Criminological and Legal Analysis of the Role of Sports in Preventing Violent Crimes

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Abstract

In recent decades, alongside the rise in violent crimes and the ineffectiveness of certain traditional punitive strategies, researchers and policymakers have increasingly turned their attention to multifaceted preventive approaches, including the use of sports as a social, psychological, and biological tool for crime prevention. The role of hormones and neurotransmitters in either stimulating or inhibiting aggression has been well established. For instance, a decrease in serotonin (5-HT) levels is associated with increased aggressive behaviors, whereas physical exercise, by enhancing serotonergic activity, can contribute to the reduction of such behaviors. This study adopts a descriptive-analytical approach and draws upon interdisciplinary theoretical literature to examine the criminological and legal analysis of the role of sports in preventing violent crimes. The findings indicate that the integration of neuroscience into criminal policy facilitates a paradigmatic shift from a punitive model to a neuro-reformative framework. Considering the confirmed moderating role of sports on neurobiological factors associated with violence—such as cortisol modulation, enhancement of prefrontal functioning, and improvement of synaptic plasticity—it is essential to design sports-based neuro-criminal policies at three levels: prevention, adjudication, and rehabilitation. This approach requires coordinated efforts among legal institutions (the judiciary), scientific bodies (neuroscience centers), and executive agencies (prisons and correctional facilities) to develop efficient and ethically grounded legal frameworks.

Keywords: criminological, sports, violent crimes

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1. Introduction

The role of hormones and neurotransmitters in stimulating or inhibiting aggression has been well established. For instance, a reduction in serotonin (5-HT) levels is associated with increased aggressive behaviors, whereas physical activity, by enhancing serotonergic activity, can be effective in reducing such behaviors (Chaouloff, 1989; Coccaro et al., 1997).

Nevertheless, the intersectional field of sports, neuroscience, and criminal law—often referred to as neurolaw—has yet to be properly institutionalized within prevention systems and criminal justice policy frameworks. While developed countries

have begun revisiting theories of criminal responsibility and designing therapeutic interventions using neuroscientific data (Jones, Schall, et al., 2013), in developing countries such as Iran, this approach remains largely overlooked, and studies in this area are scarce.

In recent decades, with the rise in violent crimes and the inefficacy of certain traditional punitive strategies, scholars and policymakers have increasingly focused on multifaceted preventive strategies, including the use of sports as a social, psychological, and biological tool for crime prevention. Contemporary perspectives in developmental criminology, human-centered criminal policy, and neurolegal thought suggest that many violent behaviors stem from cognitive-emotional deficits, neurobiological impairments, or failures in socialization. Thus, sports can play a meaningful role in reducing the occurrence or recurrence of violence by enhancing self-regulation skills, rebuilding inhibitory neurostructures, and decreasing social isolation (Cotman & Berchtold, 2002; Lubans et al., 2016; Rodriguez-Ayllon et al., 2023).

The book *Sport and Crime Reduction* by Geoff Nichols (2007) is one of the earliest systematic sources to examine empirical evidence on sport-based crime prevention programs in countries such as the United Kingdom, the United States, and Australia. It demonstrates that sports—particularly during adolescence—can have a deterrent effect on recidivism (Nichols, 2007). This work emphasizes that sports interventions are most effective when combined with social skills training, psychological support, and stable environmental structures. From a comparative law perspective, certain countries such as the UK, the Netherlands, and Norway have employed integrated and structured sport-based programs in their juvenile and correctional systems. Programs such as "Midnight Basketball" in the United States and *Kickz* in the UK have been designed to promote social interaction, serve as a secondary crime prevention measure, and reduce violence in high-risk areas. These programs have shown positive results in reducing street violence and increasing social belonging (Brusseau et al., 2018; Meek, 2018; Spruit et al., 2016).

On the other hand, neurolegal theory, grounded in cognitive neuroscience findings on the dysfunction of the prefrontal cortex, amygdala, and emotional regulation systems, stresses the necessity of designing interventions that target individuals' biological and behavioral rehabilitation. In this context, sports emerge not only as an enhancer of inhibitory cognition but also as an intervention marker in redefining criminal responsibility and designing rehabilitative programs. Research by Kaldewaij and colleagues (2019) has shown that increasing prefrontal cortex activity through physical exercise or cognitive stimulation can reduce impulsive and aggressive behaviors among offenders (Kaldewaij et al., 2019).

Building on this foundation, Chapter Five of the current study aims to investigate the role of sports from three complementary and integrative perspectives: (1) its place in developmental and social prevention strategies; (2) its potential integration into preventive criminal policy; and (3) the legal and ethical feasibility of utilizing neuroscientific findings within the framework of neuro-law to design treatment-oriented justice. Additionally, a comparative analysis of international experiences and the implementation challenges of this approach in criminal policymaking will comprise the final section of this chapter.

Accordingly, the present study seeks to conduct a criminological and legal analysis of the role of sports in preventing violent crimes.

2. The Role of Sports in Social (and Developmental) Crime Prevention Strategies

Social crime prevention represents one of the foundational pillars of modern criminology and justice-oriented policymaking. Rather than focusing solely on criminal responses after the commission of a crime, this approach seeks to minimize the likelihood of criminal behavior from the earliest stages of life by identifying and intervening in individual, familial, and environmental risk factors. Particularly within the frameworks of developmental and developmental social prevention, the core emphasis lies on intervening in the psychological and cognitive development processes of children and adolescents, as well as on strengthening life skills—an area in which sports holds a unique and interdisciplinary role. The studies conducted by Farrington and colleagues have demonstrated that skill-building programs involving social education, sports, and the enhancement of social interaction have meaningful effects on reducing rates of violence, delinquency, and adolescent aggression. Their meta-analysis of 55 studies revealed that such programs can reduce criminal and antisocial behaviors by

approximately 30%, especially when implemented from early childhood and supported by school-based or community structures (Farrington & Welsh, 2016).

Within this framework, sport is not merely a physical activity, but a medium through which discipline, self-control, empathy, teamwork, and emotional regulation are taught. As Dandurand and Heidt (2022) emphasized, numerous sport-based social prevention programs—such as "Midnight Basketball" in the United States or collaborative projects in Canada—have employed sport as a “hook” to engage high-risk youth in educational and social activities. These initiatives have contributed to reducing social exclusion, increasing a sense of belonging, and enhancing cognitive-emotional functioning, thus supporting sustainable personal growth and deterring violent tendencies (Dandurand & Heidt, 2022).

Consequently, the role of sport in developmental criminology transcends recreational activity. Evidence indicates that when sport is embedded in a structured design accompanied by socio-emotional training, it becomes a vehicle for strengthening prefrontal cortex function, hormonal regulation (such as balancing cortisol and testosterone), and reducing impulsivity. These interventions, grounded in the concept of developmental neuroscience, play a critical role in shaping resilient and prosocial behavior.

One of the key reasons for prioritizing sport in social prevention strategies is its capacity to alter the neuropsychological mechanisms underlying behavioral control in adolescents and other at-risk populations. During development, the adolescent brain is still maturing, and many executive structures, including the prefrontal cortex, hippocampus, and inhibitory pathways, remain under construction. At the same time, hormonal fluctuations and emotional dysregulation increase susceptibility to aggressive or antisocial behaviors. In this context, sport serves not merely as a physical tool but also as a biopsychological intervention to stimulate the neurostructures responsible for behavioral inhibition and self-regulation. A study by Tyborowska and colleagues (2016), conducted on 14-year-olds, revealed that as puberty advances, emotional control is transferred from subcortical structures (amygdala, thalamus) to the anterior prefrontal cortex. This neural shift correlates with rising testosterone levels, and adolescents exhibiting greater neural maturation demonstrated increased prefrontal activity during emotional inhibition tasks (Tyborowska et al., 2016).

In a significant study by Hillman, Castelli, and Buck (2005), researchers examined the relationship between aerobic fitness and cognitive performance in 9- to 10-year-old children. Their findings indicated that higher levels of aerobic fitness were positively associated with enhanced cognitive task performance, particularly in executive control and working memory. One of the key outcomes of the study was the marked improvement in accuracy and reaction speed in selective attention tasks (e.g., the Stroop task) and increased grey matter volume in cognition-related brain areas among children with higher aerobic capacity. This research strongly supports the idea that regular physical activity can be employed as an effective strategy for enhancing academic and cognitive performance in elementary school-aged children, thereby providing a scientific foundation for promoting physical education programs in schools (Hillman et al., 2005).

Moreover, the hormonal balance between cortisol (the stress hormone) and testosterone (a hormone related to motivation and aggression) plays a crucial role in regulating emotional and behavioral responses. The study by Biddle and Asare (2011) found that sport-based activity in adolescents with high testosterone-to-cortisol ratios enhanced functional connectivity between the amygdala and the prefrontal cortex—an improvement associated with better anger regulation. Thus, the interactive regulation of these two hormones, facilitated through physical training, may serve as the biological basis for developmental prevention (Biddle & Asare, 2011).

Recent findings also support this paradigm. Fairchild and colleagues (2011) found that in adolescent girls with conduct disorder, emotional regulation deficits were linked to reduced prefrontal activity, and therapeutic responses were associated with restoration of function in this brain region (Fairchild et al., 2011).

In the context of social prevention policies, sport is not merely a means of physical exertion or emotional ventilation; it can serve as a multidimensional intervention for empowering adolescents who are vulnerable to social exclusion, domestic violence, or structural poverty. These youth, due to their exposure to high-risk environments, are more prone than their peers to manifest aggressive behaviors or delinquent tendencies. In such situations, organized sports groups provide not only a structured environment for learning discipline, cooperation, and self-restraint but also an opportunity to rebuild social identity and strengthen a sense of belonging.

A systematic review by Brunelle and colleagues (2007) found that life-skills-based sport programs significantly reduced psychosocial risk factors and enhanced social support among disadvantaged adolescents. These programs, which emphasize active participation, positive role modeling, and structured relationships with coaches, create a foundation for replacing antisocial behavior patterns (Brunelle et al., 2007).

In a meta-analysis conducted by Spruit et al. (2016), the researchers reviewed 30 empirical studies and demonstrated that regular adolescent participation in sports was significantly associated with reductions in delinquent behavior. The key findings indicated that sports—particularly when delivered through structured programs with trained coaches—could reduce violent crimes, property destruction, and social rule violations by up to 35%. The primary mechanisms underlying this effect included enhanced self-regulation, the development of a positive social identity, and decreased opportunities to associate with delinquent peers. Importantly, the protective effects of sports were found to be independent of gender or socio-economic status but were maximized in integrated programs combining sports with life skills education. This study highlights the critical need for targeted sports interventions as part of juvenile crime prevention strategies. On a broader scale, the Dutch crime prevention program “Only You Decide Who You Are” found that adolescents in vocational schools and underprivileged neighborhoods who participated in sports for one year exhibited fewer risky behaviors—particularly when guided by ethically competent coaches and provided with effective social support (Spruit et al., 2016).

The state of Victoria in Australia has also implemented structured sports programs under the "Sports Alliance for Crime Prevention" as a means to reduce crime and enhance social cohesion, especially in marginalized communities. This initiative, conducted in partnership with sports organizations, law enforcement, and social agencies, focuses on three core components: (1) early prevention through engaging at-risk youth in sports, (2) developing life skills such as leadership and teamwork, and (3) fostering social bonds between participants, coaches, and the broader community. Successful examples of this program include collaborations with local football and basketball leagues to offer integrated sport-education courses. Reports indicate that this approach has been effective in reducing risky behaviors and improving educational outcomes among youth.

In efforts to expand innovative social interventions for violence and crime prevention, several countries have officially integrated sports into their preventive policymaking. Comparative studies on the *Kickz* programs in the United Kingdom, *Midnight Basketball* in the United States, and Nordic projects in Europe have shown that structured sports interventions have not only reduced street violence and gang affiliation rates but have also been effective in lowering recidivism (Meek, 2018; Nichols, 2007; Norman et al., 2024).

2.1. Kickz – United Kingdom

The *Kickz* program, launched in 2006 by the Football Foundation in collaboration with local police and Premier League clubs, aimed to use football as a tool to engage at-risk adolescents from underprivileged urban areas. This initiative involved not only sports activities but also life skills education, social engagement, and interaction with local police officers. According to Geoff Nichols' report (2007), an evaluation of three years of *Kickz* implementation revealed a 25% reduction in crime rates in the neighborhoods covered by the program—particularly in relation to minor street offenses, vandalism, and group conflicts. Moreover, young participants reported stronger social belonging, a more positive perception of the police, and improved social skills (Nichols, 2007).

2.2. US Midnight Basketball – United States

Midnight Basketball is a socio-sportive initiative developed to steer youth—particularly those in marginalized and high-risk areas—away from violence and delinquent behavior during nighttime hours. Originally established in the 1980s in the United States, the program offered structured basketball activities during weekend nights, which statistically correspond to higher crime rates. In addition to sports, the program included life skills training, career counseling, and addiction prevention workshops to foster personal and social development. *Midnight Basketball* not only aimed to reduce short-term crime but also fostered long-term community improvement by building positive relationships among youth, coaches, and local communities. It has since become a global model for crime prevention through sport-based interventions (Meek, 2018).

2.3. Nordic Models (Sweden, Norway, Finland)

In Northern European countries, sports are used not only as a crime prevention tool but also as an integral part of child development and social justice policy. In these countries, local sports clubs cooperate with schools, municipalities, and social services to deliver structured educational sports programs to at-risk youth. The book *Youth Crime Prevention and Sports* (2022) highlights how in Norway and Sweden, the integration of sports with psychological counseling and life skills training has significantly reduced youth involvement in criminal gangs and rates of reoffending. These countries place great emphasis on continuous program evaluation and ethical training for coaches (Dandurand & Heidt, 2022).

3. The Position of Sports in Preventive Social Policy (Integrating Sports into Education, Mental Health, and Criminal Justice)

In the contemporary landscape of social policy, sport is no longer seen merely as a recreational or educational activity, but rather as a multipurpose tool for improving mental health, enhancing cognitive capacities, and preventing social harms among high-risk children and adolescents. This cross-sectoral approach has gained recognition in both educational systems and juvenile mental health and justice services, and is supported by international research evidence.

A study examining the relationship between participation in physical activity and health indicators among youth in juvenile correctional facilities found that these adolescents generally exhibited lower levels of physical activity and physical fitness (e.g., cardiovascular endurance, muscle strength, and flexibility) compared to their community-based peers. The authors emphasized that structured sport programs in correctional settings can enhance physical and mental well-being and reduce the likelihood of relapse into risky behaviors. This study underscores the necessity of incorporating physical activity as a core component of rehabilitation and reentry programs for at-risk youth (Brusseau et al., 2018).

A scoping review by Norman et al. (2024), titled *Sport, Physical Activity, and Young People Who Are Incarcerated*, systematically analyzed existing research and concluded that structured sport interventions in correctional environments can yield multidimensional benefits. These include improvements in physical health indicators (e.g., better body composition and cardiovascular fitness), mental health (e.g., reductions in depression and anxiety), and life skills such as teamwork, anger management, and conflict resolution. The researchers emphasized the importance of culturally and demographically tailored interventions and recommended that program design consider variables such as gender, ethnicity, and duration of detention. The study also identified key research gaps regarding the mechanisms through which sport reduces recidivism and promotes successful reintegration, and called for longitudinal mixed-methods research to advance understanding of these outcomes (Norman et al., 2024).

The 2018 UK government report *A Sporting Chance: An Independent Review of Sport in Youth and Adult Prisons*, analyzed the role of sport programs in reducing recidivism and improving social outcomes for justice-involved individuals. Based on interviews with stakeholders and a review of empirical evidence, the report concluded that sport interventions—when structured and goal-oriented (e.g., life skills development, mental health support, and employment preparation)—can reduce recidivism rates by up to 20%. The authors stressed the need for inter-sectoral collaboration (among prisons, sports organizations, and social services) and long-term investment to realize the full potential of such programs. The report also provided a framework for evaluating the effectiveness of sport-based interventions within the criminal justice system (Meek, 2018).

Empirical research confirms the multifaceted benefits of structured sports programs in juvenile correctional settings. These programs enhance psychological health by reducing symptoms of depression and anxiety, foster social skills such as teamwork and communication, and increase perceived well-being, including self-efficacy and hope. Maximum effectiveness is achieved when sports activities are integrated with psychosocial and educational interventions. Findings suggest that investment in such programs should be considered an essential component of comprehensive rehabilitation strategies within juvenile justice systems (Espinoza et al., 2024).

A key aspect of legitimizing these policies lies in the contribution of neuro-law. Findings from cognitive neuroscience, particularly regarding dysfunctions in the prefrontal cortex and irregular regulation of aggression-related hormones (e.g., cortisol and testosterone), reveal that many criminal behaviors in children and adolescents stem from neuro-emotional developmental deficiencies. Within this framework, sport can serve as a scientifically grounded alternative treatment

intervention—one that enhances neural functioning and subsequently reduces delinquency risk (Biddle & Asare, 2011; Kaldewaij et al., 2019; Raine, 2013).

4. Sports, Behavioral Resilience, and the Necessity of Multi-Level Neuroscience-Based Policy

Theoretical and empirical analyses demonstrate that sport, as a biopsychosocial intervention, plays a key role in enhancing behavioral resilience in adolescents and reducing the risk of delinquency. Sport affects not only physical and psychological dimensions but also contributes to behavioral regulation by inducing neurobiological changes and rebuilding inhibitory neural networks. This intervention is most effective when designed and implemented within an integrated strategy encompassing education, mental health, and criminal justice systems.

The study by Rodriguez-Ayllon et al. (2023) examined neurobiological, psychosocial, and behavioral mechanisms mediating the relationship between physical activity and psychiatric symptoms among Dutch adolescents. The findings showed that regular physical activity influences mental health outcomes through multiple pathways: (1) neurobiological mechanisms such as increased hippocampal volume and enhanced executive functioning, (2) psychosocial factors like increased social support and self-esteem, and (3) healthy behaviors such as improved sleep patterns and reduced engagement in risky behavior. These effects were especially significant in reducing symptoms of depression, anxiety, and attention problems. The study underscores the importance of promoting physical activity in mental health prevention and intervention programs for adolescents (Rodriguez-Ayllon et al., 2023).

The models of *differential susceptibility* and *biological sensitivity to context* provide important scientific frameworks for understanding individual differences in response to environmental conditions. The *differential susceptibility model*, proposed by Belsky and Pluess (2009), posits that certain individuals, due to specific genetic characteristics, are more vulnerable to adverse environments but also benefit more from positive ones. For example, adolescents with particular serotonergic gene variants may be more prone to depression in stressful settings and simultaneously more responsive to improvement in supportive environments. Similarly, the *biological sensitivity to context* theory developed by Ellis and Boyce (2011) emphasizes physiological variability in environmental responsiveness, indicating that individuals with more reactive neuroendocrine systems are both more affected by negative environments and more positively impacted by enriched contexts. These findings highlight the need for personalized interventions such as sports programs, which can be tailored for highly sensitive individuals to maximize positive outcomes. Research has shown that such interventions, when aligned with individuals' neurobiological profiles, can effectively improve mental health and reduce risky behaviors (Belsky & Pluess, 2009; Ellis et al., 2011).

From a biological standpoint, these models suggest that adolescent responses to risk factors vary according to genetic and neurophysiological predispositions. Dual models like *differential susceptibility* and *biological sensitivity to context* support the notion that some adolescents respond more positively to interventions such as sport, thereby significantly reducing their likelihood of criminal involvement. This variability underscores the necessity of brain-based, individualized programming. Most importantly, effective policymaking should recognize the scientific foundation of sport as a neurobiological and behavioral tool. Emerging concepts in neurolaw can enhance the legal legitimacy of such interventions. For instance, if deficits in prefrontal functioning or hormonal dysregulation are acknowledged as contributing factors to aggression, sport can be positioned not only as an educational activity but also as a rehabilitative alternative to punitive sanctions (Farahany, 2015; Glannon, 2011).

5. The Integrative Potential of Sports in Preventive Criminal Policy

Preventive criminal policy, as one of the contemporary approaches within criminal law, focuses on early intervention and the reduction of risk factors that lead to criminal behavior. This policy framework aims to prevent the occurrence and especially the recurrence of crime by identifying and modifying criminogenic factors early on. Early intervention, in this context, refers to actions taken during various stages of child and adolescent development to prevent the chronic and repetitive nature of delinquency in adulthood. These interventions typically take place in primary socialization environments such as family,

school, and peer groups, and aim to eliminate or mitigate risk factors while reinforcing protective elements that enhance resistance to criminal behavior.

Within this framework, sport is increasingly viewed as an effective tool for behavioral correction, cognitive restructuring, and emotional regulation. It is not merely a physical activity but also a social and psychological process that contributes meaningfully to reducing social deviance and preventing delinquency. Multiple studies have shown that participation in structured sports programs—especially among youth—can prevent criminal involvement by fostering positive identity, a sense of empowerment, enhanced self-control, and teamwork skills. Sporting activities also decrease interaction with deviant peers and increase prosocial engagement, while promoting values such as effort, cooperation, and achievement—factors that deter antisocial and criminal behaviors (Nemati, 2019).

Practical examples confirm the preventive function of sport. In Kansas City, USA, evening and nighttime basketball programs for children and adolescents led to a significant reduction in youth crime rates. In Virginia, a decrease in delinquency was observed among young girls participating in organized walking programs. In Australia, sport-based rehabilitation initiatives for Indigenous youth offenders contributed to lower crime rates within these communities. These experiences demonstrate that sport can serve as a powerful tool in preventive criminal policy, supporting both cognitive restructuring and emotional regulation to reduce recidivism (Shamloo & Mousazadeh, 2011).

Thus, preventive criminal policy—by focusing on early intervention and risk reduction and utilizing tools such as sport—can function as a comprehensive strategy to reduce delinquency and promote psychological and social well-being, particularly among vulnerable groups. This approach not only targets individual rehabilitation but also facilitates broader societal change by improving social environments and reinforcing protective factors, ultimately contributing to a safer and more resilient society (Motavallizadeh Naeini, 2017).

6. Criminological Evidence: The Role of Sports in Primary, Secondary, and Tertiary Crime Prevention

Extensive criminological evidence indicates that sports play a significant role across all three levels of crime prevention—primary, secondary, and tertiary—and can contribute both scientifically and practically to the reduction of delinquency and the rehabilitation of offenders.

Primary prevention focuses on preventing individuals from entering the pathway to delinquency. At this level, sport serves as a tool to empower at-risk youth in schools and underserved neighborhoods. Organized sport programs, by fostering positive identity, enhancing self-efficacy, boosting self-esteem, and developing social skills, can protect adolescents from high-risk environments while offering healthy outlets for energy, excitement, and sensation-seeking. International studies have shown that sport participation significantly reduces youth crime rates in vulnerable areas. For example, *Midnight Basketball* programs in Kansas City, USA, led to a 33–66% reduction in youth crime rates. Similarly, sport camps in Canada and comparable initiatives in the UK and Australia—emphasizing teamwork and character-building—have yielded substantial reductions in delinquency. Sports enhance peer connectivity, problem-solving, and self-control, making adolescents more resilient to social pressures and criminal influences. Beyond providing recreation and energy release, these activities help youth internalize social values and responsibility, thereby deterring entry into the criminal justice system (Brunelle et al., 2007; Nichols, 2007; Spruit et al., 2016).

Secondary prevention targets individuals who have a history of risky behavior or initial contact with the justice system. In this context, sport functions as both a corrective and preventive mechanism, offering structure, discipline, and purpose that reduce the likelihood of reoffending. Supervised programs led by trained coaches and specialists provide supportive environments where participants can strengthen their self-regulation, teamwork, and accountability. Studies have demonstrated that youth with high-risk backgrounds who participate in sport are less likely to associate with deviant peers and more likely to avoid re-engagement with criminal behavior. Furthermore, these programs often provide educational and employment pathways, facilitating smoother reintegration into society (Espinoza et al., 2024; Norman et al., 2024).

Tertiary prevention focuses on the rehabilitation of offenders and the prevention of recidivism after release. In correctional facilities, sport plays a key role in behavioral reform, improving physical and mental health, and rebuilding self-confidence. Within closed environments like prisons, sport helps structure leisure time productively, reduces stress, channels negative

energy, and promotes psychological well-being. It fosters attitude change, increases social adaptability, encourages self-belief, and reduces feelings of failure. These programs transfer prosocial values, introduce positive role models, and create opportunities for constructive interaction—preparing inmates for societal reintegration and reducing the risk of reoffending (Dandurand & Heidt, 2022; Meek, 2018; Nichols, 2007).

According to both empirical and scientific evidence, sport is not only a means to physical and mental health but also an effective strategy for crime prevention and reduction across society. By cultivating social skills, reinforcing individual and collective identity, and creating positive developmental opportunities, sport can divert adolescents and young adults from deviant paths, mitigate risky behaviors, and facilitate the successful reintegration of offenders into healthy civilian life (Kalashi et al., 2020).

7. Neurobiological Mechanisms Supporting Sport-Based Interventions in Criminal Justice

The neurobiological mechanisms supporting sport-based interventions in criminal justice scientifically demonstrate how sport can reduce aggressive behaviors and enhance cognitive and behavioral competencies in offenders and at-risk individuals through direct effects on brain and nervous system function. The prefrontal cortex, known for its role in decision-making, impulse control, and social behavior regulation, is frequently impaired in violent offenders, leading to reduced inhibitory capacity and increased aggression. Regular physical exercise stimulates neuronal activity and increases cerebral blood flow to this region, thereby enhancing executive functioning and logical decision-making, which in turn contributes to the reduction of violent behaviors and supports behavioral reform (Blair, 2007; Hillman et al., 2005).

Cortisol, the stress hormone, when chronically elevated, heightens irritability and aggressiveness. Exercise acts as an effective intervention by lowering chronic cortisol levels and balancing hormonal profiles in the body. This hormonal regulation not only reduces stress but also keeps aggression-related hormones such as adrenaline and testosterone at moderated levels. Thus, physical activity contributes to reduced irritability and violent tendencies while fostering a more stable psychological environment for individuals involved in the justice system (Biddle & Asare, 2011; Dennis et al., 2021).

Cognitive flexibility, the capacity to adapt effectively to novel or complex situations, is often diminished in offenders and incarcerated individuals. Through enhanced brain activity related to memory, attention, and problem-solving, sports participation promotes improvements in cognitive flexibility and decision-making capacity. This enables juvenile and adult offenders to better analyze social situations, predict consequences of their actions, and make more responsible decisions (Zare Abandansari et al., 2022).

Scientific and criminological research confirms that sport, as a multifaceted intervention, contributes to behavioral correction and recidivism prevention by enhancing prefrontal cortex functioning, reducing chronic stress, regulating aggression-related hormones, and improving cognitive adaptability. These neurobiological mechanisms provide robust scientific justification for the integration of sport into criminal rehabilitation programs and underscore its positive effects in reducing violence and improving the psychological and social well-being of individuals engaged with the justice system (Kordlou et al., 2016; Pardo & Patterson, 2013; Rodriguez-Ayllon et al., 2023).

Challenges and Operational Requirements for Integrating Sports into the Criminal Justice System

The integration of sports into the criminal justice system as an innovative and effective approach for crime prevention and offender rehabilitation faces numerous operational and structural challenges that must be addressed systematically and scientifically to ensure the effectiveness of these interventions. One of the foremost operational prerequisites is the specialized and ethical training of sports coaches involved in criminal justice programs. These coaches must possess not only technical athletic expertise but also psychological competencies, behavioral management skills, and criminological awareness to engage constructively with offenders or at-risk individuals. Without such competencies, there is a risk of exacerbating behavioral issues, undermining rehabilitative goals, or even intensifying aggression. Criminological and sports psychology research emphasizes that coaches should receive targeted training in anger management, stress regulation, and working with vulnerable populations in order to perform their supportive and corrective roles effectively (Cooter, 2015).

To ensure the success of sport-based interventions in the justice system, it is crucial to develop and implement standardized scientific protocols for evaluating their impact on recidivism reduction and mental health improvement. These protocols should

include both quantitative and qualitative metrics, covering indicators such as psychological well-being, aggressive behaviors, social skills development, and recidivism rates. In the absence of systematic assessment mechanisms, measuring the true success and adjusting the implementation of these programs becomes impossible. Moreover, these evaluations must be conducted continuously over predetermined intervals to capture the long-term behavioral effects of sport-based interventions among offenders and high-risk individuals. The lack of such evaluation frameworks remains a major barrier to the institutional acceptance and development of sport as a formal rehabilitative tool.

Beyond technical and methodological considerations, there are significant structural and cultural obstacles impeding the adoption of sport as a formal element in penal intervention. Structurally, the absence of clear legal frameworks, lack of specialized coordinating bodies, and limited financial and infrastructural resources all serve as fundamental constraints to the development of this approach. Culturally, in many societies, traditional punitive mindsets still dominate attitudes toward criminal justice, and sport as an alternative or complementary intervention faces resistance. Common barriers include public ignorance of sport's rehabilitative benefits, negative perceptions of its effectiveness, and distrust of non-traditional programs (Daly et al., 2005).

Legal and criminological studies in various countries emphasize that successful implementation requires large-scale public education, cultural reform, and strategic policymaking to foster the institutional acceptance of sport within criminal justice. It is also imperative to foster cooperation between judicial, athletic, and social institutions to facilitate the rollout of sport-based rehabilitative programs. Despite the potential of sport to correct behavior and reduce crime, these outcomes can only be achieved if qualified, ethical coaches are trained, scientific evaluation protocols are enforced, and structural and cultural barriers are addressed. Without these conditions, sport-based criminal interventions may fail or even yield counterproductive results. Hence, the development of this model necessitates interdisciplinary collaboration among legal scholars, psychologists, sports scientists, and policymakers to establish a comprehensive and effective framework for implementing sport as a penal intervention (Dołęga et al., 2024).

As a scientific, low-cost, and socially integrative intervention, sport has gained a special status within modern criminal justice policy. Scientific and empirical evidence confirms that sport improves physical and mental health, enhances social skills, reduces aggression, and functions as a powerful tool for both prevention and rehabilitation. These features make sport an efficient, cost-effective, and socially acceptable strategy for justice systems. As a result, policymakers and criminal justice officials are increasingly turning to sport as a complementary or alternative intervention to traditional punitive measures.

It is therefore recommended that structured and evidence-based therapeutic sport programs be designed and implemented within a restorative justice framework. These programs should be grounded in principles from psychology, criminology, and exercise science and aim to promote mental health, increase self-regulation, improve cognitive flexibility, and strengthen social skills among justice-involved individuals. Therapeutic sport programs that facilitate active participation, foster responsibility, and reduce stress and aggression can play a pivotal role in reducing recidivism and enabling successful reintegration. By emphasizing rehabilitation over punishment, this approach promotes a more humane and effective model of criminal justice (Cotman & Berchtold, 2002).

Equally important is the connection between neurolaw and the legitimation of sport-based interventions in judicial settings. Neurobiological findings have shown that sport enhances prefrontal cortex function, modulates aggression-related hormones, and improves cognitive capacities, all of which can produce deep and lasting behavioral change in offenders. This emerging knowledge base provides a solid scientific foundation for the justification and legitimation of sport as a corrective tool within judicial processes. As such, sport-based interventions may increasingly be considered scientific and humane alternatives to incarceration, grounded in evidence-based neuroscience and respect for human dignity. Advancing this model requires interdisciplinary cooperation to develop appropriate legal and institutional frameworks that recognize sport as a viable, low-cost, and socially integrative method within modern criminal justice systems (Dasdemir et al., 2018).

8. Legal Analysis of Neuroscience Data in Criminal Policy (from a Neurolaw Perspective)

The rapid development of neuroimaging technologies and advancements in neuroscience over recent decades have opened new frontiers for the social sciences and humanities—particularly in criminal law. Neuroscience tools such as fMRI (functional Magnetic Resonance Imaging), EEG (Electroencephalography), and PET (Positron Emission Tomography) now allow for the

acquisition of objective, biological, and neurological data about the brain mechanisms underlying human behavior. These data—especially in contexts involving risky, violent, or antisocial behavior—have the potential to influence and even challenge traditional doctrines in criminal law (Greene & Cohen, 2004).

In response, the emerging field of neurolaw explores the application of neuroscience in the explanation, evaluation, and adjudication of legal issues. This interdisciplinary domain seeks to integrate neuroscience findings into core concepts of criminal law, such as intent, culpability, will, and behavioral predictability. Neurolaw raises foundational questions like: *Can individuals with neurological impairments still be held criminally responsible?* or *Can specific brain patterns predict or prevent crime?*—thereby introducing a new paradigm into legal analysis (Farahany, 2015; Morse, 2006).

Concurrently, criminal policy has shifted—from a strictly retributive model toward preventive, rehabilitative, and individualized approaches. Within this context, neuroscience offers promising tools for early detection of criminal risk, assessment of rehabilitation potential, and the design of targeted interventions across all levels of crime prevention (primary, secondary, tertiary) (Bublitz & Merkel, 2014; Vincent, 2006).

Nevertheless, the use of neuroscience data in criminal policymaking is not without legal, ethical, and technical challenges. Foundational principles such as individual responsibility, presumption of innocence, and the rational actor model may conflict with biological interpretations of behavior. Furthermore, concerns about privacy, neuro-stigmatization, and deterministic prediction highlight the need for well-defined and cautious legal frameworks. These frameworks must safeguard against misuse while respecting individual rights and civil liberties (Pardo & Patterson, 2013; Roskies, 2006).

Thus, the legal application of neuroscience in criminal justice—especially in the realm of violent crime prevention—requires careful theoretical, empirical, and ethical consideration. When applied within transparent and rights-based mechanisms, neuroscience can enhance understanding of the underlying causes of criminal behavior, promote more scientific and personalized penal strategies, and strengthen the effectiveness of preventive measures. However, these gains are conditional upon responsible and rights-conscious use of neuroscientific evidence in judicial and policy contexts.

The Role of Neuroscience in Analyzing Criminal Responsibility

Criminal responsibility is one of the foundational pillars of classical criminal law, built on assumptions such as rationality, free will, and an individual's voluntary control over their actions. According to this traditional perspective, an individual is held legally accountable as long as they possess the capacity to understand the nature of their actions and to distinguish right from wrong. However, the emergence of neuroscience has significantly challenged this foundation. Neuroscientific data suggest that biological, neurological, and even genetic structures can profoundly influence a person's behavior, decision-making, and self-regulation (Morse, 2006).

Brain imaging studies have demonstrated that damage or dysfunction in brain regions such as the prefrontal cortex—responsible for self-regulation, decision-making, and behavioral inhibition—is associated with an increased likelihood of impulsive, violent, and antisocial behaviors. Similarly, the amygdala, which plays a central role in processing negative emotions such as fear, anger, and threat, often shows abnormal hyperactivity or hypoactivity in some offenders. For instance, research on individuals with antisocial personality disorder and psychopathy indicates that these individuals, on average, exhibit atypical activity in these brain regions (Blair, 2007; Raine, 2013).

These findings suggest that, for some individuals, brain structure or functional abnormalities may fundamentally impair their ability to control behavior or anticipate consequences. Consequently, legal scholars and neurophilosophers have debated whether such individuals should bear the same level of criminal responsibility as others. One perspective asserts that the mere presence of a brain disorder should not automatically negate criminal responsibility unless it results in a proven incapacity to comprehend or control one's actions—a stance aligned with classical legal standards such as the insanity defense and the criteria of impaired cognition or volition (Morse, 2006).

Conversely, other scholars argue that neuroscience data may not only have exculpatory value but also provide mitigating grounds. That is, even if the brain disorder does not absolve a person of full responsibility, it may warrant sentencing leniency or the substitution of custodial punishment with medical or psychological treatment (Jones, Schall, et al., 2013; Vincent et al., 2012).

Moreover, the entry of neuroscience into criminal responsibility analysis has reignited debates around free will and conscious decision-making. Some researchers, such as Benjamin Libet (1985), have shown through experiments that the brain initiates decisions milliseconds before a person becomes consciously aware of them. Although still debated philosophically and empirically, such findings prompt deeper scientific inquiry into the mental processes behind criminal intent (Greene & Cohen, 2004; Roskies, 2006).

Nonetheless, applying neuroscience data in determining criminal responsibility must be approached with caution. Misinterpretation or oversimplification of neuroscientific findings could result in unjust outcomes. Not all individuals with brain abnormalities commit crimes, nor do all offenders have verifiable neurological disorders. Furthermore, neuroscience research is often population-based, and its application to individuals requires precise clinical, psychiatric, and legal assessments (Pardo & Patterson, 2013).

Accordingly, the role of neuroscience in assessing criminal responsibility can be considered across three levels:

1. **Exculpation**: Where neurological impairments render an individual incapable of understanding their actions or controlling their behavior, a defense based on insanity or non-responsibility may apply.
2. **Mitigation**: Where neurological deficits reduce, but do not eliminate, cognitive or volitional capacity, they may justify reduced sentencing or alternative interventions.
3. **Prediction and Prevention**: Neuroscientific data may inform courts about the likelihood of reoffending or the potential for rehabilitation, thus influencing sentencing and parole decisions.

Ultimately, integrating neuroscience into the legal assessment of responsibility requires clear legislation, standardized legal procedures, and interdisciplinary cooperation among neurologists, psychiatrists, and legal professionals to ensure that criminal justice remains both scientifically informed and respectful of fundamental rights.

9. Legal Challenges in Using Neurobiological Sport-Based Data for Violence Prevention

Recent advances in neuroscience—particularly in neuroimaging techniques (such as fMRI and PET scans) and biohormonal assessments—have enabled the identification and, in some cases, prediction of the neurobiological roots of aggressive and violent behavior. Simultaneously, multiple studies confirm that regular physical activity can prevent violence through enhanced cognitive functioning, reduced stress hormone levels (such as cortisol), and regulation of dopamine–serotonin balance (Dishman et al., 2006; Lubans et al., 2016).

However, using such data in criminal policy or judicial proceedings—particularly for preventive interventions—poses several fundamental legal challenges:

1. **Conflict with the Principle of Legality and Legislative Gaps**: One major challenge is the absence of explicit legal frameworks permitting the use of neurobiological or psychobiological data derived from sport-based activity within the criminal justice system. Under the principle of legality, any restriction on liberty or intervention in individual rights must have a clear legal basis. Yet, neither Iranian law nor the legislation of many other jurisdictions currently addresses the use of biomarkers such as testosterone levels, brain structure, or neurological responses to physical activity for risk assessment, responsibility determination, or preventive action. This regulatory vacuum creates ambiguity in the legal legitimacy of bio-based interventions and opens the door to controversial state actions (Pardo & Patterson, 2013).
2. **Judicial Acceptance and Evidentiary Status of Scientific Data**: The admissibility of neuroscience or hormonal data in criminal trials—whether as evidence for lack of control, diminished responsibility, or future crime prediction—remains unsettled in many legal systems. Comparative studies indicate that while some U.S. courts have allowed limited use of fMRI data to demonstrate cognitive impairment (Greene & Cohen, 2004), debates continue regarding the probative value, scientific validity, and risk of misinterpretation. Judges are concerned that brain-based evidence may distort human judgment or lead to flawed interpretations of neurological conditions, resulting in unjust verdicts (Morse, 2006).
3. **Conflict with Due Process and the Presumption of Innocence**: The use of biological and neurological data for preventive interventions—such as preemptive screening of at-risk youth or mandating sport-based programs for

individuals showing aggression biomarkers—could violate the presumption of innocence and the principle of individual responsibility. Classical criminal law dictates that penal intervention should follow the commission of a crime, not be based on theoretical probabilities. Even if predictive models are scientifically sound, relying on such data could result in punishment based on potential rather than actual behavior, undermining fundamental justice principles (Vincent, 2006).

4. **Inconsistency with Classical Concepts of Free Will and Responsibility**: Neuroscience—particularly in the context of violent behavior—raises foundational questions about autonomy, free will, and moral culpability. If scientific findings indicate that a person's brain is structurally or functionally predisposed to aggression, to what extent can they be considered fully autonomous and criminally responsible? Furthermore, if physical activity can improve these brain structures, does non-participation in sport amount to a form of negligence? These questions remain unresolved within legal doctrine and illustrate a growing tension between traditional legal thought and modern neuroscience (Glannon, 2011).
5. **Lack of Judicial Expertise in Interpreting Neuroscientific and Sport-Related Biological Data**: Legal professionals—judges, prosecutors, and attorneys—are typically trained within a traditional legal framework and may lack adequate understanding of complex neuroscientific or bio-sport data. This lack of expertise increases the likelihood that such data may either be ignored or misinterpreted, leading to judicial error. In the absence of interdisciplinary advisory bodies—such as neurolegal committees—the incorporation of scientific findings into criminal proceedings, especially in sensitive areas like violence, remains high-risk (Jones, Marois, et al., 2013).

10. Discussion and Conclusion

The integration of neuroscience into criminal policy facilitates a paradigmatic shift from a punishment-based model to a neuro-rehabilitative approach. Considering the moderating role of exercise on neurobiological factors associated with violence—such as cortisol regulation, enhanced prefrontal cortex function, and improved synaptic plasticity—the formulation of sports-based neuro-criminal policies is necessary at three levels: prevention, adjudication, and rehabilitation. This approach requires the collaboration of legal institutions (such as the judiciary), scientific bodies (including neuroscience centers), and executive entities (such as prisons and correctional facilities) to develop effective and ethically grounded legal frameworks. Prospective studies suggest that incorporating exercise into restorative justice programs, supported by neuroscience, can significantly reduce judicial system costs.

Neuro-law, as an interdisciplinary domain, establishes a bridge between neuroscience and legal systems, aiming to redefine fundamental concepts of criminal law such as criminal responsibility, intent, and rehabilitative capacity based on neuroscientific evidence. This approach operates at three analytical levels:

- **Legal-Procedural Level**: Utilizing brain imaging (such as fMRI and PET scans) and neuropsychological evaluations as scientific evidence in court proceedings to demonstrate functional brain impairments linked to criminal behavior.
- **Philosophical-Ethical Level**: Revisiting the notion of "free will" in light of findings from neuroscience that demonstrate how neurobiological factors can influence individual decision-making processes.
- **Policy Level**: Designing corrective interventions based on neuroscientific findings, such as neurofeedback programs aimed at reducing aggression in inmates.

Application of Neuroscientific Data Across Criminal Justice Stages

1. **Before Crime (Preventive Level):**
    - Identifying individuals at risk of violent behavior through neurobiological markers (e.g., reduced amygdala volume or impaired prefrontal cortex function) and implementing sports-based neuro-interventions to modulate these factors.
    - Regular physical activity has been shown to increase the thickness of the orbitofrontal cortex and improve limbic system performance, thereby enhancing the brain’s capacity to inhibit violent impulses.
2. **After Crime (Reactive Level):**
    - Evaluating criminal responsibility in light of neuroscientific data: courts have increasingly considered neuroscience in determining the degree of legal responsibility, especially in cases of serious violent offenses.

- Replacing traditional punishments with neuro-rehabilitative programs: therapeutic exercise regimens have demonstrated effectiveness in regulating cortisol and testosterone levels in violent offenders, contributing to reductions in recidivism rates.

3. **During Rehabilitation (Corrective Level):**
   - Developing targeted exercise protocols to enhance cognitive flexibility among inmates: combined aerobic and mindfulness-based programs have been associated with improvements in executive brain function.
   - Using neurofeedback alongside physical activity to regulate brainwave patterns associated with anger control and impulsivity.

Key Challenges:

- **Risk of Neuro-Determinism**: Attributing diminished moral responsibility to individuals solely based on abnormal brain patterns.
- **Ethical Concerns in Screening**: Potential misuse of neuroscientific data to stigmatize high-risk groups or justify intrusive surveillance measures.
- **Inconsistency with Classical Legal Standards**: Particularly in legal systems that emphasize mens rea (intent and awareness), neuroscientific arguments may disrupt established doctrines of responsibility.

Legal Remedies:

- **Developing Evidentiary Standards**: Establishing scientific criteria for the admissibility of brain imaging in legal proceedings, ensuring rigor and consistency.
- **Integrating Rehabilitative Approaches with Neuroscience**: Redefining punitive measures to include neuroscience-informed, exercise-based corrective strategies grounded in neuroplasticity principles.
- **Establishing Regulatory Frameworks for Neurodata Protection**: Ensuring that the use of brain data in legal contexts respects informed consent and safeguards personal autonomy.

In sum, while the use of neurobiological data and the physiological effects of exercise offers promising avenues for violence prevention, it also poses serious legal and ethical challenges. These challenges stem not only from legislative gaps but also from conceptual tensions between emerging scientific knowledge and the traditional foundations of criminal law. Overcoming these obstacles requires a rethinking of classical legal doctrines, interdisciplinary education, and the development of clear, transparent regulations for the legitimate use of scientific data in criminal proceedings and preventive policymaking.

The ethical dilemmas outlined here underscore that any application of neuroscience or the biological effects of exercise in criminal justice or violence prevention must be approached with precision, caution, and adherence to core ethical principles. Central to this are the values of human dignity, respect for individual autonomy, protection of biological privacy, and equitable access to rehabilitative interventions. Neglecting these principles may undermine the moral legitimacy of such programs and erode public trust in the justice system and social security.

For the effective application of neuroscience findings in reducing violence through exercise, special attention must be given to institutional and operational challenges. The development of interdisciplinary structures, the training of specialized professionals, the drafting of comprehensive guidelines, and the alignment of criminal law with emerging scientific knowledge are essential for the successful implementation of this approach. Without addressing these barriers, the theoretical potential of this field will not translate into sustainable and impactful practice.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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Conflict of Interest

The authors report no conflict of interest.

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