements in sociability were evident through increased independent participation, reduced conflicts, and enhanced peer cooperation. Initially observed shyness and reliance on adult support decreased as participants became more comfortable within the group. In line with Vygotsky's social development theory, social interaction within play-based contexts functioned as a catalyst for learning and behavioral regulation (Vygotsky, 1978). The emotional attachment to activities and instructors further suggests that therapeutic recreation fosters a sense of belonging and motivation, as supported by Dattilo (2015).

Cognitive development findings indicated gains in attention, rule comprehension, and concept learning. Individualized support, consistent routines, and the use of short verbal cues and visual familiarity facilitated cognitive engagement. These results align with previous research emphasizing the effectiveness of structured, visually supported instruction for learners with intellectual disabilities (Lieberman et al., 2002; Westling & Fox, 2009). The reduction in inattentive behaviors over time suggests that play-based learning environments can support executive functioning and sustained attention (Diamond & Lee, 2011).

From a therapeutic recreation perspective, the findings reinforce the value of purposefully designed activities addressing physical, social, and cognitive domains simultaneously. The results suggest that educational games, when integrated into a therapeutic recreation framework, serve not only as instructional tools but also as meaningful interventions that enhance participation, motivation, and overall quality of experience (Austin & Crawford, 2016).

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Chapter 3

COGNITIVE DIVERSITY IN SPORT

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Introduction

Cognitive diversity within sports teams encompasses the range of different perspectives, mental models, and problem-solving approaches that individuals bring to collective tasks, which is widely regarded as a key driver of innovation and adaptability in high-performance environments (Mathuki & Zhang, 2024). By integrating athletes and staff who think differently, teams benefit from a broader pool of ideas, enabling more nuanced decision-making and robust strategies that can better address complex, dynamic sporting challenges (Aggarwal et al., 2019). This diversity not only fosters enhanced collaboration and knowledge sharing—where team members learn from each other's unique insights and experiences—but also creates a culture that encourages questioning assumptions, thereby promoting continuous improvement (Ni & Feng, 2023).

However, the value of cognitive diversity is contingent on its management; while a spectrum of viewpoints can invigorate problem-solving, excessive divergence without proper coordination may lead to inefficiencies or decision paralysis, ultimately hindering team performance (Aggarwal et al., 2019). Thus, effective utilization of cognitive diversity requires leaders and coaches to strike a balance: encouraging open dialogue and diverse contributions while simultaneously guiding the group towards consensus and maintaining operational cohesion (Buengeler, Reinert & Daldrop, 2025). This nuanced approach emphasizes the need for deliberate interventions and team processes that harness the benefits of cognitive diversity without succumbing to its potential pitfalls, ensuring that varied thinking acts as a catalyst for, rather than a barrier to, collective success (Hoare et al., 2023).

Cognitive diversity in sports fundamentally differs from other forms of diversity—such as demographic or cultural diversity—by focusing on variations in thought processes, problem-solving approaches, and perspectives rather than visible attributes or sociocultural backgrounds (Baggio et al., 2019).

While demographic diversity (like race, gender, or nationality) often enriches teams through varied life experiences, traditions, or playing styles, cognitive diversity brings a unique layer by shaping how athletes interpret strategies, respond to dynamic situations, and contribute to tactical innovation (Wang, 2025; Eromafunu et al., 2022). The interplay between cognitive and other diversity domains is evident in that cultural backgrounds often inform cognitive styles, leading to both complementary and conflicting effects on team dynamics (Bender & Beller, 2016). However, unlike demographic diversity, cognitive diversity is less visible and can be harder to detect and leverage without intentional management practices (Baggio et al., 2019). This underscores the need for sports organizations to distinguish between

diversity types and to develop strategies that specifically identify, harness, and integrate cognitive diversity for optimal team cohesion and performance. Emphasizing targeted interventions—such as cognitive profiling, inclusive communication, and collaborative decision-making frameworks—can ensure that the benefits of cognitive diversity are fully realized without undermining team unity or efficiency.

Theoretical frameworks in sport science suggest that cognitive diversity—differences in thought processes, problem-solving approaches, and decision-making styles—can enhance athletic performance by enabling teams to draw upon a broader repertoire of strategies and perspectives during competition (Qu et al., 2024; Patrício et al., 2022). The interplay between cognitive and cultural diversity underscores the importance of creating environments where diverse perspectives are integrated rather than marginalized, as doing so maximizes the theoretical benefits of cognitive diversity for athletic outcomes. Consequently, interventions that prioritize inclusive team dynamics and foster the exchange of different viewpoints are essential to harnessing the full potential of cognitive diversity in enhancing athletic performance.

Challenges to Acceptance of Cognitive Diversity

A multitude of interconnected barriers impede the acceptance of cognitive diversity in sport environments, ranging from micro-level individual behaviors to macro-level institutional structures. At the conceptual and curricular level, sport programs often embed exclusionary practices—whether overtly or subtly—by privileging normative notions of ability and performance, which marginalize those who diverge cognitively from the perceived standard (Giese & Ruin, 2018). This is further compounded by the prevalent emphasis on individual self-determination and self-reflection in sport, which, while promoting autonomy for some, can inadvertently disadvantage athletes whose cognitive processes do not align with these ideals, thereby reinforcing exclusion (Giese & Ruin, 2018). These exclusionary tendencies are not isolated but are reinforced and perpetuated by broader meso- and macro-level dynamics, such as occupational segregation, organizational cultures resistant to difference, and institutionalized gender discrimination, all of which work in tandem to limit the visibility and value of cognitive diversity across sport environments (Taylor & Wells, 2017). Power dynamics, particularly those shaped by hegemonic masculinity, further entrench these barriers by establishing narrow standards for participation and leadership, which suppress diverse ways of thinking and engaging in sport (Taylor & Wells, 2017). To address these deeply embedded obstacles, it is essential for stakeholders to critically re-examine and transform the cultural, organizational, and structural norms within sport, fostering environments where cognitive diversity is not only accepted but actively valued.

Stereotypes and biases, both explicit and implicit, play a significant role in shaping how cognitive diversity is recognized and valued within teams, often intersecting with other domains such as gender, sexuality, and cultural background (Rykers, 2016). These biases can operate unconsciously, meaning individuals may unknowingly allow ingrained prejudices to influence their judgments about team members' abilities and perspectives, thus undermining the accurate recognition of cognitive diversity (Storm et al., 2023). For example, subtle gender biases can persist even among those who consciously endorse equality, potentially leading to the undervaluation of valuable but non-stereotypical cognitive contributions (Rykers, 2016; Storm et al., 2023). Additionally, stereotypes linked to sexual orientation can further obscure the acknowledgment of unique cognitive approaches, affecting both inclusion and the openness to diverse problem-solving strategies (Williams et al., 2022). Emotions, which are often heightened by stereotypes, can amplify these effects, causing individuals to favor familiar perspectives and resist alternative viewpoints, thereby limiting the team's collective potential (Casad & Bryant, 2016). To address these interconnected challenges, it is crucial to implement targeted interventions such as bias awareness training, structured assessment tools that separate skill evaluation from personal characteristics, and fostering self-reflection on unconscious attitudes (Ogunyemi, 2021; Rykers, 2016). Emphasizing such actions not only mitigates the negative impact of stereotypes but also helps teams unlock the full benefits of cognitive diversity, supporting both inclusivity and high performance.

Strategies for Fostering Acceptance of Cognitive Diversity

To effectively promote awareness of cognitive diversity in educational settings, institutions must implement multifaceted initiatives that go beyond superficial markers of diversity and target both curricular and extracurricular experiences. While assembling a racially and ethnically diverse student body is important, research indicates that it does not automatically translate into educational benefits without intentional programming and facilitation (Milem et al., 2005). Initiatives should focus on fostering an environment where students are encouraged to engage with diverse perspectives through structured group discussions, as such experiences have been shown to enhance cognitive complexity and push students to consider viewpoints different from their own (Milem et al., 2005). Minority students, in particular, contribute significantly by introducing novel perspectives during these exchanges, prompting their peers to reevaluate assumptions and expand their thinking (Milem et al., 2005). Furthermore, integrating cross-cutting themes of respect and cognitive diversity into curricula—supported by evidence-based research—can help learners appreciate the tangible benefits that diverse teams bring to problem-solving and innovation (Jackson-Summers et al., 2024).

These efforts must be sustained and coordinated to maximize their impact on student learning and development, necessitating a strategic approach that includes ongoing assessment, clearly defined goals, and institutional accountability (Ruggs et al., 2012; Milem et al., 2005). Ultimately, promoting awareness of cognitive diversity requires purposeful instructional design, intentional opportunities for diverse interactions, and a campus culture that values and models the benefits of cognitive variety, underscoring the need for continued institutional commitment and evaluation.

To ensure that cognitive and demographic diversity translates into tangible benefits for team performance and innovation, effective policies and practices for creating inclusive team environments are indispensable. Central to these efforts are strategies that make inclusion a salient social norm within teams, such as utilizing persuasive messaging and norm-related survey items to reinforce that inclusive behaviors are both common and expected among group members (Moreu et al., 2021). These practices are interconnected with the establishment of clear communal goals and standards before team deployment, which not only set expectations but also foster collective responsibility toward inclusivity (Karplus et al., 2022). The integration of social norms messaging through practical tools like posters, videos, and syllabi is particularly cost-effective and adaptable, supporting early and sustained adoption of inclusive values across educational and professional domains (Moreu et al., 2021). The interconnection between these domains is evident: inclusive policies and direct behavioral interventions not only enhance interpersonal dynamics within teams but are also crucial for the academic success and retention of individuals from marginalized groups, thereby supporting both diversity and performance outcomes (McKeown et al., 2025). Moving forward, organizations and institutions must prioritize direct, actionable interventions—such as formative norm-setting, regular feedback, and opportunities for meaningful intergroup collaboration—to build and maintain inclusive environments that unlock the potential of cognitive diversity.

Effective Management of Cognitive Diversity in Sports Teams

An effective management approach for optimizing the benefits of cognitive diversity involves the deliberate application of human niche theory, which provides a comprehensive framework for fostering inclusion and enabling sustainable organizational change (Blom et al., 2021). By connecting this theory to operational themes such as communication, training, motivation, resource allocation, control, monitoring, and feedback, organizations can create an environment where diverse perspectives are not only welcomed but also leveraged for continuous improvement and innovation (Verwijs & Russo, 2023). This multidimensional linkage ensures that change

initiatives are contextually relevant and responsive to the unique cognitive contributions of each team member, thereby increasing the likelihood of successful implementation. Furthermore, when managers are aware of the principles of human niche theory and actively integrate them into diversity management practices, they are better equipped to address potential conflicts, reduce emotional resistance, and harness the full spectrum of cognitive resources available within the workforce (Blom et al., 2021). Consequently, to maximize the advantages of cognitive diversity, organizations must prioritize management strategies that are informed by human niche theory, align operational processes with its core elements, and cultivate a culture of adaptive learning and psychological safety.

Building on the recognition that cognitive diversity enhances organizational adaptability and problem-solving, a range of tools and frameworks have been developed to support the integration of such perspectives across professional and organizational boundaries. Mental models, understood as psychological representations encapsulating knowledge and beliefs, are foundational tools that help individuals and groups make sense of their environment and guide action within a domain (Evans et al., 2014). When these mental models converge among stakeholders—through processes that build Shared Mental Models (SMMs)—they foster a common cognitive structure, which is critical for effective integration of diverse viewpoints (Evans et al., 2014). Notably, frameworks such as the Integration Mindsets Framework offer targeted mechanisms for mapping and measuring the convergence and divergence of these cognitive structures, enabling a more nuanced analysis of inter-professional and inter-organizational relations than broader cultural constructs can provide (Evans et al., 2014). In parallel, the HuB-CC framework organizes theories along process-level features of decision-making, positioning itself as an evolving tool for integrating insights from social and cognitive sciences, and addressing behavioral challenges in domains like sustainability (Constantino et al., 2021).

Measuring the Impact of Cognitive Diversity on Team Outcomes

To comprehensively assess the impact of cognitive diversity on team performance, researchers employ a variety of metrics that capture both structural and process-oriented dimensions of team dynamics. One of the foundational approaches involves measuring the extent of shared mental models among team members, for which tools like UCINET are commonly utilized; however, it is notable that the effect size linking shared mental models to performance tends to be smaller when using UCINET compared to other structural metrics, suggesting that measurement choice can significantly influence findings and interpretations (Wildman et al., 2014). Beyond structural assessments, cognitive-focused metrics are particularly

valuable, as they not only gauge whether interventions are enhancing team effectiveness but also shed light on the underlying cognitive mechanisms that drive these improvements, such as how team members process information, solve problems, and adapt to changing environments (Noble & Letsky, 2003). These metrics are deeply interrelated; for instance, the alignment of discursive diversity can mediate the relationship between cognitive diversity and team effectiveness, while the selection of appropriate tools and interventions requires a nuanced understanding of how different aspects of cognition interact within the team context. Therefore, it is imperative for organizations and researchers to adopt a multidimensional assessment framework that integrates structural, cognitive, and discursive metrics, ensuring a holistic evaluation of cognitive diversity's impact and informing targeted actions to maximize team performance.

Several case studies stand out in illustrating how effective cognitive diversity management has translated into measurable success within sports organizations. For instance, longitudinal and ethnographic research on collegiate athletic departments reveals that teams intentionally integrating diverse cognitive perspectives—through recruiting athletes with varied educational backgrounds and problem-solving approaches—consistently report enhanced adaptability and decision-making under pressure (Singer & Cunningham, 2012). Additionally, the proliferation of diversity policies within professional sports organizations reflects a growing recognition of the value of cognitive diversity, as these policies frequently incorporate best practices from workplace diversity literature—such as structured team dialogues and inclusive leadership training—to mitigate bias and leverage a broader range of perspectives for strategic advantage (Gardner et al., 2023). The interconnections between these domains underscore that success in cognitive diversity management is not solely a function of athlete selection or policy implementation, but also hinges on ongoing education, leadership commitment, and the willingness to adapt organizational culture. Such evidence-based strategies suggest that sports organizations seeking sustained competitive advantage must prioritize comprehensive cognitive diversity initiatives, supported by longitudinal evaluation and cross-domain learning.

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Chapter 4

THE MULTIDIMENSIONAL NATURE OF SPEED IN MODERN TENNIS PERFORMANCE

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Modern tennis presents a complex structure that requires players to demonstrate a combination of specific physical and motor capacities rather than relying solely on technical skill (Merghеş, Simion, & Nagel, 2014). While the average duration of a tennis match is approximately 1.5 hours, some matches may extend beyond five hours. However, it has been reported that only 21% to 38.5% of total match time consists of active play; during these active periods, players perform numerous short-duration, high-intensity explosive movements (Martínez-Gallego et al., 2013). The average rally lasts between 6 and 11 seconds, during which players typically change direction about four times.

During a match, the ability of players to respond effectively to the intense and variable demands they encounter is associated with the capacity to generate sufficient muscle strength and force in the shoulder complex as well as in the upper and lower extremities (Zhou et al., 2025). Furthermore, the development of adequate anaerobic capacity to perform sudden and explosive movements, as well as appropriate aerobic endurance to sustain performance throughout the match, is considered important (Kovacs, 2006). Given the dynamic and variable nature of tennis, it is crucial for players to effectively exhibit various performance components related to speed, such as decision-making, acceleration, deceleration, rapid changes of direction, and explosive jumping. In this context, speed is regarded as one of the key factors influencing performance in modern tennis (Kovacs, 2006). Sprinting can be defined as the execution of a movement in the shortest possible time through the coordinated function of the cortical and muscular systems; in simple terms, it measures how quickly a distance is covered (Young, James, & Montgomery, 2002). Particularly over short distances of 5 to 10 meters, proficient sprinting ability enables players to reach the ball more rapidly and provides additional time to prepare their strokes, thereby indirectly affecting match performance (Kramer et al., 2021). Although tennis is generally considered to rely on forward running, lateral movements, rapid change of direction and reactive starts constitute the fundamental components of on-court movements (Young et al., 2002).

This indicates that tennis speed is a complex and multidimensional concept that cannot be measured solely through linear running. Unlike a unidirectional and short-duration performance, such as a 100-meter sprint in classical athletics, tennis requires players to continuously perform high-intensity movements in multiple directions, including acceleration, deceleration, changes of direction, and reactive responses on the court. In this context, tennis speed is regarded not only as a function of physical strength and velocity but also as a multidimensional performance indicator encompassing perceptual, decision-making, and motor coordination skills (Kovacs, 2006).

The effective execution of speed-related physiological and motor components—such as acceleration, deceleration, rapid changes of direction, and explosive jumping—can be associated with the ability to move quickly and controllably on the court, reach the ball in time, perform technically accurate strokes, and respond to the opponent's actions within a short period. Therefore, speed is considered a fundamental determinant of performance and a key variable that may influence match outcomes (McBurnie & Dos'Santos, 2022).

Effects of Speed Components

Speed, as a fundamental motor ability, is defined as the capacity to perform a movement or motor task in the shortest possible time. Speed comprises several subcomponents, including sprinting ability, change-of-direction speed, reactive speed, reaction time, deceleration ability, and agility. In terms of complexity, speed is often examined within the framework of these four dimensions mentioned above (Bulgay, 2023).

Reaction time refers to the interval between the perception of an external stimulus and the athlete's conscious response to that stimulus (Pavlović, 2021). In open-skill sports such as tennis, where decisions and actions occur rapidly, reaction time is a critical component of an athlete's ability to respond effectively (Mann, Williams, Ward, & Janelle, 2007). Acceleration reflects an athlete's ability to reach maximum speed in the shortest possible time and is defined as the rate of change of velocity over time (Şahin, Kahraman, Budak, & Kaplan, 2022). Acceleration capacity, or "explosive speed," is an integral aspect of sprint performance that focuses on the ability of muscle fibers to generate force and power at very high velocities.

Effective acceleration requires a high step frequency and reduced ground contact time; simultaneously, the athlete must produce a high level of ground reaction force during the push-off phase. Recent studies in sports biomechanics and sprint performance have shown that ground reaction force is a key determinant of how quickly an athlete can reach maximum speed. Naturally, the strength of both upper and lower body muscles plays a crucial role in developing explosive acceleration (Bompa & Buzzichelli, 2015, p. 295).

The highest speed an athlete can achieve, or maximum velocity, is typically reached between 20 and 30 meters. While this speed is critical for success in athletics, it also encompasses the athlete's ability to maintain or sustain this maximum velocity (Bulgay, 2023). Speed endurance refers to the ability to sustain a high level of speed over a given period and essentially represents a combination of speed and endurance capacities (Bompa & Buzzichelli, 2015, p. 295). Speed endurance is particularly important in sports such as tennis, where high-intensity efforts are repeated with short recovery periods.

Tennis is an open-skill sport characterized by a non-linear and chaotic nature. Athletes are required to continuously respond to variable environmental conditions created by their opponents and the ball (Kovacs, 2006). Success on the court demands far more than simply running from one point to another. For instance, match analyses have shown that players change direction an average of 8 to 15 times per point, with the majority of these movements occurring over distances shorter than 5 meters (Filipčič et al., 2017). The determinants of success involve the integration of multiple factors: the ability to anticipate the opponent's next move, the capacity to initiate an explosive first step during directional changes, rapid deceleration to maintain balance during stroke execution, and subsequent re-acceleration or force production in an original or new direction (Kovacs, 2006).

The classical model of speed is therefore insufficient to fully explain the complex movement demands of tennis. To evaluate speed in the context of tennis-specific movement requirements, the concept of agility must be employed. Agility provides a more holistic model for understanding speed by integrating the cognitive components of performance with physical capabilities (Sheppard & Young, 2006). The aim of this section is to examine the constituent elements of speed in tennis in line with modern sports science's understanding of agility. This approach seeks to offer a deeper perspective on the performance dynamics essential for success in tennis.

A Holistic Performance Model in Tennis: Agility

In modern sports science, agility is no longer regarded solely as the ability to change direction quickly. The widely accepted definition in the sports science literature is as follows:

"A rapid whole-body movement with a change of velocity or direction in response to a stimulus." (Sheppard & Young, 2006).

This definition identifies two fundamental components of agility:

1. **Cognitive-perceptual processes** – the mechanisms that allow an athlete to respond to a stimulus (e.g., the opponent or the ball),
2. **Physical-motor capacities** – the physical abilities that enable the implementation of the decision made.

In tennis performance, both the accuracy and effectiveness of performance emerge from the integration and coordination of these two fundamental components (Young & Farrow, 2006).

The Cognitive Component of Agility: Perception, Decision-Making, and Response

One of the key features that clearly distinguishes elite athletes from beginners is that the perceptual and cognitive processes of elite performers occur prior to the execution of physical movement (Mann et al., 2007). Research has shown that these processes contribute to performance even within fractions of a second and can, at times, determine the difference between success and failure.

Anticipation and Visual Scanning

Elite athletes exhibit markedly superior abilities in perceiving environmental cues and anticipating opponents' actions compared to novice performers. Literature indicates that expert players employ shorter but more selective visual scanning strategies, focusing their gaze on performance-relevant areas rather than distributing it widely or randomly. This allows athletes to more effectively interpret early kinematic cues that signal the opponent's movement intentions and to rapidly evaluate potential game scenarios. Consequently, visual scanning is not merely the speed of observing the environment but involves a selective cognitive process that determines which information is processed, when, and how. This process contributes to reduced decision-making time and the generation of more appropriate motor responses during play, making it a critical determinant of high-level performance (Mann et al., 2007). Moreover, this skill shortens reaction time and facilitates optimal positioning on the court (Farrow & Abernethy, 2002).

Decision-Making Speed

In tennis, players are required to make both tactical and technical decisions under extreme time constraints. They must rapidly assess multiple variables, such as the opponent's positioning, the ball's trajectory, and their own court location, and execute the most appropriate motor response (e.g., choosing a backhand instead of a forehand, or a cross-court shot instead of a down-the-line shot) (Yu & Ali, 2025).

The Physical Dimension of Agility: Change of Direction Speed (CoD-S)

Once a player has identified the appropriate option, they must execute it as quickly and effectively as possible. This is where the physical aspect of agility, known as Change of Direction Speed (CoD-S), comes into play. CoD-S is defined as the ability to decelerate rapidly during a sprint and then explosively re-accelerate in a new direction (Chaabene et al., 2018).

Acceleration and First-Step Quickness

In tennis, more than 70% of points last less than 10 seconds, during which players are required to accelerate multiple times over very short distances (1–4 meters) (Kovacs, 2006). An explosive first step depends on lower-body muscular strength and the Rate of Force Development (RFD), which is the ability to apply force in a very short period of time (Young, James, & Montgomery, 2002).

Deceleration / Braking Strength

A crucial component of change-of-direction ability is the capacity to decelerate effectively while moving at high speed, also known as braking. This skill largely depends on the adequacy of eccentric muscle strength. Effective use of eccentric force allows an athlete to reduce speed in a controlled manner, come to a stop quickly, and transition more efficiently into the subsequent re-acceleration phase. Consequently, training approaches aimed at improving agility and change-of-direction performance increasingly emphasize the development of eccentric braking strength. Recent literature demonstrates that eccentric-focused training protocols lead to significant improvements in on-court agility and sharp change-of-direction abilities, supporting the view that eccentric strength is a critical performance component (Chaabene et al., 2018).

Reactive Force and the Split-Step

The split-step is a preparatory movement performed at the moment the opponent strikes the ball, allowing elastic energy to be pre-stored in the muscle-tendon units. This movement enables the athlete to perform an eccentric contraction followed immediately by an explosive concentric contraction within the Stretch-Shortening Cycle (SSC) (Komi, 2000).

This process allows the athlete to execute multidirectional and wide-angled movements rapidly (Southey et al., 2024). In tennis, the split-step is a fundamental component of agility, as it facilitates the "reading" of the opponent's shot and enables the player to assume the optimal position as quickly as possible.

Maximum Speed

Although tennis frequently involves short-distance accelerations and decelerations, players occasionally need to reach maximal running speed. This typically occurs when responding to short drop shots or high balls sent to the back of the court (lobs). While such high-speed efforts are relatively infrequent, they can be highly influential in determining match outcomes when they occur during critical rallies (Fernandez-Fernandez & Kovacs, 2018).

Factors Influencing Agility and Speed Components in Tennis

As discussed in the previous section, speed in tennis should be evaluated within the framework of agility. Agility is a multidimensional construct that involves the integration of perceptual-cognitive processes with physical-motor abilities. Therefore, when assessing the factors that affect a tennis player's movement speed and effectiveness on the court, this multidimensional nature must be taken into account.

Factors influencing agility and speed performance in tennis include genetic characteristics, biomechanical capacities that determine movement efficiency, tactical awareness, and the level of training. In this section, the primary determinants of tennis agility and speed performance will be examined based on physical, cognitive, and environmental factors.

Physical and Biomechanical Factors

This category encompasses the physical attributes that enable an athlete to execute movements accurately, at the right time, and in the correct location. Neuromuscular capacity is a fundamental component of the neuromuscular system and represents a core physical attribute that facilitates movement execution (Faude & Donath, 2019).

Maximum strength can be defined as the highest amount of force an athlete can voluntarily generate. Particularly, a high level of maximum strength relative to body weight is associated with an increased potential to produce additional acceleration. Strong lower-body and hip muscles contribute to higher ground reaction forces, thereby enhancing first-step acceleration (Seitz et al., 2014).

Explosive strength (or power) also plays a critical role in agility and speed, fundamentally defined as the ability to generate force in the shortest possible time. The most appropriate measure of this quality is the Rate of Force Development (RFD). In explosive sports such as tennis, athletes do not have sufficient time to reach maximal force; thus, the ability to produce force rapidly is crucial. Research has shown that plyometric training is an effective method for developing this capacity (Haff & Nimphius, 2012).

In addition, reactive force reflects how effectively an athlete can utilize the Stretch-Shortening Cycle (SSC). During the split-step movement, a high level of reactive force reduces ground contact time and enhances the initial step's change-of-direction speed. In this way, the athlete increases movement momentum by utilizing elastically stored energy (Flanagan & Comyns, 2008).

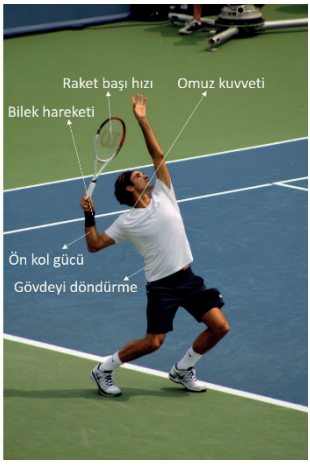

Figure 1. *Interaction of Physical and Biomechanical Components during the Tennis Serve (Aslan, 2024)*

In elite athletic performance, movement techniques and anthropometry constitute fundamental components. For an athlete to move faster and more efficiently while expending less energy, biomechanically efficient technique is essential. Examples include achieving proper timing for the split-step, lowering the center of mass during changes of direction, effectively engaging the hips to reduce load on the knee joint, and maintaining body awareness to ensure balance after executing a stroke (Kovacs, 2009).

Moreover, an athlete's height and limb lengths directly influence movement economy. Body composition, specifically the ratio of fat to muscle, also contributes to movement efficiency. Generally, lower fat mass and higher muscle mass provide a better strength-to-weight ratio, thereby enhancing acceleration capabilities (Kumartaşlı et al., 2011).

Cognitive / Tactical Factors

Cognitive and tactical skills underpinning high performance are among the primary factors that enable athletes to succeed during competitions. This section provides a cognitive perspective on how athletes evaluate mental processes to execute the right action at the right time. Perceptual-cognitive abilities are critical for accurately identifying the relevant information and integrating it with enhanced athletic performance. This is considered one of the main reasons why elite athletes appear to move faster on the court compared to others (Martines-Gallego et al., 2013).

Moreover, elite athletes can anticipate their opponents' actions before the opponent becomes aware of them. For instance, in the decision-making process, an elite tennis player focuses on the opponent's hip and trunk

region rather than arm movements. This allows for earlier and more accurate predictions of shot direction, saving valuable time (Broadbent et al., 2017).

The execution of agility also relies on correct perceptual guidance regarding where and when to focus. This skill of knowing "when" and "where" to look enables elite athletes to utilize visual attention through properly sequenced and appropriately timed fixations, allowing them to analyze critical information in time and evaluate various possible options (Mann, Williams, Ward, & Janelle, 2007).

An elite athlete's ability to anticipate potential scenarios and their likely developments within a match context provides a distinct competitive advantage. When the athlete understands the opponent's playing style, strengths and weaknesses, and which strategies may be employed depending on the score, many of the aforementioned processes become largely automatic. Increases in movement speed and more conscious, context-appropriate decision-making contribute to the athlete's mental preparation for the next action (Gréhaigne & Godbout, 2012).

Training and Environmental Factors

External or situational factors play a significant role in transforming an athlete's potential into performance. In this context, variables such as training status, fatigue level, and environmental conditions can have considerable effects. Since agility is largely task-specific, it requires both linear sprint training and multidirectional movement exercises. Therefore, the general framework of training should consider tennis as a sport that is physically demanding and cognitively challenging; in other words, it is crucial to develop the ability to respond to stimuli and change direction in response to these stimuli (Young, James, & Montgomery, 2002).

Furthermore, both mental and physical fatigue directly affect not only the athlete's inherent qualities but also overall performance. Fatigue can reduce an athlete's capacity to generate force, execute techniques, make movement decisions, and thus affect the accuracy of performance. It is well known that a large proportion of simple errors made by both sides as the match progresses are fatigue-related; the impact of fatigue on sports performance is real (Sun et al., 2021).

Among environmental conditions, the type of court surface particularly shapes the athlete's interaction with the ground and, consequently, movement mechanics. Clay courts offer slower game dynamics that limit ball speed and allow controlled sliding, whereas hard courts provide limited sliding capacity, requiring higher reaction forces and force production during sudden stops and changes of direction. Therefore, players on hard courts are expected to

execute braking, acceleration, and directional-change strategies more sharply and in a controlled manner. Accordingly, court surface type directly influences not only movement patterns but also training planning, footwork, and load distribution on the musculoskeletal system (Girard, Micallef, & Millet, 2005).

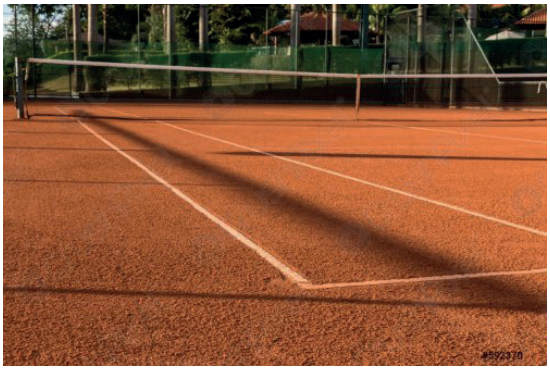

Figure 2. *Clay Court*

Figure 2. *Hard Court*

Evidence-Based Speed and Agility Training for Tennis

In tennis, what matters on the court is not merely absolute physical speed, but the ability to apply speed in the correct technique, at the right time, and in the appropriate direction. As highlighted in previous sections, tennis speed is best understood within the context of agility and through the integration of perceptual-cognitive and physical-motor components (Sheppard & Young, 2006). Therefore, a modern scientific training approach should focus not only on developing faster athletes but also on enhancing agility to meet the dynamic demands of the game.

One of the primary factors distinguishing elite tennis players from their peers is their conditioning status. Elite athletes can move more efficiently

on the court, make decisions more rapidly, recover faster after long rallies, experience less fatigue, and demonstrate greater resistance to injury; all of these factors can directly influence match outcomes. Consequently, tennis conditioning is not limited to endurance alone. It encompasses the comprehensive development of speed, strength, flexibility, and coordination. If these biomotor qualities are maintained throughout match play, performance at a competitive level can be ensured. Thus, training programs designed for tennis players should aim not only to improve general conditioning but also to meet sport-specific demands (Koçyiğit et al., 2020).

This section provides a comprehensive discussion of evidence-based strategies to enhance speed and agility in tennis players. The proposed programs progress from General Physical Preparation (GPP) to Sport-Specific Physical Preparation (SPP) and offer an integrated pathway, ranging from fundamental on-court strength exercises to task-oriented, reactive plyometric movement patterns. Each training method employed is supported by contemporary empirical evidence, enabling the integration of theoretical foundations with effective practical application.

Development of Physical Capacity

At this stage, the focus is on developing the physiological and neuromuscular systems that underpin all movement. Improvements in speed and explosiveness expand an athlete's performance potential. Strength training serves as the foundation for power development; thus, relative strength (strength-to-body weight ratio) is particularly important for acceleration and change-of-direction abilities. According to the force-velocity curve, when maximal force is achieved, athletes are expected to generate greater power even during high-velocity movements (Suchomel, Nimphius, & Stone, 2016). This underscores the necessity of mastering fundamental exercises such as squats, deadlifts, and lunges before initiating speed-specific training.

Considering the intensity and frequency of modern tennis demands, strength and conditioning programs constitute essential components of development. Most professional athletes work with full-time or part-time strength and conditioning specialists, making it critical to train in an optimal manner while minimizing injury risk. Due to the biomechanical and physiological demands of tennis, designing a sport-specific intervention program is inherently challenging.

Tennis matches consist of intermittent anaerobic periods with an approximate work-to-rest ratio of 1:2. These periods involve explosive muscle contractions to generate coordinated rotations of body segments and high racket and ball velocities. Additionally, maximal strength training has been

shown to develop tennis-specific power. Periodized resistance training, particularly using undulating methods, has demonstrated significant improvements in strength and serve velocity. Even during condensed training schedules, at least 1–2 strength sessions are typically maintained during performance-maintenance phases to prevent physical decline. Tennis-specific needs, such as strengthening the rotator cuff muscles, should be incorporated into training plans to help prevent shoulder injuries (Reid & Schneiker, 2008).

A systematic review by Miranda et al. (2020) provides a general evaluation of strength training approaches in elite tennis players. Six studies published between 2000 and 2017 were examined. Findings indicated that an approach combining traditional strength training with tennis-specific activities yielded the greatest improvements in lower-body explosive power, maximal strength, serve velocity, and agility performance. Roetert et al. (2009), in their biomechanical analysis of on-court strokes, recommended strength exercises targeting these movements. Modern strokes typically employ an "open stance" and follow a kinetic chain model from the legs through the trunk to the arms. Therefore, the authors suggested exercises such as medicine ball throws, cable rotation drills, and forearm movements (e.g., weighted wrist rolls and pronation/supination exercises). These exercises aim to enhance kinesthetic coordination within the kinetic chain, ensure effective force transfer through strong muscle groups, and reduce injury risk during strokes.

Ellenbecker and Roetert (2004) examined trunk rotational strength bilaterally (right vs. left) in elite tennis players using an isokinetic dynamometer. The study included 109 elite players (54 males, 55 females). Findings indicated no significant side-to-side differences in males, suggesting symmetrical strength. In females, a 4–8% difference favoring the right side was observed, particularly during forehand strokes. Consequently, training programs for elite tennis players are recommended to incorporate trunk rotation exercises with equal emphasis for both males and females.

Wang and Li (2023) demonstrated that a core strength program had a significant impact on serve performance in tennis players. The program was conducted three times per week over eight weeks and included exercises such as planks, double-leg bridges, side-lying hip raises, hanging leg raises, medicine ball throws, and elastic band pulls. At the conclusion of the program, the experimental group exhibited significant improvements in serve velocity and accuracy. These enhancements were attributed to the role of a strong core in improving force transmission through the kinetic chain and enhancing overall body stability.

Force production through explosive power and plyometric training enhances elite performance. In tennis, kinetic movements occur within milliseconds, making the speed of force development, or Rate of Force

Development (RFD), more critical than absolute force. The core of plyometric training involves Stretch-Shortening Cycle (SSC) exercises, which develop the capacity of the muscle-tendon unit to store and release elastic energy. Once maximal force is achieved, generating higher force in a shorter time becomes possible, which is essential for tennis performance.

Lower-body explosive power is developed through exercises such as box jumps, drop jumps, and hurdle hops, while upper-body explosive power is enhanced through medicine ball exercises and weighted drills. Tennis is a high-intensity, dynamic sport that primarily relies on explosive strength (Deng et al., 2022). Fernandez-Fernandez et al. (2015) investigated the effects of an 8-week combined repeated sprint and explosive strength training program in elite young male tennis players. The experimental group performed multidirectional repeated sprints (3–4 sets, 5–6 repetitions) and explosive strength exercises (box jumps, hurdle hops, and agility ladder drills). At the conclusion of the study, the experimental group demonstrated significant improvements in 10 m sprint time, vertical jump, and repeated sprint performance. These findings suggest that combining these two training modalities is an effective method for enhancing performance.

Deng et al. (2022) conducted a systematic review and meta-analysis to evaluate the effects of plyometric training on skill and physical performance in tennis players. A total of 12 peer-reviewed studies including 443 participants were analyzed. Results indicated that plyometric training programs produce significant improvements in serve velocity, sprint speed, lower-limb explosive power, and agility.

In tennis, agility requires not only acceleration but also effective deceleration. Players often need to slow down rapidly to prepare for shots. The braking phase represents eccentric muscle contractions in response to external forces. Eccentric strength influences both speed and change-of-direction ability and may reduce knee-related injury risk (Spiteri et al., 2013). Eccentric strength can be developed using Nordic leg curls, slow-tempo eccentric exercises, and controlled landings.

Kovacs et al. (2008) addressed effective deceleration as a skill in tennis-specific training and identified four main components: dynamic balance, strength, power, and reactive strength. They subsequently recommended specific exercises for both the upper and lower body. Examples for the upper body included reverse catches and explosive ball-drop exercises, while lower-body examples comprised Romanian deadlifts, landing-focused box jumps, multidirectional lunges, and balance drills. The authors emphasized that eccentric strength and deceleration training are crucial for enhancing performance and reducing injury risk.

Smajla et al. (2022) investigated the relationship between change-of-direction (COD) speed and eccentric strength in tennis and basketball players. Their findings demonstrated that Nordic hamstring exercises and vertical jump measurements were associated with COD performance. Eccentric strength measures accounted for 37.4% of the variance in 180° COD performance. Consequently, training programs aimed at improving change-of-direction speed should incorporate a variety of eccentric strength exercises.

Biomechanics and Technical Coordination

Initiating movement on the court and effectively transmitting force throughout the body largely depend on biomechanical and technical proficiency. An effective change-of-direction (COD) maneuver involves lowering the center of mass, rotating the hips and torso toward the intended direction, placing the support foot at an optimal angle, and accelerating in the new direction with a powerful push. Closed-skill drills using predetermined cone patterns or court lines facilitate the automatization of these technical components.

A comprehensive review by Dos Santos et al. (2019) confirms the optimal biomechanical principles for enhancing COD technique. High-level athletes were observed to maintain a lower center of mass during movement, which improves balance and allows more effective horizontal force application. Additionally, rotating the torso and hips toward the new direction only just before the final step supports the initial push-off, while the plant foot plays a critical role in generating and absorbing force. The authors concluded that the technical components of COD can be effectively developed through closed-skill training.

The split-step is a preparatory movement that allows a tennis player to explosively move in any direction from a neutral stance. The timing of ground contact during the split-step should coincide with the opponent's racket-ball contact, maximizing utilization of the Stretch-Shortening Cycle (SSC).

Filipcic et al. (2017) analyzed the split-step timing of professional and junior tennis players in game contexts using video analysis. Results indicated slower reaction times from the split-step during specific game situations such as serve reception, baseline rallies, and specialized strokes. Additionally, significant differences in split-step timing were observed between professional and junior male and female players, suggesting that each player or group employs a distinct timing mechanism.

These scientific findings demonstrate that the split-step is not merely a simple jump but a complex perceptual-motor skill requiring anticipation, which can be refined through practice.

Cognitive-Perceptual Training

The aim of this stage is to link improvements in physical capabilities with accurate decision-making processes in the complex environment encountered during play, ultimately enhancing on-court decision-making ability. Reactive agility differs from conventional cone drills; instead, it requires the athlete to respond to unpredictable stimuli. This approach more accurately reflects the demands of tennis matches and directly engages the player's decision-making processes.

Young and Willey (2010) applied a reactive agility assessment in semi-professional Australian football players. The test duration was divided into three components: stimulus presentation time, decision-making time, and, finally, movement execution time following the decision. A key finding was that decision-making time showed a stronger correlation with overall reactive agility performance ($r = 0.77$) than physical movement speed ($r = 0.59$). Additionally, the low correlation between decision time and movement execution suggests that these abilities may be independent; some athletes may decide quickly but move slowly, or vice versa. These findings strongly indicate that perceptual skills should be explicitly included as a limiting factor in reactive agility training programs (Young & Willey, 2010).

Modern motor learning theories, particularly from a Constraints-Led Approach (CLA) perspective, emphasize that modifying constraints related to the athlete, environment, and task facilitates skill acquisition. A comprehensive review by Piquer-Piquer et al. (2025) highlights one of the most practical approaches in tennis learning, focusing on tailoring training to the characteristics of beginner players while progressively integrating perceptual and cognitive demands.

It also involves the use of adapted equipment. The authors note that modifying task constraints (e.g., using smaller rackets or low-pressure balls) provides players with more time to perceive the ball and make decisions. This effectively enhances court usage during rallies, promotes a dynamic playing style, and encourages offensive-oriented behaviors. These adaptations allow players to maintain rapid court responses even in the early stages of competition (Piquer-Piquer et al., 2015).

Giménez-Egido et al. (2020) provided empirical support for this perspective. Their study compared the standard tournament format (GC) with a modified format (MC) featuring reduced court dimensions and lower net height for players under 10 years old. The modified format led to notable changes in tactical behavior. While the standard format primarily improved serving skills, the modified format increased the variety of "special and positional shots" (e.g., approach shots, lob returns) and enhanced technical-tactical variability. Moreover, the modified format encouraged players to adopt a more offensive approach, prompting more frequent net approaches and positional

adjustments. The authors conclude that even minor rule modifications can stimulate players to explore creative and varied playing patterns and improve tactical problem-solving abilities, which is a core principle of the Game-Based Approach (GBA).

Conclusion and Future Directions

In tennis performance, speed is not a unidimensional physical attribute; rather, it is a multidimensional construct encompassing interrelated movement components such as linear sprinting, change of direction (CoD) capacity, curvilinear running, and agility. The effective manifestation of these movement qualities depends not only on muscular strength and neuromuscular coordination but also on the player's ability to perceive environmental cues, evaluate in-game situations, and initiate appropriate motor responses in a timely manner. Consequently, assessing and developing tennis-specific speed requires an integrated consideration of both biomechanical and cognitive processes.

Although the current literature includes a substantial number of studies on speed components, research often examines physical and cognitive elements separately. As a result, training practices frequently address physical speed enhancement and decision-making development in isolation. However, match contexts necessitate that players employ their speed capacity within a simultaneous "stimulus–decision–movement" cycle. Therefore, speed should be conceptualized not merely as movement velocity but as contextual or situational speed, reflecting its application within game-specific scenarios.

Future research should prioritize examining speed components under conditions that closely simulate real match scenarios. Key directions include:

- Development of tennis-specific performance tests assessing reactive agility and first-step speed,
- Design of integrated training models that combine physical speed exercises with perceptual-decision-making processes,
- Comparative analysis of change-of-direction strategies across different court surfaces,
- Longitudinal monitoring of combined speed-agility protocols to evaluate their effects on performance and injury risk.

Understanding the multidimensional nature of speed will enable coaches to design more purposeful, sport-specific, and player-profile-adapted training programs. Such an approach will not only enhance performance but also facilitate safer and more sustainable adaptation to the demanding and variable conditions of competitive tennis.

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