Mind, Movement and Behavior: PERSPECTIVES ON EXERCISE AND PHYSICAL EDUCATION

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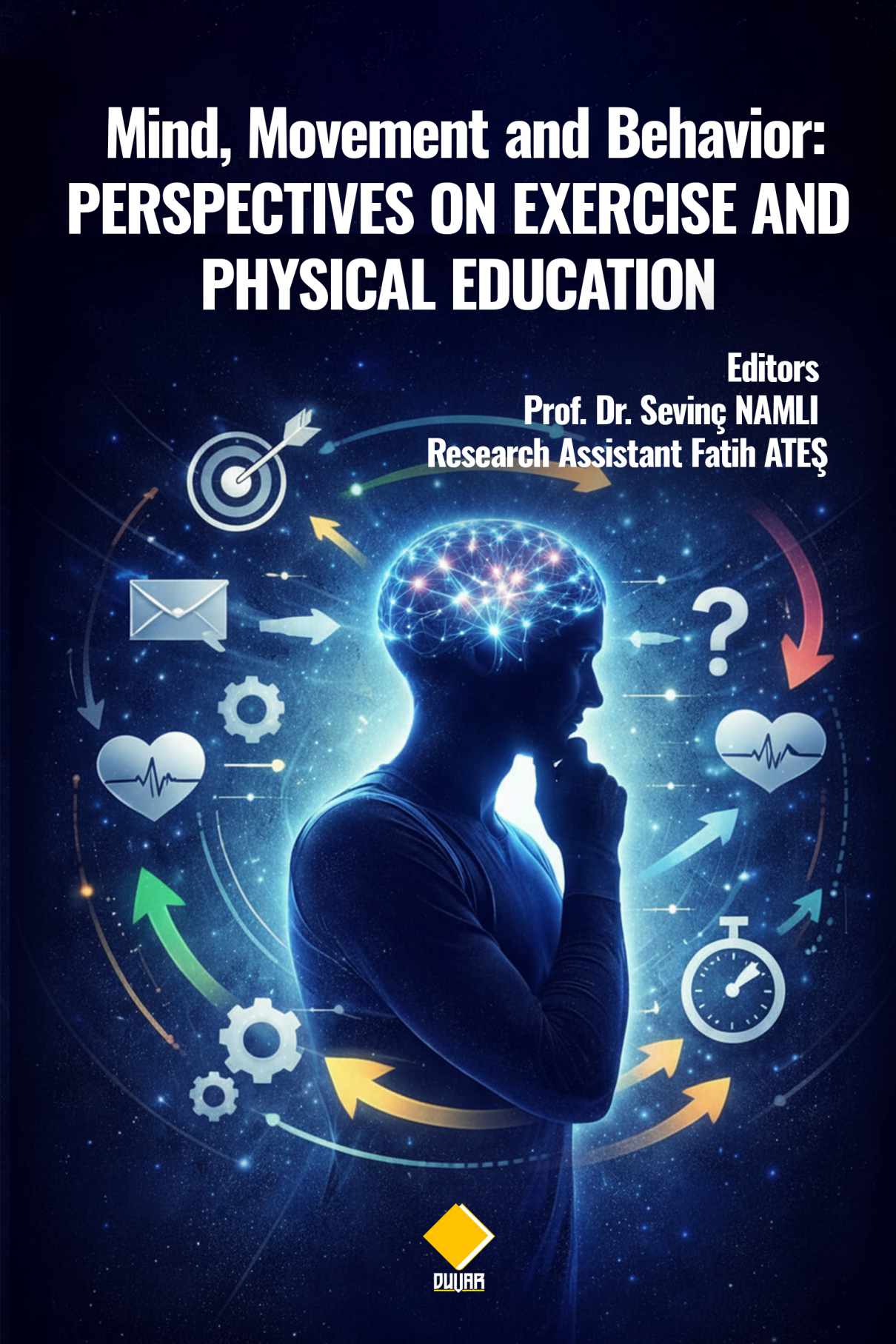

DUVAR

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PREFACE

Titled From Mind to Movement and Behavior: Exercise and Physical Education, this work aims to demonstrate that human movement is not merely a biomechanical process but rather a holistic construct encompassing cognitive, emotional, and neuropsychological dimensions. Contemporary perspectives in sports sciences and physical education clearly indicate that performance is shaped not only by physical capacity but also by mental processes, psychological resilience, and environmental interactions. Centered on this multidimensional framework, the book seeks to provide readers with an interdisciplinary perspective.

The volume examines brain-based mechanisms of movement and the relationship between neurophysiological structures and mental resilience. Current practices such as mental training, psychological skill development, and motor imagery are discussed through both theoretical and practical lenses. In addition, the work integrates historical and contemporary approaches by addressing topics such as athletes' perception of fatigue, the psychological effects on performance, the role of exercise in combating neurodegenerative diseases, and Avicenna's (Ibn Sina's) perspective on exercise.

In the later chapters, contemporary educational issues—including talent identification and psychosocial determinants, factors influencing Generation Z students' participation in physical education classes, and peer bullying—are explored. Through these discussions, the transformative role of physical education and sport is emphasized not only in terms of performance but also in character development, social growth, and mental health.

In this respect, the book serves as both a theoretical and practical reference resource for academics, students, and practitioners working in the fields of sports sciences, physical education, psychology, and education.

Chapter 1

The Neuropsychology of Movement: Brain-Derived Neurotrophic Factor and Mental Resilience in the Context Of Physical Education

Ferhat CANYURT[1], Muhammet Raşit İNAÇ[2]

Introduction

An Overview of the Effects of Movement on the Brain and Mind

According to data from the World Health Organization (WHO), neurodegenerative diseases and mental disorders represent major global public health concerns. It is estimated that more than 55 million people worldwide are living with dementia, with Alzheimer's disease being the most prevalent form (Romero Garavito et al., 2025). Approximately 30% of individuals worldwide have experienced a mental disorder at some point in their lives (Steel et al., 2014) Moreover, neurological conditions alone accounted for more than 9 million deaths in 2016 (Feigin et al., 2019). In addition, the prevalence of Parkinson's disease has increased significantly in recent years. It is estimated that more than 8.5 million people were affected in 2019, which is twice the number reported 25 years earlier (Romero Garavito et al., 2025). Cognitive functions encompass a wide range of mental processes, including memory, attention, and executive functions, all of which play crucial roles in an individual's daily life and overall well-being (Singh et al., 2025). Cognitive decline and related neurodegenerative diseases have become a significant global health concern in recent years. This situation underscores the necessity of developing effective strategies to preserve and enhance cognitive functions throughout the lifespan (Murman, 2015).

Exercise is considered one of the most important lifestyle behaviors, playing a fundamental role in maintaining and improving an individual's physical health (Caspersen et al., 1985). However, a growing body of evidence suggests that these effects extend beyond physical health, encompassing cognitive health as well (Mandolesi et al., 2018) and have a positive impact on mental well-being (Singh et al., 2023). The relationship between exercise and cognitive function has

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become an increasingly prominent topic of research due to its importance at both healthcare and societal levels. With the growing interest in this field, a substantial number of systematic reviews employing diverse scopes and methodological approaches have emerged in the literature in recent years (Bhattacharyya et al., 2021; Coelho-Junior et al., 2022; Liu et al., 2022; Sember et al., 2020; Singh et al., 2025; Song et al., 2023; Liya Xu et al., 2023). Animal studies have shown that physical exercise and cognitive stimulation contribute differently to neuroplasticity in the mouse brain; while physical exercise promotes neurogenesis, cognitive stimulation facilitates the differentiation of these newly formed cells (Kempermann et al., 2010; Kronenberg et al., 2006). Similarly, numerous studies in humans have demonstrated that physical exercise exerts beneficial effects on cognitive and functional brain plasticity in older adults, particularly within hippocampal regions (Erickson et al., 2011; Niemann et al., 2014), This suggests the presence of neurogenesis mechanisms similar to those observed in animal models. Moreover, regular exercise has been associated with increased levels of Brain-Derived Neurotrophic Factor (BDNF), which plays a crucial role in neurogenesis, synaptogenesis, and dendritic branching (Håkansson et al., 2016; Ruscheweyh et al., 2011), this, in turn, leads to an enhancement of learning-related plasticity (Cassilhas et al., 2016; Hötting & Röder, 2013). When physical exercise is performed prior to cognitive training, the release of serum BDNF is significantly higher compared to performing the activities in the reverse order (Nilsson et al., 2020), this suggests that physical exercise may have a facilitating effect on cognitive interventions.

Physical Education and Neuropsychological Development: The Role of Physical Activity in Supporting Executive Functions

Contemporary educational institutions suggest that children's experiences in sports and physical education (PE) contribute to the development of mental acuity, skills, and strategies that are essential for coping with challenges encountered throughout life (Donnelly et al., 2016). Similarly, existing evidence indicates that regular physical activity is associated with enhanced mental toughness, reduced anxiety levels, and improved cognitive imagery skills. Moreover, mental imagery has been shown to support neuromuscular activation, facilitate motor planning processes, and be positively associated with increased motivation and self-efficacy among athletes (Demir et al., 2025; Yılmaz & Namlı, 2023). These findings suggest that not only physical education and sports participation but also physical activity practices supported by mental training may have a comprehensive influence on cognitive, emotional, and performance-related functions.

The perceived importance of physical education or physical activity and its contribution to children's academic achievement has changed significantly throughout the history of modern education systems (Tomporowski et al., 2011). Advocates of physical activity (PA) have long emphasised the necessity of school-based physical activity and argued that time allocated to physical activity not only improves health but also positively contributes to academic performance (Trudeau & Shephard, 2008).

Recent studies have highlighted the potential of physical activity (PA) to enhance executive functions in school-aged populations. Evidence suggests that exercise programs involving cognitively demanding components such as planning, attention, or rapid decision-making can improve executive functions by inducing neuroplastic changes in brain regions associated with cognitive control, particularly within the dorsolateral prefrontal cortex (Diamond & Ling, 2016; Mao et al., 2024). Some of these changes have been associated with increased levels of Brain-Derived Neurotrophic Factor (BDNF), a key mediator of synaptic growth and neural connectivity (Diamond, 2013; Kamijo et al., 2011). Specifically, aerobic exercise has been shown to strengthen the neurophysiological basis of executive function improvement by enhancing cerebral blood flow and increasing BDNF concentrations in the prefrontal cortex (Colcombe et al., 2006). The development of executive functions (EFs) has been shown, through neuroimaging studies, to progress in parallel with the development of multiple motor skills, owing to the overlapping networks of motor coordination and executive control (Diamond, 2013; Koziol & Lutz, 2013). Moreover, longitudinal studies have shown that motor skills acquired in early childhood are strong predictors of cognitive abilities later in life. These findings highlight that motor development plays a critical role not only in physical competence but also in cognitive maturation and the foundation of executive functions. Early-acquired skills such as coordination, attentional focus, and movement planning are thought to support problem-solving, decision-making, and self-regulation processes in later stages of life (Murray et al., 2006).

In this context, the systematic inclusion of physical education and physical activity from early childhood forms the foundation of a holistic educational approach, supporting not only physical health but also cognitive and emotional development. Therefore, it is essential that educational policies and curriculum programs be structured with careful consideration of the multifaceted effects of physical activity on cognitive development.

Neuropsychological Foundations

The Relationship Between Movement and Cognitive Functions

The number of health problems caused by physical inactivity continues to rise worldwide. A recent study demonstrated that physical inactivity during the COVID-19 pandemic had a negative impact on both mental and physical health, leading to increased levels of anxiety, depression, stress, insomnia, fatigue, and other mental health issues (Li et al., 2023). In addition, it has been reported that physical inactivity also leads to statistically significant decreases in body composition, endurance, muscle strength, and agility parameters (Asan et al., 2024).

Research has shown that physical activity (PA) during childhood and adolescence positively impacts physical fitness (Janssen & LeBlanc, 2010), psychological well-being (Biddle & Asare, 2011), academic performance (Santana et al., 2017) and school engagement (Ateş & Uğraş), and also helps prevent overweight and obesity (Bleich et al., 2018; Verrotti et al., 2014). PA is also associated with the prevention of chronic diseases in adulthood (Kemper & Monyeki, 2019). Studies have also shown that the longer individuals engage in physical activity (PA) during childhood and adolescence, the more likely they are to remain physically active in adulthood (Batista et al., 2019). Therefore, participation in physical activity (PA) during childhood is considered to have a powerful and lasting impact on health throughout the lifespan (Wu et al., 2023).

Children with higher levels of physical activity (PA) and greater aerobic capacity have been reported to possess larger brain volumes and better brain structure and function in regions associated with cognitive control and memory, such as the basal ganglia and the hippocampus (Chaddock et al., 2010). Research indicates that aerobic fitness can have significant effects on hippocampal structure and function. Experimental studies have shown that voluntary aerobic exercise increases cell proliferation and neuronal survival in the dentate gyrus of the hippocampus, thereby enhancing learning and memory processes. These beneficial effects are associated with elevated levels of neurotrophic factors involved in neuronal growth and plasticity, such as BDNF (Brain-Derived Neurotrophic Factor), IGF (Insulin-Like Growth Factor), and VEGF (Vascular Endothelial Growth Factor). Although the specific mechanisms in humans have not yet been fully elucidated, animal studies suggest that higher aerobic fitness during childhood may be linked to greater hippocampal volume and improved memory functions (Berchtold et al., 2005; Chaddock et al., 2010; Van Praag et al., 2005; Vaynman et al., 2004). PA has been found to be associated with executive function, information processing speed, language, and memory, and it has also been shown to be positively correlated with hippocampal capacity and

memory performance in children (Thomas et al., 2012). PA and the resulting changes in white matter networks are reported to lead to physiological adaptations such as increased blood volume and enhanced fat mobilization capacity (Chaddock et al., 2010; Thomas et al., 2012). A high level of aerobic fitness during childhood has been associated with superior performance in the effective encoding and retrieval of relational information. This finding suggests that physically fit children aged 9–10 are able to use their memory more flexibly and efficiently through enhanced executive control abilities and prefrontal–hippocampal interactions (Chaddock et al., 2011). Research using magnetic resonance angiography (MRA) has revealed that aerobic activity in older adults is associated with both the number and tortuosity of cerebral blood vessels. These findings suggest that aerobic exercise may lead to regional increases in brain volume as well as overall improvements in cerebral circulation and vascular structure (Thomas et al., 2012).

Taken together, all these findings indicate that physical activity plays a fundamental role not only in physical health but also in cognitive development and the maintenance of brain structure. Therefore, promoting regular physical activity from early childhood emerges as a critical strategy for supporting mental, neurological, and physical health throughout the lifespan.

The Effects of Exercise on Attention, Memory, and Executive Functions

Attention-Deficit/Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders (Brassell et al., 2017; Du Rietz et al., 2021; Yang et al., 2024). The global prevalence of ADHD is estimated to be approximately 5.29% (Rooney, 2011). Up to 7.2% of children are affected by ADHD, and its symptoms persist into adulthood in approximately 60% of cases (Sibley et al., 2017; Thomas et al., 2015).

In recent years, various physical activity interventions aimed at enhancing the development of executive functions have been investigated. One such intervention is aerobic exercise (AE), which is a form of physical activity performed over extended periods and at varying intensities, during which the body meets its energy demands through the use of oxygen (McArdle et al., 2006; Plowman & Smith, 2013). Research has shown that aerobic exercise (AE) may help reduce executive function (EF) deficits in children with Attention-Deficit/Hyperactivity Disorder (ADHD) (Brassell et al., 2017; Chang et al., 2014; Liu et al., 2022; Miklós et al., 2020). Different types of exercises such as running, swimming, and aerobic conditioning have been associated with significant improvements in inhibitory control (IC) and cognitive flexibility (CF), which are core components of executive function (EF). Moreover, high-intensity aerobic exercise has been reported to enhance prefrontal cortex–based cognitive

performance by increasing cerebral oxygenation and blood volume (Gondoh et al., 2009; Hwang et al., 2016). In addition, it has been reported that pharmacological treatment in children with ADHD exerts direct effects on metabolic organs, thereby shortening the course of treatment, whereas aerobic exercise (AE) helps regulate the body's metabolic activity and provides a physiological foundation for efficient neural transmission (Yang et al., 2024). According to the results of a recent study, aerobic exercise interventions can effectively enhance executive functions in children with Attention-Deficit/Hyperactivity Disorder (ADHD). The study reported that single sessions of aerobic exercise produced short-term improvements in executive functioning, while regular programs lasting 6–12 weeks led to more sustained effects. Furthermore, moderate-intensity exercises lasting 50–90 minutes were found to produce significant improvements, particularly in inhibitory control and cognitive flexibility, with these effects being more pronounced in children undergoing pharmacological treatment for ADHD (Yang et al., 2024).

BDNF: The Neurobiological Key To Learning

The Structure of BDNF and Its Role in Brain Functions

As a member of the neurotrophin family, Brain-Derived Neurotrophic Factor (BDNF) plays a critical role not only in the growth and development of the nervous system but also in supporting neuronal survival and facilitating neurogenesis. In addition, BDNF is involved in glutamatergic and gamma-aminobutyric acid (GABA)–ergic synaptic plasticity, and it influences serotonergic and dopaminergic neurotransmission (Li et al., 2022). Brain-Derived Neurotrophic Factor (BDNF) exerts its effects primarily through two receptors: TrkB and p75. Among these, the TrkB receptor is considered the principal receptor in the adult brain, as it binds to BDNF with greater affinity. When activated, TrkB stimulates several intracellular signaling pathways including PLC, MAPK, and PI3K through its tyrosine kinase domain, thereby promoting neuronal survival, growth, and maintenance (Teng & Hempstead, 2004).

Brain-Derived Neurotrophic Factor (BDNF) is primarily produced by neurons and glial cells, and it serves multifunctional roles within the central nervous system (CNS) (Leßmann & Brigadski, 2009). BDNF is essential for neuronal formation, differentiation, growth, and survival; moreover, it plays a regulatory role in processes such as synaptic plasticity, neural transmission, and neuronal resilience (Kowiański et al., 2018). In the human brain, BDNF exists in two forms: the precursor form (proBDNF) and the mature form (mBDNF). ProBDNF is synthesized in the endoplasmic reticulum as pre-proBDNF, processed in the Golgi apparatus to form proBDNF, and subsequently stored in dendrites or axons

(Li et al., 2022). Mature BDNF (mBDNF) is generated from proBDNF through the cleavage of its pro-domain, which occurs either intracellularly via enzymes such as furin or PC1/3/7, or extracellularly through the action of tPA/plasmin or matrix metalloproteinases (Wang et al., 2021).

The Mechanism by Which Exercise Increases BDNF Levels

The Mechanism by Which Exercise Increases BDNF Levels Physical Exercise (PE) is one of the most effective non-pharmacological strategies for maintaining health and preventing disease. Regular physical activity not only reduces the risk of cardiovascular, metabolic, and chronic disorders but also preserves brain health, thereby decreasing the prevalence of neurological and psychiatric conditions. Furthermore, it has been reported to exert positive effects on cognitive functions and neuroplasticity throughout the lifespan (Cefis et al., 2023). Exercise has been shown to reduce the incidence of both neurological disorders such as stroke, Alzheimer's disease, and Parkinson's disease and psychiatric conditions, including depression, schizophrenia, and addiction (Dunn et al., 2005; Paillard et al., 2015; Sofi et al., 2011; Longfei Xu et al., 2023).

The beneficial effects of exercise on the brain are largely explained by an increase in hippocampal neurogenesis, an enhancement of long-term potentiation (LTP), and the regulation of synaptic plasticity (Cefis et al., 2020). In addition, exercise has been shown to stimulate angiogenesis by promoting the formation of new capillaries from existing blood vessels (Ding et al., 2004). Both animal and human studies have demonstrated that the Brain-Derived Neurotrophic Factor (BDNF) is the primary mediator of these beneficial neurological effects. Widely distributed throughout the brain, BDNF plays a central role in neurogenesis, synaptic plasticity, and angiogenesis, while also exerting significant neuroprotective effects (Bartoletti et al., 2002; Kim et al., 2004; Korte et al., 1995).

BDNF is classified as an immediate early gene, meaning that it shows a rapid increase in mRNA expression without the need for new protein synthesis, through the quick activation of pre-existing transcription factors. In a pioneering study, voluntary wheel running was shown for the first time to increase BDNF mRNA levels in the hippocampus and cortex of rats (Neeper et al., 1995). This finding has since been replicated by subsequent studies using various types, durations, and intensities of exercise (Berchtold et al., 2005; Cefis et al., 2019; Griffin et al., 2009; Oliff et al., 1998; Pedard et al., 2019). It is well established that synaptic activity regulates the synthesis and release of neuronal BDNF, which in turn modifies synaptic structure and function (Poo, 2001). In this context, the exercise-induced increase in BDNF is thought to result primarily from transcriptional

upregulation. Furthermore, studies have reported a significant increase in endothelial BDNF expression in the aorta, veins, and cerebral microvascular tissues following exercise (Cefis et al., 2020). In contrast, pathologies associated with endothelial dysfunction such as diabetes, cerebral ischemia, hypertension, and rheumatoid arthritis have been reported to cause a reduction in cerebral BDNF levels (Cefis et al., 2023).

The specific cell types involved in exercise-induced BDNF production have not yet been fully elucidated. Research suggests that exercise promotes astrocyte proliferation, induces morphological changes, and increases BDNF–TrkB expression, indicating that these cells may support hippocampal neurogenesis and regulate synaptic function (Palasz et al., 2019). Given the central role of astrocytes in maintaining the blood–brain barrier, synaptic transmission, and brain homeostasis, the exercise-induced increase in astrocytic BDNF expression may reflect a mechanism that mediates interactions between endothelial cells and neurons. Moreover, oligodendrocytes have also been reported to play a role in exercise-induced BDNF production; these cells secrete BDNF to modulate synaptic transmission and have been shown to exhibit increased oligodendrogenesis following exercise (Guo et al., 2020). In addition, exercise has been reported to modulate microglial activation, enhance anti-inflammatory responses, and increase the number of BDNF-positive microglial cells (Mee-Inta et al., 2019). However, there is no clear consensus regarding the extent of microglia's involvement in BDNF production (Cefis et al., 2023). Taking together, these findings suggest that astrocytes, oligodendrocytes, and microglia may all contribute to BDNF expression in response to exercise; however, further research is needed to fully elucidate these cellular mechanisms.

Gene expression regulated by neuronal activity is considered one of the key mechanisms underlying experience-dependent plasticity and functional changes within the nervous system (Katz & Shatz, 1996). Exercise stimulates BDNF synthesis by generating sustained electrical activity in hippocampal neurons through both central motor control and afferent feedback pathways (Vanderwolf, 1969). In this process, calcium (Ca^{2+}) influx plays a crucial role in transmitting neuronal depolarization and initiating synaptic activity. The production of BDNF is associated not only with extracellular Ca^{2+} entry but also with the mobilization of intracellular Ca^{2+} stores (Balkowiec & Katz, 2002). Elevated Ca^{2+} levels activate signaling pathways such as CREB, MAPK, PI3K/Akt, and CaMK, thereby regulating activity-dependent gene expression and protein synthesis (Ghosh & Greenberg, 1995).

In response to neuronal activity, the promoter IV region of the bdnf gene is transcriptionally activated through three calcium-responsive elements (CaRE1–3) (Tao et al., 2002; Hong et al., 2008). Within this region, transcription factors such as the Calcium-Responsive Factor (CaRF) and the cAMP Response Element-Binding Protein (CREB) play essential roles; in particular, the phosphorylation of CREB at serine-133 is crucial for initiating BDNF transcription (Tao et al., 1998; Ma et al., 2014). This phosphorylation process is supported by Ca^{2+}-dependent mechanisms, including the adenylate cyclase/PKA, CaMK, Ras/MAPK, and redox signaling pathways (Shen et al., 2001; Bito et al., 1996; Wu et al., 2001; Radak et al., 2016). Moreover, BDNF interacts with NMDA receptors and the MAPK pathway, forming a positive feedback loop that reinforces its own expression (Vaynman et al., 2003; Nakata & Nakamura, 2007). These findings indicate that exercise enhances neuronal plasticity by upregulating BDNF gene expression through Ca^{2+}-mediated signaling pathways.

The effect of exercise on BDNF gene expression is not limited to glutamatergic transmission but is also shaped by the interaction of cholinergic, noradrenergic, dopaminergic, serotonergic, and GABAergic neurotransmitter systems (Garcia et al., 2003). Research has shown that cortical acetylcholine (ACh) levels increase following short periods of walking, indicating that cholinergic activity is stimulated even during low-intensity exercise (Kurosawa et al., 1993). Disruption of cholinergic transmission leads to a reduction in hippocampal BDNF expression, a condition that can be reversed by acetylcholinesterase inhibitors such as galantamine (Gil-Bea et al., 2011).

Furthermore, the blockade of noradrenergic signaling suppresses exercise-induced BDNF transcription, whereas activation of adrenergic receptors triggers phosphorylation cascades that stimulate BDNF production in hippocampal neurons (Garcia et al., 2003). Similarly, exercise increases dopamine (DA) levels and promotes dopamine synthesis in the brain through an associated rise in serum Ca^{2+} concentrations (Sutoo & Akiyama, 2003). In addition, the activation of D1-like receptors plays a significant role in the upregulation of BDNF expression (Küppers & Beyer, 2001).

The role of the serotonin (5-HT) system in this process is more limited; blockade of 5-HT_2A/C receptors has been found to minimally affect exercise-induced increases in BDNF mRNA expression (Ivy et al., 2003). On the other hand, GABA, the primary inhibitory neurotransmitter of the central nervous system, reduces hippocampal BDNF expression, thereby negatively affecting learning and memory; conversely, the $GABA_a$ receptor antagonist bicuculline has been shown to increase BDNF levels and enhance memory consolidation (Kim et al., 2012). Interestingly, in a study conducted on mice, the anxiolytic effect of

a three-week exercise protocol was abolished by the infusion of bicuculline into the ventral hippocampus. This finding suggests that GABAergic transmission plays a crucial role in suppressing excessive excitatory circuits during exercise. (Schoenfeld et al., 2013)

Conclusion

This work highlights the essential role of physical activity in enhancing not only physical well-being but also cognitive and neuropsychological development throughout life. Findings from both human and animal studies demonstrate that regular exercise promotes neuroplasticity, supports neurogenesis, and strengthens the structural and functional integrity of key brain regions such as the hippocampus and prefrontal cortex. A core mechanism underlying these effects is the upregulation of Brain-Derived Neurotrophic Factor (BDNF), which contributes to synaptic growth, neuronal survival, and cognitive flexibility. Exercise-induced increases in BDNF occur through several biological pathways, including calcium-dependent signaling and the interaction of glutamatergic, cholinergic, noradrenergic, dopaminergic, serotonergic, and GABAergic systems, reflecting the complex and integrated nature of brain adaptation to physical activity.

Beyond its biological impact, the relationship between movement and cognition holds important implications for education, mental health, and lifelong resilience. Integrating structured physical activity into early education supports executive functioning, attention, and memory, fostering balanced cognitive and emotional development. In clinical and rehabilitative contexts, exercise has been shown to alleviate symptoms of various neurodevelopmental and neurodegenerative disorders, emphasizing its therapeutic potential. Altogether, movement serves as a foundation for neurocognitive health and resilience, underscoring the need for continued interdisciplinary research to optimize the benefits of physical activity for brain function and overall human well-being.

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Chapter 2

Mental Training in Sport: From Theory to Practice

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Introduction

Sport psychology is an applied scientific discipline that seeks to understand athletes' mental processes and utilize them to optimize performance. In contemporary sports, success is no longer determined solely by physical capacity but also by cognitive and emotional factors (Browne & Mahoney, 1984; Vealey, 2024). Especially for elite athletes who compete at the highest levels, sustainable performance improvement requires not only technical and physical preparation but also the systematic integration of mental preparation into training programs. Within this context, mental training has emerged as a critical component positioned at the intersection of performance psychology and motor-learning processes (Hammermeister & Von Guenthner, 2005).

Mental training can be defined as the process through which an individual mentally rehearses a movement in all its dimensions without physically performing it. During this process, the athlete repeatedly activates the motor program at the cognitive level, thereby engaging both neural and psychological mechanisms. Among the various techniques used, imagery or visualization is considered one of the most effective tools. Through mental rehearsal, athletes experience the movement as if it were real; consequently, both the nervous system and psychological readiness are enhanced (Murphy, 1990; Vealey, 2024). Empirical evidence indicates that mental training positively influences key psychological variables such as attention, self-confidence, motivation, anxiety regulation, and focus which in turn accelerate the acquisition of motor skills and improve technical precision (Lindsay et al., 2023).

From the perspective of motor-learning theory, learning is not confined to the muscles; rather, it is an adaptive process of the brain. Each new movement requires the formation of specific neural patterns. Mental rehearsal strengthens

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these neural pathways even in the absence of physical execution (Frank et al., 2024). Consequently, mental training functions as a pivotal mechanism for consolidating motor skills, refining strategic decision-making, and facilitating athletes' cognitive preparedness for performance.

Across different sports (particularly those involving complex motor coordination such as gymnastics, boxing, tennis, shooting, and skiing) the effects of mental training on performance have long been investigated. The majority of these studies reveal that imagery-based interventions improve both motor control and psychological resilience (Rogers, 2006; Behrendt et al., 2021). Moreover, mental rehearsal assists athletes in managing pre-competition stress, enhancing error-correction processes, and strengthening self-confidence (Ulucan & Bölükbaşı, 2020).

Recent technological developments have broadened the scope of mental training applications. Virtual-reality environments, mobile applications, and neurofeedback systems now provide innovative means of developing mental skills (Choy et al., 2023). As emphasized by Ateş (2025), artificial intelligence, augmented reality, and virtual reality technologies are regarded as tools that have the potential to enrich learning processes, support motivation, and contribute to the cognitive mechanisms associated with motor skill development in the fields of sport sciences and physical education.

Nevertheless, the fundamental principle remains unchanged: mental preparation is an inseparable part of performance and must be systematically incorporated into the training process.

Accordingly, this chapter explores the conceptual foundations of mental training and visualization techniques, their relationship with motor-learning processes, and their diverse applications in sport. Furthermore, based on recent literature, the chapter discusses the role of mental training in enhancing athletic performance and presents practical recommendations for coaches and sport psychologists.

Fundamental Principles of Mental Training

Mental training refers to the process through which an athlete mentally plans, rehearses, and reenacts the movements, strategies, or performance scenarios that they aim to execute physically. Although fundamentally a cognitive form of preparation, mental training exerts direct effects on behavioral outcomes as well. It is not merely an act of "imagination" but rather a multifaceted practice that simultaneously engages attention, memory, motivation, emotional regulation, and motor planning processes (Murphy, 1990; Vealey, 2024).

At the core of mental training lies the principle known as the mind–muscle connection. According to this principle, when a movement is mentally simulated, neural patterns similar to those activated during actual execution are engaged within the brain (Frank et al., 2024). Repeated mental rehearsal strengthens these neural representations, facilitating faster and more efficient learning. This demonstrates that physical and mental training are not competing but complementary processes. Indeed, empirical studies show that the combination of physical and mental training produces greater performance improvements than physical training alone (Rogers, 2006; Behrendt et al., 2021).

The effectiveness of mental training depends on adherence to several fundamental principles. Foremost among these are regularity and continuity. Much like physical training, mental rehearsal must follow a systematic plan. Random or inconsistent imagery sessions may yield temporary effects, but sustainable performance gains can only be achieved through consistent practice over time. Mental training also demands focused attention; during imagery, the athlete must eliminate external distractions and channel their cognitive resources entirely toward the target behavior (Li et al., 2024).

Another crucial principle involves achieving emotional intensity and a sense of realism. Effective mental rehearsal requires not only the visualization of movements but also the recreation of the accompanying emotions. When athletes mentally experience the excitement, pressure, and confidence associated with competition, these emotional states reinforce both motor learning and psychological resilience (Ulucan & Bölükbaşı, 2020). Thus, high-quality mental training aims not simply to form an image but to transform that image into a "lived experience."

Timing and frequency of mental practice sessions are also decisive factors for success. Sessions should generally be short but concentrated, typically lasting 10–15 minutes, and may be repeated multiple times per day (Vealey, 2024). Furthermore, the timing of imagery within the training cycle is critical: it may be employed before competition to enhance motivation and focus, or after competition to facilitate performance analysis and error correction.

Finally, the effectiveness of mental training relies heavily on the athlete's self-awareness. Understanding one's strengths, weaknesses, stress responses, and psychological tendencies allows the athlete to tailor mental practice more consciously and effectively. Such awareness fosters the integration of mental skills with physical performance, leading to more consistent outcomes in competition (Atasoy & Ekiz, 2021).

In summary, mental training is not merely a cognitive rehearsal but a structured process of learning and preparation. Rooted in principles of regularity,

concentration, emotional engagement, and self-awareness, it serves as an effective means of enhancing both the psychological resilience and motor proficiency of athletes.

The Concept of Imagery (Visualization)

One of the most fundamental and effective components of mental training is imagery, also referred to as visualization. Imagery involves mentally simulating a specific movement, situation, or performance scenario with sensory detail and vividness. In this process, the athlete "experiences" the movement without physically executing it. The brain processes this mental experience as if it were a real performance, thereby supporting learning at both cognitive and physiological levels (Munzert et al., 2009; Frank et al., 2024). Imagery thus serves as a bridge between physical execution and mental preparation and is widely recognized as a cognitive strategy that enhances sport performance (Vealey, 2024).

Imagery is not limited to visual representation; rather, it is a multisensory experience. An effective imagery session integrates visual, auditory, kinesthetic (sense of movement), tactile, and even emotional cues. For instance, a boxer may mentally picture stepping into the ring, hearing the rhythm of footwork and glove contact, feeling the texture of the gloves, and sensing muscular tension throughout the body. This sensory richness amplifies the neurophysiological impact of imagery by stimulating neural activity in motor-planning regions similar to that produced during actual movement (Frank et al., 2024; Murphy, 1990).

Imagery techniques are generally classified as internal or external. Internal imagery occurs from the athlete's own perspective seeing and feeling the movement as though performing it in real time. This type is particularly effective for improving technical precision, proprioceptive awareness, and muscular control. In contrast, external imagery involves observing oneself from an outsider's perspective, which is advantageous for enhancing tactical awareness, performance evaluation, and strategic analysis. Both methods offer distinct benefits depending on the sport and individual objectives (Atasoy & Ekiz, 2021).

The psychological foundations of imagery demonstrate its powerful influence on confidence, motivation, and attentional control, all of which are key determinants of performance (Vealey, 2024). Effective imagery practice strengthens athletes' internal belief in success and enhances cognitive resilience against stressors. When employed before competition, imagery helps athletes feel mentally prepared, maintain focus during performance, and make more accurate decisions under pressure (Ulucan & Bölükbaşı, 2020).

The success of imagery practice is closely linked to the athlete's imagery ability. Not all individuals possess the same level of vividness or control in visualization. Therefore, imagery training should be introduced gradually and refined over time as the athlete's mental visualization skills develop. Past experiences, personality traits, and attentional capacities are among the key factors influencing the effectiveness of this process (Frank et al., 2024).

The application format of imagery varies according to the athlete's goals. During the skill-learning phase, imagery is used to reinforce correct sequencing and strengthen motor plans, whereas in pre-competition phases it is typically directed toward enhancing motivation and confidence. In rehabilitation settings, athletes can mentally rehearse movements that they are temporarily unable to perform physically, thereby maintaining motor competence and motivation throughout recovery (Rogers, 2006; Behrendt et al., 2021). Consequently, imagery functions as an effective tool for both performance enhancement and psychological recovery.

In conclusion, imagery is not merely a visualization method but a comprehensive learning strategy. It strengthens neural representations of movement, heightens psychological readiness, and contributes directly to physical performance. For these reasons, imagery stands as a cornerstone technique in modern sport psychology and should be systematically implemented by both coaches and sport psychologists to maximize athletic potential.

The Role of Mental Training in the Motor Learning Process

Motor learning refers to a neural and behavioral process through which an individual acquires the ability to perform a movement more efficiently, accurately, and automatically. This process involves not only muscular adaptation but also active participation of the brain in complex cognitive and perceptual mechanisms. In other words, the acquisition of motor skills depends not solely on physical practice but also on mental functions such as cognitive processing, attention, memory, and planning (Masaki & Sommer, 2012; Krakauer et al., 2019). Within this framework, mental training emerges as a natural extension of motor learning, allowing athletes to structure, plan, and evaluate movements cognitively before physical execution (Frank et al., 2024).

Traditionally, the motor learning process is described in three main stages: cognitive, associative, and autonomous (Luft & Buitrago, 2005). Mental training contributes differently to each of these stages.

The cognitive stage involves understanding the general structure, purpose, and procedure of a movement. During this phase, mental rehearsal helps the athlete form a mental representation of the action. By mentally constructing the correct

movement sequence, athletes can minimize errors and enhance accuracy. For instance, when a gymnast mentally rehearses the phases of a new balance routine before physical execution, both the motor plan and attentional control mechanisms are reinforced (Rogers, 2006).

In the associative stage, athletes already understand the movement but seek to refine and perfect it. Mental rehearsal during this period aids in improving fluidity, coordination, and timing. Athletes analyze their previous performances through imagery, reflecting on which muscle groups were activated and which technical errors occurred most frequently. Such reflective mental practice sharpens motor control and facilitates error correction. Imagery at this stage is especially valuable for reinforcing proper technique and enhancing motor precision (Abderrahmen et al., 2024; Behrendt et al., 2021).

The autonomous stage is characterized by movements executed automatically, with minimal conscious effort. Here, mental training helps sustain performance stability and preserve psychological focus. By visualizing the movement, athletes strengthen their confidence and maintain optimal performance even under pressure. For example, a boxer mentally replaying a match before entering the ring can reactivate automated motor patterns and reduce the adverse effects of stress on execution (Li et al., 2024).

Mental training also contributes to error correction and performance evaluation. Through mental rehearsal, athletes can analyze why a movement failed, reimagine proper muscle activation sequences, and mentally adjust timing without physical repetition. This cognitive feedback process allows correction of motor errors safely and efficiently an advantage particularly relevant in high-risk sports (Frank et al., 2024; Masaki & Sommer, 2012).

Another important aspect is the enhancement of attention and focus during motor learning. While engaging in imagery, athletes not only rehearse the movement but also mentally recreate the performance environment. This promotes better awareness of external cues and reduces reaction times. For instance, a tennis player who mentally anticipates an opponent's serve direction through imagery can make quicker and more accurate responses during real play (Taylor & Ivry, 2012).

Mental training further strengthens skill retention and transfer. Movements rehearsed mentally are encoded more robustly in long-term memory, making them less susceptible to forgetting even after periods without practice. Studies have demonstrated that athletes who engage in regular mental rehearsal maintain their motor proficiency longer and adapt more rapidly when re-engaging in physical practice (Behrendt et al., 2021; Rogers, 2006).

From a broader perspective, mental training functions as a form of cognitive strategy development. Athletes do not merely repeat movements, they also regulate

how they think, make decisions, and respond to errors. This meta-cognitive engagement enhances not only motor execution but also strategic and psychological performance. In team sports, this capacity fosters tactical awareness and collective coordination (Abderrahmen et al., 2024).

In conclusion, mental training represents an indispensable component of the motor learning process. Physical execution and mental rehearsal should be viewed as complementary rather than separate domains. By enhancing learning, consolidation, and automatization of movements as well as improving focus, attention, and error correction mental training serves as a vital tool for athletes, coaches, and sport psychologists. It should thus be regarded not as an auxiliary method but as a core element of motor skill development in contemporary sport science.

Models and Practical Methods of Mental Training

When systematically planned, mental training is a powerful tool that directly supports performance development. However, for it to be effective, it must follow scientifically grounded models rather than rely on arbitrary or unstructured application. One of the most widely adopted approaches for this purpose is the PETTLEP Model. PETTLEP is an acronym derived from the words Physical, Environment, Task, Timing, Learning, Emotion, and Perspective and aims to conduct mental rehearsal in a manner that most closely mirrors the physical and psychological realities of performance (Wakefield et al., 2013; Morone et al., 2022).

Core Principles of the PETTLEP Model

Physical: The imagery session should recreate physical conditions as closely as possible to the real environment and equipment. For instance, a boxer conducting mental rehearsal may wear gloves or stand in the ring during visualization to reinforce the sense of realism and bodily engagement (Collins & Carson, 2017).

Environment: Imagery should take place in a context similar to the actual performance setting. Replicating environmental stimuli (such as sounds, lighting, or crowd atmosphere) helps athletes manage pre-competition stress and increases ecological validity (Wakefield et al., 2013).

Task: The content of the mental rehearsal must include sport-specific technical details. Instead of general fantasies of success, the athlete should visualize a concrete movement sequence or tactical scenario with high precision (Vealey, 2024).

Timing: Imagery should be performed in real time. The duration of the imagined movement should match that of the physical execution to reinforce accurate temporal mapping and neuromotor synchronization (Eaves et al., 2024).

Learning: Imagery scripts must be adapted to the athlete's level of expertise. Beginners benefit from technique-oriented imagery, whereas advanced athletes can incorporate strategic and emotional dimensions (Morone et al., 2022).

Emotion: Effective imagery involves the recreation of emotional states associated with performance. Experiencing realistic emotions such as excitement, confidence, or anxiety enables the brain to encode the imagery as a lived event, strengthening its transfer to real performance (Vealey, 2024).

Perspective: Athletes can visualize movements from either an internal perspective (first-person) or an external perspective (third-person). The chosen perspective should correspond to the intended skill: internal imagery is more suitable for motor precision, while external imagery is preferable for tactical and evaluative tasks (Wakefield et al., 2013).

The PETTLEP model thus provides a holistic framework encompassing cognitive, emotional, and environmental dimensions of mental training. Its flexibility allows it to be effectively applied in both individual and team sports, enhancing realism and transferability to competition settings (Morone et al., 2022; Collins & Carson, 2017).

The Effects of Mental Training on Athletic Performance

The effects of mental training on athletic performance have long been a central topic in sport psychology and motor-learning research. Both experimental and applied studies consistently demonstrate that mental training significantly enhances athletes' physical performance, psychological resilience, and cognitive functioning (Yazgan et al., 2025; Lindsay et al., 2023). Through mental rehearsal of movements, athletes accelerate motor-skill acquisition and positively influence psychological variables such as attention, motivation, confidence, and stress management (Vealey, 2024; Murphy, 1990).

The impact of mental training can be analyzed across several key dimensions. The first is motor performance development. Research has shown that imagery-based interventions improve technical accuracy, movement timing, reaction time, and coordination skills (Frank et al., 2024; Wieland et al., 2022). A classic study by Yue and Cole (1992) revealed that participants who practiced solely through mental training achieved up to a 13% increase in muscle strength, suggesting that mental rehearsal strengthens neuromuscular command pathways and contributes indirectly to physical outputs.

The second dimension concerns psychological resilience and stress regulation. Mental training helps athletes balance pre-competition anxiety, manage intrusive thoughts, and maintain concentration even under pressure (McNeil et al., 2025). By mentally simulating the competition environment beforehand, athletes reduce

uncertainty-related anxiety and foster a calmer cognitive state during performance. This effect is particularly pronounced in individual sports (such as boxing, shooting, or tennis) where the ability to self-regulate under stress is critical (Ulucan & Bölükbaşı, 2020).

A third major dimension is enhanced motivation and self-confidence. Imagery focused on successful performance strengthens an athlete's self-efficacy and belief in their own competence. Mentally replaying successful outcomes generates a positive feedback loop in the brain, reinforcing the conviction that success is attainable (Vealey, 2024; Li et al., 2024). This psychological mechanism not only increases engagement during training but also supports consistent performance under challenging circumstances.

The effects of mental training extend beyond psychological factors to include biomotor capacities. Studies indicate that mental rehearsal improves balance, coordination, and movement fluidity particularly in complex skill-based sports such as artistic gymnastics, skiing, diving, and combat disciplines (Yazgan et al., 2025; Debarnot et al., 2014). These findings suggest that mental practice indirectly facilitates neuromuscular coordination and enables athletes to execute technical movements more efficiently and economically.

Mental training also plays a valuable role in rehabilitation and performance maintenance. For athletes temporarily sidelined due to injury, mental rehearsal preserves motor memory and sustains motivation throughout recovery. This cognitive engagement supports both psychological well-being and readiness for return to sport, promoting smoother reintegration into competition settings (Nanbancha et al., 2023; Batson, 2004).

Finally, mental training enhances cognitive performance components. Imagery-based interventions have been found to improve decision-making speed, reaction time, sustained attention, and situational awareness (Yao et al., 2023; Wieland et al., 2022). As such, mental training contributes not only to physical execution but also to higher-order cognitive functions such as reading the game, generating strategies, and making tactical decisions under pressure. Similarly, Yılmaz and Namlı (2025) emphasized that increasing individuals' awareness of the benefits of sport significantly promotes participation in physical activity.

In summary, mental training exerts a comprehensive influence on both the physical and psychological components of athletic performance. When practiced systematically and consistently, it accelerates learning, enhances self-confidence, strengthens coping abilities, and promotes long-term performance stability. Consequently, mental training is no longer viewed as a supplementary tool but as a core pillar of performance enhancement in modern sport science.

Conclusion and Recommendations

Mental training has become an essential component of both the theoretical and applied domains of modern sport psychology. Today, it is well established that optimal athletic performance depends not only on physical competence but also on the effective management of cognitive and emotional processes (Vealey, 2024; Browne & Mahoney, 1984). In this regard, mental training is regarded as a complementary educational tool that reinforces the motor skills developed through physical practice while strengthening attention, motivation, and self-confidence.

Research has consistently demonstrated that mental training directly contributes to the motor learning process and produces significant improvements across multiple dimensions of performance. Imagery and visualization techniques, in particular, lead to measurable gains in technical accuracy, timing, decision-making, and stress regulation (Yazgan et al., 2025; Lindsay et al., 2023). However, for mental training to be effective, it must be systematically structured and implemented according to established principles. Random or inconsistent imagery sessions may yield temporary benefits, but only regular and goal-oriented practice ensures long-term performance enhancement (Wakefield et al., 2013; Morone et al., 2022).

The application of mental training is not limited to pre-competition preparation. It can be utilized effectively throughout all phases of learning from the acquisition of technical skills to post-injury rehabilitation and long-term motivation maintenance (Batson, 2004; Nanbancha et al., 2023). In this sense, mental training serves as a mechanism that sustains both physical and psychological development, fostering consistent and sustainable performance.

For coaches and sport psychologists, the integration of mental training into structured training programs is of paramount importance. Within weekly or periodic training cycles, mental rehearsal sessions should be incorporated alongside physical workloads. Evidence-based frameworks such as the PETTLEP model can guide the organization of these practices to ensure ecological validity and individual adaptation (Collins & Carson, 2017; Eaves et al., 2024). Moreover, since athletes differ in cognitive capacity, attentional span, and imagery ability, mental training protocols should always be personalized to optimize engagement and effectiveness (Ulucan & Bölükbaşı, 2020).

Looking forward, technological advances are expected to become increasingly integrated into mental training practices. Virtual reality platforms, neurofeedback systems, and mobile-based imagery applications offer innovative pathways for developing mental skills (Choy et al., 2023). Nevertheless, the fundamental principle remains unchanged: mental readiness is an inseparable part of physical preparation.

In conclusion, mental training is an indispensable educational method that promotes motor-skill development, psychological resilience, and long-term performance consistency. When designed according to scientific principles and applied regularly in an individualized manner, mental training programs enhance not only athletes' performance potential but also the effectiveness of coaching and applied sport psychology practice.

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Chapter 3

Methods For Enhancing Mental Toughness in Athletes

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Introduction

The concept of mental toughness has become one of the most prominent areas of research today, particularly due to its critical role in maximizing athletic performance. Among the key characteristics that make mental toughness important are the ability to cope effectively with pressure and adversity, perseverance, rapid recovery after setbacks, resilience, and possessing superior self-regulation skills (Crust & Keegan, 2010; Gucciardi, 2017). Mental toughness is a cognitive process, often described as a form of psychological resilience. Athletes with high levels of mental toughness are better equipped to manage stressful situations and regulate their emotions more effectively (Shang & Yang, 2021).

Another definition describes mental toughness as the most important psychological capacity associated with success in elite athletes, as identified by athletes, coaches, and applied sport psychologists (Crust, 2007). Although this capacity is influenced by innate personality traits, recent studies have demonstrated that mental toughness is a learnable and improvable characteristic (Gucciardi, 2017; Guszkowska & Wójcik, 2021). In light of this evidence, mental toughness is regarded as one of the key determinants of enhanced athletic performance for both individual and team sport athletes (Wu et al., 2021). In this context, mental toughness not only distinguishes highly successful athletes from those with lower levels of achievement but also serves as an essential concept for developing psychological skills such as attention, motivation, and self-confidence (Ajilchi et al., 2022; Wu et al., 2021).

Research has shown that athletes who regularly participate in training and psychological interventions aimed at developing mental toughness experience improvements not only in their performance levels but also in their overall psychological well-being (Arora et al., 2022; Turkington et al., 2023). For example, mindfulness-based intervention programs have been found to enhance mental toughness and psychological well-being among female athletes (Ajilchi et al., 2022).

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Similarly, another study demonstrated that athletes who received psychological skills training exhibited significant improvements in their mental toughness abilities (Wu et al., 2021). In addition, social support, self-management skills, and intrinsic motivation are also considered important determinants of mental toughness (Shang & Yang, 2021; Gameiro et al., 2023).

Similar findings have been reported in studies conducted in Türkiye. For example, Kalkavan, Özdilek, and Çakır (2020) examined mountain bikers and identified their levels of mental toughness, reporting that these parameters contributed positively to athletic performance. Yılmaz (2021) addressed the concept of mental toughness in sport from both theoretical and applied perspectives, emphasizing its importance for athlete development. Additionally, Eroğlu et al. (2020) demonstrated a significant relationship between mental toughness and moral attitudes in sport.

In conclusion, mental toughness emerges as one of the most crucial psychological capacities influencing not only athletes' immediate performance but also their long-term development, psychological well-being, responses to competitive environments, and sustainable success. For this reason, the concept of mental toughness has become a key factor for athletes, coaches, and sport psychologists alike, as it significantly shapes the psychological functioning and overall performance trajectory of athletes.

Mental Toughness and Athletic Performance

In recent years, with the growing interest in the field of sport psychology, the concept of mental toughness has become one of the most significant factors influencing athletic performance. Mental toughness refers to an athlete's ability to persist toward their goals and maintain performance under challenging conditions. It is also characterized by the capacity to make effective decisions under pressure and to cope more efficiently with stressful situations (Clough & Strycharczyk, 2012). In sport psychology, this ability represents a multidimensional construct that influences not only psychological resilience but also the continuity of physical performance (Hsieh et al., 2024).

Clough and colleagues (2002) categorized mental toughness into four fundamental components: control (emotional and life regulation), commitment (goal adherence), challenge (perceiving difficulties as opportunities), and confidence. These components shape how athletes manage uncertainty and pressure during training and competition. In another prominent study, Mahoney et al. (2014) argued that athletes with high levels of mental toughness not only demonstrate more consistent performance but also exhibit psychological flexibility and well-being,

forming a multidimensional construct that emerges from the interaction of physical, technical, and psychological factors.

The role of mental toughness in enhancing performance becomes particularly evident through psychological processes such as decision-making under pressure, maintaining attentional focus, recovering after failure, and sustaining motivation. Furthermore, a meta-analysis conducted by Hsieh et al. (2024) demonstrated that mental toughness has a significant and strong effect on athletic performance. Similarly, Guszkowska and Wójcik (2021) identified mental toughness as one of the most critical psychological determinants of performance.

Studies conducted in Türkiye also support this relationship. Sarı, Sağ, and Demir (2020) found a positive association between mental toughness levels and competition performance among taekwondo athletes. Arıkan and Özdemir (2024) examined the factors influencing mental toughness in female volleyball players and reported that mental toughness contributes not only to individual performance but also to overall team performance. Additionally, Güvendi et al. (2018) identified a strong relationship between mental toughness and courage as well as risk-taking tendencies among elite wrestlers. Furthermore, mental toughness is known to be associated with individual differences. Altıntaş (2015) reported that athletes' levels of motivation and goal orientation significantly predict their mental toughness. In another study, Akman (2019) found that self-talk and imagery skills directly influence mental toughness.

In the international literature, mental toughness is described as a trait that, although partly innate, can be developed through targeted training and experiences. In a longitudinal intervention study conducted by Bell, Hardy, and Beattie (2013), young athletes who participated in a two-year mental skills training program demonstrated improved performance under pressure. Similarly, Crust and Azadi (2010) reported that athletes with higher levels of mental toughness tend to use psychological strategies more effectively, which directly contributes to competitive success.

In light of all this evidence, mental toughness is not merely an advantage in the sport environment; it is a fundamental psychological process required for sustaining success. Athletes with high levels of mental toughness are better able to maintain their performance under stress and pressure, and they recover more quickly following failure. Incorporating training activities aimed at enhancing mental toughness into coaching programs can support not only athletes' performance but also their overall psychological well-being.

Psychological Methods for Developing Mental Toughness

Imagery Techniques

Achieving high levels of performance in athletes is possible not only through physical capacity but also through the effective use of cognitive and psychological processes. In recent years, the concept of imagery one of the central topics in sport psychology has become one of the leading mental training techniques used to enhance athletic performance (Weinberg & Gould, 2018). Imagery is defined as the mental recreation of a movement, situation, or emotional experience using sensory elements (Cumming et al., 2023). Research indicates that imagery closely resembles real experiences both neurologically and behaviorally.

Imagery ability is a mental skill that can be improved through systematic training and is used in a versatile manner. It is regarded as one of the most effective strategies for performance enhancement and is widely used in applied fields such as sport psychology, dance, and exercise (Cumming et al., 2023). This process influences not only motor behaviors but also cognitive components such as decision-making, self-confidence, and motivation (Kolayiş, Sarı, & Köle, 2015; Wicken, Keogh, & Pearson, 2021).

In psychology, the imagery concept gained its theoretical foundation primarily through Paivio's (1985) "Dual-Processing Model of Imagery." This model emphasizes both the cognitive functions of imagery (developing technical skills, strategic planning) and its motivational functions (self-confidence, arousal regulation, goal setting). Correspondingly, the types of imagery used by athletes have been classified as **cognitive specific, cognitive general, motivational specific, motivational general–arousal,** and **motivational general–mastery** (Nordin & Cumming, 2008). This classification helps athletes structure the imagery process according to its intended purpose.

In sport psychology, imagery involves mentally recreating experiences by actively engaging the senses. This technique is effective in developing motor skills, improving focus, managing anxiety, and enhancing motivation (Morris, Spittle, & Watt, 2005).

Studies conducted with Turkish athletes also demonstrate that imagery is widely used and positively associated with performance. The Sport Imagery Questionnaire, adapted for Turkish athletes by Kızıldağ and Tiryaki (2012), is one of the key contributions enabling the systematic assessment of different types of imagery. Atasoy and Ekiz (2021) and Doğan (2019) further reported that imagery enhances motivation and reduces anxiety, particularly among athletes engaged in team sports.

Neuropsychological research on the biological foundations of imagery has demonstrated that mentally simulated movements activate motor cortex regions in patterns similar to those observed during actual physical movements (Ladda, Lebon, &

Lotze, 2021; Olsson, Jonsson, & Nyberg, 2008). This finding highlights that imagery is not only a psychological technique but also an effective training method at the neurological level. Moreover, conditions in which mental imagery capacity is impaired such as aphantasia are known to create limitations in emotional regulation and performance-related strategies (Dance, Ward, & Simner, 2021; Wicken et al., 2021).

Types of Imagery

Motor Imagery: Motor imagery (MI) has been defined by neuroscientists as the mental rehearsal of voluntary movements without engaging in actual motor execution (Morone et al., 2022). This cognitive process activates neural networks similar to those involved in performing real motor actions, making it a critical tool both for enhancing athletic performance and for applications in neurological rehabilitation (Ladda, Lebon, & Lotze, 2021).

Strategic Imagery: It refers to the athlete's mental rehearsal of game plans and the tactical dynamics of a competition. Through this type of imagery, the athlete can pre-experience strategic decisions for different scenarios, which in turn enhances cognitive flexibility and increases decision-making speed during competition (Cumming & Williams, 2012).

Emotional Imagery: Emotional imagery refers to the athlete's mental simulation of the emotional reactions they may experience in response to stress-inducing situations or potential success and failure scenarios. This type of imagery is important for helping athletes cope with negative emotions such as competitive anxiety, pressure, and stress, and for developing the psychological resilience required to manage these emotions in advance (Dance, Ward, & Simner, 2021).

Success Imagery: It refers to the athlete's mental visualization of achieving a specific goal and experiencing the emotional satisfaction associated with that success in advance. This type of imagery is particularly effective in strengthening intrinsic motivation, increasing commitment to goals, and reinforcing the belief in one's ability to succeed within the framework of sport psychology (Weinberg & Gould, 2018). When athletes repeatedly visualize success moments such as winning a medal, breaking a record, or being selected for a team this mental experience enhances their internal readiness for actual performance. Success imagery also positively influences self-efficacy perceptions and psychological resilience (Paivio, 1985).

Self-Talk

Self-talk, one of the core components of sport psychology, is a cognitive technique used either as a means of influencing an individual's emotions and thoughts or as a consequence of them. Self-talk can directly affect an individual's thoughts, behaviors, and emotions. In athletes particularly, self-talk is employed as a strategic tool with various functions, such as enhancing motivation, increasing attentional focus, improving self-confidence, and reducing anxiety (Hardy, 2006; Latinjak et al., 2023). Self-talk is an essential component of successful athletic performance, as it enables athletes to regulate their thoughts through structured internal dialogue plans. It is also regarded as an integral part of psychological skills training programs (Hatzigeorgiadis et al., 2009).

Mental toughness refers to the ability to remain stable in the face of adversity, perform under pressure, stay goal-oriented, and maintain psychological resilience. Individuals with high levels of mental toughness can sustain goal-directed behaviors even in stressful and uncertain situations, regulate their emotions effectively, and persist without giving up (Clough et al., 2002; Gucciardi, 2017). These characteristics are critically important for achieving success in both individual and team sports.

There is a natural interaction between self-talk and mental toughness. Positive self-talk enhances an individual's belief in their abilities, supports mental toughness, and particularly under high pressure motivational or self-affirming statements strengthen psychological resilience, contributing to the sustainability of athletic performance (Hatzigeorgiadis et al., 2009; Cooper et al., 2021). In athletes, self-talk and mental toughness have a decisive impact not only on immediate performance but also on long-term development. A regularly implemented mental training program enables athletes to compete with greater determination, resilience, and motivation in competitive environments (Weinberg & Gould, 2018). Therefore, modern sport psychology emphasizes the systematic development of mental skills alongside physical abilities.

Goal Setting

Goal setting is defined as a systematic process that directs behavior, enhances motivation, and improves performance. The classic work of Locke et al. (1981) emphasized that goals not only clarify intentions but also serve as a powerful motivational mechanism that directly influences performance. According to this theory, goals facilitate athletes' progression toward success by providing direction, increasing effort, promoting persistence, and encouraging strategic planning. Research has shown that goal setting affects not only performance but also learning, self-efficacy, and psychological well-being (Chung, Chen, & Olson, 2021; Chang,

Lin, Hajian, & Wang, 2023). Goal setting is applied in various fields in different ways. For example, in rehabilitation, patient-centered goals have been shown to enhance motivation and treatment adherence, although several practical barriers to implementation have been identified (Crawford et al., 2022). Similarly, in the field of mental health, goals based on individuals' subjective needs have been reported to improve engagement and collaboration during therapy (Okita et al., 2024). In educational contexts, goal-setting practices that support self-regulated learning processes strengthen students' academic performance (Chang et al., 2023).

In sport psychology, goal setting emerges as a strategy that enhances both performance and psychological adjustment. Swann et al. (2021) emphasized the need to update goal-setting theory within interventions aimed at promoting physical activity, drawing attention to individuals' motivational sources and contextual factors. Systematic reviews and meta-analyses examining the performance and psychological effects of goal setting in sport have demonstrated the effectiveness of this approach (Williamson et al., 2024; Jeong, Healy, & McEwan, 2023). In particular, the integration of goal setting with self-determination theory contributes to the development of life skills in sport. Furthermore, it has been shown to support qualities such as self-discipline, responsibility, and mental toughness among young athletes (Cronin et al., 2022).

From another perspective, goal setting not only enhances performance but also strengthens athletes' subjective experiences, self-confidence, and mental toughness. Bird, Swann, and Jackman (2024) emphasize that in applied sport psychology, the goal-setting process should address not only the questions of "what" and "why," but also "how." Likewise, the comprehensive review by Lochbaum et al. (2022) demonstrates that meta-analyses in the sport psychology literature consistently show positive effects of goal setting on motivational processes and performance outcomes. Therefore, goal setting is a critical tool that supports athletes not only in achieving success but also in becoming more psychologically balanced, motivated, and persistent.

In summary, goal setting is an important process that increases motivation, directs performance, and supports individuals' development across learning, health, and sport contexts. Specifically within sport psychology, goal setting contributes not only to the development of technical and physical skills but also to the enhancement of mental toughness, self-efficacy, and life skills.

Coping with Stress

The rapid changes, intense information flow, and increasing individual responsibilities characteristic of modern life place significant pressure on human psychology. In this context, stress is defined as the totality of physiological and

psychological responses an individual exhibits when confronted with environmental, social, or psychological stimuli (Selye, 2013). First conceptualized by Hans Selye as a physiological phenomenon, stress has since been examined extensively across various fields, including psychology, education, sport, and health. Today, stress is regarded not merely as a negative state but as a dual-process phenomenon that triggers adaptive efforts (Cüceloğlu, 1994).

Stress is a complex process in which an individual mobilizes physical and psychological resources in response to perceived threats or demands (Lazarus & Folkman, 1984). This process becomes particularly pronounced in situations involving uncertainty, loss of control, or demands that exceed one's capacity. Because stress perception varies across individuals, the same event may generate stress for some while serving as an opportunity for adaptation or growth for others (Eryılmaz, 2009). At this point, factors such as personality traits, life experiences, and coping strategies play a decisive role.

Athletes, in particular, are in constant confrontation with stress due to intense training schedules, competitive environments, injury risks, and performance expectations. Therefore, stress management in sports is critically important not only for enhancing performance but also for strengthening athletes' psychological resilience (Yılmaz, 2021). Consequently, improving individuals' stress-coping skills contributes to better quality of life, the protection of psychological well-being, and the enhancement of mental toughness.

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Chapter 4

Psychological Skills Training

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Psychological Skills Training

In today's Olympic Games and international-level competitions, it has been determined that the technical, physical, and strategic differences between athletes have diminished. Less talented athletes are able to surpass those who are more talented. While some athletes exhibit flawless performance in the semi-finals, they create disappointment by performing poorly in the finals. The increasing pressure caused by performance intensity on athletes has led to a growing interest in psychological skills training in recent years (Birrer & Morgan, 2010). Initially, coaches and athletes recognized the importance of mental state for optimal performance. However, a false belief that psychological skills are innate and a lack of knowledge regarding the training of these abilities have prevented the development of the field of sport psychology education (Vealey, 1988; Weinberg, 1988). An example of this situation can be seen in the experience of national athlete Oğuz Uyar. Uyar stated that being away from his family and coach during training camps reduced his motivation and that he did not receive sufficient psychological support. Such situations demonstrate how necessary psychological skills training is for athletes (Uğraş et al., 2024).

In the late 1970s, sport psychology practices and mental training programs for athletes began to become widespread in the United States. It is known that Griffith conducted the first studies in the field of sport psychology in the 1920s (Kornspan & Alfred, 2013). From the 1920s until the mid-1960s, however, there appear to have been few studies conducted on sport psychology (Vealey, 1988; Landers et al., 1986). At the end of the 1980s, Vealey suggested that the future directions of psychological skills training particularly included expanding the target audience, improving specific implementation procedures, and distinguishing between psychological skills and methods (Vealey, 1988).

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The systematic improvement, correction, and development of the athlete's behaviors who is in the position of the client through the psychological methods applied by the consultant is defined as psychological skills training. In this process, it has been determined that when the values of the consultant and the client align, the purpose and effectiveness of psychological skills training increase (Afacan et al., 2020).

Types of Psychological Skills Training Goal Setting

In a study conducted by Locke and Latham (1985). in 1985, it was determined that a large number of studies had been carried out on goal setting and that these studies had been examined in detail. In order for athletes to perform successfully, they need to set goals appropriate to their level. Short-term goals of athletes will facilitate the achievement of long-term goals. Athletes regularly check whether or not they have reached the predetermined goal. These goals of the athletes also need to be adopted by their coaches.

It is important for athletes to pay attention to certain principles when setting goals. Paying attention to these principles is an effective method for improving athletes' performance. Research in the literature reveals that goal setting methods have been implemented and their outcomes tested, and that certain changes have been made during this process based on the principles of goal setting. Within the framework of these changes, the following are listed as requirements for effective goal setting. These are;

- Clearly establishing realistic goals,
- Setting both process and outcome goals,
- Differentiating between competition and training goals,
- Ensuring that the determined goals are recorded,
- Identifying tactics for achieving the goals during the goal-setting phase,
- Providing feedback and evaluation related to the goal by taking athletes' personality traits into account (Kale et al., 2020; Locke & Latham, 1985).

Goal setting activities help the athlete decide where they want to be and what they want to do (Needham, 2013). Although asking athletes what they want may seem simple in the goal setting process, it is necessary to be careful when deciding what the desired goal actually is.

After determining what the athletes' goals are, they need to decide what kind of preparations they will make to achieve these goals. It is observed that successful athletes are particularly successful in everything they do. The reason for this is stated to be that athletes use only a positive mental mechanism on the path to reaching the predetermined goal (Needham, 2013). Within the framework

of psychological skills training, goal setting is seen as the first step in achieving and managing mental control.

Imagery

Imagery is the process of mentally visualizing an action. Imagery is the creation of a mental image of an experience, either desired or previously lived, through the use of all senses related to that experience (Ballıkaya & Saraç, 2024; Kızıldağ & Tiryaki, 2012).

It has been shown that creating a mental image of an action has a meaningful effect when it is translated into physical practice. It has been argued that during the mental visualization of a movement, electrical currents similar to those generated when the movement is physically performed occur in the relevant muscles (Akandere et al., 2018).

The human brain cannot distinguish between actual physical training and imagery. By evaluating these two experiences in the same way, the brain sends signals to the muscles. Imagery is less effective than physical training. Athletes achieve neuromuscular activity by practicing imagery without performing physical training. Through this method, it has been observed that the muscle groups used during physical training are stimulated (Kale et al., 2020). Imagery practices, especially when combined with high motivation, have a positive effect on increasing both the athletes' level of mental preparation and their physical performance. The ways in which athletes perform imagery are divided into two. These are;

Internal Imagery: Defined as the situation in which athletes imagine themselves performing the desired action using all sensory channels during the execution.

External Imagery: During execution, athletes try to observe themselves from every angle as if watching a video recording of themselves performing the action.

The type of imagery athletes choose is related to their skill levels. Imagery contributes to the development of mental, physical, and perceptual skills. The timing of imagery practice varies depending on the athlete's needs. Imagery is applied before and after competition, during critical moments, and before or after training (Kale et al., 2020).

Imagery (mental visualization) occurs in three stages. These stages are:

- First Stage: Self-talk in a low voice,
- Second Stage: The awareness stage,
- Third Stage: Mental rehearsal. In this stage, athletes give themselves instructions on how to perform specific movements (Muratlı et al., 2007).

Performance Profile

The performance profile is defined as a technique frequently used in the past by sport psychologists. In 1989, the performance profile was developed by Butler as an assessment tool used with the Great Britain Olympic Boxing Team in order to increase athletes' awareness of their performance. It was determined that the dissatisfaction arising from traditional approaches led sport psychologists to feel the need to develop a new method. It is observed that athletes need psychological skills training to improve their performance. In this training, the athletes' intrinsic motivation will be ensured through this method, thereby promoting development (Birrer & Morgan, 2010; McCombs, 1984).

The performance profile method serves as a tool in monitoring and goal-setting processes (Butler & Hardy, 1992). The performance profile application procedure is implemented for individual athletes and team athletes. When the application steps of the performance profile method are examined, it is found that athletes are first interviewed either individually or by dividing the team into small groups, with the clarification that there are no right or wrong answers and that the outcome of the application can be used to plan future training programs. During the application of this method, athletes' perceived strengths and weaknesses particularly those relevant to their specific sport are taken into account, and a performance profile is created by identifying technical, physical, tactical, and psychological skills (Weston, 2005).

The performance profile application helps to identify the psychological strengths and weaknesses of athletes (Butler & Hardy, 1992). This method increases athletes' self-awareness. It evaluates and monitors the athlete's performance. From the athletes' perspective, this assessment helps them decide which skill to focus on. The method motivates athletes to improve their skills. Through the performance profile, it assists athletes in setting goals, and after monitoring and evaluating their performance, it helps the athlete take greater responsibility for their own development (Weinberg & Gould, 2014).

Autogenic Training

Autogenic training is defined as a well-established self-relaxation technique that is based on the idea of passive concentration on bodily sensations of heaviness and warmth, accompanied by slow breathing, and that evokes a psychophysiological relaxation response (Stetter & Kupper, 2002). The first study on this subject was developed in 1932 by Johannes Heinrich Schultz (Schultz, 1932).

Autogenic therapeutic approaches are methods based on homeostatic self-regulatory brain mechanisms designed to support and facilitate the body's existing natural self-healing mechanisms, thereby helping to regulate and readjust various functional disorders (e.g., stress or trauma) (Litwic-Kaminska et al., 2022; Luthe & Schultz, 1970). Autogenic therapy employs a variety of techniques and their combinations to alleviate an individual's responses to distressing stimuli. The scope of this therapy includes methods such as autogenic training, autogenic neutralization, meditative practices, autogenic modification, progressive active hypnosis, autogenic feedback procedures, and autogenic behavior therapy (Luthe, 1979).

Standard exercises (SE) involve the individual's passive attention to bodily sensations and aim to enhance self-regulation ability in order to improve homeostatic balance (Kanji, 1997). These exercises have a step-by-step structure that must be learned progressively and can be taught in both individual and group settings. In addition to the clinical applications of autogenic methods, their regular practice plays an important role in daily life (e.g., in the fields of education, industry, sports, and creativity), both by enhancing the efficiency of various physical and/or mental activities and by serving as a beneficial psychophysiological stress reliever (Caponnetto et al., 2018).

Self-Talk

Talking to oneself is a uniquely human skill and has a significant impact on performance, especially in the field of sports. Research in the field of sport psychology has shown that athletes frequently engage in self-talk and use it to express their mental or emotional states (Fritsch et al., 2024). These internal dialogues often lead athletes to become aware of their negative thoughts or emotions. This awareness prompts them to try to distance themselves from these negativities in order to improve their performance (Hardy et al., 2001).

However, this process is not always easy. For this reason, sport psychologists have developed specialized training programs to help athletes make their internal self-talk more effective. In addition, techniques have been developed based on repeated use of specific "cue words" to accelerate athletes' learning processes, better manage their emotional responses, or enhance their motivation.

In general, research shows that self-talk plays an important role in individuals' control over their own behavior; that it can be improved; and that self-talk involving cue words, in particular, has positive effects on attention, motivation, and overall performance (Oliver et al., 2008).

One characteristic that distinguishes some athletes from others and makes them more successful is also a uniquely human behavior: self-talk. While there are many elements that differentiate humans from other animals, one of them is the ability to engage in internal dialogue with themselves in their minds (Hedeager, 2019). This internal dialogue can be a powerful tool, especially for athletes, in shaping their performance.

This is referred to as self-talk. The words or sentences a person says to themselves either out loud or silently, addressed to oneself, have been extensively studied in sport psychology because they are essential for helping athletes perform at their best. Hardy (2006) defines self-talk as the words or sentences spoken out loud or as a voice heard inside one's head. Self-talk can be categorized into several types (Latinjak et al., 2019).

Spontaneous self-talk**:** Defined as internal speech that occurs involuntarily and expresses thoughts and emotions such as hopes ("I hope I win!") or fears ("Am I going to make a fool of myself?"). This is an expression that reflects who we are and how we feel. Sometimes we say things to ourselves like "Why am I so forgetful?" or "I'm so angry!", which reflect aspects of our personalities or the emotions we are experiencing.

In difficult moments, we talk to ourselves. Sentences like "Stay calm, take a deep breath" or "Ignore the crowd, focus on your task" are small forms of support that many of us use without even realizing it. These types of internal dialogues are not random; they are powerful mental tools used to enhance performance and solve problems.

For example, while focusing on the ball on the field, we guide ourselves by giving clear instructions such as "Get into position, move quickly." In such moments, our inner voice almost acts as a coach. When athletes use this self-talk consciously, it helps them perform better under pressure. For this reason, sport psychologists often have athletes repeat short and effective phrases like "Bend your knees," "Focus," or "You can do it." These kinds of cues function as a bridge between the mind and the body, making movements more controlled and more efficient.

In fact, this is something everyone does naturally it simply requires awareness and proper use. Your inner voice can be your guide, as long as you know how to use it at the right time and in the right way. The process of creating one's own cues involves developing verbal reminder phrases to enhance motivation (e.g., "I can do this!") or to maintain task-related focus (e.g., "Focus on the ball!"). It is not merely a reflection of our thoughts like spontaneous or goal-directed self-talk, but it has been shown to influence both our thinking and our motivation.

Through self-talk, individuals can better understand who they are, what they think, and how they feel. These internal dialogues are a significant cognitive process that enhances an individual's self-awareness. For example, when someone is asked why they like or dislike a particular sport, they may need to rely not only on external dialogues but also on their internal self-talk to answer the question. In this context, the internal dialogues a person engages in with themselves play a fundamental role in the construction of cognitive structures.

Athletes' self-talk often emerges spontaneously when they are alone or do not wish to express their emotions outwardly. This type of spontaneous self-talk typically expresses the individual's current physical or mental state ("I'm so tired.") or their thoughts and feelings about specific events ("I prefer playing in the evening rather than in the morning."). This process is functional in terms of enhancing the individual's self-awareness.

Although such self-talk typically occurs automatically, it serves important functions for the individual. For example, when a young athlete does not want to attend training due to fatigue after school, they may internally express this feeling with a statement such as "I don't feel like training today." This internal response allows the individual to recognize the mental challenge they are experiencing and can thereby help activate self-regulation mechanisms. Self-control is defined as the ability to regulate one's emotions, thoughts, and behaviors, and it lies at the core of motivational processes.

In the course of social life, individuals learn how to communicate with others. For example, the way individuals communicate with their friends differs from how they communicate with their teachers. Additionally, the style of speech may vary depending on the emotional states of others. However, most individuals are not specifically taught how to direct their internal self-talk (Winsler, 2009). This gap is being addressed through research in sport psychology.

In this regard, sport psychologists have developed various educational self-talk strategies to help athletes manage their internal dialogue more effectively (Latinjak et al., 2020). In these techniques, the first step is to help athletes become aware of their spontaneous internal self-talk. This awareness is a fundamental step in allowing the athlete to evaluate their mental and emotional state. In the second step, athletes learn when, how, and what to say to themselves. For example, a professional football player may recognize that they feel angry after performing poorly and express this emotion by saying, "Great players always win and never get angry." Such cognitive awareness allows individuals to restructure their internal self-talk patterns and develop more functional cognitive strategies.

In conclusion, self-talk is an important mental process that enhances emotional awareness, helps individuals identify mental challenges, and supports

self-regulation skills. This ability is particularly important in the context of sport psychology for improving performance and maintaining emotional balance.

Examples from Recent National and International Studies on Psychological Skills Training

Psychological Skills Training (PST) is a systematically implemented set of methods aimed at helping athletes enhance the quality and consistency of their performance (Weinberg, 2019). This approach seeks to improve not only athletes' physical capacities but also their mental resilience. Psychological Skills Training (PST) is of great importance in terms of facilitating the transfer of psychological skills acquired in the training environment to competitive settings.

Practitioners and researchers hold differing views regarding the definition of the concept of 'psychological skills.' While Behncke (2004) classifies psychological skills as cognitive-somatic techniques such as imagery, relaxation, and self-talk, some researchers approach this concept more in terms of trait-like dimensions. In this second approach, it is emphasized that psychological constructs such as confidence, motivation, attention, and concentration are determinants of performance (Vealey, 2019).

Psychological Skills Training (PST) content, in this context, typically encompasses both technique-based and trait-based components. Skills within the technical dimension are considered learnable and applicable methods, whereas trait-like constructs such as confidence or motivation are more closely related to the individual's overall psychological makeup. An effective PST program should be designed to incorporate both dimensions in a balanced manner.

To clarify the subject, Dohme et al. (2017) systematically examined the terms used in experimental studies to identify the psychological components claimed to facilitate athletic performance, and interpretations were made based on this analysis. In the sport psychology literature, psychological skills are regarded as fundamental elements in enhancing an athlete's capacity to regulate mental processes. According to Dohme and colleagues (2017), psychological skills refer to the competence to use structured methods that athletes acquire and apply in order to enhance or stabilize their mental processes. This definition emphasizes the learnable and teachable nature of psychological skills, while also drawing attention to their interaction with individual psychological structures.

According to researchers, psychological traits are qualities that appear structurally stable in the individual but can be shaped through goal-oriented practices (Dohme et al., 2019). Within this framework, there exists a dynamic relationship between psychological skills and traits. For example, cognitive techniques such as imagery have been shown to be effective in enhancing athletes'

self-confidence levels. This indicates that psychological skills not only contribute to immediate performance enhancement but also support long-term psychological development.

In recent years, the increased use of Psychological Skills Training (PST) by athletes has been accompanied by a notable rise in empirical studies examining the effectiveness of such interventions. The expansion of literature in this field has led researchers to systematically analyze the findings and synthesize evidence regarding the effectiveness of PST practices in sport. Meta-analyses and systematic reviews have demonstrated the impact of PST interventions on key variables such as performance, mental resilience, motivation, and self-confidence (Agosti & Sirico, 2020; Brown & Fletcher, 2017; Tod et al., 2011).

These studies indicate that PST interventions are not limited to elite-level athletes but can also be effectively applied to amateur and developmental-level athletes. However, the success of PST programs may vary depending on factors such as the duration and content of the intervention, the qualifications of the practitioner, and the alignment with individual needs. Therefore, refining applied research on PST to account for contextual variables will enhance the quality of knowledge in the field.

A review of the existing literature reveals a rapid increase in studies, including systematic, narrative, and meta-analytic reviews. Although the growing number of studies appears to be a positive development, it also presents certain limitations. First, stakeholders often face the challenge of filtering through a large volume of evidence, which may further complicate the problems they encounter. Second, many of these reviews tend to present conflicting results. For example, the studies by Brown and Fletcher (2017) and Pelka et al. (2016) illustrate such contradictions. While Brown and Fletcher (2017) found that PST techniques such as relaxation and imagery contribute to improved sport performance, Pelka et al. (2016) reported that PST techniques do not enhance athletic performance. To understand the emergence of such conflicting findings, a critical evaluation is necessary. The primary reasons identified for these inconsistencies include:

- the use of different populations,
- variation in inclusion criteria,
- differences in comparators,
- and the limited quality of the studies.

Overviews systematically document evidence derived from existing systematic reviews on a given topic, with the aim of providing a high-level synthesis (Higgins et al., 2019). The overview employed in this research represents one of the highest forms of evidence synthesis currently in use. This approach is particularly effective in the biomedical and health literature (Fusar-

Poli & Radua, 2018; Hartling et al., 2016). The comprehensive literature search conducted by Faulkner et al. (2021) provides access to studies in the field of sport and exercise psychology (Biddle et al., 2011; Biddle et al., 2019). However, both studies primarily focus on physical activity and public health, and do not present an overview specifically addressing Psychological Skills Training (PST) in the context of sport performance. This finding indicates the absence of a holistic and systematic overview of PST interventions within the sport psychology literature. The perspectives of authors conducting research in this area also confirm this gap, highlighting the need for a comprehensive synthesis study examining PST practices in sport contexts.

Psychological Skills Training (PST) has been shown to contribute significantly to performance enhancement. A review of the literature regarding the use or non-use of PST indicates that PST interventions have a positive effect on athletes

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Chapter 5

Motor Imagery: Paralympic Athletes

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Definition and Brief Historical Background

Motor imagery is defined as the mental simulation or rehearsal of a movement without physically performing it. During this process, the individual visualizes or imagines the movement in detail, engaging visual, auditory, tactile, and kinesthetic senses to rehearse their real performance internally (Wraga & Kosslyn, 2002). Research in cognitive neuroscience has demonstrated that motor imagery activates cortical and subcortical areas similar to those involved in actual movement execution, including the primary motor cortex, premotor area, supplementary motor area, cingulate cortex, parietal lobule, and cerebellum (Hétu et al., 2013). This phenomenon is explained by the functional equivalence theory, which posits that both imagined and executed movements are mediated by similar neural processes (Morone et al., 2022).

Empirical studies have shown that motor imagery positively influences motor skill acquisition, muscle activation, neural excitability, and neuroplasticity (Lebon et al., 2012, Demir et al., 2025). The traditional approach conceptualizes imagery as consisting of three interacting components: cognitive, motivational, and emotional. The cognitive component reflects what the individual knows and perceives about the object; the motivational component pertains to future behavioral intentions toward the object; and the emotional component represents the feelings associated with the object (Schiffman et al., 2012).

Numerous motor imagery methods have been discussed in the literature. One of the most widely cited is the PETTLEP model (Physical, Environment, Task, Timing, Learning, Emotion, Perspective), developed by Holmes and Collins (2001), which emphasizes that imagery should closely resemble physical performance to maximize its effectiveness. This model highlights the importance of aligning imagery practice with physical and environmental conditions, task

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characteristics, timing, learning stages, emotional states, and perspective. Motor imagery can significantly influence athletes' performance by allowing them to mentally recreate desired performance conditions in advance. Furthermore, by contributing to technical development, it may reshape athletes' self-perception, helping them feel stronger, more resilient, and more competitive (Morone et al., 2022; Robin & Dominique, 2022).

Motor imagery is used across various sports, age groups, skill levels, and competitive contexts (She & Morris, 1997; Scholefield et al., 2015).

In recent years, research focusing on Paralympic athletes has gained attention. Increasing competitive pressure, participation challenges, and inequities in access to sport can create additional difficulties for Paralympic athletes (Aydoğan & Arslanoğlu, 2023; Hellwege & Hallmann, 2020; Saint-Martin et al., 2020; Almufareh et al., 2023; Cumming & Williams, 2012). Motor imagery has been used to enhance motivation, concentration, psychological resilience, rehabilitation, and pain management in Paralympic athletes (Morone et al., 2022). Based on this evidence, the present work aims to raise awareness of how motor imagery may benefit Paralympic athletes.

Psychoneuromuscular Theory (PNM)

The Psychoneuromuscular (PNM) theory explains the neurophysiological basis of motor imagery, proposing that imagining a movement activates the same neural pathways involved in actual execution (Decety, 1995). Motor imagery is therefore not only a cognitive process but also a physiological one that produces low-level muscle activations. Early electromyography studies by Jacobson and subsequent EMG research showed increased muscle activity in the corresponding muscle groups while participants merely imagined a movement. During imagery, the motor cortex sends signals to muscles similar to those used in actual movement, suggesting that motor imagery exerts neurophysiological effects. Contemporary fMRI meta-analyses confirm that motor imagery activates areas such as the motor cortex, cerebellum, and parietal regions (Hétu et al., 2013).

These findings suggest that motor imagery can help maintain motor cortical activation and support neuroplasticity in Paralympic athletes experiencing movement limitations or amputation.

Symbolic Learning Theory

Originally proposed by Sackett (1934), the Symbolic Learning Theory asserts that the primary function of motor imagery is to cognitively encode movement sequences within the central nervous system. When an athlete mentally rehearses movement, they are not only activating their muscles but also organizing the

temporal, sequential, and spatial components of that movement. Imagery is especially effective during the cognitive stage of learning, when motor plans are not yet fully automated.

This perspective has strong implications for Paralympic athletes who experience limited sensory or motor feedback. According to the theory, even when physical execution is not possible, symbolic representation and mental rehearsal of movement schemata can support learning (Cuence-Martinez et al., 2020).

Recent findings support this view. A meta-analysis by Deng et al. (2024) showed that mental imagery training significantly improved tennis serve accuracy and technical execution, but had limited effects on serve velocity. This aligns with the theory, suggesting that motor imagery primarily enhances cognitive aspects of movement representation planning, timing, and precision rather than directly influencing muscular output.

PETTLEP Model (Physical, Environment, Task, Timing, Learning, Emotion, Perspective)

The PETTLEP model (Holmes & Collins, 2001) argues that imagery is most effective when it closely replicates real performance conditions. The model incorporates seven components: Physical, Environment, Task, Timing, Learning, Emotion, and Perspective, all intended to bridge the gap between mental rehearsal and actual performance.

A systematic review by Morone et al. (2022) demonstrated that PETTLEP-based interventions produce significant performance improvements across various sports. Similarly, Robin and Dominique (2022) reported that the model strengthens functional equivalence in both sport and rehabilitation contexts and that emotional engagement enhances its effectiveness.

For Paralympic athletes, PETTLEP offers a framework that can be personalized to account for sensory and physical differences. For example, the Physical component may be modified to reflect a seated position for wheelchair athletes, while the Environment or Perspective components may prioritize auditory or kinesthetic cues in visually impaired athletes. Thus, PETTLEP integrates the neurophysiological foundations of PNM theory with the cognitive principles of Symbolic Learning Theory, offering a comprehensive approach to imagery-based interventions (Robin & Dominique, 2022).

Embodied Cognition and Multisensory Motor Imagery

Embodied cognition proposes that cognitive processes are not confined to the brain but are fundamentally shaped by bodily and environmental interactions (Ibanez et al., 2023). According to this view, learning and thought emerge from the integration of sensory and motor systems, and bodily experience directly influences cognitive performance.

Multisensory motor imagery or sensory imagery refers to imagery that extends beyond the visual modality to involve auditory, tactile, kinesthetic, and sensory components (Krüger, 2022). Current research demonstrates the effectiveness of such imagery methods in motor performance, learning, and rehabilitation. Marre (2021) reported that embodied and multisensory imagery methods significantly enhance memory and motor learning. Meanwhile, virtual reality technology allows individuals to engage in richer and more immersive multisensory imagery experiences (Muraki, 2023).

From an embodied cognition perspective, multisensory motor imagery represents not just a mental process but a holistic cognitive approach based on interaction with the body and environment, holding strong potential for sport psychology, education, and clinical applications (Ibanez et al., 2023).

For Paralympic athletes, embodied cognition and multisensory imagery play a particularly crucial role in motor learning and performance processes. Due to physical restrictions and atypical bodily mechanics, Paralympic athletes receive different types of sensory feedback, which creates unique imagery experiences (Shimada, 2022). For example, athletes with visual or motor impairments may rely more heavily on kinesthetic and auditory cues to mentally represent movement. This enhances motor skill acquisition and provides opportunities for safe and accurate performance execution (Muraki, 2023).

Multisensory motor imagery also supports motor planning and body–environment integration for athletes using prosthetics or wheelchairs, enabling them to mentally rehearse responses to variable conditions (Ibanez et al., 2023). Thus, embodied cognition provides a framework for integrating physical, cognitive, and sensory processes when designing imagery-based training and rehabilitation protocols (Sullivan, 2018).

In conclusion, integrating multisensory motor imagery techniques into Paralympic training and performance programs may enhance motor learning while also supporting confidence and motivation.

Applications of Motor Imagery

Motor imagery is increasingly used to enhance motor performance, support rehabilitation, and provide training opportunities when physical practice is limited.

In performance enhancement, motor imagery improves technical skills, reaction times, and decision-making processes (Guillot & Collet, 2005, Çağın et al., 2024). Imagery-based pre-performance routines increase confidence and reduce error rates during competitive simulations (Robin & Dominique, 2022). The PETTLEP model emphasizes aligning imagery with physical, environmental, and emotional components to maximize training effects (Holmes & Collins, 2001).

In rehabilitation and motor recovery, imagery is a key tool. Based on principles of neuroplasticity, mental practice activates motor-related brain regions and produces effects similar to physical exercise (Schuster et al., 2011). This approach supports upper limb recovery in patients with stroke or sports injuries and allows safe rehearsal of movements that cannot yet be performed physically.

Additionally, motor imagery offers practical advantages regarding accessibility when training conditions are limited due to injury, disability, or logistical constraints. For Paralympic athletes, imagery enables the development of technical and strategic skills despite restricted physical movement. It is also an inclusive method applicable across age groups and impairment types (Mulder, 2007).

Recent evidence indicates that motor imagery is effective across performance, rehabilitation, and accessibility contexts, and that simulation and virtual reality technology further enhance its application. Thus, motor imagery has emerged as a personalized and scientifically grounded approach to motor learning and skill development.

Factors Influencing Motor Imagery

Motor imagery is shaped by variables such as individual imagery ability, physical condition, task characteristics, and the use of technological tools. These factors influence both the quality of imagery and its transfer to performance (Guillot & Collet, 2005).

Individual differences / imagery ability refer to an individual's capacity to generate vivid, controllable mental images (Hall et al., 1998). Those with higher imagery ability benefit more from mental training (Cumming & Williams, 2012). Factors such as age, experience, attentional focus, and motivation also influence imagery performance (Moran, 2016).

Impairment-specific factors affect imagery differently in individuals with physical or neurological disabilities. In Paralympic athletes or individuals with motor deficits, kinesthetic imagery may weaken while visual imagery remains intact (Li et al., 2024). Therefore, rehabilitation protocols require individualized imagery strategies based on impairment type. Audio guidance, video modeling, and virtual reality can help compensate for perceptual limitations (Choy et al., 2023).

Task and environmental factors (PETTLEP elements) also determine imagery effectiveness. The PETTLEP model emphasizes the importance of replicating real-life movement contexts using its seven components (Holmes & Collins, 2001). Maintaining environmental realism is especially critical when learning complex motor tasks (Singer et al., 2024).

Technical and technological factors include the method and tools used for imagery. Guided imagery is generally more effective than unguided imagery. VR, augmented reality (AR), and brain–computer interface (BCI) technology now allow highly realistic mental practice. Choy et al. (2023) reported that VR-based imagery increases motor cortex activation. A systematic review further showed promising outcomes when BCI-based rehabilitation was combined with motor imagery interventions (Almufareh et al., 2023).

Why Paralympic Athletes?

According to the International Paralympic Committee (IPC), Paralympic athletes are recognized first and foremost as athletes, with impairment treated as secondary (Hellwege & Hallmann, 2020). Increasingly, sport psychologists emphasize the importance of psychological skills for performance among athletes with disabilities. Elite Paralympic sport environments are becoming more competitive, and the need for effective psychological competencies is growing (Aydoğan & Arslanoğlu, 2023).

Cognitive-behavioral psychological skills training provides athletes and teams with techniques for managing internal states during practice and competition. Common techniques include imagery, relaxation, arousal regulation, and self-talk (Saint-Martin et al., 2020). Imagery-based interventions, along with relaxation, goal-setting, and cognitive restructuring, are well supported in both sport psychology and clinical psychology research (Weaver et al., 2014).

Motor imagery is particularly important for Paralympic athletes due to the presence of impairments such as visual loss, amputation, and spinal cord injury. Use of prosthetics or assistive equipment creates unique mental representations during imagery and may influence imagery–performance transfer. As a result, imagery-based interventions in Paralympic sport involve both challenges and benefits. The limited number of studies makes generalization difficult, and the high variability

across Paralympic sport classes reinforces the need for individualized and inclusive imagery models.

Motor imagery interventions for Paralympic athletes must account for individual differences, impairment type, and task–environment demands. Research indicates that imagery can support neuroplasticity and motor function even in the absence of physical movement. Almufareh et al. (2023) demonstrated that imagery training improves neurological and motor recovery independent of physical execution. Studies also show that PETTLEP-based task and environmental adaptations increase imagery effectiveness. In VR-supported interventions, participation and effect sizes are notably higher among individuals with motor limitations.

In conclusion, evaluating imagery ability in Paralympic athletes, implementing a PETTLEP-based impairment-specific and task–environment–adapted protocol, integrating technological tools, and assessing outcomes using motor performance, functional recovery, and participation measures represent a promising approach.

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Chapter 6

The Effect of Athletes' Perceived Physical and Cognitive Fatigue on Performance

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Introduction

The sustainability of athletic performance depends not only on physical capacity but also on cognitive processes and mental resilience. It is known that athletes are exposed to both physical and cognitive load during intense training and competition periods. Fatigue resulting from this load can directly affect many performance components, from technical skills to decision-making speed, from motivation level to in-game behavior. Perceived fatigue is characterized by a decrease in physical and cognitive functions and a feeling of burnout and is one of the important indicators of decreased performance (Jones et al., 2017). Similarly, Korotkova (2006) states that athletes experience not only physical but also cognitive fatigue, making it difficult for them to perform to their full potential. Studies conducted in recent years offer a more comprehensive perspective by examining the effects of fatigue on performance in a multidimensional manner. For example, studies in football have shown that mental fatigue (MF) negatively affects performance components such as sprint distance, passing accuracy and shooting success in small-sided games (SSGs) (Trecroci et al., 2020). Similarly, Soylu et al. (2021) revealed that mental fatigue in young football players led to significant deterioration in physiological responses (heart rate, perceived exertion) and technical performance. However, some meta-analysis findings emphasize that mental fatigue does not always have a significant effect on total running distance or tactical behavior but has more pronounced effects on technical and cognitive skills (Clemente, 2021). Studies conducted in basketball also report similar results; it is stated that mental fatigue negatively affects technical-cognitive skills such as free throws, three-point shots and decision-making (Cao et al., 2021).

With the increase in research evaluating the physical, technical, tactical and mental dimensions of performance together, fatigue management has become a

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critical research area in modern sports sciences. Díaz García et al (2023) examined the effects of different point systems on mental fatigue, physical load, and game behaviors and showed that even small changes in game structure can affect fatigue perception and behavioral outcomes. Additionally, systematic reviews on mental fatigue reveal that mental load has an impact on many variables such as heart rate, subjective fatigue, motivation and cognitive performance (Soylu, 2022).

In this context, while the literature reveals the effects of perceived physical and cognitive fatigue on different components of performance in athletes, it also emphasizes that current approaches should evaluate fatigue in a multidimensional manner. This increasingly important topic in sports sciences sheds light on the development of both training planning and competition strategies, and provides valuable information for coaches, sports psychologists and performance scientists. In this section, the impact of physical and cognitive fatigue perceived by athletes on performance will be discussed in light of current research results and application examples; the multidimensional nature of fatigue will be explained and the key points to consider in performance management will be discussed.

The Concept of Sports and Basic Components of Performance

The concept of sports has evolved beyond being merely a physical activity and has taken on a multidimensional structure throughout history. Stula (2018) defines sports as a systematic activity carried out within the framework of certain rules that supports the physical, mental and moral development of the individual. According to this definition, sports not only improve the physical capacity of the individual but also reinforce values such as self-discipline, determination and competition.

Tikhonova (2018), on the other hand, considers sports as a special form of physical culture and as a cultural phenomenon that contributes to the self-realization of people at both individual and social levels. In this respect, sport is not only an activity based on physical performance, but also a development process that nourishes the mental, emotional and social aspects of the individual and is intertwined with cultural values. Therefore, sport can be defined as a multidimensional human activity in which people reveal their cognitive, emotional and ethical capacities as well as their physical strength. Kobiela (2016) draws attention to the aesthetic dimension of sports and states that sports is not only an action based on physical performance, but also an activity that integrates technical mastery, formal beauty and human body-mind coordination. In this context, sport can be defined as a multidimensional human activity that not only improves the physical capacity of the individual but also nourishes their cognitive, affective, ethical and aesthetic aspects. Filiz (2002) states that the scope of sport is wide and versatile, therefore its boundaries and definition should be clarified by a common

consensus. In line with these perspectives, sport can be considered not only as a physical action but also as a holistic activity supported by discipline and motivation that develops the cognitive, emotional, ethical and aesthetic capacities of the individual. Başoğlu (2017) defines sports as a process that encourages the physical and spiritual development of individuals, supports the formation of character and personality, and strengthens social solidarity and the transmission of cultural values. In line with this definition, sport can be considered as a universal activity that not only provides a tool for individual development, social harmony and social integration, but also contributes to the support of economic, social and cultural development. Therefore, beyond physical performance, sport is a holistic process that nourishes the ethical, cultural, social and aesthetic capacities of the individual. Sport constitutes a multi-dimensional and multi-layered domain of activity that supports the physical, social and psychological development of individuals. Therefore, the definition and scope of sports should not be limited to physical activities only, but should also include social interactions, educational processes and cultural participation of individuals (Yıldız, 2009).

Fatigue

Fatigue can be defined as the processes in which individuals experience physical or mental difficulties in daily life and the inability to perform some functions adequately as a result of these processes (Seven, 2022). When a feeling of fatigue occurs, it means that energy resources are used above resting levels during the completion of a task and tend to be depleted over time (Middlewood et al., 2016). Baas and colleagues suggest that individuals with positive moods may have higher information integration, mental flexibility, and executive memory capacity as the feeling of fatigue increases (Baas et al., 2008). In addition, Middlewood et al. (2016) define the feeling of fatigue as a state of weakness caused by physical and mental processes or a combination of both, which occurs under the influence of factors such as intense daily life conditions, demanding work or procrastination. Fatigue can be defined as a decrease in both physical and mental capacity of an individual, causing the individual to perform activities of daily life or in a sports environment below normal levels (Ream & Richardson, 1996; Mota & Pimenta, 2006). In addition, fatigue is also considered as a process that causes a decrease in the amount of power produced by the muscles and a loss of performance (Billat, 2001).

In the context of sports, fatigue is a multidimensional phenomenon that encompasses sport-specific muscle actions, electrolyte balance, the cardiovascular and respiratory systems, the central nervous system, and the athlete's psychological state. A change in any of these factors may trigger the perception of fatigue (Allen et al., 2008).

The effects of fatigue on athletes are frequently emphasized in the literature. For example, distraction (Boksem & Tops, 2008), decreased force production (Green, 1997), and the emergence of symptoms of depression or anxiety (Johansson et al., 2012) are cited as consequences of fatigue. These effects can directly lead to decreased performance (Scott et al., 2003; Martin et al., 2018).

Fatigue cannot be considered solely as physical exhaustion in sports sciences; it is a multidimensional phenomenon that leads to a decrease in both physical and cognitive performance and increases the risk of injury in athletes. Bestwick-Stevenson et al. (2022) define fatigue as a complex process that occurs with declines in physical and cognitive functions, and emphasize that the different definitions in the literature arise from the multifaceted nature of the concept. Therefore, fatigue should be considered as a comprehensive concept that cannot be reduced to a single biological mechanism but is shaped by the interaction of physiological, cognitive and neuromuscular processes. Tekkurşun-Demir et al. (2023) show that fatigue in athletes can be measured separately as perceived physical and cognitive components; therefore, fatigue should be considered as a multidimensional structure.

Physical Fatigue

From a psychological perspective, weakness is defined as the decreased function of rested muscles to exert force, while fatigue is defined as the loss of maximal force production capacity developed during muscular activity (Lewis and Haller, 1991). It is also expressed as the disruption of the homeostatic balance in the body, starting from exercises, physical activities, etc., due to internal and external stresses created by the physical condition (Tornero-Aguilera et al., 2022).

At the subjective level, physical fatigue manifests itself through a desire to rest, tiredness, low energy and a sense of physical weakness (Chalder et al., 1993).

Physical fatigue is a multidimensional condition characterized by a decrease in the force-producing capacity of muscles and an increase in the subjective perception of effort. This fatigue consists of two main components: central and peripheral. Central fatigue is associated with the inability of the motor cortex to adequately sustain muscle activation and changes in neurotransmitter balance. Peripheral fatigue occurs as a result of intramuscular metabolic accumulation, ATP depletion and biochemical changes in muscle fibers. These two processes affect each other during exercise, leading to decreased performance (Tornero Aguilera et al., 2022). Physical fatigue occurs when muscle metabolism cannot perform at a high level after intense exercise or training and homeostatic balance is disrupted (Schubert et al., 1998; Tornero Aguilera et al., 2022). Physical internal and external stresses can disrupt the body's homeostatic balance, starting during an activity. Workloads applied in the acute phase cause strain on the muscles and a process of adaptation to the stress

created by the activity. The most obvious indicator of this process is the gradual increase in the level of difficulty perceived by individuals during the activity (Tornero Aguilera et al., 2022).

Disruption of homeostatic balance during sporting activities increases metabolite accumulation in the muscles. This gradually reduces the excitability of the muscles, leading to a decrease in power production capacity and, after a certain period of time, to the emergence of physical fatigue (Meeusen et al., 2006). Changes in Central Nervous System (CNS) mechanisms are also important during the fatigue process; possible decreases in nerve conduction speed in the CNS may negatively affect cognitive processes (Tornero Aguilera et al., 2022).

Cognitive Fatigue

Cognitive fatigue is a psycho-biological condition that occurs as a result of prolonged mental activities (Desmond & Hancock, 2001). This type of fatigue reduces the effectiveness of mental processes such as attention, concentration and decision-making (Finsterer and Mahjoub, 2014). The individual often feels symptoms of cognitive fatigue before perceiving physical fatigue (Signal et al., 2008). Pageaux and Lepers (2018) define cognitive fatigue as a psychobiological condition that occurs after tasks that last for a long time and require a high level of cognitive effort. According to researchers, mental fatigue can be explained by a growing feeling of exhaustion, a reluctance to continue the task at hand, and a significant decrease in cognitive performance. This situation can negatively affect the individual's decision-making processes, motor control mechanisms, and especially physical performance that requires endurance. Prolonged mental effort, low motivation, lack of energy, distraction and decreased cognitive control are the main causes of cognitive fatigue (Boksem and Tops, 2008). In this process, decreased concentration, decreased information processing speed, increased decision-making errors and slower reactions are frequently observed (Johansson & Rönnbäck, 2012). Cognitive fatigue can occur independently of physical fatigue. This type of fatigue manifests itself through characteristics such as lack of focus, slowed thinking skills, difficulty with attention and decision-making, and decreased ability to be motivated and take action (Boksem & Tops, 2008; Finsterer & Mahjoub, 2014). Prolonged physical activities as well as intense mental activities can lead to cognitive fatigue (Job & Dalziel, 2001; Signal et al., 2008). In this chapter, the terms "mental fatigue" and "cognitive fatigue" are used interchangeably to refer to the same psychobiological state unless otherwise specified.

Cognitive fatigue, which affects performance in sports, occurs after prolonged cognitive efforts and affects both mental and behavioral functions (Desmond & Hancock, 2001; Job & Dalziel, 2001). It has been emphasized in the literature that

cognitive fatigue increases the risk of making errors at work and is associated with neurological symptoms common in adults (Chaudhuri & Behan, 2004; McCormick et al., 2012). The negative effects of cognitive fatigue on performance manifest themselves in the form of loss of attention, reaction delays, memory problems and a decrease in decision-making ability (Van der Linden et al., 2003; Lorist et al., 2005; Ackerman et al., 2010; Tanaka et al., 2015; Rozand et al., 2015). Mental fatigue is a condition that occurs after tasks requiring long-term and high cognitive effort and affects sports performance. This state of fatigue manifests itself with an increasing feeling of exhaustion and lack of energy; it can also directly affect the athlete's performance by causing deterioration in decision-making, attention and executive functions (Sun et al., 2021). Yuan et al. (2023) emphasize that high cognitive demand and unpredictable playing conditions, especially in team sports, significantly increase the effects of mental fatigue. Mental fatigue increases athletes' perceived effort and leads to decreases in sport-specific motor performance.

Research shows that cognitive fatigue has negative effects on sport-specific performance. For example, it negatively affects the decision-making process and technical skills in branches such as cricket (Veness et al., 2017), table tennis (Le Mansec et al., 2018), marksmanship (Head et al., 2017) and football (Badin et al., 2016; Smith et al., 2016). Marcora et al. (2009) stated that mental fatigue reduces performance without changes in physiological parameters and that this is only related to the level of perceived mental difficulty. Van Cutsem et al. (2017) emphasized that cognitive fatigue causes loss of performance in activities requiring endurance.

Physiological and Cognitive Aspects of Fatigue

Considering the physiological and cognitive components of fatigue together is critical to understanding the nature of the concept. Bestwick-Stevenson et al (2022) state that due to the multidimensional nature of fatigue, different classifications such as central and peripheral fatigue have emerged in the literature. In this context, fatigue is examined by physiological indicators such as metabolic responses, neuromuscular dysfunctions and hormonal changes, while it is also characterized by psychological processes such as loss of motivation, decline in cognitive performance and subjective feeling of burnout. Evaluating physiological and cognitive indicators together provides a more holistic view of fatigue and recovery processes. Literature shows that mental fatigue involves not only cognitive functions but also some physiological mechanisms that affect exercise performance. Pageaux and Lepers (2018) state that mental fatigue increases perceived effort, but this does not always lead to a decrease in maximal force production. This suggests that the physiological effects of fatigue are not directly reflected in muscle strength, but rather in the perception of effort and the capacity to sustain performance.

The cognitive dimension of mental fatigue is particularly evident: Increased perceived exertion creates impairments in decision-making, attention and technical skills, leading to performance reductions in complex sports actions such as ball possession, passing or anticipating the opponent's movement. Yuan et al. (2023) also stated that MF causes the exhaustion of attentional resources and deterioration in visual-perceptual attention functions of athletes, indicating that explaining the performance loss solely by physical fatigue is insufficient. These findings reveal that mental fatigue limits sports performance and acts mostly through cognitive and psychological mechanisms.

Tekkurşun-Demir et al. (2023) also report that during periods of intensive training, athletes frequently experience both physical and cognitive fatigue, and that these perceptions are closely related to their readiness to perform.

Interaction Between Physical and Cognitive Fatigue

Physical and cognitive fatigue are two interrelated processes. Physical fatigue can lead to impaired cognitive function by reducing nerve conduction velocity in the central nervous system (CNS) (Johansson et al., 2012). Likewise, cognitive fatigue indirectly reduces muscle performance by reducing the individual's ability to use their physical capacity (Baumeister and Vohs, 2016). The simultaneous occurrence of these two types of fatigue in athletes negatively affects performance by creating both mental and physical exhaustion. Especially during intense training periods or long-lasting competitions, the perceived fatigue level increases, motivation decreases and decision-making processes slow down (Martin et al., 2018).

There is a strong interaction between physical and cognitive fatigue. One study shows that mental fatigue negatively impacts both a team athlete's physical performance (e.g., intermittent endurance and total distance) and technical skills (turnovers, passing/shooting errors, tackling success). These findings reveal that cognitively exhausted athletes have difficulty not only in decision-making or attention processes but also in using their physical resources efficiently. Increased perceived exertion, especially under fatigue, has been observed together with decreases in technical and motor performance, supporting a reciprocal relationship between mental load and loss of physical performance (Yuan et al., 2023).

Aras et al (2020) emphasize that cognitive fatigue has direct effects on sports performance. According to research, in cases of mental fatigue, a decrease is observed in both executive functions (decision making, attention, problem solving) and sport-specific physical performance of athletes. This effect, along with an increase in perceived exertion, leads to earlier onset of physical fatigue symptoms. Therefore, cognitive fatigue not only affects mental processes but also negatively shapes the sustainability of physical performance and motor skill efficiency. The

study states that cognitive and physical fatigue are processes that mutually affect each other; the negative effects of mental fatigue on physical performance become especially evident in team sports and activities requiring high coordination (Aras et al., 2020). The Algılanan Fiziksel ve Bilişsel Yorgunluk Ölçeği (Perceived Physical and Cognitive Fatigue Scale; AFBYÖ) is a tool developed to measure both physical and cognitive dimensions of fatigue in athletes. The scale aims to objectively evaluate the levels of burnout felt by individuals during and after exercise or sporting activities. The physical fatigue subscale measures subjective perceptions related to muscular strength, endurance, and physical performance, while the cognitive fatigue subscale assesses perceptions related to attention, focus, decision-making, and mental effort. Validity and reliability analyses during the development process of the AFBYÖ showed that the scale could be used reliably in athletes. In this way, researchers and coaches can make more informed decisions about training loads, recovery processes and performance evaluations by monitoring both physical and cognitive fatigue. The scale is considered an important tool for measuring perceived fatigue in sports sciences literature (Tekkurşun-Demir et al., 2023). Another study shows that perceived physical and cognitive fatigue is a multidimensional phenomenon that affects not only performance but also mental competencies in athletes. Therefore, considering physical and cognitive dimensions together in fatigue assessments is of critical importance for the sustainability of both performance and cognitive capacity (Karakuş et al., 2024).

The Effect of Physical Fatigue on Athlete Performance

Physical fatigue is considered one of the main factors limiting the athlete's performance and occurs as a result of various physiological processes occurring in both the central nervous system and the peripheral muscular system. Fatigue is associated with multidimensional mechanisms such as decreased force-producing capacity of muscles, depletion of energy stores, accumulation of metabolic byproducts, and slowing of neuromuscular transmission (Gandevia, 2001; Enoka & Duchateau, 2008). Therefore, physical fatigue is a critical performance component that directly affects the execution of technical skills, speed and force production, endurance, and coordination in athletes. Research shows that lactate accumulation in the muscles during exercise, ion imbalance and ATP insufficiency reduce muscle contraction efficiency and negatively affect the athlete's movement quality (Fitts, 2008). In high-intensity exercises, especially fast-twitch muscle fibers become fatigued earlier, which can lead to significant decreases in sport-specific performance elements such as sprint performance, jump height and sudden changes of direction (Girard et al., 2011). In endurance sports, decreased oxygen transport

capacity, increased cardiovascular stress and inefficient energy metabolism are the main mechanisms that cause performance loss (Noakes, 2012).

Physical fatigue produces effects not only at the muscular level but also at the central nervous system level. Studies have shown that long-term or high-intensity exercises reduce the excitability of the central nervous system, limiting motor unit activation and reducing voluntary contraction strength (Taylor et al., 2016). This negatively impacts the athlete's ability to control movements and maintain optimal technical execution. As a matter of fact, the increase in technical errors towards the end of the competition, the prolongation of decision-making time and the deterioration of movement economy are considered as indirect reflections of physical fatigue on performance. Additionally, physical fatigue is known to increase the level of perceived exertion and affect motivational processes. Increased perceived exertion may cause athletes to exert themselves less or perform below optimal levels during training and competition (Marcora & Staiano, 2010). Therefore, fatigue should be considered not only as a physiological but also as a behavioral and psychobiological process.

In conclusion, physical fatigue is a multi-layered phenomenon that affects athlete performance in both direct and indirect ways. Metabolic changes occurring at the muscle level, loss of excitability in the central nervous system and increased perceived effort significantly limit the application of the athlete's technical, tactical and motor skills. Therefore, planning training programs to include fatigue management is critical for the sustainability of performance.

The Effect of Cognitive Fatigue on Athlete Performance

Cognitive fatigue can lead to attention deficit, prolonged reaction time, faulty decision making, and a decrease in strategic thinking skills in athletes. This situation causes a decrease in performance, especially in branches that require technical skills and quick decision-making (Badin et al., 2016). Additionally, mental fatigue causes loss of motivation, lack of energy and decreased alertness, limiting the athlete's physical effort (Thompson et al., 2019). In order to maintain athlete performance at an optimal level, both physical and cognitive recovery processes must be managed in a balanced manner. Cognitive (mental) fatigue in athletes is defined as a condition that occurs as a result of prolonged and intense cognitive efforts and increases the level of perceived exertion. This state of fatigue can lead to deterioration in athletes' decision-making, attention and reaction processes, leading to decreased performance during training or competition. Failure to manage mental fatigue properly may lead to a decrease in the perceptual and cognitive functions of athletes, thus leading to loss of performance (Türkmen & Genç, 2023).

Slimani et al (2018) reported that cognitive fatigue negatively impacted selective attention performance in young endurance athletes subjected to a 30-min Stroop test. In the study, a significant decrease in attention performance value and an increase in the number of errors were observed. Furthermore, cognitive fatigue is not only limited to attention but also reduces aerobic capacity: VO_2max and vVO_2max values were significantly decreased in the mentally fatigued condition compared to the control condition. In addition, athletes reported higher perceived exertion after exercise in the fatigue zone condition. These findings show that cognitive fatigue has a negative impact on sports performance both through cognitive functions (attention, concentration) and aerobic capacity related to physical endurance (Slimani et al., 2018).

Trecroci et al.'s (2020) field-based study reveals that cognitive fatigue impairs athlete performance in small-sided games in a multidimensional manner. Following a fatiguing Stroop task, players experienced decreased physical activity levels (e.g., acceleration distance) as well as decreased technical skills (passing accuracy, shooting accuracy) and decision-making performance (negative passes, dribbling accuracy). This provides strong evidence that cognitive load is not limited to the mind, but limits the athlete's holistic performance potential by negatively impacting physical energy use and in-game cognitive strategies.

Fatigue Management and Recovery Strategies

Fatigue management and recovery strategies are critical to the sustainability of athlete performance. A comprehensive review indicates that cryotherapy and compression garments provide positive results in the recovery process. However, the same study also emphasized that a single universal recovery strategy does not provide consistent benefits in all athletes (Li et al., 2024). In addition, proper hydration, nutrition, and sleep patterns are also key components in fatigue management (Ulusoy, 2021). Strategies developed for mental (cognitive) fatigue are also important. For example, a systematic review reveals that various interventions aimed at reducing the impact of mental fatigue have been examined (Sun et al., 2024). Additionally, a study shows the positive effects of methods such as short-term mindfulness training, listening to music, and self-talk on cognitive fatigue and technical/cognitive performance (Pan et al., 2024).

Fatigue management in athletes is critical to ensuring performance sustainability and reducing the risk of injury. After long periods of intense training or post-competition loads, implementing effective recovery strategies helps balance both the physiological and psychological state of the athlete. These strategies aim to establish a balance between training load and recovery (Gümüşdağ, Egesoy & Cerit, 2015). Cognitive fatigue can negatively impact sports performance, and mental recovery

strategies are important to mitigate this effect. A recent systematic review showed that interventions such as mindfulness, nature contact, self-regulation, and transcutaneous direct current stimulation improve cognitive-motor functions in sports performance. Additionally, mental rest strategies during short breaks can also be effective. For example, a study conducted on air rifle shooters found that power naps and systematic breathing exercises had a positive effect on performance and mental fatigue in some individuals (Loch, 2023). Recovery strategies should be individualized and adapted to the athlete's branch, loading tempo, competition program and physiological characteristics. For example, when planning according to the game schedule and critical periods of the season, coaches and sports scientists should use active and passive recovery methods in a balanced way, taking into account both physiological and mental fatigue (Gümüşdağ, Egesoy & Cerit, 2015).

As a result, recovery strategies need to be addressed holistically for both physical and mental fatigue. Methods such as cryotherapy and compression equipment applied after physical loads, as well as the use of methods such as mindfulness, music, and self-talk to cope with mental fatigue, are important indicators for maintaining and improving athlete performance. In addition, these strategies need to be planned by taking into consideration individual differences, sports branch characteristics and loading times.

Current Research and Application Examples

Current research addresses the effects of perceived physical and cognitive fatigue on performance in athletes in a more holistic manner. For example, mental fatigue has been shown to negatively impact physical activity, technical skills, and decision-making performance in small-sided games. In a study by Trecroci et al (2020), mentally fatigued players (after undergoing the Stroop test) experienced a decrease in acceleration distance, passing accuracy, and shooting success on SSGs. Similarly, the study by Soylu et al. (2021) revealed that mental fatigue caused significant deterioration in both physiological (heart rate, perceived exertion) and technical performance measures (turnover, unsuccessful passes) in small-sided games with young football players. In a meta-analysis examining tactical behavior and match dynamics, it was found that mental fatigue had no significant effect on total running distance or tactical behavior. This suggests that fatigue may not always directly affect physical performance, but instead may be more evident in technical or cognitive skills (Clemente, 2021).

Similar effects have been reported in other branches such as basketball. A systematic review indicates that mental fatigue negatively affects basketball players' technical performance (e.g., free throw, three-point shot) and decision-making skills (Cao et al., 2021). Additionally, studies on point systems are investigating the

relationship between fatigue and physical-tactical demands. For example, Díaz García et al. (2023) examined the effects of different scoring systems on mental fatigue, physical load, and tactical behavior, showing that even small changes in the scoring system can affect fatigue and game behavior.

The effect of perceived fatigue on performance in athletes is discussed in a multidimensional manner. Perceived fatigue is defined as a decrease in both physical and cognitive functions and a feeling of exhaustion (Jones et al., 2017). Korotkova (2006) reported that athletes experience not only physical but also cognitive fatigue as a result of intense training processes. This situation makes it difficult for the athlete to demonstrate her current potential and leads to loss of performance. Finally, a systematic review of fatigue research in small-sided football reported that mental fatigue interventions were effective on heart rate, subjective fatigue, motivation, and cognitive performance (e.g., attention tests) (Soylu, 2022).

Conclusion and Recommendations

Fatigue is a key factor affecting sustained performance in athletes. Physical and cognitive fatigue, both individually and in combination, impair an athlete's motor, psychological, and cognitive functions. Therefore, training plans should consider not only physiological but also cognitive recovery processes. A holistic fatigue management approach should be adopted to ensure athletes maintain both their physical capacity and mental resilience.

This study addressed the phenomenon of fatigue affecting athletes' performance in both physical and cognitive dimensions. In line with the literature review and current research, it has been revealed that fatigue cannot be considered only as physical exhaustion; it is a multidimensional phenomenon that limits performance through cognitive and psychological processes. While physical fatigue manifests itself with changes in muscle metabolism, central and peripheral fatigue processes and disruption of homeostatic balance, cognitive fatigue leads to a decrease in attention, focus, decision-making, executive functions and motivation. This situation shows that performance loss in athletes cannot be explained solely by muscle strength or endurance, but cognitive mechanisms are also decisive.

Research reveals that physical and cognitive fatigue interact. While physical fatigue affects the central nervous system and leads to a weakening of cognitive functions, cognitive fatigue can also negatively affect physical performance by increasing perceived effort. This mutual interaction causes a holistic decrease in performance, especially in team sports and branches that require high coordination. Therefore, evaluating athletes' fatigue levels not only in a one-dimensional manner but also in a way that encompasses both physiological and cognitive processes is of critical importance for the sustainability of performance. In addition, it has been

determined in the literature that cognitive fatigue has indirect, if not direct, effects on physical performance, causing significant decreases in decision-making, technical skills and strategic practices. This finding reveals the necessity of considering mental load in training and competition planning. When mental fatigue is not managed, athletes experience a decline in both cognitive and physical performance, limiting their potential for optimal success.

In conclusion, fatigue in athletes is a complex phenomenon that should be evaluated in terms of physical, cognitive and psychological dimensions. Fatigue must be monitored from a holistic perspective to ensure sustainability of performance, protect athlete health and achieve successful results. The simultaneous application of physical and cognitive recovery strategies is a critical requirement for athletes to maintain their technical, tactical and motor performance at maximum levels. In this context, it is of great importance for coaches and sports scientists to develop individualized training and recovery plans that take into account the multidimensional nature of fatigue.

Suggestions

1. Fatigue assessments of athletes should not be limited to physical parameters only; cognitive functions and psychological indicators should also be monitored regularly. Perceived fatigue scales can be used as a systematic tool in this process.
2. Appropriate nutrition, hydration, sleep and active rest methods should be applied for physical fatigue; mindfulness, music, breathing exercises and self-talk techniques should be applied for cognitive fatigue. Recovery strategies should be planned by taking into consideration the sport, training load and individual characteristics.
3. In team sports or activities requiring high cognitive demand, short-term interventions to reduce mental fatigue (listening to music, mindfulness exercises, self-talk) should be integrated before or during training and competition.
4. Simultaneous monitoring of both physical and cognitive dimensions of fatigue is a fundamental requirement to sustainably manage the technical, tactical and motor performance of athletes. This approach is important for reducing the risk of injury and maintaining long-term performance.
5. In future studies, the interactions of physical and cognitive fatigue in different sports branches can be examined with larger sample groups in relation to long-term performance and recovery processes. Additionally, the neurobiological mechanisms of fatigue and the effects of cognitive load management strategies on performance should be investigated in detail.

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Chapter 7

The Role of Exercise in Combating Neurodegenerative Diseases

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Introduction

Mustafa Kemal Atatürk's statement, "A healthy mind resides in a healthy body," emphasizes that mental and physical health are complementary elements. Data obtained from scientific studies support this notion, suggesting that regular exercise has a significant effect on the prevention of neurodegenerative diseases (Alzheimer's, Parkinson's, Amyotrophic Lateral Sclerosis, and Huntington's) and on slowing their progression. Elderly individuals are considered a high-risk group for neurodegenerative diseases. Due to the increasing mortality rates associated with these disorders, there is a growing search for new treatment methods. In this context, the aim of this study is to examine the effects of exercise, a non-pharmacological intervention, on neurodegenerative diseases.

Aging Period And Emerging General Problems

With developments in technology and healthcare, human life expectancy has increased both worldwide and in our country, leading to a rise in the number of elderly individuals. According to the World Health Organization (WHO) in 2020, the number of people aged 60 and above was 1 billion in 2019. They predict that this number will reach 1.4 billion by 2030 and 2.1 billion by 2050. According to the 2024 data from the Turkish Statistical Institute (TÜİK), the population aged 65 and above in Turkey constitutes 10.6% of the total population. This proportion is projected to reach 12.9% in 2030 and 16.3% in 2040 (TÜİK, 2025). The aging period occurs in all living beings, and its main mechanisms are not yet fully understood (Hadem et al., 2019). This period is a multidimensional and complex phenomenon that leads to slowing and reduction in the body's biological and physiological functions (Bayram, 2020). As a result of inevitable functional changes at the molecular, cellular, organ,

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tissue, and system levels during old age, individuals may experience various physiological, psychological, cognitive, mental, and social problems. Aging can also bring psychological issues such as stress. Since stress negatively affects the immune system, it can play a role in triggering numerous mental and physical illnesses (Küçük & Karadeniz, 2021). Elderly individuals may experience conditions such as depression, loneliness, fear of death, anxiety, changes in body image perception, anger, and sensitivity (Petretto & Pili, 2020). Psychological states can affect brain structure and function, potentially leading to the onset of dementia. In elderly individuals, there is a risk of decline in functions such as memory, problem-solving, and information processing (Yorulmaz et al., 2023). Especially in sedentary individuals, aging can lead to structural and functional impairments in the cells of the nervous system. Slowing can be observed in decision-making, attention, and reaction times in response to events or external stimuli (Çağın et al., 2024). Due to cognitive impairments, elderly individuals may experience difficulties in recalling events, people's names, or even what they consumed during the previous evening's meal. Parallel to these situations, losses in learning ability may also occur. In addition, reductions in sensory abilities such as vision and hearing can take place (Özmen & Contarlı, 2023). The brain weight of elderly individuals shows a significant decrease compared to younger people. Moreover, the hippocampus, located adjacent to the brain, is negatively affected, leading to functional impairments in brain performance (Hollmann et al., 2007). With aging, certain problems may also arise in the respiratory and cardiovascular systems. In the cardiovascular system of individuals at this stage, maximum heart rate, stroke volume, cardiac output, and VO2 max all decrease. In their study on the rate of VO2 max decline by age decades, Fleg et al. (2005) found that the decrease progressed from 3%–6% in the second and third decades and exceeded 20% after the seventh decade (Fleg et al., 2005). In another similar study, it was reported that the rate of decline in VO2 max was 14% in men and 7% in women (Stathokostas et al., 2004). One of the main reasons for decreased endurance in old age is the reduction in VO2 max. In addition, endothelial cell (cells lining the interior of blood vessels) deterioration, increased pericardial fat, and morphological changes in the heart valves, aorta, and left ventricle may occur (Küçük & Karadeniz, 2021). As aging progresses, the structure of the lungs changes, including atrophy of the respiratory muscles, flattening of the diaphragm, and alterations in the dimensions of the thoracic cage (Küçük & Karadeniz, 2021). Due to these structural changes in the lungs, oxygen delivery to the cells decreases, and risks of infection, fatigue, weakness, and reduced sleep quality may arise (Kaptan & Dedeli, 2012). Increasing respiratory problems in elderly individuals can lead to a parallel decrease in physical activity capacity. This situation is closely related to changes in the musculoskeletal

system. Functional impairments in the musculoskeletal system include restrictions in joint mobility, reductions in muscle strength and muscle mass. The causes of these declines include a sedentary lifestyle, degeneration of the nervous system, decreased basal metabolic rate, osteoporosis, decreased functional capacity, and reductions in growth hormone, androgens, and estrogen. Osteoporosis is a skeletal disease that may emerge during aging and carries a risk of morbidity (Ağar, 2020). Bone fractures in elderly individuals may result from osteoporosis (Novotny et al., 2015). In older adults, calcium deficiency, decreased muscle tone and strength can increase the risk of bone fractures (Orhan & Kaya, 2024). After the sixth decade of life, reductions in muscle strength accelerate. Extensor muscle groups, particularly the knee and ankle extensors, are adversely affected. These muscle groups play an important role in daily life because they are frequently used during physical activities. All these changes set the stage for sarcopenia in elderly individuals. Sarcopenia is a musculoskeletal disorder characterized by decreases in muscle function, strength, mass, and protein content (Kaptan & Dedeli, 2012). These changes can lead to postural deterioration, fatigue, and problems with balance and gait (Sanchez-Rodriguez et al., 2020). Furthermore, the etiopathogenesis of sarcopenia is influenced by multiple factors, including motor neuron loss, oxidative stress, hormonal changes, mitochondrial dysfunction, and a reduced number of satellite cells. Sarcopenia can also progress due to poor nutrition, chronic diseases, hormonal changes, and a sedentary lifestyle. Today, sarcopenia is not only observed in elderly individuals but also draws attention in the context of muscle loss associated with neurodegenerative diseases (Fırat, 2025). Sarcopenia may accelerate the progression of neurodegenerative and similar diseases.

Neurodegeneration Mechanism

The brain is an organ composed of billions of neuronal cells, playing a crucial role in numerous functions such as thinking, speaking, moving, and remembering (Samal & Nandha, 2025). Even minor synaptic connection issues between these neurons can lead to various problems. Among the significant factors affecting these connection disruptions are neurodegenerative diseases (Barmen & Bayati, 2018). Etymologically, the term "neurodegenerative" is derived from "neuro" (nerve cells) and "degeneration" (deterioration in cells or loss of tissue and organs). Neurodegenerative diseases are a general category of disorders characterized by neuronal loss, causing impairments in motor and cognitive processes (Hasan et al., 2023). Additionally, these diseases may be facilitated by mitochondrial dysfunction, protein accumulation, neuronal overexcitation due to excessive glutamate, oxidative stress, excessive calcium accumulation, proteolytic stress, chronic inflammation in the nervous system, and cellular and molecular impairments associated with aging

(Wu et al., 2023). These factors can lead to neuronal loss and atrophy. With the increasing elderly population, the prevalence of neurodegenerative diseases has also risen. In older adults, neurodegenerative diseases result in cognitive issues such as communication difficulties, memory impairment, attention deficits, and concentration problems, as well as reductions in muscle strength, motor capacity, and the ability to perform activities of daily living. Preventing or slowing neurodegeneration is important for ensuring healthy aging (Coşkun & Hanoğlu, 2019). The earliest indicators of neurodegeneration can be identified as depression, insufficient digestive function, and fatigue following cognitive activities. Fatigue after cognitively demanding tasks may indicate neuronal loss and problems in ATP production (Coşkun & Hanoğlu, 2019). Psychological problems such as depression, which predispose elderly individuals to neurodegenerative diseases, may prevent neurons in the frontal cortex from generating optimal action potentials, leading to atrophy. Different types of neurodegenerative diseases manifest in specific regions of the brain (Berman & Bayati, 2018). The leading types of neurodegenerative diseases include Alzheimer's disease, Parkinson's disease, Amyotrophic Lateral Sclerosis (ALS), and Huntington's disease (Muddapu et al., 2020). Neurodegenerative diseases initially appear in subcortical areas and later spread to cortical regions as the disease progresses. Neuronal loss occurs in the striatal regions, which play a critical role in movement control and coordination, depending on the type of disease. Due to their severe and destructive effects, neurodegenerative diseases are considered among the most debilitating conditions a person can experience (Berman & Bayati, 2018). Although promising treatments involve the replacement of lost neurons with stem cells, there is currently no definitive cure, and disease progression can only be slowed (Garcia-Gonzalez et al., 2024). To prevent these diseases, it has become essential to identify strategies that delay aging and keep individuals more active and healthy. These strategies should be planned and implemented before the onset of the disease. Research has shown that exercise programs designed for individuals with neurodegenerative diseases improve aerobic capacity, strength, and balance (Latimer-Cheung et al., 2013; Uhrbrand et al., 2015). Furthermore, some findings indicate that exercise interventions may prevent or slow the progression of neurodegenerative diseases. Epidemiological studies have shown that physical activity reduces the risk of dementia by 28% and Alzheimer's disease by 45% (Motl et al., 2012; Lahue et al., 2016). Data from in vivo studies and individuals with neurodegenerative diseases have demonstrated that exercising positively affects cognitive performance (Stranaham et al., 2012; Allard et al., 2017). One of the main factors contributing to the onset of neurodegenerative diseases is a sedentary lifestyle (Kimura, 2013).

The recommended interventions for combating neurodegeneration can be summarized as follows:

- It is necessary to avoid food toxins as much as possible (such as seed oils, excessive sugar, grains, and industrially packaged foods).
- Adequate intake of micronutrients (B12, folate, magnesium, iron, and vitamin D) is important.
- Maintaining a proper balance of fatty acids (omega-3 and omega-6 ratio) is essential.
- Optimize gut function.
- Stay cognitively active.
- Increase cerebral blood flow.
- Manage stress and maintain psychological well-being.
- Improve sleep quality.
- Engage in regular exercise.

In a study conducted in the United States involving 200 individuals diagnosed with Alzheimer's disease, all patients were initially placed on a gluten-free diet, and their meals were reduced by half according to a personalized nutrition plan. Additionally, patients' overnight fasting periods were extended to 12–14 hours, sleep quality was improved, and various exercise programs were implemented. According to the results obtained from the study, in nearly all patients, the progressive course of Alzheimer's disease was halted, and in some cases, patients returned to their pre-disease condition. Consequently, it was demonstrated that regulating certain parameters can significantly influence the progression of the disease and may have a protective effect (Bredesen, 2014; Bredesen et al., 2016).

Exercise In Older Adults

With the problems that arise during aging, a sedentary lifestyle can lead to numerous chronic diseases and health issues. For maintaining a healthy life, exercise is as important as adequate and balanced nutrition. According to the World Health Organization, engaging in exercise improves cognitive and physical function, prevents psychological problems such as anxiety and depression, preserves muscle strength, prevents musculoskeletal disorders like sarcopenia, reduces the risk of diseases such as type II diabetes and stroke, and provides various social benefits (WHO, 2015). Exercise is recommended for elderly individuals to help them maintain a healthy, independent life despite increasing age-related problems. Exercise plays a crucial role in preventing osteoporosis-related bone fractures in older adults (Eckstrom et al., 2020). Elderly individuals who remain physically active in their daily lives have been reported to experience better quality of life, with

lower stress and anxiety levels compared to sedentary peers (Anantanasuwong et al., 2022; Oliveira et al., 2017). The American College of Sports Medicine (ACSM) recommends aerobic, balance, flexibility, and resistance exercises to preserve and enhance health in older adults (Chodzko-Zajko et al., 2009). Aerobic exercises include physical activities such as cycling, walking, and swimming, aimed at improving cardiovascular endurance. For older adults, it is recommended to perform moderate-intensity aerobic exercise (fatigue score 3–4 on the Borg CR10 scale or below 70% of heart rate reserve) for at least 20–30 minutes per session, three times per week. Aerobic exercise is recommended for elderly individuals because it contributes to resistance gain, increased cerebral blood flow, muscle strength, improved posture, and flexibility (Park et al., 2020; Sultana et al., 2020). Aerobic-based exercises have been shown to benefit the age-related decline in hippocampal volume. In a study involving middle-aged women with fibromyalgia (average age 35.76) experiencing cognitive dysfunction, 12 weeks of Zumba dance-based aerobic exercise resulted in improvements in working memory performance and motor function, whereas no improvements were observed in the control group (Norouzi et al., 2020). In another study based on aerobic exercise, moderate-intensity walking exercises were applied to individuals over 60 years of age with mild cognitive impairment, and it was found that these exercises had positive effects on cognitive functions, sleep quality, and depressive mood (Song & Doris, 2019). Since problems in cognitive function, posture, and muscle strength negatively affect balance skills in elderly individuals, balance-focused exercises are also recommended. Reduced balance ability leads to an increased risk of falls (Akgül et al., 2018). Exercises such as meditation and yoga have been reported to positively affect balance, flexibility, and strength parameters (Youkhana et al., 2016). In another study on elderly individuals, an 8-week yoga program applied twice a week was found to improve balance skills and reduce fall risk (Nick et al., 2016). Thai Chi exercises, originating from East Asian martial arts, have been shown to aid balance development due to their slow and controlled movements (Yıldırım, 2014). Thai Chi exercises applied to elderly individuals with chronic knee pain improved postural alignment and walking function (You et al., 2021). Aging-related deterioration in bones and soft tissues reduces flexibility. Therefore, exercises that maintain and improve flexibility are necessary. For elderly individuals, static flexibility exercises targeting large muscle groups twice a week are recommended (Chodzko-Zajko et al., 2009). In a study on elderly participants, static stretching exercises performed three times per week over four weeks resulted in significant improvements in walking speed and stride length (Cristopoliski et al., 2009). A meta-analysis examining the effects of flexibility exercises in older adults found that flexibility-focused exercises reduce arterial stiffness, lower muscle tension, and improve resting heart rate and

endothelial cell function (Kato et al., 2020). Resistance exercises are another effective method for improving health parameters in elderly individuals. Aging causes reductions in muscle strength and muscle mass, which can lead to sarcopenia, a musculoskeletal disorder. Therefore, resistance-based exercises are recommended. Resistance exercises consist of movements performed against weight or force. Even performing resistance exercises once a week has been shown to benefit muscle strength. It is recommended that resistance exercises for older adults focus on major muscle groups, performed 2–3 times per week with 8–12 repetitions. Resistance exercises can include simple movement patterns using body weight, step climbing, elastic bands, or weightlifting. In a study involving elderly individuals over 80 years of age, resistance exercises using elastic bands and chairs were found to be more effective than stationary cycling in improving muscle strength and balance parameters (Cancele Carral et al., 2017). Moreira et al. (2020) reported that 16-week resistance exercises performed in water reduced fall rates in elderly participants. To achieve a healthy aging process, it is considered beneficial to combine different types of exercises. Accordingly, the following details should be considered when designing exercise programs for older adults:

- Potential risk factors should be identified before planning an exercise program for elderly individuals.
- In older adults with advanced mobility limitations or rheumatic diseases, exercises should be personalized.
- Elderly individuals with diabetes or coronary heart disease may be on regular medication. Exercise programs should be designed considering the effects of these medications.
- Attention should be paid to hydration to prevent dehydration during exercise.
- Warm-up activities before and cool-down/recovery activities after exercise are important.
- Exercises should be performed in appropriate environments. Avoid exercising on hard surfaces or in extremely cold, hot, humid, or poorly ventilated areas. Appropriate clothing and orthopedic footwear are important for health.
- Elderly individuals with balance or similar health issues are recommended to exercise under the supervision of a specialized instructor (Özmen & Contarlı, 2023).

Neurobiological Effects of Exercise On The Brain

When the neurobiological effects of exercise on the brain are examined, it plays an important role in supporting neurotrophic factors, cerebral blood flow, neurogenesis, and synaptic plasticity, as well as in improving mitochondrial function

and reducing oxidative stress (Festa et al., 2023). Among the neurotrophic factors are brain-derived neurotrophic factor (BDNF), insulin-like growth factor 1 (IGF-1), and vascular endothelial growth factor (VEGF). BDNF, a neurotrophic protein in the central nervous system, supports connections between neurons, strengthens synaptic transmission, and promotes the growth and maintenance of neurons, thereby aiding memory, learning, and cognitive functions. BDNF production may decrease with aging, which is considered a contributing factor to neurodegenerative diseases. Another neurotrophic factor, IGF-1, is a key component of cerebrovascular function and glucose metabolism. IGF-1 plays an important role in supporting BDNF production, regulating angiogenesis and synaptogenesis in the brain. Insufficient IGF-1 secretion may lead to cognitive problems. VEGF supports angiogenesis in the brain, promoting neuronal nutrition and survival. A study reported that aerobic exercise increases the production of VEGF, IGF-1, and BDNF proteins, enhancing plasticity and signal communication across different regions of the brain (Voss et al., 2013). Increased cerebral blood flow contributes to the development of cognitive functions such as attention and executive function. Exercise supports increased cerebral blood flow, ensuring better oxygen delivery to brain cells. Mitochondria help meet the energy needs of neurons. Impairments in mitochondrial function may contribute to the onset of neurodegenerative diseases. Regular exercise supports mitochondrial production, playing a crucial role in energy generation in brain cells. Oxidative stress arises from the accumulation of reactive oxygen species (ROS) due to insufficient antioxidant defense mechanisms. Increased oxidative stress is considered a major factor in the development of neurodegenerative diseases. Exercise enhances the activity of antioxidant enzymes, such as superoxide dismutase, helping to reduce oxidative stress.

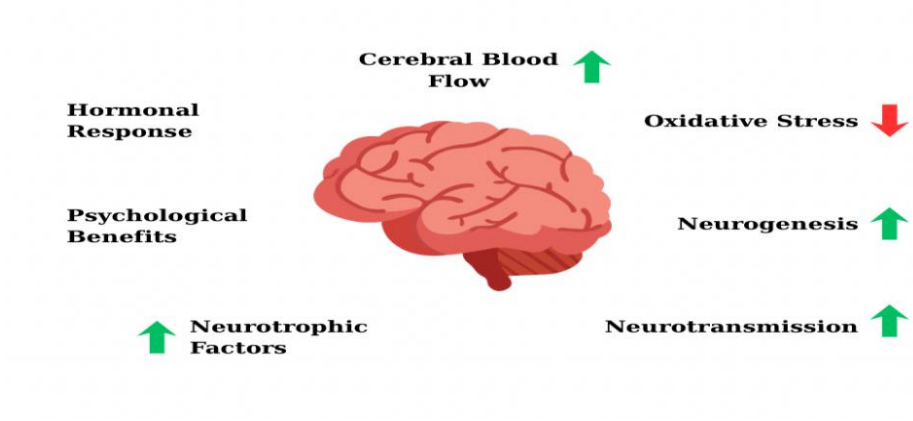

Figure 1: Neurobiological effects of exercise on the brain (De La Rosa et al., 2020).

Alzheımer's Disease And Exercise

Alzheimer's disease, which accounts for 60–80% of dementia cases, is a neurodegenerative disorder resulting from impairments in cognitive functions (Yılmaz, 2025). With the increasing elderly population in Turkey, the prevalence of Alzheimer's disease has also risen. According to data from the Turkish Alzheimer Association, approximately 600,000 individuals are living with this disease. Women are more frequently affected by Alzheimer's disease than men. Elderly individuals are considered the primary risk group for Alzheimer's disease (AD). It has been reported that after the age of 65, the incidence of AD doubles every five years (WHO, 2012). Regarding the pathophysiology of Alzheimer's disease, the accumulation of tau proteins and amyloid-beta plaques between neurons is thought to play a critical role in disease progression (Alıcılar & Çalışkan, 2021). These factors spread across the cerebral cortex, hippocampus, and subcortical regions, leading to neuronal atrophy and loss, which disrupts normal brain function (Amin et al., 2019). The frontal lobe of the brain is involved in cognitive functions such as memory, language, planning, problem-solving, abstract thinking, social engagement, and capacity (Bozkurt & Karadakovan, 2020). Alzheimer's disease disrupts the structure and functioning of these processes. The progression of Alzheimer's disease is classified into mild (early), moderate, and severe (late) stages. The mild stage is often overlooked because early symptoms are subtle and can be mistaken for common age-related issues. Patients in the mild stage may exhibit forgetfulness even shortly after events occur, difficulty in finding words and communicating, problems keeping track of time, impaired decision-making, apathy (reduced hobbies and motivation), getting lost in familiar environments, psychological issues such as depression or anxiety, and occasional anger or aggressive behaviors. In the moderate stage, cognitive deficits (such as apraxia and aphasia) become more pronounced compared to the early stage. Patients may forget events and names more frequently, have longer recall times, and require more assistance in daily activities (meal preparation, shopping, cleaning, personal hygiene). They may experience sleep disturbances, hallucinations, and behavioral changes, such as wandering, calling out, clinging, or repeatedly asking questions. In the severe stage, patients become fully dependent. In addition to the progression of problems observed in earlier stages, they may require assistance while eating, experience bladder and bowel incontinence, have reduced muscle strength and coordination leading to falls, lose spatial orientation within the home, exhibit aggressive behavior, sudden outbursts of anger, agitation (kicking, shouting, hitting, or moaning), and be more susceptible to infections such as pneumonia (Keleş & Özalevli, 2018). Research indicates that exercise, education, and abstaining from smoking and alcohol have protective effects against Alzheimer's disease, whereas diabetes, hypertension, cholesterol disorders, high

blood sugar, blood pressure abnormalities, and nutritional deficiencies are associated with increased risk of the disease (Xu et al., 2015). In addition to nutrition, studies suggest that a diet rich in polyunsaturated fatty acids (omega-3) and antioxidants, such as the Mediterranean diet, may have a protective effect against Alzheimer's disease (Karşıdağ, 2012). Although there is no definitive treatment for Alzheimer's disease, the disease progression can be slowed through pharmacological and non-pharmacological interventions. Due to the side effects of pharmacological treatments, quality of life may be negatively affected. Therefore, non-pharmacological therapies aimed at improving quality of life are also recommended. These interventions include music, art, psychotherapy, and exercise, with exercise being the most preferred non-pharmacological therapy for Alzheimer's disease compared to other methods (Alpat & Ersoy, 2022). Exercise is an effective intervention for preventing or slowing cognitive decline in aging and Alzheimer's disease. Research findings indicate that exercise helps maintain neuronal integrity and mood, preventing psychological disorders and neurological impairments. When designing an exercise program for individuals with Alzheimer's disease, it is essential that the program is practical, simple, realistic, and tailored to the patient's disease stage. To observe the benefits of an exercise program for Alzheimer's patients, it is recommended that it be applied consistently over a period of 12–16 weeks (Rolland et al., 2008). Studies generally report the application of aerobic, resistance (strengthening), flexibility, and balance exercises (Rolland et al., 2008; Volkers et al., 2011). Considering the stages of the disease, exercises and activities recommended for mild to moderate stages include gardening, music-based dance, Tai Chi, swimming, and simple bodyweight exercises. Gardening provides physical activity while also enhancing psychological motivation. If a garden is not available, indoor plants can create a similar environment to increase physical activity. Music-based dance activities can be organized as improvisational pair or group dances using props such as hoops, balls, or balloons. For individuals with limited mobility, seated movements synchronized with rhythm can encourage participation. Music-based dance allows individuals with Alzheimer's disease to express emotions and recall past memories. Group-based activities also help prevent psychological problems associated with Alzheimer's, such as loneliness, anxiety, and depression, while simultaneously improving flexibility and strength parameters (Buchman et al., 2012). Swimming exercises are recommended for patients in the mild and moderate stages of Alzheimer's disease, as they engage all major muscle groups. It is advised that swimming be performed under the supervision of an instructor. The relaxing effects of water during swimming can reduce agitation and stress, enhance self-confidence, and promote a sense of relaxation (Çağın et al., 2023). Tai Chi involves meditation with fundamental movements aimed at improving balance and well-

being. It is reported to promote relaxation and reduce stress. Simple exercise routines, such as squatting/standing, walking, and arm and leg movements, can improve physical parameters. Individuals in the advanced stage of Alzheimer's disease may experience movement limitations due to the destructive effects of the disease. Therefore, exercises recommended for advanced-stage patients should be simpler compared to those for mild or moderate stages. Suggested activities include changing sitting positions and areas, short walks from room to room, and repositioning in bed at intervals (Lök & Lök, 2015). Aerobic exercises help support synaptic plasticity and hippocampal neurogenesis in individuals with Alzheimer's disease. Depending on the patient's disease stage, aerobic-based exercises are recommended at least three times per week for a minimum of 30 minutes to aid the recovery process (Lee et al., 2024). Resistance exercises are among the effective interventions for improving reduced muscle strength and balance parameters associated with Alzheimer's disease. Additionally, they promote the production of neurotrophic factors such as BDNF and IGF-1, supporting synaptic structure in Alzheimer's disease (Baek et al., 2024). Balance- and coordination-based exercises, such as yoga and Pilates, are recommended to reduce the risk of falls in Alzheimer's patients (Barha et al., 2020). High-intensity interval training (HIIT) is another exercise type recommended, as it helps enhance BDNF production and synaptic plasticity in Alzheimer's patients (Nogueira Godinho et al., 2022). HIIT exercises are preferred due to their ability to be performed in a short period at high intensity. Before planning exercise programs for Alzheimer's patients, it is important to consider the disease stage and individual-specific needs. These exercise recommendations can help slow disease progression and reduce care requirements. Studies indicate that resistance- and aerobic-based exercises improve executive functions (working memory, self-control, and reasoning), physical function, and memory in patients with mild (early), moderate, and severe (late) stages of Alzheimer's disease. Both BDNF and blood levels are lower than optimal in Alzheimer's disease. Exercise positively affects BDNF production, making it recommended for individuals with or without Alzheimer's disease. In a study investigating the relationship between BDNF and exercise, BDNF levels measured during exercise were found to be three times higher than those measured at rest in participants performing aerobic exercise (Rasmussen et al., 2009). Litchke et al. (2012) reported that chair yoga exercises performed on 18 individuals with mild, moderate, or severe Alzheimer's disease improved mood and activities of daily living. A meta-analysis of 16 studies with over 160,000 participants found that regular exercise reduced the risk of developing Alzheimer's disease by 45% (Hamer & Chida, 2009). In another study including 716 older adults, sedentary individuals had a 53% higher risk of developing Alzheimer's disease compared to active

individuals (Buchman et al., 2012). Exercising during the mild cognitive impairment stage, considered the initial stage of Alzheimer's disease, can yield positive outcomes. In a study of 100 individuals aged 55–86 with mild cognitive impairment, six months of resistance exercise improved attention, memory, and executive functions. These benefits were reported to persist even one year after the study ended (Singh et al., 2014). Under the "Finland Alzheimer's Disease Exercise" program, 210 Alzheimer's patients participated in a nationwide study where exercises were conducted twice weekly for one year under the supervision of a physiotherapist. The program improved physical function in patients at the mild stage and reduced falls in the advanced-stage group (Öhman et al., 2016). Machado et al. (2017) stated that exercise against Alzheimer's disease is neuroprotective, providing protective effects and positively enhancing brain function.

Parkinson's Disease And Exercise

Parkinson's disease (PD) is a neurodegenerative disorder that causes dysfunctions in the basal ganglia due to the degeneration of dopaminergic neurons in the substantia nigra pars compacta (Bouquiaux et al., 2022). Parkinson's disease is progressive, and the risk of developing it in individuals over 60 years old is approximately 1%, with the risk increasing with age (Mahalakshmi et al., 2020). Although the exact causes are still unknown, it is thought to result from a complex interaction between genetic inheritance and environmental factors. Individuals with Parkinson's disease experience both motor and non-motor symptoms. Motor problems in PD include balance deficits, bradykinesia, impaired gait, tremor, muscle rigidity, and postural instability (Kurt Türkoğlu et al., 2023). While walking, simultaneous tasks (such as speaking or counting backward) lead to decreased walking speed and reduced step length (Yogev-Seligmann et al., 2012). Freezing of gait, characterized by the sensation of the feet being "stuck" to the ground and temporary inability to walk, is also a common symptom of PD. This often occurs during dual-task situations (e.g., walking through narrow spaces or turning) and tasks requiring simple coordination (Giladi et al., 2013). Causes of freezing of gait include visuomotor set-shifting deficits, impaired response inhibition, perceptual disturbances, and disrupted neural integration between gait and posture. Optimal balance is necessary to perform daily physical activities. In Parkinson's patients, the systems responsible for postural balance (vestibular, proprioceptive, and visual channels) may be partially or entirely insufficient (Mehta et al., 2020). Increased rigidity and postural instability can further contribute to balance problems. Reaction times in PD patients are also reduced (Alavi et al., 2021). Non-motor symptoms include depression, fatigue, anxiety, sleep disturbances, constipation, cognitive impairment, dysphagia, apathy, and neuropsychiatric conditions (Mahalakshmi et

al., 2020). Depression and anxiety can emerge years before the formal diagnosis of Parkinson's disease. These symptoms contribute to mobility limitations, negatively affecting patients' quality of life. Due to increased dependence on others for daily activities, Parkinson's disease also imposes a significant financial and caregiving burden on families and caregivers. Treatment of Parkinson's disease includes both pharmacological and non-pharmacological approaches. While pharmacological treatments remain the primary approach, patients often continue to experience balance and gait problems, which frequently lead to falls. Exercise, as a non-pharmacological intervention for Parkinson's patients, is encouraged to slow down or delay the progression of these functional impairments. The American College of Sports Medicine (ACSM) recommends aerobic, resistance, flexibility, and balance-based exercises for individuals with Parkinson's disease. ACSM emphasizes that balance exercises should be initiated before the disease progresses. Such exercise interventions may include Tai Chi, dance, Pilates, and yoga (Van Der Kolk & King, 2013). Exercises like yoga enhance body awareness and provide psychological benefits, including reductions in anxiety, depression, and stress. Studies examining the effects of exercise on Parkinson's patients show variations in duration, intensity, and type of exercise. Research on Tai Chi interventions for Parkinson's patients has reported positive outcomes on postural balance (Liv et al., 2012). In a study involving 30 patients performing home-based exercises (breathing exercises, stretching and relaxation, facial exercises, mobility exercises, and balance training) over two months, improvements in motor performance were observed (Çağlar et al., 2005). Mind–body interventions enhance cognitive function, energy, and concentration, supporting physical recovery and tolerance to potential illnesses. In another study, 21 Parkinson's patients participated in a six-week aquatic exercise program, which resulted in improved motor functions and reduced disability (Carroll et al., 2017). Research on moderate dances, such as tango or waltz, has indicated that dance interventions can enhance quality of life in individuals with Parkinson's disease. These improvements are thought to result from enhanced motor skills and social interaction (Sharma et al., 2015). A study comparing tango and waltz in Parkinson's patients reported that tango yielded greater improvements in six-minute walk test performance and Berg balance scores than waltz (Hackney et al., 2009). Home-based physiotherapy sessions, including stretching, strengthening, balance, and gait training performed for 45–60 minutes, were found to positively affect Berg balance scores in Parkinson's patients (Mehta et al., 2020). In another year-long home-based exercise program focusing on strength, balance, and mobility, 142 Parkinson's patients demonstrated improvements in motor function and quality of life (Ashburn et al., 2007). Home-based exercise is considered suitable for Parkinson's patients due to its simplicity, affordability, and feasibility. Rhythmic

walking with music or a metronome is recommended to improve gait function and prevent freezing of gait. In conclusion, for individuals with Parkinson's disease, selecting and integrating exercise interventions tailored to disease stage is recommended to enhance both cognitive and physical function.

Amyotrophic Lateral Sclerosis (Als) And Exercıse

Amyotrophic Lateral Sclerosis (ALS), one of the rare neurodegenerative diseases worldwide, is a form of muscular paralysis caused by selective loss of both upper and lower motor neurons in the brainstem, corticospinal system, primary motor cortex, and spinal cord (De Almeida et al., 2012). Depending on whether the upper or lower motor neurons are primarily affected, the disease is classified as either spinal onset or bulbar onset based on the presenting symptoms. In spinal onset (observed in 75% of cases), symptoms manifest as decreased muscle strength and atrophy in trunk and/or limb muscles, along with fasciculations and cramps. In bulbar onset (observed in 25% of cases), the lips, tongue, and throat muscles are primarily affected, leading to progressive dysarthria and dysphagia. The initial stage of ALS may provide prognostic information regarding disease progression. Life expectancy is generally shorter in bulbar onset; however, individual factors such as age and respiratory function can influence the course of the disease. Other problems associated with ALS include depression, anxiety, balance issues, respiratory difficulties, and altered reflexes (Tsitkanou et al., 2019). As ALS is a progressive disease, it can lead to disability, and mortality may occur within 2–5 years after diagnosis due to respiratory failure (De Almeida et al., 2012). ALS cases are categorized into sporadic ALS (SALS, 90–95%) and familial ALS (FALS, 5–10%). SALS arises from a combination of genetic and environmental factors, while FALS results from gene mutations (Maugeri & D'Agata, 2020; Huisman et al., 2013). The etymology of ALS derives from "a" (no), "myo" (muscle), "trophic" (nutrition), and "sclerosis" (hardening). Although the exact pathophysiology of motor neuron degeneration in ALS remains unclear, it is thought to involve oxidative stress, glutamate excitotoxicity, neurofibrillary aggregation, protein misfolding/aggregation, axonal transport disruption, dysregulated microRNA expression, satellite cell activity, and mitochondrial dysfunction leading to skeletal muscle impairment (Andreadou et al., 2009). Management of ALS patients is recommended to be conducted by a multidisciplinary team, including psychologists, physicians, physiotherapists, nurses, dietitians, and occupational therapists. Due to the complex nature of the disease, no single treatment is definitive. For respiratory complications, non-pharmacological interventions such as non-invasive ventilation (assisted breathing masks) are recommended, as they can prolong survival (De Almeida et al., 2012). Exercise is considered the primary non-pharmacological

therapeutic approach for neurodegenerative diseases, including ALS. However, the role of exercise as a therapeutic approach in Amyotrophic Lateral Sclerosis (ALS) remains debated in many studies. Some epidemiological research has reported that athletes and professional football players exposed to intense physical activity have a higher risk of developing ALS (Lehman et al., 2008). It is suggested that professional athletes, due to intense training, may trigger glutamate excitotoxicity and oxidative stress, increasing the risk of neuronal degeneration (Maugeri & D'Agata, 2020). Exercise stimulates motor neurons, generating chemical responses such as free radical production, oxidative stress, and glutamate excitation. While these biochemical responses are controllable in healthy individuals, ALS patients may experience neurotoxicity in neuronal cells due to impaired regulatory mechanisms. This inability to regulate biochemical responses in ALS patients is thought to result from dysfunction in the Na^+ and K^+ pumps in axons, which fail to function properly after intense exercise (De Almeida et al., 2012). Some studies, however, suggest that light- to moderate-intensity exercise may have protective effects in ALS. While high-intensity exercise in transgenic SOD1 mouse models has been found to have harmful effects, moderate-intensity exercise appears to be beneficial both in these animal models and in ALS patients (Bello-Haas et al., 2007; Deforges et al., 2009). Another study reported that rats subjected to high-speed running exhibited axonal degeneration, whereas moderate-intensity exercise reduced ALS symptoms (Carreras et al., 2010). Short-term light or moderate-intensity exercise in ALS patients and animal models is suggested to slow disease progression (Tsitkanou et al., 2019). In a study comparing ALS patients who performed aerobic exercise for 16 weeks (one day per week with a physiotherapist, two days at home) with a self-care group, patients in the aerobic exercise group demonstrated improved respiratory function and quality of life compared to the control group (Zucchi et al., 2019). Kalron et al. (2021) examined the effects of a mixed exercise program including aerobic, resistance, and stretching exercises performed twice weekly on ALS Functional Rating Scale-Revised (ALSFRS-R) scores, mobility, respiratory function, quality of life, and fatigue levels. Significant improvements were observed in the mixed exercise group compared to the group performing only stretching exercises. Preclinical studies suggest swimming as one of the most beneficial exercise methods for ALS patients. Exercise selection for ALS patients should be performed carefully and under supervision to prevent issues such as sprains, falls, and other complications (Desseille et al., 2017). Before creating an exercise program for a patient, factors such as ongoing medication, age, disease stage, and cardiopulmonary status should be carefully considered.

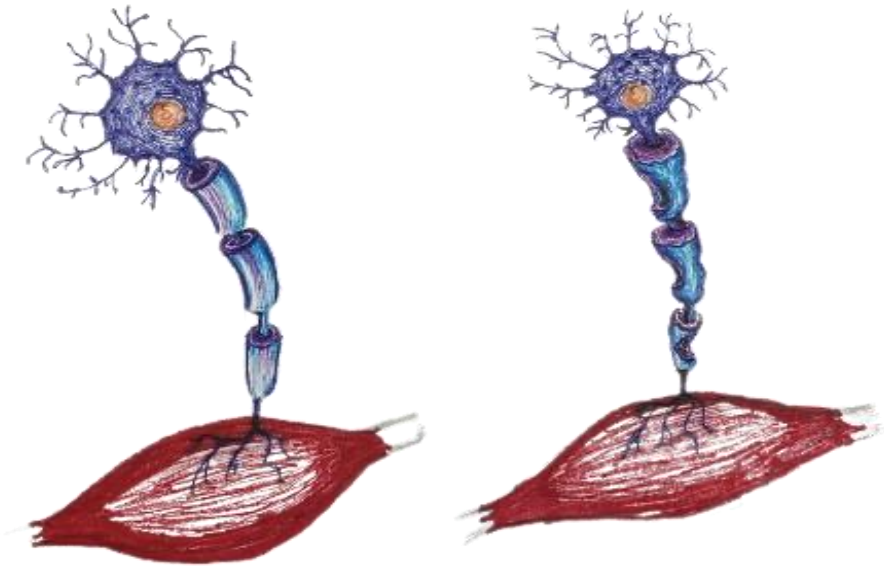

Figure 2: Normal Nerve Cell and Sclerotic Nerve Cell (Muriqi, 2023).

Huntington's Disease And Exercise

Huntington's disease (HD), a neurodegenerative disorder, is characterized by an elongated polyglutamine sequence resulting from increased CAG trinucleotide repeats (cytosine, guanine, and adenine) in the Huntingtin (HTT) gene located on chromosome 4p16, leading to psychiatric, choreic, and cognitive impairments (Ajitkumar & De Jesus, 2023). While the optimal CAG length can range from 6 to 26, in Huntington's disease it is associated with 39 or more repeats (McColgan & Tabrizi, 2018). Genetic testing can identify CAG status before symptom onset. The HTT protein is widely expressed in structures such as the heart, brain, skeletal muscles, liver, and kidneys, and mutations in this gene cause dysfunction in these structures. As a result, cardiomyopathy, reduced muscle strength, cognitive impairments, abnormal fat distribution, decreased optimal body weight, and impaired glucose homeostasis occur (Busse et al., 2008). Additionally, this disease causes dystonia (affecting facial muscles), dysphagia (swallowing difficulties), and dysphasia (language and speech impairments) (Ross et al., 2014). Beyond physical effects, Huntington's disease can also have devastating impacts on psychological health, including depression, psychosis, obsessive-compulsive disorder, and anxiety. The most commonly observed type is choreic Huntington's disease. In choreic HD, involuntary abnormal movements, rigidity, and irregular short muscle contractions characterize the disease (Gibson & Claassen, 2021). Typically, the onset of Huntington's disease occurs around 40 years of age and results in mortality within 15–20 years (Andhale & Shrivastava, 2022). Compared to healthy peers, individuals

with HD exhibit low body weight, gait, and balance impairments, which negatively affect quality of life and cause dependency in daily physical activities (Trovato et al., 2022). While pharmacological treatments focus on reducing symptoms, no treatment is fully effective in mitigating physical (chorea, etc.) and psychiatric (depression and anxiety) problems (Playle et al., 2019). Research involving both humans and animal models of Huntington's disease has shown that exercise can slow disease progression, improve motor functions, and positively affect quality of life (Zinzi et al., 2007). Therefore, exercise therapy is recommended alongside pharmacological treatment. In neurodegenerative diseases such as Huntington's, physical activity is suggested to improve cardiovascular health, gait ability, and postural control (Bohlen et al., 2013). An 8-week home-based exercise program for 25 mild to moderate HD patients (3 times per week, progressive walking program) significantly improved balance skills, gait variability, and walking speed, as measured by the Berg Balance Scale (Khalil et al., 2013). Bartlett et al. (2020) applied a 9-month program including aerobic and resistance exercises twice a week and dual-task training once a week to 18 HD patients. Compared to the control group, the intervention group showed significantly reduced right hypothalamic gray matter loss and preserved neurotrophic levels. In another study, a 12-week program of cycling (30 minutes at 65–85% age-predicted maximum heart rate) and resistance exercises (chair stands, seated wood chops, chair lunges, plank: 2×10–12 repetitions) improved motor skills and VO_2 max levels, measured by the Unified Huntington's Disease Rating Scale (UHDRS) (Quinn et al., 2016). In a study of 40 HD patients, various exercises, aerobic-based cognitive rehabilitation, and therapies (speech, occupational, and physical therapy) helped maintain motor parameters and functions in patients at mild and moderate stages (Zinzi et al., 2007). Aerobic, resistance, flexibility, balance, and high-intensity interval training (HIIT) exercises are among the recommended exercise types for neurodegenerative diseases such as Huntington's. Frese et al. (2017) demonstrated that HIIT, aerobic, and endurance exercises are feasible for HD patients. A 26-week program (first 10 weeks: 30 minutes cycling at 65% intensity; second stage 8 weeks: HIIT 4×4 minutes at 90–95% max heart rate, 3 times per week; final 6 weeks: endurance exercise 3 times per week) resulted in increased VO_2 max, stable UHDRS motor scores, and benefits for patients. Another study using the same protocol showed improvements in citrate synthase, fatty acid oxidative capacity, and complex III+V activity (Mueller et al., 2017).

Conclusion

General problems that emerge during the aging process can become chronic and lay the groundwork for neurodegenerative diseases. A sedentary lifestyle can be a significant contributing factor to the development of these problems. Exercise therapy in neurodegenerative diseases (Alzheimer's, Parkinson's, Amyotrophic Lateral Sclerosis, and Huntington's) has been shown in the literature to provide improvements in symptoms, slow disease progression, offer protective effects, and enhance quality of life. Neurodegenerative diseases pose psychological challenges both for the affected individuals and their caregivers. Since exercise therapy can improve the patient's quality of life, it can also alleviate the burden on caregivers. Older adults are considered a high-risk group for these diseases, and the risk increases with a sedentary lifestyle. Literature reviews on neurodegenerative diseases indicate that the effects of exercise can be exemplified under relevant headings. It should be noted that exercise interventions, as non-pharmacological treatments, may vary depending on the type and stage of the disease, the patient's age, and individual differences. When planning exercise programs for these patients, it is recommended to collaborate with multidisciplinary specialists and ensure that the interventions do not adversely affect the patient's health.

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Chapter 8

Ibn Sina's Perspective on Exercise: A Contemporary Discussion of an Age-Old Concept

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Abstract

The aim of this study is to examine the approaches of the great Turkish scholar Ibn Sina, who laid the foundations for many essential principles and observations regarding exercise, while drawing attention to the historical depth of exercise as one of the most significant components of modern life. Many of the principles that contemporary training science and exercise physiology present as modern scientific concepts can in fact be found in Ibn Sina's writings centuries ago, forming the basis of current theoretical frameworks. Known as the "Great Master," Ibn Sina became renowned for his seminal work Al-Qanun fi al-Tibb (The Canon of Medicine), which remained the primary medical reference in various European universities until the mid-17th century. His work known in the West as that of Avicenna consists of five books. The third book includes the topic of pulse, describing pulse characteristics and discussing the effects of exercise, seasonal changes, and internal factors. In the section on the preservation of health, Ibn Sina elaborates on exercise, its types, timing, limits, massage, sleep and wakefulness, exercise-induced fatigue, physiological effects of exercise, and the regulation of imbalanced temperament issues that form the foundation of physical education and sport today. His emphasis on rationality, medical practice, physical education, and movement-based therapeutic methods demonstrates that the fundamentals of exercise science were laid many centuries ago. In conclusion, the findings of this study show that principles widely used today such as exercise type, intensity, repetitions, and targeted physical adaptations were systematically described by Ibn Sina centuries before modern theories emerged. He even distinguished between aerobic and anaerobic exercise and specified their physiological conditions. Ibn Sina also defined strength and flexibility

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exercises, and remarkably, anticipated modern understandings of muscle damage and recovery following high-intensity activity.

Introduction

Ibn Sina was born in 980 in the village of Afshana near Bukhara (present-day Uzbekistan) and died in 1037 in Hamadan (Iran). He authored approximately 200 works across various fields, with a particular emphasis on medicine and philosophy. Acknowledged in the West as the founder of modern medieval science and the leading physician of his era, Ibn Sina was also known by the title "The Great Master." His most famous work, Al-Qanun fi al-Tibb (The Canon of Medicine), served as a central medical text for over seven centuries and remained the primary reference in many European universities until the mid-17th century. Al-Qanun fi al-Tibb (Latin: Canon medicinae) is a 14-volume encyclopedia of medicine, completed in 1025 and originally written in Arabic.

Regarded for centuries as the most prestigious medical text among Turkish, Islamic, and Western scholars, The Canon was translated into Latin by Gerard of Cremona at the end of the 12th century, thereby popularizing Ibn Sina as "Avicenna." Later, François and Antuan prepared a condensed version for instructional use at the University of Padua. On September 8, 1309, Pope Clement V restructured university curricula and established chairs dedicated to teaching various sections of The Canon of Medicine. From the 13th to the 17th century, Ibn Sina's works continued to be translated into Latin and were taught widely across European universities.

The Canon consists of five books. The first volume, titled Kulliyat (General Principles), includes a section on pulse within its third chapter, addressing the influence of sleep, nutrition, exercise, seasons, and internal factors. In the subsection on the preservation of health, the Canon discusses nutrition, types of exercise, intensity, rest intervals, massage, sleep and wakefulness, exercise-induced fatigue, and the regulation of temperament subjects that today form the core of exercise science and physical education (Ercan & Örsçelik, 2022). The second book focuses on herbal medicine; the third discusses diseases of specific organs; the fourth covers systemic and general diseases; and the fifth addresses pharmacology and compound remedies. In addition to being a masterpiece of medicine, Ibn Sina's Canon also stands as one of the earliest systematic defenses of physical education and exercise.

Exercise Theory In The Canon of Medicine

Physical Activity and Exercise

In Al-Qanun fi al-Tibb, Ibn Sina identifies three fundamental principles for maintaining health: exercise, diet, and sleep. He emphasizes that regular exercise supports temperament and humoral balance, thereby playing a protective role against disease.

Effects of Exercise

According to Ibn Sina, exercise stimulates the body's natural heat, producing a mild increase in internal temperature that results in a feeling of lightness and prevents the accumulation of toxic wastes by:

a) dispersing excess substances,

b) mobilizing unnecessary matter within excretory pathways, and

c) facilitating the outward movement of waste products.

Exercise strengthens muscles and joints, accelerates nutrient absorption, increases resilience to disease, and enhances general physiological function. Physical inactivity, on the other hand, can signal early signs of disease such as tuberculosis, as stagnant natural forces fail to reach their target organs.

Types of Exercise

Ibn Sina categorizes exercise into two main types:

1. **Accidental Exercise:** Unintentional physical activity arising naturally from daily tasks.
2. **Intentional Exercise:** Purposefully structured exercise intended for physical benefit.

Intentional exercise varies by duration, intensity, and form and may be classified as long or short, vigorous or moderate, slow or fast, or mixed in structure. Moderate exercise is emphasized as the most beneficial.

Forms of Exercise

Vigorous Exercises:

Wrestling, strength trials, boxing, running, fast walking, archery, javelin throwing, single-leg hopping, sword play, and mounted fencing. Additionally, repetitive arm lifts, trunk extensions, and similar dynamic movements are included.

Moderate Exercises:

Gentle rocking while seated, standing or lying transitions, walking, light ambulation, horseback or elephant riding, and carriage travel.

Strenuous Exercises:

These include running specific distances and returning, shadow fighting with a sword or spear, jumping, fencing, ball games, lifting weights, leaping with a horse, and restraining a horse at full speed.

Wrestling and Strength Trials:

These involve various forms of grappling, joint manipulation, takedowns, headbutting, and forced displacement using tactics similar to those seen in modern wrestling.

Fast Exercises:

Quick directional changes, leapfrogging movements, switching positions between two fixed points without altering orientation, forward–backward shifts, and paired reactive drills.

Specialized Exercises for Each Organ

Apart from the hands and feet, which exercise themselves naturally, there are specific forms of exercise designated for different parts of the body. The chest and respiratory organs are trained by shouting in high-pitched and deep tones. This expands the chest and improves the complexion, facial color, and skin. Another exercise for the chest and respiratory system consists of taking a long, deep inhalation followed by slow exhalation. This movement activates the entire body and clears the respiratory passages. However, loud and prolonged shouting that involves excessive inhalation or forced exhalation can be dangerous. Therefore, in chest exercises, the voice must initially be soft and gentle, gradually rising to a higher pitch, which should then be maintained at a moderate level for a reasonable duration. Once the exercise is regulated in this manner, it yields maximum benefit. If, however, the high tone is sustained for too long, even healthy individuals may suffer harm.

Every individual requires an exercise appropriate to their condition. For example, gentle rocking movements are most suitable for those weakened by fever, unable to sit or stand, incapable of walking or moving, or debilitated by purgatives such as turpentine, as well as for those suffering from diaphragmatic inflammation. Mild rocking induces sleep and alleviates gas. It is beneficial against the effects of cerebral impairment such as memory loss and

absentmindedness. It also increases appetite; rocking on a firm wooden board is useful in semitertian and complex fevers, as well as in ascites, gout, and kidney ailments because it helps eliminate and expel harmful matter. The intensity of rocking soft or vigorous should be adjusted based on whether the accumulated pathogenic matter is hard or soft. Riding in a vehicle has similar effects to rocking. Aside from unnecessary jarring of the body, rocking produces no harmful consequences. Riding a horse while facing backward is beneficial for weak eyes and impaired vision.

Voyaging by ship or sailing along the coast in small or large vessels stimulates the mind by arousing the senses through mixed odors.

Exercises targeting the nervous system generally support the overall exercise of the body. Therefore, all exercise benefits digestion. One exercise intended to improve eyesight consists of focusing intently on very small objects for a brief period. An auditory exercise involves listening carefully to low-pitched sounds; another consists of occasionally listening to very loud sounds.

Necessary Instructions

Weak organs should be protected from strenuous exercise; however, they do not suffer harm if they engage in mild activity along with other organs. Therefore, individuals with varicose veins must avoid excessive movement of the legs. Their activity should be restricted, and exercise should predominantly involve the upper parts of the body, such as the head, neck, and hands. Leg exercises should remain secondary in comparison. Exercise must be mild for those with a weak constitution, while vigorous exercise is recommended for those who are strong. It must be remembered that every organ of the body has its own specific exercise.

Timing and Limits of Exercise

Exercise should be performed under the following conditions:

- When the body is clean and free from immature or excessive humors circulating in the blood vessels,
- When the previous day's food has already been digested in the stomach, liver, and blood, and it is nearly time for the next meal.

The state of digestion may be inferred from the urine its color, consistency, and maturity. If too much time has passed since the last meal and the urine, instead of being normal yellow, turns bright red, exercise will weaken the body and become harmful. If vigorous exercise cannot be avoided under such circumstances, the stomach should be completely empty or contain only a small amount of food.

Exercise on an empty stomach is preferable to exercising while full. Likewise, warm and humid conditions are more favorable for exercise than cold and dry ones. The ideal time for exercise is when the body is in balance. In spring, exercise is best taken around noon in a moderately warm room; in summer, unless conditions dictate otherwise, late afternoon exercise is preferable. During winter, it should be performed earlier in a well-heated room. Generally, the ideal circumstances for exercise occur when digestion is complete and the bowels have moved, and the exercise should be performed in a warm environment.

Amount of Exercise

Exercise should continue until the complexion changes, the hands and feet become free and agile, and swelling of the organs persists. Once these signs begin to fade and perspiration replaces vaporous exhalation, running or strenuous exercise should cease. This rule is especially important for exercises that involve repeated breath-holding. Once a dietary and exercise regimen is established, it must be followed strictly and changes should be avoided as much as possible.

Fatigue Resulting from Exercise

There are three types of fatigue, although a fourth has also been described: pain, stiffness, swelling, and dryness.

Pain (Istirāp): Felt beneath the skin like a wound, accompanied by discomfort on touch or movement. A pricking sensation, as if from needles, is common, caused by muscular exhaustion. Individuals suffering from this type of fatigue should avoid all strenuous movement, including stretching, and instead engage only in gentle activity. It results from the breakdown of muscle and fat tissues during severe exercise, producing an excess of thin, active harmful substances. These substances are partially corrupted and cause pain when they migrate toward the skin.

Stiffness: Experienced as soreness accompanied by a sensation of heat and tension. It arises from excessive exercise and results in disinclination for further movement, even if the limbs can be extended normally. Stiffness arises from stagnation of superfluous harmful matter in the muscles, although these substances do not typically cause tension. Sleep often follows this condition; if it persists afterward, other underlying causes should be considered. Stiffness accompanied by tension in the muscles is more severe.

Swelling: Identified by abnormal redness, warmth, and enlargement in the affected area. Movement becomes difficult, and the affected region is painful to the touch and tense.

Dryness: This form of fatigue occurs when the body becomes dry. Sometimes it results from invigorating massage and intense exercise even if no pre-existing humoral imbalance is present. The causes of fatigue are ordinary exercise and spontaneous exhaustion. The former is usually not severe and has a specific treatment; the latter often signals the onset of disease and requires expulsion of corrupted matter according to its nature. These different forms of fatigue may overlap. The general rule is that one must prioritize the most serious symptoms first. This principle applies when determining whether the condition is improving, deteriorating, or worsening.

When fatigue involves two or three factors simultaneously, it becomes more serious and requires urgent treatment. If only one factor predominates, it should be treated individually (Sarıalp, 1990; Ibn Sina, 1995).

Conclusion

Ibn Sina defines exercise as a means of increasing the body's innate heat and facilitating the elimination of toxins. In doing so, he emphasizes that exercise not only enhances muscular strength but also plays a crucial role in preserving the health of internal organs and contributes significantly to psychological well-being. He classifies the objectives of exercise under three main headings: preservation of health (hifz al-sihhah), prevention of disease, and psychological support.

Ibn Sina's conceptualization of exercise parallels contemporary holistic approaches to healthy living incorporating regular physical activity, mental and emotional balance, and overall well-being. These propositions must be understood as early expressions of modern concepts. The most striking finding from the analysis of Ibn Sina's works is that, centuries before modern medicine, he articulated principles of exercise, rest, and nutrition that closely resemble current preventive health recommendations.

In summary, Ibn Sina recognizes exercise not merely as a means of physical improvement, but as a pathway to mental and spiritual well-being. His perspective can be seen as a foundational precursor to modern concepts such as physical fitness and wellness.

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Chapter 9

Talent Identification in Sports and Psychosocial Determinants

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The Concept of Talent In Sports

The concept of talent is a complex term that does not convey meaning on its own. There are numerous ways to determine whether an individual possesses talent in a particular domain. Talent may be hereditary and transmitted genetically through family lineage, yet it can also be shaped by environmental conditions. For instance, if an individual comes from a family engaged in sports, has achieved athletic success, or participates successfully in multiple sport disciplines, this may indicate a hereditary predisposition for talent. Likewise, being surrounded by athletes, having access to appropriate training facilities and equipment are considered environmental factors. Even monozygotic twins who are genetically identical but raised in different environments may demonstrate differences in talent (Kozel, 1996).

Talent has been defined in many ways. One definition conceptualizes talent as a power that exists innately. Another refers to talent as a natural ability to learn or perform something competently (Özal, 2003). From the perspective of sport science, talent is the set of superior yet underdeveloped characteristics inherent in an individual. Those who possess such qualities are regarded as talented in that field (Röthing, 1972). Sport science differs from other fields in that it examines talent by considering variables such as social environment, psychological state, environmental conditions, and family background (Muratlı, 1997).

Sport talent may be viewed as a set of qualities that develops quantitatively and qualitatively depending on environmental conditions but may also diminish in the absence of such factors (Muratlı et al., 2005). Coaches through their values and behaviors play a crucial role in influencing young athletes' choice of sport and thus serve as key figures in the talent identification process (Fraser, Thomas & Côté,

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2009; Newin, Bloom & Loughead, 2008; Smith & Smoll, 2002). Young athletes' satisfaction with sport participation and their continued desire to engage in training are largely shaped by the influence of their coaches (Fraser et al., 2005; Smoll, Smith, Barnett & Everett, 1993; Weiss & Williams, 2004).

The fundamental aim of talent identification is to maximize an athlete's genetically endowed potential in a specific sport through structured and systematic training (Epstein, 2014). Talent in youth is still considered an evolving process; for this reason, once talent is identified, appropriate guidance and training is expected to enhance performance (Bayar, 1993).

Talent Identification And Its Importance

One of the most significant advantages of modern sports systems is the ability to enable talented individuals to enter structured training programs in a sport in which they are both interested and naturally gifted. Although all children can run, dance, and draw, only a small proportion will reach advanced skill levels in these areas. Therefore, identifying talented children and engaging them in appropriate sports at early ages is crucial (Bompa, 2009).

International success in sports requires discovering and developing talented athletes. For this reason, in addition to coordinated and systematic training, athletes must be matched with the most suitable sport discipline (Demiral et al., 2006). Early identification of athletes' predispositions and directing them toward appropriate sport branches is one of the primary factors contributing to high-level performance. Talent requirements differ from one sport to another, as each discipline demands its own set of abilities. Thus, coaches play a critical role in ensuring the correct match between the athlete's abilities and the sport chosen.

Achieving elite performance requires early sport specialization. Directing children and adolescents toward the sport in which they can perform most efficiently at the appropriate time is a primary objective of sport science (Tutkun, 2002). Countries that recognize the importance of athletic prestige have invested heavily in early talent development and have reaped international success as a result. One of the key factors in their success lies in the implementation of early talent identification programs, infrastructure investments, and the provision of suitable facilities and equipment according to sport requirements (Açıkada & Ergen, 1990).

A core objective of talent selection is to enable athletes to reach maximal performance levels by utilizing their inherited genetic capacity (Epstein, 2013). From a biological standpoint, factors such as race, genetic background, sex, intelligence, anatomical structure, and psychological health play a decisive role in determining sport-specific talent (Epstein, 2013).

Early identification and systematic long-term planning during the earliest stages of sport participation are therefore essential to ensure that athletes develop and succeed in an appropriate sport.

Stages of Talent Identification And Development

Talent identification in sport involves coach observation, talent screening, coaching decisions, and ongoing athlete development. Talent screening, an essential component of talent selection, consists of five major stages that must be implemented effectively:

1-Identification
2-Verification
3-Development
4-Perfection
5-Management (Sevim, 2015).

Characteristics And Identification of Talented Athletes

Barraclough et al. (2022) highlighted several important considerations regarding limitations in defining talent and the methods used at the selection stage. They emphasized that most talent assessments rely on cross-sectional data, which does not account for the nonlinear and dynamic process of growth and development in children and adolescents. Since growth rates differ among individuals, researchers have proposed longitudinal assessments rather than cross-sectional ones.

Pre-season talent selection often focuses on physical and anthropometric characteristics due to the simplicity of measurement (Çağın et al., 2023). The research team recommends a multidisciplinary approach for holistic assessment, taking into account both strengths and weaknesses (Barraclough et al., 2022). While talent identification and development are important in fields such as music and art, the concept is more heavily institutionalized in sports (Baker & Schorer, 2010).

Differentiating more talented athletes from less talented ones during development has made talent identification a central concern (Muratlı, 2003). Talented athletes typically exhibit the following features:

- Demonstrate superior performance in training
- Adapt more quickly to coaching cues and provide immediate feedback
- Learn motor skills faster than less talented athletes
- Complete training programs more efficiently
- Are more willing to take risks
- Recover better from failure and use setbacks as motivation
- Make more realistic and accurate assessments during competition

- Show continuous performance improvement and high levels of sport commitment

Talent identification varies by sport. In many disciplines, long-term training decisions are not based solely on motivation or effort but also on the cumulative motor skills acquired throughout earlier training (Lee, 1993; Çağın et al., 2024).

Criteria Used In Talent Identification

Talent identification and guidance in individuals is a valid practice for those who aim to achieve high performance outcomes in sport. For individuals who do not seek high athletic performance and only participate in sports for recreational or exercise purposes, talent selection is not necessary. In talent identification and placement, both the biological and psychological attributes of athletes are of significant importance. Each sport branch requires different prerequisites for talent selection. Therefore, directing an individual toward talent identification implies an orientation toward high-performance sport (Muratlı, 1997).

Possessing a natural talent or skill from birth is not sufficient in all circumstances. For instance, if an individual has biological limitations, even intensive training and appropriate content may not be enough to compensate for these limitations despite having natural talent. Thus, scientific evaluation is essential for achieving maximal athletic efficiency. Some of the factors influencing talent identification and orientation are listed below:

- Technomotor characteristics
- Social factors
- Emotional factors
- Psychological factors
- Physical factors
- Cognitive characteristics
- Readiness level
- Ability to learn tasks
- Motor characteristics
- Health status
- Anthropometric characteristics

Health

Health is a critical factor for all individuals participating in training. Therefore, individuals should undergo medical examinations before initiating a sport, and based on the results, they should either be cleared for sport participation or redirected if contraindications exist. Athletes with no health-related restrictions should be

selected by coaches. Since functional capacity is a criterion in determining suitability for dynamic versus static sports, it must be closely considered (Bompa, 2009).

Biometric Characteristics

Biometric or anthropometric characteristics provide a considerable advantage in certain sports and are therefore regarded as one of the most productive criteria for talent identification. Variables such as height, weight, and segment lengths (e.g., limbs or muscle groups) may be advantageous depending on the sport. Assessing growth and development in children aged 4–6 particularly in sports such as gymnastics and swimming presents challenges in the early stages of talent identification. Thus, during initial screening, coaches and instructors must evaluate whether the athlete's physical development aligns with the sport's demands. Proportions such as leg joint alignment, shoulder-to-hip ratio, and segment symmetry are often used as indicators. At later stages, wrist and hand radiography may be used to assess skeletal maturity and growth completion (Bompa, 2009).

Heredity

Although children may alter their characteristics through training and social interaction, they still inherit biological and psychological traits from their families. Heredity plays a significant role in determining training efficiency and athletic potential.

Muscle Fiber Distribution

An athlete's muscle fiber composition provides insight into which sport disciplines they may perform more efficiently in. The distribution of red (slow-twitch) and white (fast-twitch) muscle fibers is genetically inherited. The metabolic functions of these fiber types differ considerably: red muscle fibers possess superior biochemical properties for aerobic endurance activities, whereas white fibers are more suitable for short, high-intensity anaerobic efforts due to their higher carbohydrate content. While the proportion of fiber types cannot be altered, specific training can enhance the functional efficiency of these fibers. Therefore, determining whether an athlete predominantly possesses red or white muscle fibers can help identify potential success in particular sport disciplines (Bompa, 2009).

Sport Environment and Seasonal Factors

The athlete's living environment, climate, and seasonal conditions can restrict sport specialization. For example, if a region lacks proper facilities or sufficient equipment for basketball or volleyball, the athlete may need to be directed to another sport. In some cases, even if the athlete possesses high talent in a particular sport, it

may be more beneficial to guide them toward a different discipline with better facility conditions, adequate equipment, and structured development opportunities.

Stages of Talent Identification

Research suggests that the stages of talent identification do not vary significantly between models. In many sources, talent identification is divided into three main phases (Aydos et al., 2010).

First Stage of Talent Identification:

This stage generally involves children between the ages of 3 and 10, prior to puberty (Bompa, 2009). It is often referred to as pre-selection. The primary goal is to reach a large number of children and repeatedly administer screening tests. Initial selection focuses on general sport readiness and performance potential. In this stage, the repeated administration and evaluation of tests is crucial. The parameters used primarily assess the child's predisposition to various sport branches (Aydos et al., 2010).

Three major considerations at this stage include:

1. Determining whether the child has any constraints preventing participation in sport
2. Interpreting the child's physical development through measurement
3. Identifying hereditary traits that may influence potential athletic success

Since predictive accuracy is limited during early childhood, definitive evaluations should be avoided. However, in sports such as swimming and gymnastics, early identification followed by structured training planning is necessary (Muratlı, 2003).

Second Stage of Talent Identification

This is considered the most critical stage of the process and applies to children who have already participated in structured training (Dragan, 1978). At this stage, because the athlete's body has already adapted to a particular sport, assessments must include technical, tactical, biometric, and functional factors.

Health screening is essential to prevent performance-limiting issues in the selected sport. Research shows that high-intensity strength training during childhood can negatively affect growth by compressing cartilage tissues. Thus, hereditary deficiencies and anatomical or functional impairments play a major role in talent determination. In addition to physical evaluations, psychological testing should be conducted to assess whether the athlete possesses the mental characteristics required for the sport (Aydos et al., 2010).

Third Stage of Talent Identification

The final stage generally concerns athletes who are candidates for national teams. This stage must be fully objective and directly aligned with the performance demands of the sport. Athlete evaluations should include variables such as:

- Health status
- Attitude toward competition
- Attitude toward the coach
- Attitude toward training
- Ability to cope with stress
- Response to environmental factors

These observations should be documented and analyzed (Aydos et al., 2010).

Early Identification of Sport Talent

Talent identification in children often begins in physical education classes and sport clubs, where teachers and coaches observe, detect, and guide young athletes.

Key considerations include:

- Identifying children's existing abilities through standardized tests and directing them into appropriate sport branches while monitoring development through regular training
- Paying attention to genetic predispositions that may influence high performance
- Detecting potential during inter-school competitions
- Systematically screening and selecting children based on relevant test outcomes
- Recognizing that biological maturation varies among children of the same age and therefore sport performance should not be evaluated solely based on chronological age
- Utilizing critical test points in specialized competitions for talent detection
- Implementing a two-phase selection process, where general athletic ability is first evaluated and then children are assigned to appropriate sport branches based on their capacity for development and test results

The Concept Of Talent In Coaching

Each sport discipline requires specialized coaches who must be capable of analyzing and monitoring the physiological and psychological conditions of athletes. For example, an adolescent athlete may grow approximately 5 cm per year, which alters anthropometric proportions. Therefore, coaches must regularly conduct anthropometric assessments (Bayli et al., 2005).

Using accurate measurements enables coaches to prescribe optimal training loads. Appropriate loading leads to progressive performance development consistent with

training objectives (Bayli et al., 2005). Excessive loading, however, can negatively affect athletes physically and psychologically. Coaches must therefore be competent in regulating training and recovery intervals through individualized programming (Bompa, 2000). A coach's expertise in their sport can also help minimize injury risk and promote positive outcomes in adverse conditions (Maughan, 2009).

Factors influencing an athlete's ability to train at an optimal level include:

- Adequate time
- Proper training equipment
- Available energy resources
- Appropriate sport selection based on talent
- A qualified and talented coach (Ericsson, 1993).

Psychosocial Determinants In Sport

The term psychosocial refers to the dynamic interplay between psychological and sociological influences (IASC, 2007). Therefore, psychosocial support does not focus solely on psychological disorders; rather, it aims to strengthen and empower individuals affected by adverse circumstances through continued engagement in training and structured activities (Kızılay, 2008).

Psychosocial support requires a multidisciplinary approach grounded in psychology and sociology. Such support has been found to contribute positively even to medical recovery processes (Hyun et al., 2016). Psychosocial interventions are a key component of treatment for individuals with health problems (Alagraa et al., 2015). These interventions also strengthen individuals facing life-threatening or high-stress conditions and are particularly important for children and adolescents exposed to challenging environments (Varela et al., 2013). The same principle applies to sports, where psychosocial support enables athletes to manage stress effectively.

Understanding an athlete's psychosocial needs is a critical component of success. Providing psychological and mental support is one method for helping athletes cope with the challenges they face. Although many coaches are knowledgeable about post-injury rehabilitation and return-to-sport processes (Podlog & Dionigi, 2010), they are not experts in psychosocial counseling. Therefore, referring athletes to psychosocial support professionals is often more effective.

Despite advancements in technical, tactical, and physical performance achieved through regular training, athletes also require psychological and social development. Therefore, coaches and sport organizations should ensure that athletes receive appropriate psychosocial support, whether sport-related or not, according to their developmental needs and life circumstances.

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Chapter 10

The Importance Of Physical Education Classes for Generation Alpha and Factors Inhibiting Class Participation

Batuhan BATU[1], Gönül TEKKURŞUN DEMİR[2]

Introduction

Generation Alpha, often described as the first cohort born entirely in the 21st century, includes children born after 2010. This generation is distinctly different from previous generations because they grew up surrounded by digital technologies from the moment they were born, their habits of accessing information quickly, and their strong connection to social media (Voroncova & Raikina, 2023; Ziatdinov & Cilliers, 2022). Generation Alpha children are defined as individuals who are curious, have strong individual orientations, use technology intensively, are emotionally sensitive, and develop different forms of interaction in peer relationships (Cırık & Aksoy, 2023).

The intense relationship with the digital world is one of the most striking aspects of Generation Alpha. One study compared the perspectives of teachers and students on digital education and found that Generation Alpha quickly adapted to the use of technology (Eren et al., 2023). However, social media and online interaction also bring risks such as peer bullying, threats and psychological pressure to this generation (Yılmaz, Aktürk & Yıldırım, 2023). According to the research of Yılmaz and Aktürk (2023), some of the Generation Alpha students do not see school as "necessary", but the majority prefer to continue school even if it is not a necessity. This shows that school is important not only as an academic but also as a social environment. On the other hand, it has been determined that students of the same generation allocate more limited time to homework and extracurricular learning activities. In a study comparing the Generation Alpha children in the preschool period, the observations of teachers and mothers revealed that the Generation Alpha children showed higher self-confidence and mobility, but they needed support in some social-emotional characteristics (Göçmen, 2024).

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The characteristics of this period are of particular importance for physical education classes. Factors such as Generation Alpha's tendency toward digital activities, sensitivity in peer relationships, and self-confidence and body image can directly impact class participation. Therefore, understanding the characteristics of Generation Alpha students becomes a critical requirement to maximize both the physical and psychosocial contributions of physical education classes.

Significance of the Topic

It is known that adequate physical activity during childhood is critical for healthy development. According to the World Health Organization (2020) report, “81% of adolescents aged 11–17 do not meet the recommended daily level of 60 minutes of moderate-to-vigorous physical activity” (p. 15). This finding shows that a sedentary lifestyle has become a serious problem on a global scale. A similar picture prevails in Turkey. According to the results of the Turkey Childhood Obesity Survey (2022), "the obesity rate in primary school-aged children is 9.9%, and the overweight rate is 14.6%" (Republic of Turkey Ministry of Health, 2022, p. 27). These rates highlight the importance of children's need for regular physical activity.

Physical education classes are a fundamental learning area that supports not only the physical but also the psychosocial development of children. Bailey (2006) expresses this situation as follows: “Physical education provides unique opportunities for children to develop their motor skills as well as self-confidence, social interaction and lifelong healthy habits.” The importance of this course becomes even more significant, especially considering the Alpha Generation's short attention span, dependence on digital tools, and differing dynamics in social relationships. Studies on Generation Alpha also emphasize that this generation has different needs and expectations than previous generations (Demir, 2022). McCrindle and Fell (2020) define Generation Alpha as “natural users of artificial intelligence and technology, beyond digital natives” and underline their need for differentiated practices in their learning processes. In this context, it can be said that physical education classes are a critical tool in terms of both increasing the level of physical activity and supporting the social-emotional development of children.

General Characteristics of Generation Alpha

Generation Alpha is defined as the first generation born into the digital age, born after 2010. This generation interacts with smartphones, tablets, the internet, and digital platforms from an early age; their learning, communication, and daily life practices are largely shaped by technology. The general characteristics of the alpha generation are as follows (Hidayat, Matondang, & Syukron, 2024);

• They grew up surrounded by digital technologies and are technologically adept.

• Prefers visual and interactive materials in educational processes.
• Has the ability to learn quickly and access information quickly.
• Tends to be individualistic and work independently.
• Children living in marginalized communities may have varying adaptation and learning styles due to differences in access to social and educational resources.

According to Demirel (2021), the general characteristics of Generation Alpha are:

• Fast learning, creative thinking and problem-solving abilities have improved.
• Gives importance to individuality and independence.
• Prefers visual and interactive learning environments.
• Is impatient and expects immediate feedback.
• Uses digital platforms more in social interaction.

Generation Alpha's nature, growing up surrounded by digital technology and expecting rapid learning and instant feedback, necessitates the adoption of new approaches in educational environments. This generation's short attention span and high preference for visual and interactive learning limits the effectiveness of traditional teaching methods (Demirel, 2021). In this context, physical education classes have the potential to provide a holistic learning environment that supports not only the physical development of Generation Alpha but also their social, emotional and cognitive needs (Hidayat et al., 2024).

Educational and Developmental Contributions of Physical Education Classes

Physical Education and Sports is a vital educational field that greatly contributes to the overall development of students. The patience, tolerance, and motivation of physical education teachers play an essential role in fostering Generation Alpha's enthusiasm for physical education (Demir, 2025). When teachers maintain a positive attitude, the course not only enhances students' physical health but also positively influences their social, emotional, and cognitive development. Educationally, physical education classes help students acquire core values such as patriotism, justice, friendship, honesty, self-control, patience, respect, love, responsibility, & helpfulness; students learn these values practically during class & integrate them into their daily lives. Additionally, social skills such as teamwork, communication, & leadership are developed through physical education activities; students reinforce these skills by cooperating in groups & experimenting with different social roles. From a developmental perspective, regular physical education activities improve students' motor skills & overall physical health, while also increasing their self-confidence & improving their ability to cope with stress. In addition, their emotional resilience is strengthened through experiences of success & failure. As a result, the Physical Education & Sports course is a comprehensive educational area that

supports not only the physical but also the social, emotional & cognitive development of students, & its effective implementation contributes to students becoming healthier & more balanced individuals in their individual & social lives. (Arslan and Eren, 2022). According to the review by Bailey (2009), these lessons not only support the development of physical health and motor skills, but also provide various gains in social, emotional and cognitive areas. Physical education classes strengthen students' social skills such as teamwork, communication, and leadership; through group interactions and game-based activities, students learn to cooperate and take social responsibility (Bailey, 2009). Knaus, Lechner, and Reimers (2018) examined the effects of PE on child development using differences in physical education (PE) lesson hours across states in Germany. Research shows that PE courses provide positive improvements in cognitive skills. It has been observed that PE can have negative effects on social skills, especially in male students, and problems in peer relationships increase. In female students, improvement in motor skills and increased participation in extracurricular physical activities were observed. However, no significant change was found in general health parameters. These findings suggest that while PE contributes to children's cognitive and motor development, its effects on social skills may be complex and gender differences may shape these effects. Physical Education (PE) courses not only support students' physical health but also contribute significantly to their mental and social development. Regular physical activity improves cardiovascular health, strengthens muscles, increases flexibility and improves posture and balance. Additionally, PE courses can improve students' academic performance; students who participate in regular physical activity may exhibit better concentration, memory, and problem-solving skills. PE classes allow students to develop soft skills such as communication, cooperation and leadership through team games and group activities. These lessons also help students gain healthy living habits and raise awareness about issues such as balanced nutrition, adequate sleep, and regular exercise (All Kids Bike, 2023).

The Relationship Between Generation Alpha and Physical Education

Generation Alpha uses digital tools as a natural part of their processes of accessing information, communicating and learning; this also affects their perspective on physical education classes (Yılmaz & Aktürk, 2023). Growing up in an environment surrounded by digital culture, Generation Alpha children tend to engage in more screen-based activities, which leads to a decrease in physical mobility and the establishment of a sedentary lifestyle at an early age (Piepiora, Bagińska, Piepiora, & Vveinhardt, 2025). Over time, this may result in reduced physical activity and lower levels of traditional gaming. It could also lead to

increased time spent on digital platforms and a growing fondness for, or even addiction to, these platforms (Tekkurşun Demir & Cicioğlu, 2019).

A study conducted in Poland indicated that there has been a significant decline in the physical activity levels of Generation Alpha children compared to previous generations; in particular, outdoor games have been replaced by virtual games. This situation can negatively affect the development of children's physical awareness, endurance & social interaction skills (Piepiora et al., 2025). Similarly, in the study by Yılmaz and Aktürk (2023), teachers stated that Generation Alpha students have short attention spans, are impatient, and expect instant feedback. These features make it difficult to maintain motivation and participation in physical education classes. In another study, a positive relationship was found between physical education's use of cooperative learning strategies and students' emotional intelligence levels; While this strategy is applied especially to adolescent students, it contributes to the development of skills such as social acceptance and emotional control in the classroom environment (Rivera-Pérez et al., 2020).

In short, the relationship between Generation Alpha and physical education is shaped not only by physical activity habits, but also by digital culture, learning styles, and social interaction dynamics (Piepiora et al., 2025). For this reason, physical education classes should be transformed into gamified, interactive and technology-supported learning environments that will attract the attention of Generation Alpha. Thus, both physical and cognitive and emotional development can be supporte). In this context, in order to understand the attitudes and participation levels of Generation Alpha towards physical education classes, it is necessary to first examine in depth the relationship of this generation with technology. Because digital culture directly shapes their learning styles, motivation sources, and interest in physical activities (Yılmaz & Aktürk, 2023).

Generation Alpha's Relationship with Technology and Digital Culture

Generation Alpha (individuals born after 2010) is defined as the first generation to grow up under the direct influence of digital technology (McCrindle & Fell, 2020). This generation grows up interacting with mobile devices, smart toys and online learning environments. Therefore, digital culture significantly shapes their learning styles, social relationships and physical activities (Prensky, 2012). However, this digital intensity can reduce participation in physical games and movement-based activities (Karasar & Güven, 2022). As children turn to screen-based activities, they spend less time on outdoor games and physical experiences, which can negatively affect motor skill development (Süner & Güneş, 2021). In this context, physical education lessons play a balancing role for the Generation Alpha's need for physical interaction, which has decreased with digitalization.

The Role of Movement, Play and Sports in Child Development

Movement and play in early childhood form the basis of cognitive, social and emotional development (Pellegrini & Smith, 1998). Play is the way children get to know both their bodies and their environment. Although the alpha generation's lifestyle, which is intertwined with technology, limits their natural movement environment, physical education classes are of great importance in compensating for this deficiency (Bağcı & Yıldız, 2023).

Sports and movement activities develop self-control, empathy, cooperation and leadership skills in children (Weiss, 2008). In addition, physical activities serve to reduce the risks of attention deficit, sleep disturbances, and obesity caused by digital screen use (Tremblay et al., 2017). Therefore, physical education can be considered as an important learning area that supports the holistic development of the Generation Alpha.

Perception of Physical Education Classes in Generation Alpha

Generation Alpha students show higher interest in fun, gamified and technologically supported applications in learning (Yılmaz & Çelik, 2023). It is emphasized that the traditional understanding of physical education is not motivating enough for this generation and that the lessons should be supported with digital tools, interactive applications and augmented reality elements (Öztürk & Koca, 2022). Research shows that the use of technology in physical education classes increases students' motivation, participation, and positive attitudes towards the course (Casey, Goodyear, & Armour, 2017). Therefore, physical education teachers need to understand the digital interests of Generation Alpha and redesign their pedagogical approaches accordingly.

The Importance of Physical Education Classes for Generation Alpha

The fact that Generation Alpha has grown up surrounded by technology since the moment they were born has brought about a decrease in physical activity levels, a decrease in interest in outdoor games, and a widespread sedentary lifestyle (Danilova, 2023; Cırık & Aksoy, 2023). In this context, physical education classes have a critical role in supporting the multifaceted development of Generation Alpha individuals. Physical education is not only an activity that improves physical fitness; it is also a learning environment that strengthens the psychological, emotional, social and academic aspects of the individual (Bailey, 2006; Hills et al., 2015).

Contributions to Physical Development

In Generation Alpha, where technological addiction is common, the risks of inactivity, obesity, and motor skill retardation are noteworthy (Ziatdinov & Cilliers,

2022). Physical education classes support muscle and bone development, improve children's basic movement skills (running, jumping, balance, etc.) and enable them to acquire active life habits at an early age (Strong et al., 2005). Regular physical activities also strengthen cardiovascular health, support posture and contribute to the development of lifelong physical health awareness (WHO, 2020).

Psychological and Emotional Contributions

Physical education is an important tool in developing Generation Alpha students' self-confidence, self-awareness, and stress-coping skills. Physical activity increases the level of happiness and reduces depressive feelings by increasing the secretion of serotonin and endorphin (Eime et al., 2013). In addition, success in physical activities supports children's self-confidence and sense of competence (Bailey, 2006). Unlike passive, technology-based entertainment, physical education allows students to channel their emotional energy in healthy ways.

Contributions to Social Development

Generation Alpha children may have difficulty in peer interactions because they generally spend time playing individual digital games. Physical education classes contribute to the development of social skills such as teamwork, sharing, leadership, cooperation and communication (Holt et al., 2011). Through group activities, students strengthen their sense of empathy and social responsibility by interacting with different individuals (Bailey, 2006). Additionally, concepts such as rule-following, patience, respect and fair play are also promoted through physical education as important components of social cohesion.

Indirect Effects on Academic Success

It has been emphasized in many studies that physical activities support cognitive functions and therefore have an indirect effect on academic achievement (Donnelly et al., 2016; Singh et al., 2019). Regular physical activity prolongs attention span, improves executive functions, and increases motivation to learn (Tomporowski et al., 2015). In this regard, PE classes contribute not only to physical fitness but also to the development of cognitive performance. It also serves as a protective function against phenomena such as distraction and digital addiction, which are frequently observed in Generation Alpha students.

Factors Inhibiting Participation in Physical Education Classes

Although physical education classes contribute significantly to students' physical, social and emotional development, various internal and external factors can negatively affect participation in this class. Students' lack of interest in the course, environmental limitations, family attitudes, peer relationships, digital influences and psychological variables constitute obstacles to participation in physical education classes (Bailey, 2006; Subramaniam & Silverman, 2007; Trout & Graber, 2009).

Environmental Factors

The physical conditions of the school directly affect students' participation in physical education classes. Hardman and Marshall (2000) stated that in many countries, schools are inadequate in terms of gyms, playgrounds and appropriate equipment, and this reduces the efficiency of physical education classes. Additionally, Sallis et al. (2012) emphasized that the lack of safe playgrounds and green areas in the environment where students live reduces participation in physical activity. The limited physical environment becomes a factor that encourages a sedentary lifestyle, especially for students living in city centers.

Family Factors

The family's view of physical education class significantly affects the student's attitude towards the class and level of participation. Subramaniam and Silverman (2007) state that families' prioritization of academic success pushes physical education classes into the background. Bailey (2006) also emphasized that some parents' perception of physical education as an area that does not contribute to academic progress negatively affects students' motivation towards the course. Additionally, family socioeconomic status is an important factor; in low-income families, access to sports equipment may be limited and children may have difficulty participating in physical activities outside of school.

Peer Factors

Peer relationships are social factors that strongly influence students' participation in physical education classes, especially during adolescence. Trout & Graber (2009) revealed that overweight students fear being ridiculed by their peers in physical education class and therefore avoid participating in class. While peer pressure limits students' active participation in class, factors such as the desire for social acceptance and popularity anxiety may cause students to be reluctant to perform in physical activities.

Digital Factors

Twenge (2019) states that the “iGen” generation, called children of the digital age, spends a large amount of time in front of the screen, and this situation significantly reduces participation in physical activity. Digital games, social media and online entertainment platforms offer children alternative satisfaction areas that replace physical movement. According to the WHO (2020) report, increased screen time increases the rate of inactivity in children and increases the risk of obesity. Therefore, digital addiction has become one of the most important contemporary factors that hinder participation in physical education classes for today's students.

Material Constraints

Lack of sports equipment is one of the main factors that limit the practical dimension of physical education classes. Hardman and Marshall (2000) reported that sports equipment was inadequate in many schools, causing lessons to be limited to theoretical instruction. Additionally, it becomes difficult for teachers to effectively carry out the practical aspect of the course without material support. Bailey (2006) also stated that when the necessary infrastructure for physical activity is not provided, students' motivation decreases and the educational value of the course decreases.

Psychological Factors

Psychological factors are among the most complex variables affecting participation in physical education classes. Cairney et al. (2012) showed that students' enjoyment of physical education class depends largely on their level of “perceived competence”. Students who feel inadequate avoid attending classes or exhibit poor performance. Trout and Graber (2009) emphasized that students' body image and self-confidence levels affect their participation in physical education; embarrassment and anxiety about failure are particularly prominent during adolescence. Bailey (2006) states that physical education classes have the potential to strengthen self-confidence, but negative social experiences can weaken this potential. When all these factors are evaluated together, it can be seen that participation in physical education classes is a multidimensional phenomenon. Environmental, familial, kinship, digital, material and psychological factors interact with each other. Therefore, in the design of physical education programs, not only physical competence but also students' social environment, psychological state and digital life habits should be taken into account (Bailey, 2006; Cairney et al., 2012; Twenge, 2019; WHO, 2020).

Recommendations to Increase Participation

Educational Policies and School Management Level Recommendations

In order to increase participation in physical education classes, education policies must first be restructured to support students' motivation for physical activity & the learning climate. As stated in the study of Castillo et al. (2020), conducting teaching processes in line with the principles of transformational leadership strengthens students' self-determination motivation and attitudes towards learning. In this context, it is recommended that school administrators provide continuous professional development opportunities for physical education teachers, encourage innovative teaching approaches, and support physical activities to become a part of school culture. Additionally, seeing physical education as equally important as academic success at the management level can positively affect participation rates by increasing the seriousness of the course.

Awareness-Raising Activities for Families

Families' support plays a critical role in students' active participation in physical education classes. The study by Castillo et al. (2020) emphasizes that the learning climate should be made sustainable not only in the classroom but also in the student's living environment. In this regard, informative seminars and awareness-raising activities can be organized for families by school administrations and physical education teachers. Families' support for their children's participation in physical activities helps them maintain active lifestyle habits in their free time. In this way, the attitudes and behaviors acquired in physical education classes can be carried outside the school and made permanent.

Integrating Digital Tools into Physical Education (Gamification and Applications)

The integration of digital technologies into educational processes is an effective strategy to increase student interest and make learning more interactive. A systematic review by Knoke et al. (2024) revealed that digital media increased health behaviors and participation motivation in physical education classes. Similarly, other studies show that gamification and virtual reality-based applications positively affect students' attitudes towards the course. In this context, active participation of students can be encouraged by using mobile applications, virtual reality environments and digital gamification elements in physical education classes. Moreover, such tools support self-regulation and competition among students, as they allow monitoring individual progress (Arufe-Giráldez et al., 2022; Fernández-Vázquez et al., 2024).

The Role of Teachers and Variety of Methods

A key element that increases participation is that physical education teachers use teaching methods appropriate to students' individual differences and motivation levels. In the study by Castillo et al. (2020), it was stated that when teachers adopted a transformative teaching style, students perceived the learning climate more positively and participated in physical activities voluntarily. In this context, it is recommended that teachers use student-centered, collaborative and feedback-oriented methods. Another study also shows that developing teachers' inclusive education skills supports the active participation of all students in the classroom. Therefore, strengthening teachers' pedagogical and digital competencies through in-service training will directly contribute to increasing participation in physical education classes (Celestino et al., 2024).

Social-Emotional Learning and Creating an Inclusive Classroom Environment

Social-emotional learning (SEL) strengthens classroom engagement by supporting students' skills such as self-awareness, self-regulation, and empathy. Clearly structured IBL activities in physical education classes increase students' motivation, self-confidence, and in-group interaction. Likewise, creating inclusive classroom environments strengthens students' sense of belonging and facilitates participation in the lesson (Dimitrellou et al., 2024). The findings of Celestino et al. (2024) show that teachers' adoption of inclusive teaching strategies enables students with different needs to actively participate in the lesson. In this regard, it is recommended to increase social-emotional learning-focused content in physical education programs and to create a safe learning environment where every student feels valued.

Discussion and Conclusion

In this study, the relationship between the characteristics of Generation Alpha students and their attitudes towards physical education classes was discussed. Generation Alpha stands out as a generation that grew up surrounded by technology, thinks quickly, and prefers visual and interactive learning environments. However, this digital density causes a decrease in physical mobility, a lack of interest in outdoor activities, and the establishment of a sedentary lifestyle at an early age. At this point, physical education classes stand out as one of the most important educational areas that support both the physical and social-emotional development of Generation Alpha.

Research shows that physical education classes develop not only physical skills but also multifaceted skills such as self-confidence, self-control, empathy,

cooperation, leadership and social responsibility. However, the short attention spans, preference for immediate feedback, and strong digital orientation of Generation Alpha students make it difficult to deliver the course using traditional methods. Therefore, it is important to include gamified, interactive and technology-supported teaching approaches in physical education classes.

Physical education class is not just a time for movement for Generation Alpha children, but also a space of balance that allows them to move away from the passive nature of the digital world. This course not only protects their physical health but also helps them gain lifelong skills such as social relationships, emotional management and self-awareness. However, factors such as environmental deficiencies, material shortages, family attitudes and digital addiction can negatively affect students' participation in class.

In conclusion, physical education classes restructured to suit the needs and characteristics of Generation Alpha will contribute to children growing up as healthier individuals not only physically but also cognitively and emotionally. In this regard, it is of great importance for teachers to use technology effectively as a pedagogical tool, to plan innovative activities that will increase students' interest, and to improve the physical conditions of schools.

Generation Alpha is a generation that grew up in the rapidly changing digital age, has instant access to information, can multitask, and lives intertwined with technology. Traditional teaching methods are no longer sufficient for these children. The future of physical education must be reshaped to adapt to the characteristics of this generation. The future understanding of physical education is evolving into a holistic structure where digital tools and technological innovations are used effectively for educational purposes and at the same time support the physical, cognitive and emotional development of children. Applications such as augmented reality (AR), virtual reality (VR), and wearable technology are expected to be used as learning support tools in physical education classes. This will allow students to both learn while having fun and track their performance in real time. However, maintaining children's physical activity levels is as important as the effective use of technology. Even if physical education classes are supported by digital tools in the future, the main goal should be to ensure that children acquire active living habits. In this context, teachers' guidance is the most critical element in the course planning process. Teachers should view technology as a tool, not an end in itself, and enrich lessons with gamified, interactive, and collaborative activities that will attract the attention of Generation Alpha.

Furthermore, the future of physical education shouldn't be limited to school. The scope of the course can be expanded through digital platforms, with short exercises, virtual tournaments, and online sports events that can be implemented at home. This

will help children embrace sports as a lifestyle, not just as an activity limited to class time.

In conclusion, the future of physical education lessons for Generation Alpha should be shaped by an approach that is technology-supported yet human-focused, innovative yet movement-based, sensitive to individual differences yet strengthening social solidarity. This transformation will be decisive in adapting not only physical education lessons but also the general structure of education to the future.

Recommendations for Researchers and Practitioners

Recommendations for Researchers

- Qualitative and quantitative research should be conducted to examine the impact of Generation Alpha students' digital habits on participation and motivation in physical education classes.
- Experimental studies should be conducted to reveal the effects of technologies such as gamification, augmented reality (AR) and virtual reality (VR) on learning motivation and performance in physical education classes.
- Long-term longitudinal studies should be designed to address the impact of digital environments on social-emotional learning.
- Comparative analyses of technology-supported physical education practices should be conducted in schools of different socioeconomic levels.
- New scales and assessment tools can be developed to measure students' perceptions of physical activity in the digital age.
- The relationship between teachers' digital pedagogical competencies and their physical education practice styles should be investigated.

Recommendations for Practitioners (Teachers and School Administrators)

- Technology integration in physical education classes should be planned in accordance with pedagogical objectives and should be meaningfully included in the teaching process.
- Students' interest and participation in the course can be increased by using gamification, mobile applications and digital monitoring tools.
- Digital literacy and innovative teaching methods should be supported through continuous in-service training for teachers.
- Physical education teachers should focus not only on physical skills but also on the development of social-emotional skills such as cooperation, empathy, self-confidence and self-regulation.
- Classroom environments should be designed in an inclusive manner to support the participation of students with different proficiency levels.

- School administrators should work in cooperation with local governments to improve physical facilities (gym, equipment, etc.).
- Flexible and student-centered teaching approaches compatible with the requirements of the digital age should be adopted.
- Joint projects should be carried out between researchers and practitioners to ensure that scientific data is transferred to classroom practice.
- Education policies should emphasize that physical education is not only a tool for physical development but also a tool that supports lifelong health, digital awareness and emotional resilience.

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Chapter 11

Peer Bullying in Physical Education Classes: Types, Consequences, and Intervention Approaches

Fatih ATEŞ [1]

Introduction

Today, students spend a significant portion of their daily lives within the boundaries of the school environment. The school institution provides a setting in which students interact with peers, teachers, and the school administration, leading to a range of both positive and negative experiences in their lives (Havik & Westergård, 2020; Parinduri, 2014). One of the increasingly prevalent negative experiences encountered in schools is bullying (Menesini & Salmivalli, 2017). Bullying refers to the intention of one or more students to engage in unjust, persistent, and repeated aggressive behavior toward another classmate (Olweus et al., 1999). According to another definition, bullying emerges as a result of prolonged, repetitive, and deliberate aggressive actions directed at vulnerable peers (Smith et al., 2002).

Bullying in educational settings is a problem encountered at various levels, from early childhood education to university. While verbal and physical bullying are more commonly observed at the preschool level, more complex forms such as psychological and cyberbullying tend to emerge as the level of education increases toward university (Pörhölä et al., 2020; Saracho, 2017). Bullying can manifest in various forms, including physical, verbal, relational, and cyberbullying.

All of these behaviors negatively affect not only students' mental health but also their academic and social functioning (Moore et al., 2017; Wolke & Lereya, 2015). Violence is a phenomenon involving harmful behaviors directed by individuals toward other individuals or living beings; despite societal advancement, its continued prevalence in social media and news outlets indicates that the search for solutions remains ongoing (Namlı et al., 2024). Data from the OECD (2019) show that the rates of encountering bullying are significantly high and have increased over the years. This indicates that bullying within the school context has become a multidimensional and increasingly complex problem.

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Significance and Scope of the Topic

Bullying is a critical issue that must be addressed on an international scale, as it produces both short- and long-term effects on students' individual and social development (Gini & Pozzoli, 2013). Its occurrence within schools one of the fundamental settings for social learning leads to alarming outcomes in terms of educational well-being (Juvonen & Graham, 2014).

An examination of the PISA 2015 and 2018 data reveals that nearly 20% of students in many countries, including Turkey, report being regularly subjected to bullying (OECD, 2017; 2019). These figures highlight the need for education systems to take more systematic and preventive measures to support children's well-being.

Definition, Types, and Manifestations of Bullying

Bullying is defined as intentional, repetitive, and harmful behavior by one or more individuals directed toward another individual, based on a power imbalance (Olweus et al., 1999; Smith et al., 2002). The core characteristics of such behaviors are their persistence, intentionality, and the victim's inability to defend themselves.

The most common types of bullying can be categorized as follows:

- Physical Bullying: Involves acts of direct physical aggression such as pushing, hitting, kicking, or damaging property.
- Verbal Bullying: Includes verbal attacks such as mocking, name-calling, insults, or threats.
- Relational Bullying: Targets social relationships through behaviors such as spreading rumors, exclusion, or isolating individuals from peer groups.
- Cyberbullying: Refers to behaviors conducted via social media and digital platforms, including insults, humiliation, threats, or the exposure of personal information (Johansson & Englund, 2021; Wang et al., 2009).

Characteristics of Bullying in the Context of Physical Education

Physical education constitutes a specific risk area for bullying, as it involves a class structure in which students openly display their bodies, engage in competition, and participate in interactions that often include physical contact (Ball et al., 2021; Wei & Graber, 2023). In these classes, students are frequently subjected to ridicule, exclusion, or direct aggressive behavior by their peers, particularly due to factors such as poor motor skills, obesity, physical appearance, or disability (Sağın et al., 2022).

Indeed, research indicates that approximately 28% of students experience bullying during physical education classes (Jiménez-Barbero et al., 2020). This figure suggests that bullying may be more prevalent in physical education than in other areas of the school environment. Additionally, the risk of unobserved bullying incidents increases in this context, as these classes often involve spaces such as locker rooms and situations where teacher supervision is more difficult (Jiménez-Barbero et al., 2020).

The following types of bullying are particularly prominent in physical education settings:

- Exclusion of students with inadequate motor skills from games,
- Derogatory comments related to body weight and physical appearance,
- Belittling or ignoring students with disabilities,
- The creation of a competitive atmosphere often unintentionally reinforced by the teacher that leads to exclusionary effects (Borowiec et al., 2021; Gill et al., 2010; Sağın et al., 2022).

Such situations may lead students to develop negative attitudes toward physical activity, experience a loss of self-confidence, and become disengaged from school (Samara et al., 2021; Mehta et al., 2012). Moreover, physical education teachers' awareness of bullying and their intervention strategies have a direct impact on the classroom climate (Zhou et al., 2023).

Prevalence and Manifestation of Bullying in the Physical Education Environment

Physical education classes are environments characterized by intense physical interaction and competition. These features create conditions in which bullying behaviors occur more frequently and take on various forms. This section will address the types of bullying, student groups at risk, and the specific settings in which bullying tends to occur.

Types of Bullying in Physical Education Classes

Physical education classes provide a dynamic environment in which students demonstrate their physical competencies, are subject to peer evaluation within group settings, and where teacher supervision can be limited (Escalié et al., 2019). Due to these characteristics, physical education classes represent high-risk settings in which various types of bullying behaviors are frequently observed. The most commonly reported types of bullying among students include physical, verbal, relational (social exclusion), cyber, and gender-based bullying (Maharjan & Shrestha, 2022).

Physical bullying includes actions such as pushing, tripping, or hitting, while verbal bullying involves language-based attacks such as mocking a student's appearance, insulting, or threatening. Social (relational) bullying manifests through behaviors like excluding a student from games, isolating them, or keeping them out of peer groups. Gender-based bullying encompasses discrimination, humiliation, and exclusion based on gender identity or societal gender roles (Johansson & Englund, 2021; Wang et al., 2009).

According to participating teachers, physical bullying is more common among male students, whereas behaviors such as social exclusion and mocking are more prevalent among female students (Sağın et al., 2022). However, some teachers tend to perceive social exclusion as less serious than physical or verbal bullying, which may lead to certain forms of bullying being overlooked (Duy, 2013).

At-Risk Student Groups

Although bullying poses a potential threat to all students in physical education classes, certain groups are systematically at higher risk. These include individuals with visual impairments, students with poor motor skills, and those who deviate from normative body image standards (e.g., those who are overweight, underweight, very tall, or very short) (Ball et al., 2021; Borowiec et al., 2021; Ješina et al., 2022).

Visually impaired students are frequently excluded or targeted in team games due to perceived inadequate performance. Studies have shown that 93% of these students experience bullying in physical education classes, with 21% reporting that such bullying occurs in locker rooms (Ball et al., 2021).

Students with low motor skills are often excluded from games and become targets of ridicule when they fail to perform successfully in skill-based activities. This situation lowers students' self-efficacy and self-confidence, ultimately leading to decreased participation in physical education classes (Bejerot et al., 2011; Gasser-Haas et al., 2020).

Students with diverse gender identities and sexual orientations are among the groups at higher risk within the physical education environment. Research indicates that these individuals are often targeted due to behaviors that do not conform to traditional gender norms, and that teacher intervention is frequently inadequate (Gill et al., 2010).

In addition, overweight or underweight students are frequently subjected to negative comments about their body image, name-calling, or physical exclusion (Ballarin et al., 2023; Zhou et al., 2023). Qualitative interviews with teachers have revealed that these students are often not included in games or are pushed to the margins of class activities by their peers (Sağın et al., 2022).

Settings Where Bullying Occurs

Three primary settings can be identified where bullying occurs in physical education: the class environment, locker rooms, and out-of-school sports settings. Research shows that 93% of bullying incidents take place during physical education class time, 21% occur in locker rooms, and 7% happen during extracurricular sports activities (Ball et al., 2021).

Locker rooms are spaces where privacy is reduced and teacher supervision is limited. As a result, incidents such as mocking, humiliation, and ridicule related to clothing, body size, or personal circumstances are frequently observed among students (O'Connor & Graber, 2014).

In addition, bullying is also observed in other settings such as the cafeteria during lunch, during recess, on school buses, and between or during other classes (Ball et al., 2021). Since teacher supervision is more limited in these environments, peer bullying tends to occur more frequently and with greater intensity (O'Connor & Graber, 2014).

Academic, Psychological, and Social Consequences of Bullying

Bullying is not merely a temporary issue confined to the school environment; it is a multidimensional societal problem that leaves long-term impacts on individuals' cognitive, emotional, and social development. Bullying experienced by students in physical education classes can lead to a wide range of negative outcomes, including reduced academic achievement, diminished self-efficacy, impaired social adjustment, and compromised mental health.

Academic Outcomes

Students who are subjected to bullying may struggle to maintain their academic performance, and often experience a decline in interest and motivation toward learning (Samara et al., 2021). Numerous studies, supported by international examples, have shown that victims of bullying tend to have lower grade point averages, reduced academic motivation, and weakened school engagement (Li et al., 2020; Nikolaou, 2022; Samara et al., 2021).

A large-scale study conducted with 7,304 ninth-grade students in the state of Virginia, USA, found that academic achievement rates were significantly lower in schools where bullying and teasing were prevalent (Lacey & Cornell, 2013).

A large-scale study conducted by Mehta et al. (2012) with ninth-grade students demonstrated that a climate of bullying negatively affects not only individual victims but also the overall student body's attitudes and sense of connection to school. According to the findings, as students' perceptions of widespread bullying in their school increased, their sense of school belonging declined, along with

their motivation to learn and participation in school activities. These results clearly indicate that bullying contributes to student disengagement and a decline in academic aspirations (Mehta et al., 2012).

Psychological Outcomes

Bullying is one of the most severe school-based risks that can undermine an individual's psychological resilience. Comprehensive meta-analyses have demonstrated that victims of bullying frequently exhibit symptoms such as depression, anxiety, suicidal ideation, and self-harm (Dantchev et al., 2019).

Both traditional and cyberbullying are significantly associated with serious mental health problems in children and adolescents, including depression, suicidal ideation, suicide attempts, and self-harm (Li et al., 2024). Although the risk levels of cyberbullying appear slightly higher than those of traditional bullying in some mental health outcomes, individuals exposed to both forms simultaneously face markedly increased risks. Therefore, the combination of these two types of bullying presents the greatest mental health risk for young people (Li et al., 2024). Another study found that school bullying victimization did not have a direct effect on suicidal ideation. However, when controlling for mediating variables, it was revealed that the impact of school bullying on suicidal ideation occurs indirectly through anxiety and depressive symptoms (Park, 2025). Furthermore, research has shown that perceived peer bullying in physical education classes increases school burnout and decreases school satisfaction among middle school students, highlighting that the structural characteristics of physical education classes may facilitate bullying. This underscores the necessity of designing a more inclusive, protective, and supportive learning environment in physical education (Uğraş et al., 2025).

Social Outcomes

A study examining the relationship between being a victim of school bullying and engaging in bullying behavior found that having fun and talkative friends, as well as a supportive peer network outside of school, significantly weakened this association (Ho et al., 2022).

The fact that victims in these groups exhibit higher levels of depression and anxiety symptoms, along with lower levels of subjective well-being, indicates that they are socially excluded and psychologically at risk (Huang & Chui, 2024). In particular, family and peer support have been shown to play a protective role in mitigating the negative consequences of bullying victimization. Indeed, a study conducted by Lee et al. (2022) found that family and peer support significantly reduced experiences of multiple forms of bullying among adolescents.

In environments like physical education classes, where performance-based comparisons are prominent, bullying tends to occur more overtly. For example, visually impaired students are often excluded from team games due to perceived inadequacy, with 93% reporting experiences of bullying (Ball et al., 2021). Additionally, students with low motor skills are mocked for their performance, which reduces their participation (Bejerot et al., 2011). Similarly, students with diverse gender identities and sexual orientations are among the groups at higher risk of being targeted for not conforming to gender norms, while teacher intervention is often insufficient (Gill et al., 2010). Furthermore, students who deviate from normative body image standards are also excluded and subjected to name-calling or ridicule (Sağın et al., 2022). When students perceive themselves as "unsuccessful," "different," or "inadequate" in such environments, they tend to experience a decline in social connections and become more withdrawn. For example, Haegele and Maher's (2022) study revealed that male students with autism felt different, inadequate, and excluded during physical education classes; these experiences led to social withdrawal, emotional isolation, and, in some cases, self-harming behaviors. Similarly, in a study with sixth-grade students, O'Connor and Graber (2014) found that perceived differences in appearance, physical ability, and gender expression resulted in bullying during physical education classes. This, in turn, led students to avoid class, exhibit a tendency toward isolation, and withdraw from social interactions. Both studies provide strong evidence that when students feel unsuccessful, different, or inadequate in physical education, their social bonds weaken, and withdrawal behaviors increase.

Intervention Approaches for Preventing Bullying in Physical Education

Addressing bullying in physical education requires a multidimensional and systematic approach. Solution strategies are being developed at various levels, including school-based programs, physical education-specific interventions, social-emotional learning initiatives, and teacher training.

School-Based Programs

KiVa (Finland) and OBPP (Olweus Bullying Prevention Program, Norway) are the most well-known intervention programs developed to prevent bullying on a school-wide basis. The Olweus Bullying Prevention Program (OBPP) achieved a 35% reduction in bullying behaviors and a 29% reduction in victimization in Norway. In the United States, these rates were recorded as 25% and 11%, respectively (Gaffney et al., 2021).

The effect of the KiVa program on bully-victim students has been examined. In a study involving 23,520 students from 195 schools, the rate of bully-victims in schools where the KiVa program was implemented decreased by 8% according to self-reports and by 41% according to peer reports. The risk of being a bully-victim among students in the control group is 1.5 times higher than that of the KiVa group. Additionally, a significant portion of bully-victims in the KiVa-implemented group are no longer involved in bullying. These results indicate that the program is also effective for bully-victim students (Yang and Salmivalli, 2015).

In another study, the effects of the KiVa program implementation in Italy were examined through a randomized controlled trial, and significant results were obtained especially at the primary school (4th grade) level. According to single-item evaluations, the rate of students engaging in bullying in schools where KiVa was implemented decreased from 9% to 4.4%, and the rate of victimized students decreased from 22.2% to 10.9%, showing reductions of 51% and 50.9%, respectively. At the middle school (6th grade) level, the bullying rate decreased from 4.3% to 2.5%, showing a 41.9% reduction; the victimization rate slightly decreased from 7% to 6.1%, whereas an increase was observed in the control group. These findings indicate that the KiVa program is particularly effective in combating bullying at the primary school level (Nocentini and Menesini, 2016).

Physical Education-Focused Interventions

In the study conducted by Centeio et al. (2017), 104 primary school students participated in a 10-week yoga-based intervention program. During the program, students practiced yoga once a week. In the pre- and post-intervention measurements, a significant decrease was observed in students' levels of bullying. Bullying scores decreased in both male and female students, but no significant difference was found between genders. Additionally, students stated that they coped better with stress and anger by using yoga techniques, and thus remained calmer in bullying situations. In the study conducted by Montero-Carretero and colleagues (2021), the effects of an intervention program called A-Judo, aimed at preventing bullying, were examined. Students in the experimental group participated in a judo-based program during physical education classes twice a week for five weeks, totaling 10 sessions. In the pre- and post-intervention measurements, significant improvements were observed in the experimental group in terms of basic psychological needs, intrinsic motivation, respect–tolerance, moral identity, and levels of bullying.

In the study conducted by Murillo-Moraño et al. (2025), the effects of the PREBULLPE program implemented during physical education classes and the

cooperative learning method on bullying behaviors were examined. In Spain, a total of 293 students aged between 11 and 16 were divided into intervention and control groups. Students in the PREBULLPE group participated in a 6-session program over 6 weeks, with one-hour sessions each week. The program included symbolic games, cooperative activities, and bullying-awareness practices within physical education. In the pre- and post-intervention evaluations, a significant decrease in bullying behaviors was observed among students who participated in the PREBULLPE program, especially among girls. No significant change was observed in the level of victimization. The cooperative learning method did not have a significant effect compared to the control group. It was found that the positive effects obtained after the intervention decreased over time.

The Relationship Between Bullying, Physical Activity, and Sedentary Behavior

Bullying not only leads to psychosocial consequences but also creates lasting effects on individuals' lifestyles and health behaviors. Especially during childhood and adolescence, exposure to bullying can decrease individuals' levels of participation in physical activity and increase sedentary behaviors, thereby negatively affecting health (Pacífico et al., 2024).

Bullying Victimization and Physical Activity Level

The findings of the systematic review and meta-analysis conducted by Pacífico et al. (2024) indicate that children and adolescents who are victims of bullying have significantly lower levels of participation in physical activity. According to the meta-analysis results, the likelihood of bullying victims participating in any physical activity is 9% lower. Zhou et al. (2023) show that the level of participation in physical education classes is inversely related to bullying. It was found that students who experience bullying tend to avoid participating in physical activities.

Sedentary behaviors such as lack of physical activity and excessive screen time are significantly associated with bullying victimization in children and adolescents. Individuals whose physical activity levels do not meet the recommended guidelines have been found to be at higher risk of being bullied. Furthermore, children and adolescents who spend more than two hours per day in front of screens have an increased risk of experiencing both traditional and cyberbullying victimization (García-Hermoso et al., 2020).

Conclusion and Discussion

This book chapter has addressed bullying behaviors that occur in the school environment, particularly in the context of physical education classes, from a

multidimensional perspective, offering a broad framework ranging from conceptual definitions to field findings, and from psychosocial outcomes to intervention strategies. The findings indicate that physical education classes can present both risks and benefits in relation to bullying (Ball et al., 2021; Wei and Graber, 2023).

It has been shown that physical, verbal, relational, and gender-based forms of bullying occur frequently in physical education classes; students with low motor skills, visual impairments, or diverse gender identities and sexual orientations, as well as those who do not conform to body image norms, are among the groups at higher risk of being targeted during lessons (Borowiec et al., 2021; Gill et al., 2010; Sağın et al., 2022). It has been determined that bullying has negative effects not only on victims but also on the overall classroom climate and academic achievement, and that such behaviors reduce students' school engagement and academic motivation (Samara et al., 2021; Mehta et al., 2012).

The mental health effects of bullying are more commonly observed. Outcomes such as depression, anxiety, suicidal ideation, and social isolation are common consequences of both traditional and cyberbullying (Li et al., 2024; Park, 2025). These negative effects are not limited to the individual level but also lead to consequences such as withdrawal from social groups, a weakened sense of belonging, and school dropout (Huang and Chui, 2024).

The effects of bullying on physical activity behavior are also noteworthy. It has been found that bullying victims have lower rates of participation in physical activity, while sedentary behaviors and screen time are higher among these individuals (Pacífico et al., 2024; García-Hermoso et al., 2020).

In this context, the importance of multi-level and sustainable intervention approaches becomes evident. School-wide programs such as KiVa and OBPP have created statistically significant and lasting effects in reducing bullying (Yang and Salmivalli, 2015; Nocentini and Menesini, 2016). Among PE-specific practices, methods such as judo, yoga, and cooperative learning have been found to reduce levels of bullying, support students' psychological needs, and create a positive classroom climate (Centeio et al., 2017; Montero-Carretero et al., 2021; Murillo-Moraño et al., 2025).

The role of physical education teachers is one of the most crucial components within this framework. Teaching style, observational capacity, intervention strategies, and the ability to manage communication among students play a critical role in reducing bullying (Sağın et al., 2022; Zhou et al., 2023).

Original Contributions of This Chapter

This chapter provides comprehensive theoretical, methodological, and practical contributions to the school-based bullying research literature, particularly in the context of physical education, in the following ways:

Multilayered Analysis of Higher-Risk Groups: Individuals with visual impairments, diverse gender identities and sexual orientations, students with low motor skills, and those who do not conform to body norms have been evaluated in a multidimensional manner not only in terms of victimization, but also through the lenses of social exclusion, teacher attitudes, classroom structure, and peer relationships.

Interdisciplinary Approach to the Psychosocial, Academic, and Behavioral Outcomes of Bullying: Beyond its mental health effects such as depression, anxiety, and social isolation, the impact of bullying on academic achievement, school engagement, participation in physical activity, and sedentary lifestyle has been presented within a multidisciplinary framework. This strengthens the theoretical fluidity between the fields of education, psychology, and health sciences.

Comparative and Practical Examination of Intervention Strategies: School-based programs such as OBPP and KiVa, along with physical education-focused interventions such as yoga, judo, and PREBULLPE, have been comparatively analyzed in terms of their effectiveness and contextual suitability. In this respect, the study offers original contributions to the integration of intervention models into instructional settings.

Emphasis on the Transformative Role of Teacher Interactions: Physical education teachers are highlighted not merely as observers but as climate-shaping and transformative agents in the fight against bullying. Within this framework, teaching style, intervention strategies, and the use of pedagogical language are addressed as central variables in the prevention of bullying.

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