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The Relationship between in Health Gymnastics Participation and Social Integration: A Comparative Study among Secondary School

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ABSTRACT. This study aims to conduct a comparative investigation of the level of social integration between gymnastics practitioners and non-practitioners among secondary school students in the Wilaya of Guelma, Algeria. The sample consisted of 60 final-year students, equally divided by gender (30 males and 30 females). Each gender group was further divided into 15 practitioners and 15 non-practitioners. The Social Integration Scale was used as the research instrument, comprising 40 items distributed across three dimensions: Peer Relations, Teacher-Student Relations, and Participation in School Activities. The study was conducted during March and April 2024. Data were statistically analyzed using descriptive statistics (mean and standard deviation) and an Independent Samples t-test via SPSS (Version 25), with a significance level set at ($\alpha = 0.05$). The results revealed statistically significant differences in the level of social integration between gymnastics practitioners and non-practitioners for both male and female students. Practitioners recorded higher scores, reflecting a superior level of social integration compared to their non-practitioner counterparts. Consequently, the study concludes that participation in gymnastics significantly contributes to enhancing students' social integration within the school environment.

Keywords: *Social integration ; gymnastics ; Secondary School; students.*

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INTRODUCTION

Social integration is considered one of the central pillars of students' overall development, as it enhances their capacity to establish positive interpersonal relationships and to participate actively in school life (Wentzel, 2017). A well-integrated student is more likely to feel a sense of belonging and acceptance, which in turn positively affects academic achievement and psychological well-being. Thus, investigating the factors that contribute to social integration remains a priority in educational and social sciences research. Physical activity has been widely recognized as a major contributor to social development among adolescents. Participation in sports fosters cooperation, communication, and teamwork, which are essential components of social integration (Bailey et al., 2013). Adolescents involved in structured physical activities often exhibit stronger interpersonal relationships and enhanced emotional regulation compared to their non-participating peers.

Gymnastics, as a structured physical discipline, is particularly relevant to fostering social and personal growth. Beyond its physical benefits, gymnastics emphasizes discipline, perseverance, and collaboration, which can directly contribute to higher levels of social integration (Kruger & Saayman, 2015). Studies suggest that gymnasts often demonstrate superior levels of confidence and group cohesion when compared to non-athletes. Adolescence, particularly the secondary school stage, is a crucial developmental period during which students seek belonging, peer approval, and identity formation (Steinberg, 2014). Social integration during this phase significantly influences students' mental health, self-esteem, and their readiness to participate constructively in society. The lack of integration, by contrast, can lead to isolation, behavioral problems, and reduced academic motivation.

Several empirical studies have demonstrated the positive correlation between sports participation and social integration. For instance, Eime et al. (2013) highlighted that organized sports provide adolescents with structured opportunities for socialization, cultural exchange, and skill-building. These experiences extend beyond the physical domain, contributing to psychological resilience and stronger school engagement.

In Algeria, increasing attention has been given to the integration of physical education and extracurricular sports within secondary schools. Gymnastics, in particular, has been introduced as a means to promote both health and social values among youth (Bouzid & Slimani, 2020). However, comparative studies assessing the relationship between participation in gymnastics and social integration among Algerian students remain scarce, highlighting a research gap.

Participation in gymnastics is considered the independent variable in this research, as it represents a structured extracurricular activity that combines both individual performance and collective involvement. Previous research has indicated that physical education and sports create environments where students can develop social skills such as cooperation, communication, and respect for rules, which are integral to social integration (Bailey, 2006).

On the other hand, social integration is the dependent variable in this framework. It is operationalized through multiple dimensions, including peer relationships, teacher-student relationships, and participation in school activities. These dimensions reflect how well students are embedded in their social and academic environment, and they collectively capture the overall construct of social integration (Brown & Evans, 2002).

The interaction between gymnastics participation and social integration can be explained through the lens of social capital theory. Sports activities like gymnastics often provide a platform for the formation of trust, reciprocity, and networks of support among students. This social capital, in turn, contributes positively to students' integration within their school and peer groups (Putnam, 2000).

Moreover, participation in gymnastics is associated with the development of psychosocial competencies, such as self-confidence, emotional regulation, and resilience. These competencies act as mediating factors that facilitate stronger social ties and a greater sense of belonging among peers. Students who participate in gymnastics are thus more likely to exhibit higher levels of social integration compared to non-participants (Weiss & Smith, 2002).

The conceptual framework of this study, therefore, posits a direct causal pathway from participation in gymnastics to improved levels of social integration, mediated by enhanced peer interaction, improved teacher-student relations, and increased engagement in school activities. It also recognizes that this relationship may be influenced by contextual factors such as gender, cultural environment, and school policies (Fredricks & Eccles, 2006).

Finally, the framework emphasizes that gymnastics, by combining both individual skill development and collective participation, creates a unique environment that fosters not only physical but also social growth. Hence, the model assumes that students' involvement in gymnastics enhances their opportunities for interaction, collaboration, and acceptance, thereby improving their overall social integration (Eccles & Barber, 1999).

Based on the above context, the present study seeks to examine the relationship between gymnastics participation and social integration among secondary school students in the Wilaya of Guelma, Algeria. By comparing practitioners and non-practitioners across genders, the study aims to provide empirical evidence on how engagement in gymnastics may foster social cohesion,

peer relationships, and active participation in school life. This research is expected to contribute to both academic literature and educational policy by emphasizing the role of sports as a catalyst for social integration in adolescence.

MATERIAL AND METHODS

Participants in the study

This study involved 60 final-year secondary school students from the province of Guelma, Algeria. The sample comprised 30 male students, of whom 15 were gymnastics practitioners and 15 were non-practitioners. Similarly, the female sample consisted of 30 students, with 15 gymnastics practitioners and 15 non-practitioners. The participants were selected randomly. Subsequently, comparisons were conducted on the same tests between the male practitioners and non-practitioners, as well as between the female practitioners and non-practitioners.

Research design

Tests were conducted on the research sample to distinguish between male and female gymnasts who practiced and did not practice gymnastics, to measure their level of social integration.

The study, which was conducted in March and April 2024, consisted of the following stages:

- Social Integration Scale tests were conducted for the male sample from March 20 to April 1.
- Social Integration Scale tests were conducted for the female sample from April 5 to April 15.

Assessments:

Among the field instruments utilized in the study is the following:

The Social Integration Scale

The "Social Integration Scale" was developed by the researcher Abdel Aziz Al-Shakhs specifically for high school students. The scale comprises 40 items, which are both positively and negatively worded.

Objective: The purpose of the scale is to measure a student's ability to adapt and socially integrate within the school environment, both with peers and teachers.

Structure: The scale consists of the following three dimensions (or subscales):

- Relationships with Peers
- Relationships with Teachers
- Participation in School Activities

Response Method: Responses are measured on a five-point Likert scale, ranging from "Strongly Agree" (5 points) to "Strongly Disagree" (1 point).

Interpretation: A high score on the scale reflects a high level of social integration, whereas a low score indicates poor social integration.

Interpretation of Total Scores:

- 15 – 34 points: Low social integration
- 35 – 54 points: Moderate social integration
- 55 – 75 points: High social integration

Validity and Reliability: The scale's validity was established using construct validity and content validity (assessed by expert judges). The reliability of the scale, measured using Cronbach's Alpha, ranged from 0.81 to 0.88. (Al-Shakhis, 2003).

Analysis of statistics:

- The statistical analysis of the research was conducted using SPSS version 25.
- standard deviation (SD) and arithmetic mean.
- independent samples T test.
- The study used &=0.05 as the significance criterion, which translates to a 95% confidence interval.

RESULTS

Table 1. Statistical analysis of the results for the social integration test for females

Social integration test for Females		
Test grade	Practice variable	
	practitioners	non-practitioners
N	15	15
Mean	56.07	10.46
Std. Deviation	37.33	12.53
T test	4.45	
df	28	
Significance level	α=0,05	
Sig	0,00	
Statistical estimate	significant	

Source: Present research

The statistical analysis presented in Table 1 demonstrates significant differences in the social integration test scores between female practitioners and non-practitioners. The mean score for practitioners (M = 56.07, SD = 37.33) was substantially higher than that of non-practitioners (M = 10.46, SD = 12.53). This indicates that female participants engaged in sports activities exhibited notably higher levels of social integration compared to their non-practicing counterparts.

The independent samples t-test yielded a value of $t(28) = 4.45$, with a significance level of $p < 0.001$, which is well below the predetermined threshold of $\alpha = 0.05$. This confirms that the observed difference between the two groups is statistically significant and not attributable to random variation. The results suggest that sports practice has a strong positive effect on enhancing social integration among female students.

These findings align with previous research that highlights the role of physical activity and sports participation in fostering social skills, group belonging, and peer interaction. Engaging in sports provides structured opportunities for communication, teamwork, and collaboration, all of which contribute to higher levels of social integration.

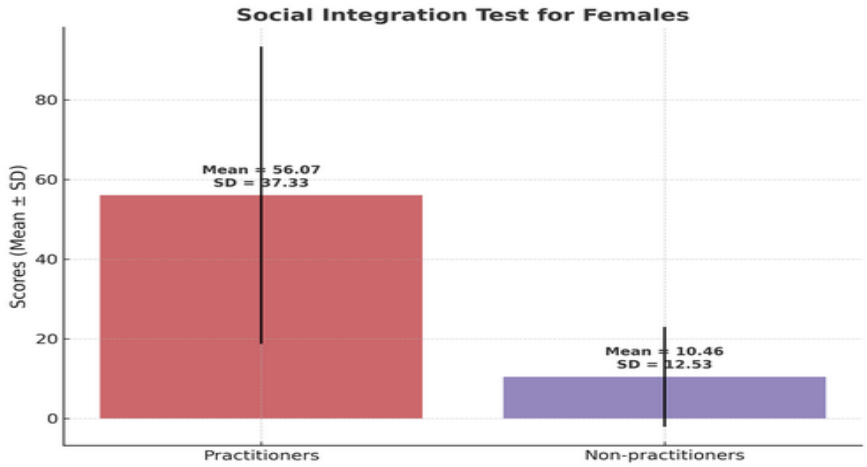

Figure 1. Graph of mean scores and standard deviations in the Social Integration Test for females

Table 2. Statistical analysis of the results for the social integration test for males

social integration test for males		
test grade	Practice variable	
	practitioners	non-practitioners
N	15	15
Mean	59.40	27.93
Std. Deviation	10.99	9.25
T test	8.39	
df	28	
Significance level	α=0,05	
Sig	0,00	
Statistical estimate	significant	

Source: Present research

The results presented in Table 2 reveal statistically significant differences in social integration test scores between male practitioners and non-practitioners. The mean score for practitioners (M = 59.40, SD = 10.99) was considerably higher than that of non-practitioners (M = 27.93, SD = 9.25). This difference indicates that male students who participate in sports exhibit higher levels of social integration compared to those who do not engage in sports activities.

The independent samples t-test confirmed the robustness of this difference, yielding a value of $t(28) = 8.39$ with $p < 0.001$, which is below the predetermined significance threshold of $\alpha = 0.05$. Therefore, the difference in social integration levels between practitioners and non-practitioners is statistically significant, suggesting that sports participation plays a decisive role in enhancing social integration among male students.

These findings suggest that engagement in sports provides male students with greater opportunities for social interaction, teamwork, and cooperation, which are essential components of social integration. Compared to their non-practicing peers, sports practitioners appear to benefit from structured group dynamics, peer bonding, and the development of interpersonal skills, all of which contribute to their elevated social integration scores.

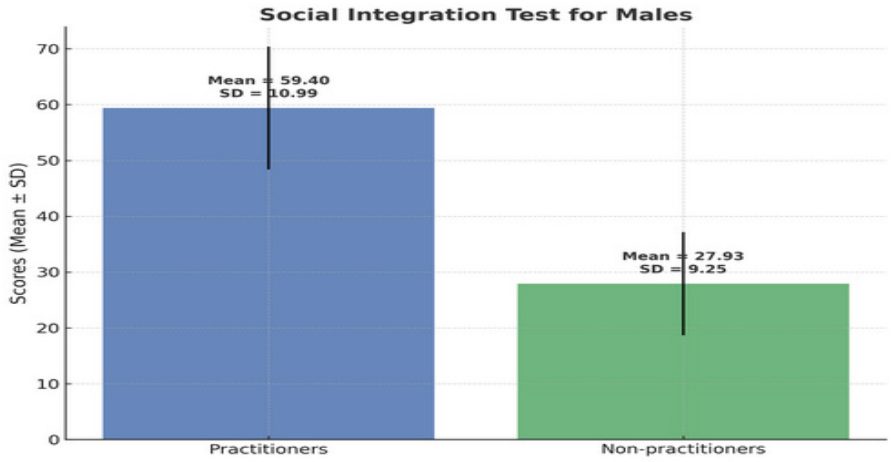

Figure 2 :Graph of the Mean and std Deviation of the social integration test for males.

DISCUSSION

The findings of this study revealed that female students who practiced gymnastics demonstrated significantly higher levels of social integration compared to their non-practicing counterparts. This outcome aligns with the argument that structured sports activities create inclusive environments where female adolescents can develop communication skills, build trust, and strengthen peer relationships. Gymnastics, in particular, fosters cooperation and interaction through group exercises and performances, thereby enhancing social connectedness (Weiss & Smith, 2002). The results indicated that female students practicing gymnastics reported significantly higher levels of social integration compared to non-practicing females. This suggests that participation in gymnastics provides structured opportunities for social interaction, peer support, and cooperation, which are essential elements in fostering school integration. Contemporary studies have shown that girls involved in organized physical activities are more likely to experience positive peer relationships and enhanced social adjustment (Sanchez-Miguel et al., 2019).

Moreover, the findings align with evidence that sports participation enhances social skills, teamwork, and resilience among female adolescents, contributing to stronger integration into school communities. Gymnastics, by its nature, requires discipline, group coordination, and mutual encouragement, all of which reinforce social connectedness. Recent research highlights that adolescent girls engaging in regular sports demonstrate improved communication

and collaboration skills, positively influencing their overall school integration (Howie et al., 2020).

In addition, female practitioners of gymnastics appeared to benefit from increased self-confidence and social recognition, which play vital roles in their integration into peer networks and school activities. This result supports recent findings that participation in extracurricular sports is strongly associated with social inclusion, reduced isolation, and higher school engagement among adolescent girls (Larson et al., 2021).

Finally, the gap observed between female practitioners and non-practitioners may reflect the limited social interaction opportunities available to non-participants. Non-practicing girls may lack access to structured environments that promote teamwork and peer bonding, thereby experiencing lower levels of social integration. Recent literature emphasizes that the absence of sports participation can reduce opportunities for social capital formation, which is critical for enhancing school belonging and integration (Camiré et al., 2019).The study revealed that female gymnastics practitioners achieved higher levels of social integration compared to their non-practicing peers. This outcome supports the idea that structured physical activities such as gymnastics create environments that promote collaboration, collective responsibility, and mutual support. Recent evidence indicates that adolescent girls engaged in organized sports tend to experience better interpersonal relationships and greater social acceptance within their peer groups (Holt et al., 2017).

Furthermore, gymnastics practice appeared to strengthen female students' relationships with teachers and classmates, which reflects the role of sports in enhancing broader social networks within the school. Research shows that adolescents, especially girls, who participate in extracurricular activities, report stronger bonds with both peers and authority figures, contributing to higher levels of social integration (O'Donnell et al., 2020).

In addition, the findings suggest that female gymnasts may gain important psychosocial benefits such as self-confidence, leadership skills, and resilience, which contribute to their ability to integrate into the school community. A longitudinal study confirmed that girls who engage in regular sports demonstrate higher levels of social competence and school engagement than those who do not (Martínez-Martí & Ruch, 2017).

Furthermore, the higher integration levels among female practitioners may be attributed to the psychosocial benefits of sports participation. Research suggests that girls involved in extracurricular physical activities report stronger self-esteem, emotional regulation, and social competence, all of which contribute to better adaptation within the school environment (Eccles & Barber, 1999). In this sense, gymnastics serves as more than just a physical activity; it becomes a

socializing agent that equips female students with the resources necessary to integrate effectively into their school community.

The findings showed that male students practicing gymnastics exhibited significantly higher levels of social integration compared to their non-practicing peers. This supports the idea that participation in structured physical activity enhances social networks, teamwork, and peer solidarity among adolescent males. Studies have demonstrated that male adolescents engaged in sports are more likely to report stronger peer connections and mutual trust, which contribute to better integration within the school environment (Holt et al., 2017).

Gymnastics practice also appeared to strengthen male students' self-discipline and leadership skills, which are essential for navigating school social systems. Participation in sports has been associated with higher levels of social competence and respect for group norms, particularly among boys who often view sports as a primary arena for socialization (Côté & Hancock, 2016). This may explain why male practitioners reported higher levels of integration compared to their non-practicing counterparts.

Moreover, gymnastics participation provides boys with opportunities to develop emotional regulation and coping strategies, which indirectly enhance their ability to build and maintain positive relationships. Research indicates that adolescent males who regularly engage in physical activity demonstrate lower levels of social isolation and higher levels of school belonging (Allen et al., 2019). This is consistent with the results obtained in this study.

At the same time, the observed differences between practitioners and non-practitioners suggest that boys who do not engage in gymnastics may face reduced opportunities for social interaction and skill development. Non-participation in sports has been linked to weaker peer ties and lower engagement in school activities, factors that negatively impact social integration (Ramos et al., 2020). This highlights the importance of structured extracurricular activities in preventing social exclusion among adolescent males.

The results revealed that male students who practiced gymnastics reported higher levels of social integration compared to their non-practicing peers. This finding suggests that engagement in structured physical activities such as gymnastics provides an avenue for building peer connections, mutual respect, and collaboration. Sports participation, especially in skill-based disciplines, fosters opportunities for teamwork, peer interaction, and shared goals, which are central to social integration (Holt et al., 2023). These outcomes align with prior studies emphasizing that male adolescents who are physically active tend to exhibit stronger interpersonal bonds within their school environment (Eime et al., 2022).

When comparing teacher-student relations, male gymnastics practitioners demonstrated stronger integration with their teachers than non-practitioners. This could be attributed to the discipline, commitment, and self-regulation developed through sports participation, qualities that teachers often recognize positively in active students. Recent research confirms that sports involvement enhances communication between students and educators by promoting respect for authority and rules (Sæther & Aspvik, 2022). Such improved relationships facilitate smoother integration within the broader school system.

Another dimension where male gymnastics practitioners outperformed non-practitioners was in participation in school activities. Engaged athletes are more likely to transfer their motivation and leadership skills into academic and extracurricular domains. According to Strachan et al. (2023), male students involved in organized sports are often more proactive in school events, clubs, and leadership roles, which strengthens their visibility and integration in the student community. This reinforces the notion that sport contributes to holistic school participation beyond physical fitness alone.

Overall, the findings highlight the role of gymnastics practice in fostering social integration among male adolescents. The consistent advantages observed among practitioners suggest that gymnastics may serve as a protective factor against social exclusion and isolation in schools. This conclusion echoes the broader evidence indicating that structured physical activity plays a critical role in the psychosocial development of male students (Tirabassi et al., 2022). Consequently, promoting gymnastics within school settings may not only improve physical health but also support social and emotional well-being.

Finally, the findings of this study support the notion that sports serve as a mechanism of social capital for adolescent boys. By promoting cooperation, discipline, and shared goals, gymnastics contributes to the development of stronger school identities and collective belonging. Contemporary research emphasizes that participation in organized sports has long-term benefits for adolescents' social integration, reducing antisocial behavior and fostering positive youth development (Collins & Bailey, 2021).

CONCLUSIONS

The present study sought to compare the level of social integration between gymnastics practitioners and non-practitioners among secondary school students in the Wilaya of Guelma, Algeria. By analyzing a balanced sample of male and female students, the findings revealed that participation in gymnastics

was strongly associated with higher levels of social integration across all three dimensions: peer relations, teacher-student relations, and participation in school activities. Practitioners consistently outperformed their non-practicing peers, highlighting the social benefits of engaging in structured physical activity. These results underscore the role of gymnastics as more than a physical discipline; it also functions as a social platform that fosters collaboration, communication, and belonging within the school context. The significant differences observed across genders indicate that the positive effects of gymnastics are universal, providing opportunities for both boys and girls to enhance their social skills and school involvement.

Importantly, the study contributes to the growing body of evidence supporting the integration of sports into educational programs as a means of promoting holistic student development. By encouraging gymnastics and similar activities, schools can create inclusive environments that reduce isolation, strengthen interpersonal ties, and cultivate respect between students and teachers. In light of these findings, it is recommended that educational policymakers and school administrators give greater attention to sports-based initiatives as tools for fostering social cohesion. Future research should explore longitudinal impacts of gymnastics participation, as well as potential differences across other sports disciplines, to better understand how physical activity shapes adolescent social development. Ultimately, this study affirms that gymnastics practice serves as a significant contributor to students' academic and social well-being.

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The authors declare no competing interests.

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Leadership in Sport: from Coach to Manager – An Integrative Perspective

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ABSTRACT. The evolution of leadership roles in sport has generated increasing interest in recent years, especially in the context of professionalization, performance management, and organizational complexity. This theoretical article explores the transition from the traditional role of the coach — as a direct leader of athletic performance to the more complex managerial role, which encompasses strategic planning, communication, decision-making, and team coordination. Starting from a multidisciplinary review of the literature (sports sciences, organizational behavior, and psychology), the paper outlines the conceptual differences and overlaps between coaching and managing in sport environments. An integrative perspective is proposed, emphasizing the fluidity of leadership roles and the importance of adaptive leadership styles. It is argued that modern sport leaders must combine coaching expertise with managerial competence to effectively respond to both athlete's needs and organizational challenges. The article discusses key factors such as emotional intelligence, transformational leadership, team dynamics, and role conflict in dual-role positions. Furthermore, the paper highlights the increasing need for leadership development programs that target both the technical and managerial dimensions of sport professionals. By synthesizing current theoretical frameworks and research findings, the article aims to contribute to a better understanding of the coach-manager continuum and to support the development of holistic leadership approaches in sport organizations. This integrative approach may offer valuable insights for educators, policy-makers, and practitioners involved in sport leadership development.

Keywords*: sports leadership, coach, sports manager, leadership styles, team, performance.*

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INTRODUCTION

In recent decades, sport has undergone a profound transformation, distinguished not only by the rise in performance levels but also by the accelerated professionalization of institutional structures and the increased complexity of organizational frameworks. This ongoing dynamic has prompted a fundamental reassessment of leadership roles, particularly in terms of reconnecting the traditional relationship between coach and manager (Santos, Batista & Carvalho, 2020). In parallel, bibliometric analyses in the field highlight a significant growth of interest in sports leadership—focusing on dimensions such as team cohesion, motivational climate, and athletes' psychological well-being (Turnnidge & Côté, 2016; Natsuhara et al., 2022).

Traditionally, the coach was perceived as the central leader of the team, responsible for technical-tactical instruction, rigorous supervision of the training process, and direct motivation of athletes (Natsuhara et al., 2022). However, with the expansion of the multidisciplinary team (including psychologists, sports physicians, physiotherapists), the increasing institutional and media pressure, and the need to adopt a strategic vision, the role of the sports leader has evolved into a hybrid one, combining methodological expertise with managerial and social competences (Santos et al., 2020).

The specialized literature confirms the importance of transformational leadership in the sports context. Behaviors such as individualized consideration, inspirational motivation, intellectual stimulation, and the development of an ideal role model have been empirically linked to higher levels of intrinsic motivation, athlete satisfaction, group cohesion, and self-efficacy (Turnnidge & Côté, 2016; Erikstad et al., 2021; Natsuhara et al., 2022). For example, the longitudinal experiment conducted by Erikstad and colleagues (2021) found that the perception of transformational leadership among elite youth coaches is positively correlated with task cohesion, a self-development–oriented motivational climate, self-regulated learning, and athlete satisfaction, while simultaneously reducing ego-oriented climates.

Nevertheless, meta-analyses and systematic reviews (Arthur, Bastardoz & Eklund, 2017; Natsuhara et al., 2022) point to the methodological limitations of much of the dominant research—many studies are cross-sectional, rely on single data sources, and lack a clear delineation of constructs, which reduces the strength of causal inference. Consequently, there is a need to clarify concepts and to employ longitudinal and mixed-method approaches capable of capturing the dynamics of leadership over time.

From a managerial perspective, literature on sports managers emphasizes key competences such as strategic leadership, effective delegation, motivation

of support staff, resource integration, and innovative thinking (Santos et al., 2020). This profile blends the coach's technical-methodological skills with the managerial competences specific to the role of sporting director or team manager.

Furthermore, research on emotional intelligence and role conflict in sports leadership shows that hybrid leaders must manage tensions between technical requirements and organizational demands (Laborde et al., 2016; Fransen et al., 2015). A coach's emotional intelligence contributes to reducing conflicts and increasing athlete satisfaction and relational effectiveness.

Building on these interdisciplinary findings, the present article proposes an integrative analysis of the evolution of leadership in sport: from the traditional role of the coach to the expanded function of the manager, exploring the overlaps, differences, and synergies between the technical-methodological and the strategic-organizational dimensions. The analysis incorporates perspectives from sports science, organizational psychology, and transformational and adaptive leadership (including the theoretical models of Chelladurai, Bass & Riggio), offering a robust conceptual framework for understanding the coach–manager continuum.

Conceptual Framework: Leadership in Sport

Leadership is generally understood as the process by which an individual intentionally influences the behavior, attitudes, and performance of others in order to achieve shared objectives (Northouse, 2022). In the sports context, such influence is profoundly shaped by the specific dynamics of the competitive environment—characterized by performance pressure, intense interpersonal relationships, tight timeframes, and collective responsibility (Chelladurai, 2007; Cotterill & Fransen, 2016).

The specialized literature identifies several theoretical models applicable to sports leadership:

Transformational leadership (Bass & Riggio, 2006) emphasizes leaders' ability to inspire, motivate, and develop the individual potential of team members through vision, individualized consideration, and intellectual stimulation. This model is frequently applied in performance sport, showing significant correlations with athlete satisfaction, self-efficacy, and team cohesion (Turnnidge & Côté, 2016; Vella, Oades & Crowe, 2013).

Adaptive leadership (Heifetz, 1994) highlights the need for leaders to manage change, uncertainty, and emerging tensions by creating a space for collective learning and distributing responsibility within the team. In sport, this model is relevant during transition periods (e.g., roster changes, key injuries) or in contexts of organizational instability (Jones, Armour & Potrac, 2004).

The multidimensional model of sports leadership (Chelladurai, 1990) is one of the most widely used theoretical frameworks in coaching research. It posits that leadership effectiveness results from the congruence between the leadership style preferred by athletes, the style required by the context, and the leader's actual behaviors. The model provides an explanatory framework for understanding variations in leadership styles depending on factors such as type of sport, competitive level, or athletes' gender (Chelladurai & Saleh, 1980).

In sport, leadership is deeply contextualized, being influenced by:

- the nature of the sport (individual vs. team);
- the performance level (amateur vs. elite);
- the athletes' age and experience;
- the organization's cultural style (authoritarian, participative, results-oriented, or personal-development–oriented) (Fransen et al., 2015; Laborde et al., 2016).

Although the coach and manager may share common objectives, the differences between their roles are substantial.

Table 1. Comparative Framework of Coach and Sports Manager Roles

Dimension	Coach	Manager
Main objective	Sports performance	Strategic coordination
Type of relationship	Direct, with athletes	Indirect, with the organizational structure
Key competences	Technical-methodological, motivational	Strategic, administrative
Leadership style	Task- or relationship-oriented	System- and process-oriented

Nevertheless, in practice, the two roles frequently overlap, leading to situations of dual leadership or even role conflict, particularly in organizations where coaches take on managerial tasks without formal training.

Contemporary Sports Leadership: An Integrative Approach

In the contemporary context of high-performance sport, leadership can no longer be conceived as a unidimensional function focused solely on athlete instruction or competition planning. The multiple pressures of professionalization, organizational management, and interaction with various stakeholders (athletes, technical staff, sponsors, media, federations) have transformed the sports leader into a figure with complex and dynamic roles. This reality has created the need for an integrative perspective on leadership—one that transcends the traditional division between "coach" and "manager" and approaches leadership as a functional continuum (Chelladurai & Riemer, 1998; Cotterill & Fransen, 2016).

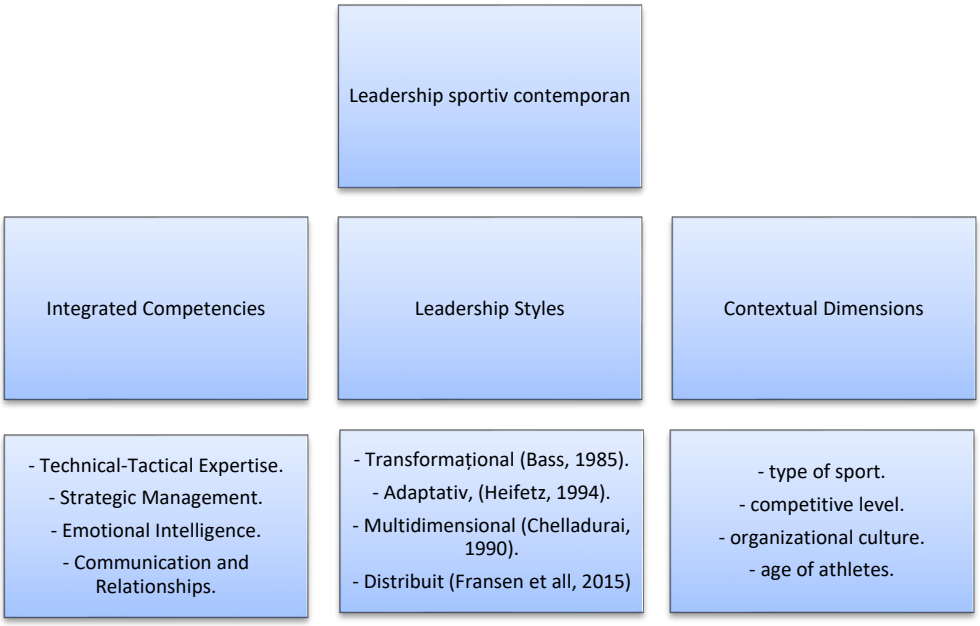

Figure 1. Conceptual framework of integrative sports leadership – dimensions, competences, and influencing contexts.

Traditionally, the coach was responsible for the technical-tactical components of sports preparation, while the manager handled logistics, budgets, and the team's external relations (Lyle, 2002). However, in current practice, these roles tend to overlap and merge, especially in teams where the head coach holds extended responsibility over the entire sports ecosystem (Fletcher & Arnold, 2011).

The integrative approach involves combining pedagogical and motivational expertise with strategic, organizational, and relational competences. A sports leader must be able to:

- plan the competitive season not only from the perspective of performance, but also considering human and material resources;
- manage internal and external conflicts;
- build a team culture based on shared values and objectives;
- interact effectively with both internal and external stakeholders (Wagstaff et al., 2012).

This functional versatility is essential in a sporting landscape where performance is no longer the sole result of technical quality, but also of effective managerial conduct.

Recent studies suggest that transformational (Bass & Riggio, 2006) and adaptive (Heifetz, 1994) leadership styles are the most suitable for the current sports context. Transformational leaders promote clear visions, leverage individual potential, and encourage athletes' intrinsic motivation (Vella et al., 2013). This style is associated with greater team cohesion, personal satisfaction, and improved performance (Turnnidge & Côté, 2016).

Conversely, adaptive leadership is essential during periods of instability—for example, changes in team structure, competitive failures, or external pressures. In such contexts, the leader must be able to redefine roles, reconfigure objectives, and facilitate collective learning while maintaining team trust and morale (Heifetz et al., 2009).

A central pillar of integrative sports leadership is emotional intelligence—the leader's ability to recognize, understand, and manage their own emotions as well as those of others (Laborde et al., 2016). The coach–athlete relationship is often characterized by emotional intensity, and the leader's ability to create a climate of trust, empathy, and mutual respect is essential for optimizing performance (Jowett, 2007).

Developing authentic relationships within the team contributes to reducing competitive anxiety, increasing motivation, and improving satisfaction with the sporting experience (Chan & Mallett, 2011). Leaders with high emotional intelligence are also more effective at managing role conflicts that can arise between technical leadership functions and managerial coordination responsibilities (Fletcher & Scott, 2010).

The integrative perspective also proposes a distribution of leadership, in which the main leader (coach/manager) collaborates with other staff members and even key athletes who take on formal or informal leadership roles (Fransen et al., 2015, Cucui, 2016). This approach fosters autonomy, responsibility, and effective communication within the team, reducing dependence on a single leader.

Studies show that teams with shared leadership tend to have higher levels of cohesion, collective motivation, and sustained long-term performance (Cotterill & Fransen, 2016; Duguay et al., 2016, Cucui et al., 2014). This type of leadership is particularly effective in team sports, where coordination and interdependence are critical.

Integrating the functions of coach and manager cannot be left to chance; it requires intentional training based on multidimensional competences. Sports leader development programs should include:

- the fundamentals of sports science;
- leadership and organizational communication;

- emotional intelligence and the psychology of motivation;
- elements of strategic and operational management (Lara-Bercial & Mallett, 2016).

The lack of such programs contributes to professional stress and managerial inefficiency for many coaches who find themselves in extended leadership positions without formal preparation for such roles (Olusoga et al., 2010).

A comparative synthesis of the most frequently used leadership styles in sport is presented in table 2.

Table 2. Characteristics, advantages, and limitations of main leadership styles in sport

Leadership Style	Key Characteristics	Advantages	Limitations	Authors / Theoretical Framework
Transformational	Inspires vision, personal development, intrinsic motivation	Team cohesion, high engagement	Requires high emotional intelligence	Bass & Riggio (2006)
Adaptive	Flexibility in the face of uncertainty, continuous learning	Rapid response to change, innovation	Can induce uncertainty in the absence of clear structure	Heifetz et al. (2009)
Multidimensional	Alignment between style, athlete preferences, and situational demands	Contextual adaptability	Difficult to apply without constant assessment	Chelladurai (1990)
Authoritarian (traditional)	Strong control, discipline, clear hierarchy	Quick decision-making	Demotivating for autonomous athletes	Classical coaching model
Democratic / participative	Active involvement of athletes in decision-making	Motivation, co-responsibility	May delay action in crisis situations	Lyle (2002); Vella et al. (2013)
Distributed (shared)	Leadership shared among coaches, staff, and key athletes	Cohesion, autonomy, communication	Requires training and mutual trust	Fransen et al. (2015); Cotterill & Fransen

CONCLUSIONS AND FUTURE DIRECTIONS

Contemporary sports leadership requires a reconceptualization of leadership roles in an increasingly complex and professionalized landscape. Traditionally, the coach was regarded as the central figure in team management, with

responsibilities focused on technical-tactical preparation and athlete motivation. However, in recent decades, the realities of high-level competition, media pressures, and organizational demands have significantly expanded the scope of the sports leader's responsibilities. In this context, the rigid distinction between coach and manager is fading, giving rise to a leadership profile that demands integrated skills—drawing from sports expertise as well as management, organizational psychology, and communication.

The integrative model proposed in this article reflects this evolution, emphasizing the need for a holistic approach to leadership in sport. The competencies of the sports leader can no longer be confined to the technical-methodological dimension; they must also encompass the ability to manage complex relationships, make strategic decisions under uncertainty, and respond to the diverse needs of both athletes and the organization. Likewise, the theoretical models discussed—transformational, adaptive, multidimensional, and distributed—provide relevant analytical frameworks for understanding and applying flexible, effective leadership styles.

In terms of future directions, there is a need to strengthen empirical research examining how sports leaders actually manage these multiple roles in practice. Qualitative studies focusing on the experiences of coaches, sports managers, or elite athletes could contribute to the development of operational models applicable in varied contexts—from elite sport to youth and amateur levels. In addition, longitudinal research could explore the impact of leadership training on team effectiveness and athlete satisfaction.

In parallel, the design of professional training and development programs that integrate technical, managerial, and psychosocial dimensions is recommended. Such programs should support the formation of a new type of sports leader—adaptable, empathetic, strategic, and development-oriented—capable of managing the complexity of modern sports systems and responding effectively to the challenges of the future.

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Effects of a Four-Week Climbing Intervention on Motor Abilities in PE Class

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ABSTRACT. *Introduction:* Regular climbing can contribute to the maintenance and development of both mental and physical well-being. Studies investigate how regular indoor climbing affects the strength endurance of specific trunk and arm muscles, as well as the joint mobility of the trunk and hips in different planes. *Objective*: The aim of this study was to evaluate the influence of climbing on adolescents' static strength, muscular endurance, lower limb explosive strength, and flexibility within a 4-week program integrated into the school physical education curriculum. *Material and methods:* A total of 48 adolescents were randomly assigned to an intervention group (IG; n = 21; 8 boys, 13 girls; M = 15.33 ± 0.50 years) and a control group (CG; n = 27; 9 boys, 18 girls; M = 15.54 ± 0.50 years), with similar gender distributions across both groups. *Results*: After the four-week intervention, there was a significant change in the hand grip strength of the IG, namely, the strength of both the dominant (from M = 30.11, SD = 8.13 kg to M = 26.84, SD = 7.89 kg), and the non-dominant hand significantly decreased (from M = 26.84, SD = 7.98 kg to M = 24.00, SD = 7.91 kg). This phenomenon can also be observed in the CG. *Conclusion*: Considering the available facilities, the age group, and the allocated time for the intervention (4 weeks, 2 sessions per week, 50 minutes each), these conditions appear insufficient to elicit a significant positive change in the examined abilities.

Keywords: *indoor climbing; physical education class; intervention study, adolescence.*

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INTRODUCTION

Simpler forms of climbing can be mastered during the early years of human development. The movement structure of basic climbing forms remains essentially unchanged, from simple tree climbing to the ascent of a challenging rock face. In both cases, the same limbs are used, performing pulling and pushing movements either alternately or even simultaneously. According to Herbert (1912, p.58), "Climbing consists of raising or moving the body using the arms or both the arms and legs from a suspension or holding position. Climbing with the arms and legs recruits the muscles of the entire body, particular the core and upper limbs."

Regular climbing can contribute to the maintenance and development of both mental and physical well-being (Garber et al., 2011). Several studies have examined the effect of climbing on physical performance in healthy adults (Heitkamp, Wörner, & Horstmann, 2005; Muehlbauer, Stuerchler, & Granacher, 2012) and children (Balas & Bunc, 2007; Balas, Strejcova, Maly, Mala, & Martin, 2009). These studies investigate how regular indoor climbing affects the strength endurance of specific trunk and arm muscles, as well as the joint mobility of the trunk and hips in different planes. Additionally, many studies explore the therapeutic applications of indoor climbing.

The effect of climbing has been studied in conditions such as cerebral palsy (Böhm, Rammelmayr, & Döderlein, 2014), multiple sclerosis (Velikonja, Curić, Ozura, & Jazbec, 2010), cerebellar ataxia (Stephan et al., 2011), and back pain (Engbert & Weber, 2011; Kim & Seo, 2015). In addition to these studies, research has also been conducted in many other areas, a comprehensive overview of which can be found in the systematic review by Gassner et al. (2022).

MATERIALS AND METHODS

Participants

The participants were 9th-graders selected from a high school in Cluj-Napoca, Romania. A total of 48 adolescents were randomly assigned to an intervention group (IG; $n = 21$; 8 boys, 13 girls; $M = 15.33$, $SD = 0.50$ years) and a control group (CG; $n = 27$; 9 boys, 18 girls; $M = 15.54$, $SD = 0.50$ years), with similar gender distributions across both groups, $\chi^2(1, N = 48) = 0.09$, $p = .770$. The results of the one-way multivariate analysis of variance (MANOVA) indicated no statistically significant differences at the multivariate level, $F(7, 38) = 0.43$, $p = .878$, for any of the investigated independent variables.

Our study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013) and approved by the ethics committee of the Faculty of Physical Education and Sports, Babeș-Bolyai University (V/1594-2/2022/EKU). All parents and students provided written informed consent prior to participation in the research.

The aim of this study was to evaluate the influence of climbing on adolescents' static strength, muscular endurance, lower limb explosive strength, and flexibility within a 4-week program integrated into the school physical education curriculum.

Procedure

The intervention took place during physical education classes in the second module of the 2022/2023 school year and was announced as a regular physical education and sports program for the participants. The initial measurements were performed on November 18, 2022. The intervention itself was conducted from November 23, 2022, to December 16, 2022, over four weeks, twice a week, for a total of 8 sessions, each lasting 50 minutes (the duration of one lesson in Romanian schools) (Balla, Boros-Bálint, & Szatmári, 2022). The final physical tests were conducted on December 22, 2022.

For the experimental group, the intervention consisted of progressively more challenging climbing activities, while the control group participated in an additional hour of physical education, during which technical elements of basketball and volleyball were practiced.

For the participants practicing climbing activities, we initially introduced the basics of wall climbing, teaching them how to grip the holds. We then progressively engaged them in more challenging tasks, including different grip techniques, foot positions, body positioning on the wall, lateral climbing, traversing, and climbing vertically and then returning. At the end, we organized a competition that incorporated all these skills, specifying the directions and colors of the grips they were allowed to use.

All activities began with a thorough 8–10-minute warm-up, which included both dynamic and static exercises. The lessons were concluded with a 5-minute evaluation and feedback session. The classes were led by two physical education teachers, and in addition, graduate students (2 per class) were present to assist with the exercises.

Measures

In this study, we applied six performance-based tests to measure different motor abilities, as well as two anthropometric tests.

Performance-based tests

1. Handgrip Strength Test: The Jamar hydraulic dynamometer was used to measure grip strength, which is considered the gold standard due to its high reliability and precision (Hamilton, McDonald, & Chenier, 1992). The test was performed with both hands according to the guidelines of the American Society of Hand Therapists (MacDermid, Solomon, & Valdes, 2015). The better result of the two attempts was recorded.

2. Sit and Reach Flexibility Test: This test was first described by Wells and Dillon in 1952 as a measure of back and leg flexibility. Mayorga-Vega, Merino-Marban, and Viciana (2014) in a meta-analysis of 34 studies found that 'sit-and-reach tests have moderate mean criterion-related validity for estimating hamstring extensibility, but they have low mean validity for estimating lumbar extensibility.' They also concluded that 'among all the sit-and-reach test protocols, the classic sit-and-reach test seems to be the best option to estimate hamstring extensibility.' The American College of Sports Medicine guidelines were followed when performing the test (ACSM, 2014).

3. Standing Long Jump Test: The broad jump is a common and simple test of explosive leg power. According to Rahman, Kamal, Noor, Geok, and Alnedral (2021), the standing long jump is a reliable and valid tool for measuring explosive leg power. Other studies also support the validity of the standing long jump test (Fernandez-Santos, Ruiz, Cohen, Gonzalez-Montesinos, & Castro-Piñero, 2015; Thomas et al., 2020).

4. YMCA Sit-Up Test: This test assesses the strength and endurance of the abdominal and hip-flexor muscles and was carried out with the subjects until exhaustion. The objective is to perform the maximum number of sit-ups. The subject performs the test with bent knees, feet flat on the floor about 45 cm from the buttocks, and hands touching the sides of the head. The examiner holds the subject's feet while the exercise is performed. The subject touches the opposite elbow to the alternate knee with each sit-up (Baumgartner & Jackson, 1999).

5. Modified Knee Push-Up Test: The purpose of this test is to assess upper-body endurance, and the objective is to perform push-ups to exhaustion. The examinees perform the arm flexion from a kneeling position, lowering the body toward the floor until the chin touches the mat (Baumgartner, Jackson, Mahar, & Rowe, 2016).

6. Modified Pull-Up Test: This test measures upper extremity strength and endurance of the elbow flexor muscles (Baumgartner, Jackson, Mahar, & Rowe, 2016). Its norm-referenced and criterion-referenced reliability was assessed by Saint Romain and Mahar in 2001. 'Norm-referenced and criterion-referenced test–

retest reliability estimates in this study were acceptable. However, criterion-referenced equivalence reliability findings were not acceptable' (Saint Romain & Mahar, 2001, p. 1).

Anthropometric measurements

1. Measuring body weight

An OMRON HBF-400 scale was used to measure the participants' body weight. Measurements were taken with minimal clothing and without shoes.

2. Measuring body height

A SECA 206 rolling measuring tape was used to measure the participants' height. Measurements were taken without shoes.

3. Body Mass Index

The BMI-for-age percentile was calculated based on the Centers for Disease Control and Prevention growth charts for children and adolescents ages 2 to 19 years.

Physical activity level measurement

The physical activity level of the sample was assessed using the PAQ-C questionnaire, which is a self-administered, 7-day recall instrument. 'It was developed to assess general levels of physical activity throughout the elementary school year for students in grades 4 to 8, approximately 8 to 14 years of age. The PAQ-C can be administered in a classroom setting and provides a summary physical activity score derived from nine items, each scored on a 5-point scale' (Kowalski, Crocker, & Donen, 2004, p. 6). The validated Hungarian version of the questionnaire was used (Makai et al., 2023).

One-way multivariate analysis of variance (one-way MANOVA), independent sample t-test, paired sample t-test, and Shapiro-Wilk test for normality were used. Statistical analysis was performed with a significance level of 0.05.

RESULTS

The anthropometric characteristics of the sample are presented in Table 1. As shown, there were no significant differences between the two groups in terms of physical characteristics, for either boys or girls. 2.2% of the sample was underweight (0% boys, 3.3% girls), 66.7% had normal weight (68.8% boys, 83.3% girls), 6.5% were overweight (0% boys, 10.0% girls), and 13% were obese (31.3% boys, 3.3% girls).

The scores for physical activity level, sit and reach test, standing long jump, and body height were normally distributed for both the intervention group (IG) and control group (CG), as assessed by the Shapiro-Wilk test ($p > .05$).

However, the scores for handgrip strength (dominant and non-dominant limbs), BMI, sit-ups, pull-ups, and push-ups were not normally distributed for either group ($p < .05$). To obtain valid results from the use of parametric tests, we applied a transformation to the data.

Table 1. Comparison of the anthropometric results of the intervention and control groups

	N	Height [cm]	Weight [kg]	BMI	Age [year]
IG Boys	8	175.25 ± 2.37	67.41 ± 17.46	21.86 ± 5.11	15.50 ± 0.53
CG Boys	8	176.50 ± 7.36	79.01 ± 24.46	25.06 ± 6.04	15.38 ± 0.51
Result of the t-test		t(14)= -.457, p= 0.655	t(14)= -1.092, p= 0.293	t(14)= -1.143, p= 0.272	t(14)= .475, p= 0.642
IG Girls	13	162.23 ± 5.87	54.17 ± 6.75	20.46 ± 2.43	15.23 ± 0.43
CG Girls	16	164.83 ± 6.70	58.23 ± 9.77	21.36 ± 2.86	15.63 ± 0.50
Result of the t-test		t(29)= -1.122, p= 0.271	t(28)= -1.252, p= 0.221	t(28)= -.888, p= 0.382	t(27)= -2.229, p= 0.340

Note: IG – intervention group; CG – control group.

The initial pre-intervention strength, flexibility, and endurance tests did not show significant differences between the groups (significance level from $p = .051$ to $p = .885$).

A paired-samples *t*-test was used to determine whether there was a statistically significant mean difference between dominant and non-dominant hand grip strength. No outliers were detected that were more than 1.5 box-lengths from the edge of the box in the boxplot. Inspection of the values did not reveal any extreme cases, and they were retained in the analysis. The assumption of normality was not violated, as assessed by the Shapiro-Wilk test ($p = .121$ and $p = .131$). Participants exerted greater hand grip strength with their dominant hand ($M = 39.31$, $SD = 1.44$ kg) than with their non-dominant hand ($M = 36.87$, $SD = 1.15$ kg). A statistically significant mean difference of 2.44 kg, 95% CI [36.23, 42.39], $t(46) = 5.24$, $p < .001$, $d = 3.36$, was observed.

The following tests were used to measure the strength and endurance of different muscles: sit-ups, modified push-ups, and modified pull-ups. A Pearson's product-moment correlation was run to assess the relationship between sit-up performance, push-up performance, and pull-up performance in males of the IG and CG groups ($n = 16$). Preliminary analyses showed the relationship to be linear, with one variable normally distributed and two variables not normally distributed, as assessed by the Shapiro-Wilk test ($p = .009$, $p = .628$, $p = .001$). There was a single outlier, which was retained in the analysis. A statistically significant, moderate positive correlation was found between the strength and

endurance of the abdominal and hip-flexor muscles and the strength and endurance of the flexor muscles of the elbow, $r(15) = .49$, $p = .045$. Also, a moderate positive statistically significant correlation was found between the strength and endurance of the abdominal muscles and upper-body endurance, $r(15) = .50$, $p = .050$. The BMI showed a negative statistically significant correlation with the strength and endurance of the muscles. The results are as follows: BMI – Sit-ups, $r(15) = –.58$, $p = .020$; BMI – Pull-ups, $r(15) = –.65$, $p = .001$; BMI – Push-ups, $r(15) = –.49$, $p = .050$. In the case of girls, this correlation could not be found between the three mentioned variables ($p = .312$, $p = .679$). No significant differences were found between the mean values for the seven variables presented in Table No. 2 and Table No. 3.

Table 2. The pre-test results of the boys on the performance tests

	N	DHGS	NDHGS	Sit-ups	Pull-ups	Push-ups	SAR	SLJ
IG Boys	8	39.0±4.8	35.6±4.3	59.2±28.6	10.0±5.5	37.0±25.1	4.7±3.6	188.6±23.4
CG Boys	8	39.6±6.9	38.1±4.8	37.6±12.9	5.8±5.1	16.6±9.7	-0.4±9.5	182.1±38.6
x̄ Boys	16	39.3±5.7	36.8±4.6	48.4±24.2	7.9±5.5	26.8±21.2	2.1±7.4	185.3±31.1

Note: DHGS = dominant hand grip strength; NDHGS = non-dominant hand grip strength; SAR = sit and reach; SLJ = standing long jump.

Table 3. The pre-test results of the girls on the performance tests

	N	DHGS	NDHGS	Sit-ups	Pull-ups	Push-ups	SAR	SLJ
IG Girls	13	24.6±2.4	21.7±3.8	37.6±19.0	1.8±2.5	11.7±8.3	10.0±7.8	158.1±15.2
CG Girls	18	26.0±4.7	24.0±5.1	42.0±28.0	2.8±4.5	12.7±8.1	12.3±6.9	162.4±23.3
x̄ Girls	31	25.5±3.9	23.1±4.7	40.2±24.4	2.4±3.8	12.3±8.1	11.4±7.3	160.6±20.2

Note: DHGS = dominant hand grip strength; NDHGS = non-dominant hand grip strength; SAR = sit and reach; SLJ = standing long jump

We measured the level of physical activity using the PAQ-C. The physical activity level was $M = 2.40$, $SD = 0.57$ in the intervention group (IG) and $M = 2.37$, $SD = 0.53$ in the control group (CG). There was no statistically significant difference between the two groups, $t(46) = 0.21$, $p = .837$.

Results of the 4-week intervention program

After the four-week intervention, there was a significant change in the hand grip strength of the IG, namely, the strength of both the dominant ($M = 30.11$, $SD = 8.13$ kg to $M = 26.84$, $SD = 7.89$ kg), and the non-dominant hand

significantly decreased (M = 26.84, SD = 7.98 kg to M = 24.00, SD = 7.91 kg), as shown by the paired-samples t-test, 95% CI [2.21, 4.31], $t(18) = 6.52$, $p < .001$, $d = 3.36$. This phenomenon can also be observed in the CG, the strength of the dominant hand decreased from M = 30.08, SD = 8.22 kg to M = 27.86, SD = 9.60 kg, the strength of the non-dominant hand decreased from M = 28.17, SD = 8.23 kg to M = 25.52, SD = 8.53 kg, 95% CI [0.86, 3.56], $t(22) = 3.41$, $p < .05$, $d = 0.71$.

Of the six tests used, only the modified pull-up test showed a significant improvement in performance (M = 4.68, SD = 5.22 to M = 5.94, SD = 6.81), 95% CI [–2.40, –0.11], $t(18) = –2.32$, $p < .05$, $d = 0.53$. This improvement was observed in both the experimental and control groups. The results of the performance tests are presented in Table 4.

Table 4. The post-test results of the intervention and control group on the performance tests

	Intervention Group	Control group	Results of the t-test
DHGS	26.84±7.89	28.50±9.89	$t(41)$= -0.595, p= 0.555
NDHGS	24.00±7.91	26.20±9.00	$t(41)$= -0.842, p= 0.405
Pull-ups	5.94±6.81	5.29±6.01	$t(41)$= 0.335, p= 0.739
Push-ups	21.10±13.41	15.70±9.05	$t(41)$= 1.572, p= 0.124
Sit-ups	48.31±24.69	45.66±25.24	$t(41)$= -0.766, p= 0.448
SAR	8.52±7.86	7.83±6.34	$t(41)$= 0.320, p= 0.751
SLJ	170.52±27.85	165.54±29.30	$t(41)$= 0.566, p= 0.575

Note: DHGS = dominant hand grip strength; NDHGS = non-dominant hand grip strength; SAR = sit and reach; SLJ = standing long jump

The independent-samples t-test showed no significant difference between the performance of the two groups for any measured variable. The physical activity level of the groups did not differ significantly in the seven days before the intervention (IG: M = 2.32, SD = 0.48; CG: M = 2.43, SD = 0.54), and likewise at the end of the intervention, we did not measure any significant difference between the groups (IG: M = 2.42, SD = 0.49; CG: M = 2.33, SD = 0.37), 95% CI [–0.18, 0.36], $t(39) = 0.66$, $p = .515$.

DISCUSSION

The aim of the present study was to investigate how indoor wall climbing affects the physical abilities of 9th-grade students, specifically grip strength, lower extremity explosiveness, abdominal and hip flexor muscle strength and endurance, upper body endurance, and back and leg flexibility. The study was conducted

within a solid theoretical framework as a field experiment, incorporating a control group. To the best of our knowledge, this is the first study of its kind to address this topic within the context of school physical education in Romania.

Balas and Bunc (2007) conducted a ten-week climbing-based intervention with 7- to 9-year-old children. The intervention consisted of 45-minute sessions, held twice a week. According to their results, this duration was insufficient for the development of static strength and muscle endurance in this age group when implemented within the context of school physical education.

In a 2017 study, children aged 11–13 spent 2.5 hours, three times a week for three weeks, in a climbing hall with a 600 m^2 wall. The sample was divided into two groups: one with children with cerebral palsy and the other with typically developing children. Among other tests, hand grip strength was measured; however, a significant increase in strength was observed only in the group with cerebral palsy (Christensen, Jensen, Voigt, Nielsen, & Lorentzen, 2017).

In a 2009 study, Balas, Strejcova, Maly, Mala, and Martin conducted an intervention with children aged 10–17 years, in which they examined, among other factors, hand grip strength and arm strength endurance in a bent suspension. Although the subjects participated in as many sessions as possible over the eight weeks, the frequency of participation did not significantly affect their performance. Instead, the climbing distances covered during the sessions led to improved performance in both sexes. As stated by Balas et al. (2009), 'there was a significant increase in relative grip strength for both hands in boys and girls with higher climbing volume' (p. 177).

Considering the available facilities, the age group, and the time allocated for the intervention (4 weeks, 2 sessions per week, 50 minutes each), it is not surprising that the measured abilities—such as back and leg flexibility, explosive leg power, and strength and endurance—did not show significant changes. In the aforementioned studies, the interventions lasted longer, yet they still failed to produce measurable changes at the end of the intervention. The most notable result in our study was the significant decrease in grip strength in both the dominant and non-dominant hands for both the experimental and control groups. We are unaware of any specific factors during the intervention that could have contributed to this decrease in grip strength performance.

Similar interventions conducted with adult participants typically confirm that at least 8 weeks of appropriate training, twice a week, is required to observe measurable effects (Heitkamp, Wörner, & Horstmann, 2005). This is consistent with the findings of Muehlbauer, Stuerchler, & Granacher (2012), where nearly all measured variables showed significant improvements, including positive changes in core strength, hand-grip strength, and trunk mobility.

Limitations of the study

The participants joined the intervention voluntarily; however, some appeared to lack sufficient motivation when performing the climbing tasks. Although we had access to two 4x4 meter vertical climbing walls (32 square meters in total), which allowed 4-6 trainees to engage in physical activity simultaneously, the class size of 20 students may have affected the effectiveness of the intervention. The density of physical education classes may not have been optimal for providing each participant with adequate attention and time for performing the tasks.

The modular structure of the academic year implemented in Romania starting in 2022 posed challenges for extended interventions. The presence of 1–2-week breaks between modules would have disrupted the continuity of the intervention. As a result, we were constrained to plan and execute the intervention within the timeframe of a single module.

Author contributions

Conceptualization, B.B.J. and B.-B.I..; methodology, B.B.J.; formal analysis, B.B.J.; investigation, B.B.J. and F.I.; writing—original draft preparation, B.B.J.; writing—review and editing, B.B.J.; visualization, B.B.J.; supervision, B.B.J. and B.-B.I.; project administration, B.B.J. and B.-B.I.

Conflicts of Interest

The authors declare no conflict of interest.

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Determining the Difference between the Chronological and Biological Age of Athletes Diagnosed with Trigeminal Neuralgia

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ABSTRACT. Trigeminal neuralgia induces severe, often intolerable pain in patients—athletes, in this context—that is frequently resistant to currently available therapeutic options. The International Association for the Study of Pain (IASP) defines trigeminal neuralgia as a sudden, typically unilateral, intense, brief, stabbing, and recurring episode of pain in the distribution of one or more branches of the trigeminal nerve. The condition may be caused by vascular compression of the trigeminal nerve, tumor-related processes, or multiple sclerosis. Compression of the nerve itself leads to demyelination, which results in abnormal depolarization and the generation of ectopic impulses. Triggers for pain may include heat, cold, eating, breathing, tooth brushing, shaving, or incidental contact. Once diagnosed by a specialist, magnetic resonance imaging (MRI) is required to confirm or exclude multiple sclerosis. Tumorous processes may also secondarily lead to trigeminal neuralgia. The first-line pharmacological treatment remains carbamazepine. If pharmacotherapy proves ineffective, more invasive interventions such as microvascular decompression, stereotactic radiosurgery (Gamma Knife), percutaneous balloon microcompression, glycerol rhizolysis, and radiofrequency (RF) ablation may be considered. This study is unique in that its sample comprises athletes diagnosed with trigeminal neuralgia. The primary objective is to examine potential differences between their chronological and biological age by analyzing their metabolic age. The findings aim to support and potentially initiate a novel paradigm or theoretical

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framework concerning the remodeling of biological aging in athletes suffering from trigeminal neuralgia, particularly in the context of optimizing training processes.

Keywords: *trigeminal neuralgia, athletes, chronological age, biological age.*

INTRODUCTION

Trigeminal neuralgia, also referred to as "tic douloureux," is characterized by extremely sharp, episodic, intense, stabbing facial pain. The pain is localized within the innervation zone of one of the trigeminal nerve branches—most commonly the second or third—and significantly diminishes the patient's quality of life (Dlaka & Vasung, 2007). It is a chronic pain disorder affecting the trigeminal nerve, which transmits sensory information from the face to the brain. To fully grasp the nature of trigeminal neuralgia, one must first understand neuralgia itself, which is defined as episodic irritation of a nerve that produces intense neural pain along a damaged nerve pathway. In cases of trigeminal neuralgia, even mild facial stimuli such as brushing teeth or applying makeup can provoke intense pain or distress.

The pain is typically described as stabbing, occurring in paroxysms at consistent locations and with consistent intensity (Scrivani, Mathews, & Maciewicz, 2005). The trigeminal nerve is one of the most important cranial nerves. According to Merskey and Bogduk (1994), damage to this nerve generally results in severe unilateral facial pain. In modern medicine, due to advances in diagnostic and treatment modalities, trigeminal neuralgia no longer necessarily condemns the patient to a lifetime of suffering. Although not life-threatening, it can severely impair physical functioning and quality of life.

There is currently no objective diagnostic test for trigeminal neuralgia; diagnosis relies entirely on clinical expertise and recognition of its distinct symptoms (Chudy et al., 2012). Patients experience sharp, stabbing pain on the affected side of the face, lasting from seconds to a minute. According to Apfelbaum (2000), the pain can be triggered by light touch, air drafts, or spontaneous neural activity. Attacks may recur at progressively shorter intervals until they become nearly continuous. In some instances, the pain is accompanied by muscle spasms that lead to visible facial tics.

As Chudy and colleagues (2012) explain, trigeminal neuralgia involves a disruption of trigeminal nerve function, often resulting from contact between a blood vessel (artery or vein) and the nerve within the brain. This contact exerts pressure on the nerve, disrupting and damaging its function. Additionally, trigeminal neuralgia can be associated with conditions such as multiple sclerosis,

particularly in younger individuals. In such cases, the pain may be bilateral and involve the ophthalmic branch, resulting in sensory disturbances in the forehead region (Fukuda, Ishikawa, & Okumura, 2003).

Initial treatment typically involves pharmacological intervention. For many patients, this is sufficient (Scrivani, Mathews, & Maciewicz, 2005). However, due to variations in individual physiology and disease progression, medications can lose efficacy over time or produce adverse effects. For such cases, modern medicine offers injections or surgical procedures, including microvascular decompression and other techniques, which can effectively manage the disorder (Chudy et al., 2012).

According to Perrudin (2005), sport as a structured physical activity engages both physical and psychological dimensions, with an inherent social component. These characteristics make sport highly relevant to overall health and well-being, encompassing physical, mental, and social domains (Mijolović, 2014). At its core, sport consists of rule-governed physical activity aimed at progress in physical, psychological, and social development (Wikipedia, 2024). Just like the general population, athletes diagnosed with trigeminal neuralgia endure intense pain that interferes with their daily lives and primary sporting activities.

Pathopsychology

According to Tolle, Dukes, and Sadosky (2006), trigeminal neuralgia most commonly occurs in middle-aged and elderly individuals, including athletes. In the literature, it is described as paroxysmal pain of extreme intensity, with burning, stabbing, and tearing characteristics. Merskey and Bogduk (1994) report that it is most often localized within the maxillary and mandibular branches of the trigeminal nerve and, less frequently, the ophthalmic branch. Patients frequently describe it as the most excruciating pain imaginable—akin to electric shocks, lightning strikes, stabbing, tearing, or burning sensations across the face.

To emphasize the severity of this condition, Tomasović (2019) notes that there have unfortunately been documented cases of suicide among patients who could no longer endure the pain. Typically, the pain episodes are brief, lasting only a few seconds to one minute, but their intensity can provoke involuntary facial muscle contractions, including tonic-clonic spasms of the eye and cheek. Following an attack, patients may experience autonomic symptoms such as facial flushing, lacrimation, nasal discharge, or salivation (Dionne, Newton-John, & Zakrzewska, 2009). Despite the frequency of these attacks, patients experience pain-free intervals between episodes.

As previously mentioned, pain can be triggered by minimal facial stimulation, speech, chewing, or exposure to cold air. In severe cases, patients may avoid all movement and contact, including speaking or eating, to prevent triggering pain—resulting in what is sometimes described as the "mummy face." Due to reduced food intake, patients—particularly athletes—often experience significant weight loss over short periods.

The condition typically begins with alternating periods of pain and remission, complicating the structuring of a consistent training regimen. According to Androja et al. (2021), pain episodes may persist for several months before spontaneously resolving. However, Radoš (2004) observes that over time, painful periods lengthen and pain-free intervals shorten, ultimately leading to a state of continuous pain in all patients. After prolonged disease progression, approximately one-quarter of patients develop sensory deficits in the area innervated by the trigeminal nerve (Radoš, 2004).

Symptomatic trigeminal neuralgia occurs when the nerve is irritated by an underlying pathological condition such as multiple sclerosis, vascular compression, a basilar artery aneurysm, or a pontocerebellar tumor. Numerous studies and authors report that sensory loss on the face and diminished corneal reflexes are characteristic findings. Miočić and Komšo (2020) emphasize that diagnosis is primarily clinical, although magnetic resonance imaging (MRI) in idiopathic cases may reveal dilation of the superior cerebellar artery loop, exerting pressure on the nerve and leading to demyelination. According to Tomasović (2019), in younger patients, trigeminal neuralgia most frequently arises as a consequence of demyelinating lesions or neoplasms.

Sport and Trigeminal Neuralgia

For athletes, physical movement, active engagement, communication, and dynamic social interaction are essential to participating in sports. The coexistence of such a physically demanding lifestyle with a condition as debilitating as trigeminal neuralgia appears paradoxical—yet it occurs. Athletes diagnosed with this disorder face daily battles to maintain functionality and continue their professional activities.

Imagine an individual for whom deep breathing, swallowing, chewing, or even speaking triggers excruciating pain—described as akin to a needle prick or an electric shock. Now, imagine that this individual is a professional athlete. According to Chong et al. (2023), trigeminal neuralgia is widely recognized in both medical and public discourse due to the extreme facial pain it causes. Affecting approximately 12 out of every 100,000 individuals worldwide (Machado, Ogrin, Rosenow, & Henderson, 2021), the condition's rarity makes its presence among elite athletes particularly noteworthy.

Although the identities of affected athletes are generally kept private, an exception can be made in the case of Álvaro Morata, a prominent football player and member of the Spanish national team. Public reports have confirmed that Morata suffers from trigeminal neuralgia (Sport, 2024). His club, Atlético Madrid, has openly expressed concern, highlighting that although the condition is rare, it poses a significant challenge to maintaining a normal lifestyle and consistent football training.

The lead author of this paper, himself a former athlete and now an official in the sports sector, also lives with what he refers to as a "condition" rather than a disease—trigeminal neuralgia. Like others—both athletes and non-athletes—he contends with pain episodes that arise suddenly, last for varying durations over days or weeks, and then subside. This erratic pattern inevitably impacts quality of life, professional obligations, and the ability to participate in either competitive or recreational physical activity. Nevertheless, his experience serves as evidence that coexisting with such a condition, while difficult, is possible.

As previously noted, diagnosing this disorder is far from straightforward, especially in athletes, for whom time-sensitive performance requirements demand rapid medical clarity. There is no definitive diagnostic test; diagnosis depends heavily on patient interviews and thorough clinical and neurological examinations. According to Professor Klepac, diagnostic procedures are primarily aimed at ruling out other conditions that may mimic trigeminal neuralgia. These include vascular compression, tumors, or demyelinating diseases such as multiple sclerosis (Xu & Jackson, 2021).

Timely medical consultation is essential, as chronic pain severely compromises quality of life. In conclusion, trigeminal neuralgia is a neurological condition that causes chronic facial pain due to damage or dysfunction of the trigeminal nerve. It presents significant obstacles for athletes, hindering both their routine training activities and their ability to maintain a full quality of life.

Chronological and Biological Age

According to Vásquez-Alvarez et al. (2021), chronological age is measured in years from an individual's date of birth. A crucial distinction exists between how many years a person has lived—referred to as chronological age—and the overall condition of their body, known as biological age. This difference can help demystify the aging process and support a more holistic and robust approach to health assessment.

As noted by Mišigoj-Duraković et al. (2018), biological or physiological age can be defined as an individual's capacity to adapt to environmental conditions, most commonly expressed through endurance, strength, flexibility, coordination,

and work capacity. Both chronological and biological age serve as metrics for understanding aging and the impact of time on the human body. Chronological age quantifies the number of years a person has lived. According to Pisaruk et al. (2021), individuals born in the same year share the same chronological age regardless of how old or young they may appear or feel.

In contrast, biological age varies between individuals and more accurately reflects the diversity in aging processes. Donma and Donma (2020) argue that biological age reveals how a person is aging based on numerous factors and biomarkers. However, no single biomarker or diagnostic test can definitively determine a person's age. Various studies have advanced the theoretical framework in this domain. For instance, Paolisso, Barbieri, Bonafè, and Franceschi (2001) proposed a new paradigm—the theory of aging remodeling. This has been further developed by researchers such as Kusnoputranto et al. (2020) and Pisaruk et al. (2021).

MATERIALS AND METHODS

The study was conducted in Croatia, where, based on the authors' knowledge and the available literature, a total of 46 athletes from various sports disciplines and competitive levels diagnosed with trigeminal neuralgia (G50.0) were included. Statistical analysis was performed using the Statistica 14.0 software package, with the level of significance set at $p < 0.05$.

Descriptive statistical parameters were calculated, including arithmetic mean (AM), standard deviation (SD), minimum (MIN), and maximum (MAX) values. To determine differences between chronological age and metabolic age among participants, a paired-samples t-test was applied. Furthermore, to examine the relationship between the variables representing the difference between chronological and metabolic age, a correlation analysis using Pearson's correlation coefficient was conducted.

Prior to the measurement of morphological variables, participants completed a questionnaire containing personal data, including their chronological age (CA). The morphological status variables used in the research included body mass, hydration status, fat mass, lean mass, and muscle mass, all measured using the Tanita BC-418 body composition analyzer, which employs bioelectrical impedance analysis. Body height was assessed using an anthropometer.

Based on the results obtained from the morphological measurements, the Tanita device calculated each participant's metabolic age (MA). For the purpose of this study, the difference between chronological age and metabolic age (CA–MA) was subsequently calculated and analyzed.

RESULTS

An athlete's chronological age may serve as one indicator of their physical conditioning relative to other athletes. In contrast, metabolic age reflects the athlete's basal metabolic rate in comparison with peers. In other words, if an athlete's chronological age aligns with their metabolic age, this suggests that the athlete's physiological status is consistent with that of the broader athletic population within the same age range.

Table 1. Descriptive Statistical Indicators of the Applied Variables
(*N* – number of participants, *AM* – arithmetic mean, *SD* – standard deviation, *MIN* – minimum value, *MAX* – maximum value)

	N	AS	SD	MIN	MAX
KD	46	66.08	5.56	51.00	78.00
MD	46	52.45	8.41	38.00	72.'00
KD-MD	46	12.89	8.69	-14-00	17.00
ST	46	132.10	23.04	90	166.00
DT	46	76.62	10.04	51.00	95.00
FS	46	72.40	10.01	51.00	94.00

Legend: KD – chronological age, **MD** – metabolic age, **KD-MD** – difference between chronological and metabolic age, **ST** – systolic pressure, **DT** – diastolic pressure, **FS** – heart rate

The research findings emphasize the fact that elevated heart rate is a strong predictor of cardiovascular mortality—more commonly observed in men (Palatini et al., 1999)—and that it is essential to monitor heart rate regularly, both at rest and during physical activity in athletes.

Table 2. Results of the Paired-Samples t-Test
(Differences Between Chronological and Metabolic Age)

	AS	SD	N	t	df	p
KD	64.07	5.65	46	9.44	41.00	0.00
MD	51.40	8.79				

Legend: KD – chronological age, **MD** – metabolic age

The results of the paired-samples t-test (Table 2) confirmed the hypothesis regarding the statistical significance of differences between the chronological and metabolic age of participants engaged in recreational exercise programs (p = 0.00). Additionally, the t-test results confirmed the significance of differences between chronological and metabolic age among participants involved in professional sports programs (p = 0.00). These significant differences highlight the fact that metabolic age is a much stronger predictor of cardiovascular risk than chronological age (Elguezabal-Rodelo et al., 2021).

Table 3. Results of the Correlation Analysis Between Cardiac Functions (Systolic and Diastolic Blood Pressure and Heart Rate) and the Difference Between Chronological and Metabolic Age

	KD-MD	FS	DT	ST
KD-MD	1.00	-	-	-
FS	-0.14	1.00	-	-
DT	-0.51	0.16	1.00	-
ST	-0.19	0.006	0.65	1.00

Legend: KD-MD – difference between chronological and metabolic age, **ST** – systolic pressure, **DT** – diastolic pressure, **FS** – heart rate

Within this study, the only statistically significant correlation was observed between the difference in chronological and metabolic age and diastolic blood pressure (r = -0.51). A higher basal metabolic rate was associated with lower diastolic pressure. Although this outcome is logically coherent, it contrasts with several previous findings (Seghieri et al., 2008). It is important to emphasize that the study sample predominantly consisted of male participants, most of whom were classified as non-obese.

CONCLUSION

The conducted research established a significant difference between the chronological and metabolic age of athletes diagnosed with trigeminal neuralgia. Furthermore, the findings confirmed the paradigm that there is a meaningful correlation between heart rate and the difference between chronological and

metabolic age among the examined athletes. In addition, a significant association was observed between diastolic blood pressure and the difference between chronological and metabolic age in the same population.

These results support the premise that professional athletes affected by trigeminal neuralgia—a condition that causes intense and often debilitating facial pain—may still exhibit a lower metabolic age despite the limitations imposed by their condition. Moreover, participants with a greater discrepancy between chronological and metabolic age also showed lower diastolic blood pressure values, regardless of the influence of trigeminal neuralgia.

The findings contribute valuable insight into the role of biological and chronological age in the context of athletic training among individuals with trigeminal neuralgia. Importantly, the study underscores the need for continued research to further explore this topic and potentially influence how differences between chronological and biological age are assessed in athletes suffering from this neurological condition.

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Muscle, Femininity, and Stigma: A Feminist Exploration of Women's Bodybuilding

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ABSTRACT. Becoming a bodybuilder does not 'naturally' correspond to the social expectations traditionally directed towards women. The discipline demands extensive training and other lifestyle commitments in building a muscular female body. Drawing on personal experiences, this project explores key dimensions of a journey through the world of bodybuilding. Utilizing a feminist approach and the concept of stigma, the study focuses on the emotional and physical labour involved in developing a muscular physique while simultaneously navigating the socio-cultural expectations attached to femininity. This article centres on a three-year period and includes insights gained from a European competition's Figure and Physique divisions. Central to this exploration is the tension between constructing a muscular body and negotiating the challenges of being a woman in the male-dominated subculture of bodybuilding.

Keywords: *bodybuilding, women, autoethnography, sociocultural norms*

INTRODUCTION

The first author embarked on her fitness journey at the age of 23, specifically to address her weight concerns. With limited fitness knowledge and driven by the desire to shed 30 kilos, she considered her body as a project in need of transformation. She began her journey by reading a book on bodybuilding that her father had purchased from a thrift shop, which became her number one

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guide. The cover featured Frank and Christine Zane, well-known figures in the bodybuilding sub-culture, was entitled *Super Bodies in 12 Weeks*. She followed its guidelines religiously to transform her body to a more desirable form.

A year later, the first author returned to the Philippines and her first thing to do was to join a local gym. She found one just a five-minute walk from home. When entering the gym, she encountered a typical bodybuilding facility characterized by its spartan simplicity. The atmosphere was set by loud rock music emanating from a nearly broken speaker and by the equipment which bore the marks of heavy use. One, rickety treadmill stood on the verge of collapse, a stationary bike was alongside it, and rows of dumbbells and barbells, encrusted in a rust, stood at the ready. Although the facilities were worn, they were functional. The walls were plastered with centrefolds from exercise magazines and the serious 'stares' of the male bodybuilders in them welcomed as she entered. Instead of feeling discomfort at seeing their prominently muscular physiques, she experienced a surprising sense of belonging. She vividly remembers being drawn to a poster of Ronnie Coleman (ex-pro bodybuilder), which seemed to epitomize the spirit of the environment. His image did not merely stand as a representation of physical excellence, but as a symbol of the deeply gendered landscape that defines much of the bodybuilding culture.

Two decades later during the first author's doctoral studies, the question of gender imbalance in bodybuilding re-surfaced as she re-entered this male-dominated arena. She could not help but wonder: Does she belong here? Or is she just an outsider in this over-masculinized environment? These questions reflect the broader tensions between cultural norms, **gender identity, and embodied practice**, especially in settings such as bodybuilding, where dominant forms of masculinity are frequently praised (Connell & Messerschmidt, 2005). The fascination with that image of Ronnie Coleman was not purely a form of admiration. It was also a confrontation of her own situation in a sport that historically has excluded and marginalized women, especially in the Philippines (Junio, 2024). This observation led to a critical reflection on whether her passion and the tacit idea that power, strength, and visibility are, by cultural default, male preserves.

Consequently, this autoethnographic study explores her lived experience as a female bodybuilder through the lens of Judith Butler's (1990) concept of gender performativity and framed around two main themes: becoming a female bodybuilder in a man's world and facing socio-cultural challenges as a female bodybuilder. In the sections below, her experience of building her body and the challenges inherent in being a woman in this male-dominated subculture are connected and critically analysed. There is specific emphasis on the psychological work involved in building muscle and balancing the sociocultural 'demands'

of Western womanhood. Thus, this study critically examines the discourse surrounding women's (lack of) agency in sport, the objectification of the female body, and the gendered expectations imposed on bodies in competitive settings through deploying Goffman's (1963) theory of stigma.

Bodybuilding – A male dominated sport

He evolution of women's participation in bodybuilding reflects broader tensions surrounding gender norms and athletic embodiment. Chapman (1994) notes that bodybuilding emerged as a fundamentally male-dominated arena, with female participation only beginning to take shape in the late 1970s (Aspiridis et al., 2014). Women were largely absent from competitive bodybuilding until Doris Barilleux, the First Lady of woman's bodybuilding and thirteen other women participated in what is widely regarded as the first national women's bodybuilding competition in 1978 (Todd & Harguess, 2012). The subsequent decades witnessed a substantial growth in women's engagement with both recreational training and competitive bodybuilding (Andersen, Brownell, Morgan, & Bartlett, 1998; Probert, Leberman, & Palmer, 2007a), with the early 1980s marking a particularly significant surge in female involvement (Bunsell, 2013; Grogan, Shepherd, Evans, Wright, & Hunter, 2006).

This expanding participation necessitated the creation of specialized competitive frameworks, each governed by distinct categories, regulations, and stringent qualification criteria designed specifically for female athletes (Grogan et al., 2006; Grogan, 2017). The competitive landscape has undergone continuous transformation since 1986, characterized by the introduction of new divisions and evolving judging standards that reflect changing perspectives on female muscularity (Grogan, Evans, Wright, & Hunter, 2004). However, the mainstreaming of women's bodybuilding has not occurred without resistance. The 1991 Ms. Olympia contest, broadcast for the first time on ESPN (a multinational sports media conglomerate), generated significant viewer backlash, with the network and the International Federation of Bodybuilding & Fitness (IFBB) receiving numerous complaints expressing discomfort with the display of highly developed female muscularity (Lowe, 1998). This public pressure ultimately compelled the IFBB to impose restrictions on female competitors' muscular development, revealing the cultural anxieties surrounding women's transgression of traditional Western gender boundaries and the perceived threat posed by muscular female bodies in mainstream media discourse.

Role of autoethnography

Autoethnography was identified as the most appropriate methodological framework for this study given the first author's established position within bodybuilding culture. Maréchal (2010, p. 43) characterises autoethnography as fundamentally "associated with narrative inquiry and autobiography," emphasising experience and personal narrative as central mechanisms for meaning-making. The first author's identity as a female bodybuilder provides critical insider access to a subculture that paradoxically champions women's empowerment through strength and discipline while perpetuating exclusionary practices that have historically marginalised female participants.

This deep cultural immersion fundamentally informs the methodological approach. Autoethnography functions both as analytical process and scholarly product, enabling critical examination of personal experience within broader cultural, gendered, and institutional contexts. Rather than treating subjective knowledge as methodological limitation, this approach positions it as an essential, reality-congruent lens for exploring how power relations, gender norms, and identity are embodied and enacted (Maréchal, 2010). As Bochner and Ellis (2006, p. 111) articulate, autoethnography "depicts people struggling to overcome adversity" and portrays individuals" in the process of figuring out what to do, how to live, and the meaning of their struggles."

The alignment between autoethnography and feminist scholarship proves particularly significant, as both recognize that the political is personal and that individual experience can illuminate concealed dynamics of systemic oppression (Ellis, Adams, & Bochner, 2011). This methodological approach enables the integration of memory, emotion, observation, and embodied knowledge into an account that maintains both reflective depth and analytical rigor.

Drawing upon the theoretical frameworks of Judith Butler and Tanya Bunsell, this study demonstrates that female muscularity extends beyond the physical boundaries of gym spaces, emerging through negotiation with broader social discourses. Through autoethnography, the researcher's body becomes simultaneously a site of inquiry and a mechanism of knowledge production, asserting that writing about lived experience, particularly embodied experience, generates novel epistemological possibilities (Silverman & Rowe, 2020).

The research process resonated strongly with McLean's (2023) reflections as an academic bodybuilder, particularly her observation that simultaneous research participation and cultural immersion reignited personal aspirations toward idealized physique achievement while intensifying engagement with cultural practices and rituals. Similarly, this investigation not only rekindled personal physique improvement goals, but also created additional accountability

pressures, pursued independently without established support networks. Engaging deeply with bodybuilding culture enhanced cultural awareness and sharpened understanding of gender as a socially constructed and contested category. Despite entering this research with prior amateur competition experience, the extent to which the investigation would demand sustained mental, physical, and emotional labour remained underestimated. The process ultimately proved far more challenging and personally revelatory than initially anticipated.

Challenging Norms: A Feminist Framework for Understanding Muscularity

Feminist scholars have extensively documented bodybuilding's empowering potential for women, positioning muscular development as a form of corporeal resistance (Brace-Govan, 2004; Brady, 2001; Heywood, 1998; Krane et al., 2004; Ryan, 2001; Shea, 2001). Wesely (2001, p. 173) demonstrates how female bodybuilders frequently conceptualize their muscular development as a "semi-rebellious act" that directly challenges dominant Western constructions of femininity. This perspective aligns with Griffin's (1998) assertion that women's serious athletic engagement inherently constitutes feminist praxis. Through muscular embodiment, women can strategically (re)negotiate social interactions and life circumstances, thereby disrupting binary assumptions traditionally governing the relationship between muscle and gender (Edwards, Molnar, & Tod, 2017).

Certain feminist theorists argue that female bodybuilders fundamentally contest hegemonic gender norms by reshaping their bodies according to self-determined standards, creating autonomous spaces of resistance (Bunsell, 2013). Shilling's (1993) concept of 'body projects' proves particularly salient here, emphasising how women's bodybuilding can subvert conventional beauty ideals to produce alternative, empowering physiques. Similarly, Hewitt (1997) contends that women who radically transform their bodies not only defy societal expectations but also reclaim agency over their own physicality, offering critical insights into how patriarchal norms operate both within broader society and specifically within bodybuilding culture.

Reflecting upon the first author's embodied practice reveals the persistent gendered nature of strength and muscularity while questioning how women's bodybuilding participation simultaneously challenges and reinforces existing gender norms. As Molnar and Kelly (2013) argue, the persistence of patriarchal systems continues to exclude women, necessitating from a radical feminist perspective the creation of alternative structures by women themselves. Through muscular development, women challenge cultural narratives associating femininity with softness, passivity, and physical restraint, transforming their bodies into

active sites of cultural resistance (Bunsell, 2013). In other words, for a female bodybuilder, the body functions not merely as a source of physical strength but as a powerful site of resistance. Female muscularity actively challenges traditional Western ideals of femininity. From a feminist perspective, physical strength should not undermine or negate womanhood but rather expand the possibilities of what it means to be a woman. By applying feminist theoretical frameworks, this study examines the intersections between gendered ideologies and physical culture, particularly focusing on muscle building and constructions of womanhood.

Feminist theorists advocate reconceptualising the gendered body not as a fixed, static entity but as a product of accumulated and repeated actions. Butler (1988) argues that gender is not an innate quality but is performed through a continuous succession of acts that are repeated, reinforced, and ultimately solidified over time. From this perspective, bodybuilding practice represents not merely physical transformation, but a means of engaging with and ultimately disrupting gendered performances developed throughout one's life. Thus, building muscle has deepened some women's awareness of how femininity is simultaneously socially constructed and vigilantly policed, yet remains open to subversion and resistance. Hours spent training in the gymnasium, developing a muscular physique, are far from neutral acts. Rather, they represent deliberate, gendered performances that actively resist and upset cultural narratives of female passivity and corporeal docility. Each lift, each demonstration of physical power, becomes a reconstituted act of resistance. Through this repetition, the body transforms from a symbol of gender conformity into a dynamic site where gender is continuously contested, destabilized, and reimagined.

Becoming a female Bodybuilder – The corporeal challenge

Cultural emulation involves the admiration of certain figures or ideals and often entails an internalized drive to conform to culturally sanctioned standards (Klein, 2007). Baghurst, Parish and Denny (2014) argued that emulation is a significant reason why many women become competitive amateur bodybuilders. Baghurst et.al (2014) added that emulation is conceptualized as a form of motivation originating from external sources, such as family members, professional bodybuilders, or even fictional characters.

The first author's primary objective was not explicitly to become a bodybuilder, but to lose the 30 kilograms of excess weight. Over time, this unwavering commitment to fitness, however, evolved into a deeper personal project, focusing on the following question: what would it mean to test the limits of her body and will? As noted above, bodybuilding emerged not just as a sport and physical activity, but as a personal provocation, which many bodybuilders

undertake to challenge corporeal cultural norms. However, this aspect of the sub-culture has different meaning to men and women. The first author reflected on the gender dynamics of bodybuilding:

The first author has had limited connections to the bodybuilding community within her local gym in the Philippines. At the same time, she has encountered a few individuals involved in the sport, but they all have exclusively been men and no women bodybuilders around. Additionally, none of them truly encouraged her to take this sport seriously. Therefore, at the beginnings, she often felt reluctant to disclose her aspiration to become a bodybuilder to male counterparts. There was a part of her that was driven by fear of exclusion from both the sub-culture and mainstream society. Bunsell (2013) detected similar concerns expressed by her female participants who were immediately ostracized as abnormal when they decided to embark on a quest for muscularity. The first author's fear of exclusion did not exclusively derive from her own personal insecurity, but also from a broader socio-cultural issue which have an impact on women who decided to pursue traditional male activities, leading to experiences of discouragement and exclusion.

Women's marginalisation in, and exclusion from, serious or competitive bodybuilding has largely been shaped by traditional gender norms surrounding femininity and masculinity. Bolin (1998, p. 196) captures the crux of this exclusionary logic in her observation: "...at no time has the muscled woman been regarded as a paragon of beauty." This statement highlights not only the absence of the muscular female body within hegemonic discourses of beauty but also society's broader unease with women who visibly transgress conventional boundaries of femininity.

This cultural tension is often experienced in everyday gym spaces, where female participants who demonstrate discipline, physical strength, and muscular development, achieved through sustained effort, are frequently met with confusion, discomfort, or even disapproval, rather than admiration or recognition. Bolin's insight is therefore critical for understanding how cultural standards of beauty function not merely as aesthetic ideals, but as gendered mechanisms of social control. These norms work to reinforce normative femininity while policing and disciplining bodies that deviate from entrenched gender expectations.

Lowe's *Women of Steel* (1998) offers an interesting balance around the concept and practice of female bodybuilding. On the one hand, there is the suggestion of women developing steel-like muscles, but, on the other hand, female bodybuilders to "look like women again," they must, as a duty to themselves, adorn their bodies with makeup, nail polish, and hairspray. This imperative to reassert normative femininity serves not only to conceal the physical toll of the sport, its fatigue, hunger, and dehydration, but also exposes the persistent

cultural expectation that women must perform femininity, even at the height of physical achievement. The first author reflected on Lowe's account as follows: *'Gazing at my own reflection in the mirror, my face gaunt from months of rigorous dieting and physical discipline, I felt the full emotional weight of Lowe's observation and the urge to play along and rekindle my femininity.*

Lowe's critique brings into sharp focus the enduring force of the *feminine apologetic*, the expectation that women must soften or offset their strength to remain legibly feminine. It reveals how the female bodybuilding body, despite its transformation through intense labour and discipline, remains subject to gendered cultural scripts and policing that prioritise aesthetic legibility over bodily autonomy.

"The Feminine Apologetic" (Self-Construction)

When women decided to get serious with bodybuilding, they are often unaware that they would tap into conventional gendered borders and disrupt and challenge gender norms (McGrath and Chananie-Hill, 2009). Women often feel culturally compelled to explore and align themselves with feminine cultural traits. As they become more muscular, face thinner and jaw more pronounced, women tend to respond to social pressures in a way what Ussher (1997) called "doing girl". In other words, they begin to include feminine practices into their daily life such as getting false eyelash extensions, wearing lipstick, and growing their hair longer. Grogan *et al* (2004) described it as a "balancing act" between the competing demands of femininity and muscularity as a result of training hard with heavier weights, which further deviates from gendered norms. In opposition to the image of the big hard female body, according to Joana Frueh (2001), in her book Monster/beauty: Building the body of love, "some female bodybuilders feminize themselves by dyeing their hair blonde (employing a sign of vulnerability and innocence); painting their nails and curling, ornamenting, or upsweeping their hair (using the artifice of grooming); having breast implants (emphasizing a fetishized part of female bodies); and wearing corsets or other lingerie for photo shoots becoming pinups in order to court stereotypical sexual fantasy" (p. 108).

> *I despise wearing high heels, but succumb to the idea of wearing them in the competition. With the physique that I achieved, my confidence has multiplied, covering the fact that I don't know how to wear high-heeled shoes at all. I went and got a lash extension as the fake lashes make my diet face more wide-eyed and cheerful. I had my nails done and had nail extensions, it gave the illusion of having long fingers, despite loving the veins and callus that formed on my hands and arms.*

Butler (1990) illustrates how language becomes a site for the negotiation and construction of gender, emphasizing its performative nature, where femininity is not an inherent trait but something continuously enacted and articulated. In contexts such as the Philippines, where female bodybuilding remains largely unconventional and is met with limited public acceptance, women athletes may experience discomfort under the gaze of those outside the bodybuilding subculture. The muscular female body, through its visible transformation, becomes a site of gender nonconformity (Kotzé & Antonopoulos, 2019). By cultivating an androgynous physique (Schulze, 1997), these women present a corporeal challenge to dominant gender norms, provoking stigmatization, marginalization, and various forms of sexism. As Felkar (2012) argues, such bodies disrupt culturally entrenched expectations of feminine appearance, revealing the social tensions that arise when women visibly defy normative ideals.

Turning to another dimension of the discussion, the concept of the *feminine apologetic* was first introduced by Jan Felshin (1974) in her seminal essay *The Triple Option…For Women in Sport*. Felshin argued that women in sport occupy a paradoxical position, as sport has historically been constructed as the embodiment of masculinity, strength, aggression, competition, while dominant ideals of femininity explicitly exclude these traits. The *feminine apologetic* refers to the strategies employed by women athletes to counterbalance their participation in a masculinised domain by enhancing or performing conventional femininity. In the context of bodybuilding, this might involve aesthetic gestures such as emphasising appearance, wearing makeup, or highlighting traditionally "feminine" traits to offset the muscularity, competitiveness, and strength that challenge normative gender roles.

Felshin further noted that, because women neither wish to reject sport entirely nor accept total exclusion, apologetic behaviours emerge as a way to justify their presence and participation in the face of cultural disapproval. Yet, while the feminine apologetic remains a persistent cultural mechanism, female bodybuilders' insight and experience presents a more nuanced perspective. Most women bodybuilders, the first author included, do not see it appropriate to "apologize" for their participation in bodybuilding. Instead, they seek to redefine the cultural boundaries of femininity through the activity. Such women tend to embrace both strength and femininity not as contradictions, but as a deliberate and empowered fusion. As Felshin (1974, p. 40) compellingly concluded, women must be encouraged to explore their full range of possibilities: "for it is self that is sought, and no apology is required."

Entering a Man's World

Within the traditionally male-dominated arena of bodybuilding, female participants frequently embody what Erving Goffman (1963) conceptualizes as a "discredited identity" - an identity visibly marked by stigma through its deviation from socially sanctioned norms. The muscular female body, conceived as testimony to strength, discipline, and dedication, encounters suspicion, judgment, and disapproval within public spaces. Goffman's stigma theory, particularly his concept of spoiled identity (Goffman, 1963; Jacobsen & Smith, 2022), provides a compelling framework for understanding the social consequences of gender nonconformity as they are specifically imposed upon women.

While male muscularity typically receives celebration as symbolic achievement, female muscularity becomes a contested site of social tension, subjected to scrutiny, unsolicited commentary, and assumptions regarding sexuality, gender identity, and moral character. This stigmatization positions female bodybuilders within a paradoxical space of hypervisibility and marginalization: they are consistently observed, even fixated upon, yet remain culturally unassimilated, i.e., perpetually seen but seldom accepted. These dynamics illuminate how gendered expectations fundamentally shape the reception of female athletic bodies while reproducing the boundaries of normative femininity.

Importantly, stigma operates not merely as external imposition upon female bodybuilders but also requires internal negotiation, a conscious awareness of how muscular embodiment tests gendered boundaries. Goffman's (1963) analysis of "discreditable" group membership, wherein one's body resists normative categorization, reveals the contours of dominant social norms through their transgression. The first author's experience exemplifies this dynamic:

> *During the COVID-19 pandemic, I developed significantly more muscle mass. When lockdown restrictions lifted and gyms reopened, I re-entered public spaces transformed- returning to familiar environments within an unfamiliar body. Reactions from individuals I had not encountered for months varied considerably. Some expressed admiration and inspiration, while others appeared uncertain or withdrew, seemingly unsure how to respond. I vividly recall receiving particular "looks", not hostile, yet not welcoming either. These gazes appeared to question what they observed, as if my muscularity somehow disrupted expectations they were unprepared to confront.*

Throughout their active participation, female bodybuilders often develop strategic abilities to disregard external gazes and reactions from individuals outside the bodybuilding community. This defensive approach minimizes the adverse impacts of social stigma (Goffman, 1963). Individuals face stigmatization for

failing to meet categorical expectations, in this case, gender category expectations. Goffman (1963) designates individuals as "normal" when they conform to social expectations, while those who deviate experience stigmatization. Consequently, female bodybuilders strategically redirect emphasis toward external opinions that accept their embodiment, utilizing supportive perspectives as primary reference points. By positioning themselves as intentionally "different," they render "general public" opinions (particularly negative ones) less significant (Grogan et al., 2004).

The corporeal exposure inherent in competitive bodybuilding, both on stage and within gym spaces, raises critical questions about whether such public display constitutes surrender, potentially transforming the body into a site of male gaze and desire (Patton, 2001). Laura Mulvey's (1975) "male gaze" theory demonstrates how visual culture constructs itself around masculine viewing subjects while positioning women as passive objects of desire. Within female bodybuilding contexts, this gaze operates with particular complexity: the muscular female body simultaneously invites viewing while resisting objectification, thereby offering a form of resistance to gender normativity.

Although audiences may attempt to view muscular female bodies through heteronormative frameworks, these bodies simultaneously challenge the terms of the gaze through their disruption of traditional feminine softness. The muscular female body emerges as a site of productive tension, i.e., visible yet not fully integrated within contemporary definitions of femininity, thereby exposing the limitations of conventional frameworks that reduce women to sources of visual pleasure. This embodied resistance reveals the instability of gender categories while simultaneously demonstrating the persistent power of normative expectations to shape social interactions and related self-perception.

CONCLUSION

This autoethnography traced the first author's journey into female bodybuilding, documenting her commitment to a sport deeply rooted in masculine culture and her navigation of the complex socio-cultural environment that continues to stigmatize muscular femininity. What began as an individual pursuit of strength evolved into a confrontation with deeply entrenched gender expectations. Drawing upon Judith Butler's (1990) theory of gender performativity, the analysis demonstrates how the muscular female body contradicts the scripted boundaries of femininity, rendering gender visible not as fixed essence but as continually performed and open to resistance. The author's muscular embodiment emerges as disruption - one that resists and redefines what is performatively recognized as "feminine."

By situating this autobiographical narrative within feminist theoretical discourses, the study resists hegemonic discourses that conflate muscularity with masculinity and femininity with weakness or passivity. The first author's embodied experience subverts the gender binary, and it situates the body as a site of empowerment, resistance, and performative agency.

This paradox accounts for how female bodybuilding resists but remains vulnerable to Mulvey's (1975) theory of the male gaze. The body of the muscular woman is a space of tension, both discovered and placed upon under to uncover the shameful reality of the sport's continued masculine bias. The body of the female bodybuilder, as strong as it is, is decided not in itself but according to how well it can be coaxed or talked into conforming or reassuring patriarchal sight. Each workout repetition in the gym, each bodybuilding pose under stage lights and the months of constant dieting, constitutes an act of subversive performance that recomposes understandings of womanhood through a body that refuses diminishment. The competitive stage reveals the persistent tensions within female bodybuilding, and to achieve favourable judging outcomes from the judges, the first author found herself compelled to perform "feminine apologetics" (Felshin, 1974), donning makeup, false eyelashes, and nail extensions to soften what might be perceived as excessive muscularity.

The research reveals a fundamental contradiction: women can lay claim to spaces of strength, yet they remain gendered ideals of apologetic performances of traditional femininity. Female muscle does not emerge as a contradiction but as a declaration of being strong, political, and deeply personal. This study invites readers to reconsider intersections of embodiment, gender, and identity in a way that recognizes bodybuilding as more than sport participation, but as a feminist practice. The study contributes to broader academic discussion about how women navigate traditionally masculine-coded sports while also resisting and being constricted by persistent gender norms that still shape athletic domains and competitive cultures.

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A Brief Analysis of the Correlation Between Budget and Performance in Romanian Soccer

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ABSTRACT. Starting from the widely held idea in Romanian football (and not only) that a higher budget is almost the only requirement for better performance for a club, our study investigates the existence and intensity of such a correlation. At the same time, we sought to deepen the correlations within club expenditures, through those related to the player roster as an expression of its value, where we expect a to see a higher intensity in relation to sports results. Due to data availability considerations, the analysis is limited to the latest seasons of the domestic championship. The approach is based on rank correlation, and the tools used are Kendall's coefficient and Spearman's coefficient. The results obtained confirm expectations regarding the existence of a direct relationship between the amounts spent by a club and its position in the rankings, but the intensity of this correlation is significantly lower than expected, at least at the level of total expenditures.

Keywords: *budget, sport performance, rank correlation*

INTRODUCTION AND LITERATURE REVIEW

It is evident that in the context of sports activities – like any other activity – the functioning and results obtained depend directly on the investments made. In team sports, a higher budget allows the recruitment of better players and coaches, as well as ensuring sufficiently large player squad and superior training conditions. All these provide a solid foundation for future high-level performances. An important aspect is the efficiency of capitalizing the available budgets, a matter related to sports management: clubs with top sports results are generally characterized by high efficiency in money spending.

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Increase in investment outlays contributes to the improvement of sports results in national and international competitions (Leksowski, 2021). This enables clubs to enter in an upward spiral where higher budgets ensure a better squad, leading to performance, results that generate higher revenues (rewards for national championship positions, TV rights, international competitions, ticketing, etc.), revenues that allow greater future expenditures which can further bring better performances and even greater revenues. This is the prevailing belief among patrons, club presidents, journalists, or ordinary supporters, and as result, the managerial policy of most sports entities. Such correlation must be strong and uninterrupted; otherwise, there is a risk of entering a 'vicious circle': deficits and/or budget cuts, major player sales, squad reductions, declining aspirations and lower sporting results.

Previous studies (Kulikova and Goshunova , 2013; Dimitroupolos & Limperopoulos, 2014; Ferri et al., 2017) analyzing several different foreign championships indicates that the football-clubs performance mainly depended on the skills of players and coaches and their salaries to a greater extent than other factors, which is why our analysis will distinctly focus on the level of wage expenditures and not only on total clubs budget.

Another aspect that tends to generate problems in club management is related to the dual objectives pursued in most situations: sports performance and maximizing financial results. Although the two are intertwined and interdependent, but these is not made in an absolute manner, so there are many circumstances where the latter predominates. As follow, most existing studies focus more on the connection between sports performance and the financial results of clubs (Arnold, 1991; Sakinc, Acikalin and Soyguden, 2017), while the reverse relationship is under-explored in economic literature. Studies show mixed results on the impact of sports success on financial performance.

Such studies have used various instruments and have also considered and other influencing factors, without any of the methods used to prevail or the results obtained to prove behind any doubt and in all circumstances a certain intensity of the correlations.

PURPOSE AND METHODOLOGY

The issue we focused on in our analysis is related to the financial power of a club and its performance. More precise, we examined two aspects that we consider essential, namely:

(1) the existence of a direct and significant correlation between the total budget level and sports results, and

(2) the existence of a direct and strong correlation between the value of a squad (measured by wages' expenses as a quantitative proxy of the qualitative variable) and sports results.

The hypotheses, based on the mentioned general perception, started from the existence of a direct and strong correlation between the expenses made by a club and the performance obtained. As we have already seen, a higher budget would allow for the acquisition of players with higher market value, both in terms of the possibility of paying substantial transfer fees and by ensuring higher salary caps. At the same time, it can attract a top technical staff and provide better training conditions. A more valuable squad and potentially better-trained players seem to be the keys to success. Since higher-rated players are usually paid better, the reasonable assumption we make is that the more substantial is the salary budget, the higher is the value of the players, thus increasing the chances of the team's sporting success.

To verify these premises, we relied on the situation in the first tier of the Romanian football championship (Superliga) from the last two competitive seasons: 2023-2024 and, respectively, 2024-2025. The clubs considered are the those 14 that participated in both editions: SC Fotbal Club FCSB, Fotbal Club Rapid 1923 Bucureşti, FC CFR 1907 Cluj, CS Universitatea Craiova, CS Farul Constanţa, ACS Sepsi OSK Sfântu Gheorghe, SC FC Dinamo Bucureşti, AS FC Universitatea Cluj, AFC UTA Arad, ACS Petrolul 52 Ploieşti, AFC Hermannstadt, AFC Botoşani, ACSM Politehnica Iaşi şi ACS Suporter Club Oţelul Galaţi. The extension over a longer period of time is limited by the small number of teams that manage to remain in the top league for an long period. Compared to a decade ago - when the playoff/playout system was introduced - only 5 teams have played continuously in League 1. (Farul/Viitorul Constanţa, FCSB, CFR Cluj, Universitatea Craiova şi FC Botoşani). This limits the sample and the analysis period, which requires interpreting the results with some reservations.

The data used in the analysis were extracted from the financial statements submitted by the clubs for licensing for the upcoming season and published on their own websites. Since these data pertain to the fiscal year (which corresponds to a calendar year) and not the competitive one, and in the absence of other data and information regarding the expenses for each month, I assumed an equal distribution of these. Thus, for determining the total expenses, including payroll expenses, for the 2023-2024 season, half of those found in the balances of the year 2023 (related to the second semester of that year and considered to cover the first part of the competitive season) were summed with half of the corresponding expenses from the balances of the year 2024 (related to the first fiscal semester and considered to cover the second half of the season). Furthermore, due to the fact that the financial statements for the year 2025 are not yet published, there is no available information for the

expenses of the second part of the 2024-2025 season. However, our analysis does not require exact data, but only a comparative assessment to conclude to a ranking, order which can be determine from the trends in the evolution of these budgets. As a result, we started from the reasonable assumption that the situation existing in the first part of the season (highlighted by the budgets for the fiscal year 2024) will also be present in the second part of the season, which allowed us to use the respective data for the entire season.

Considering the organization of the championship, with a regular season and a play-off and play-out system, and wishing to make analyses as comprehensive as possible, therefore at the level of the entire chosen sample, we primarily took into account the sports results materialized in the position occupied at the end of the regular season. In any case, the final situation does not differ significantly at the play-off level (the exception was Rapid in 2023-2024 season). At the level of the play-out or relegated group, the situation has registered some major changes, which led us to also monitor the final standings in the championship.

The degree of association or the intensity of the connection between the ordinal variable sport performance (mainly from the perspective of the ranking position in the regular season standings) and the total investment, respectively that in salaries (through the hierarchy of total budget sizes, respectively that of salary expenditures) will be made using rank correlation' coefficients of Spearman and Kendall's Tau. These coefficients evaluate the degree of similarity between two set of given ranks (such as sport standing and the hierarchy of clubs based on their expenses). The position in the standings essentially corresponds to the rank, except for the last two teams in the 2023-2024 regular season (Dinamo position 14 and associate rank 13, and FC Botoșani position 16 and associate rank 14), due to the exclusion from the analysis of the teams that will be relegated at the end of that season. This does not affect the analysis, as their ranks do not change.

RESULTS

On the all graphs presented, the teams are ordered on horizontal axis based on their position in the standings both at the end of the regular season (left), and at the end of the season (right). It can be easily observed (see figure 1 left) that in the first analyzed season, the order of the first six clubs in the regular season standing corresponds entirely with their rank based on total budget. The situation can be explained by the substantial differences in the absolute size of their total expenses compared to those of the other participants. For example, the budget of the team in 6th place (Sepsi) was over 15 million lei

(+39.5%) larger than that of the next team in terms of expenses (Dinamo) and over 19.5 million (+58.4%) more than the team ranked in 7th place (U Cluj). The situation remains the same in the next championship edition, but the gaps are noticeably narrowing in certain cases (CFR Cluj and Sepsi). Sepsi, still with the 6th largest budget (but slightly decreasing), has only 7 million (+15%) more than Dinamo, less than half the difference from the previous year. Only the top four teams based on budget level were to qualify for the playoff.

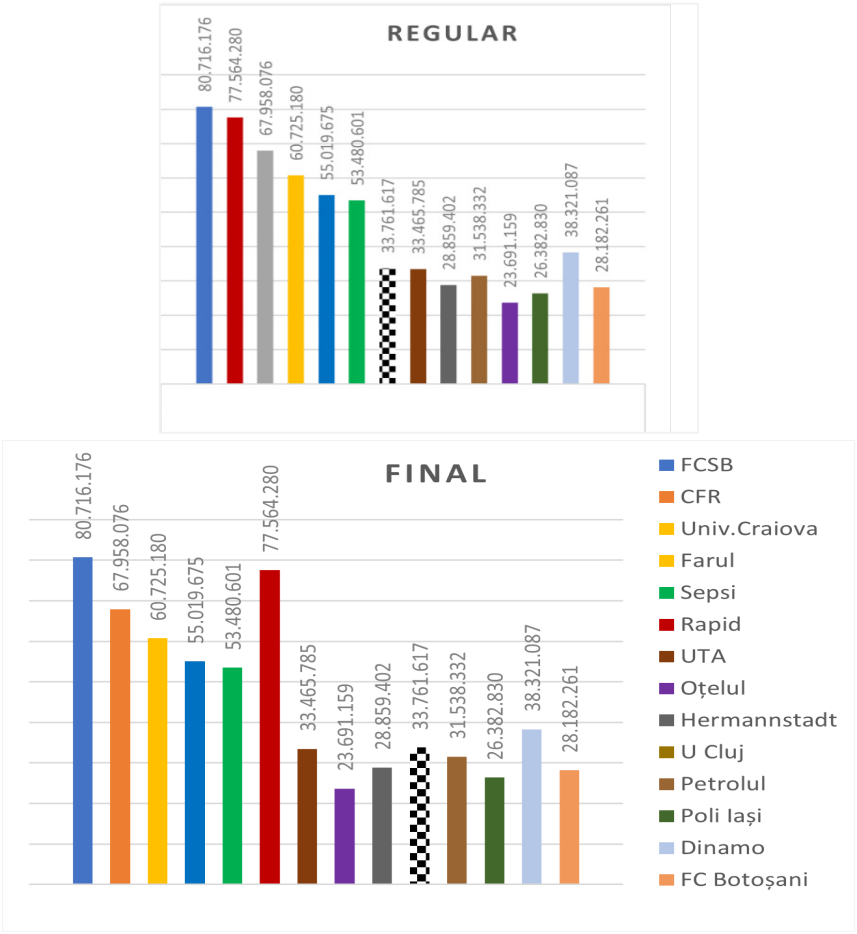


Figure 1. Total Budgets for 2023-2024 competition season

In this season, only Dinamo (minus 6 places between the budget ranking and the position in the sport standing, both in the regular season and in the end) and partially Rapid (a loss of 4 places in the playoff) seems to be the

underperformers, while the biggest gain is achieved by Oțelul (plus 3 places at the end of the regular season and plus 6 places in the end). For the 2024-2025 season, the situation is more dynamic (see Figure 2). We have several teams that perform significantly below their expenses (Rapid – minus 4 places, Farul – minus 5 places, or Sepsi - the last one especially in the playout, finally minus 8 places and relagates!), but also those that perform despite their budgets (U Cluj – plus 4 places, Hermannstadt – plus 5 places, or Oțelul - plus 3 places at regular season and plus 6 at end of championship).

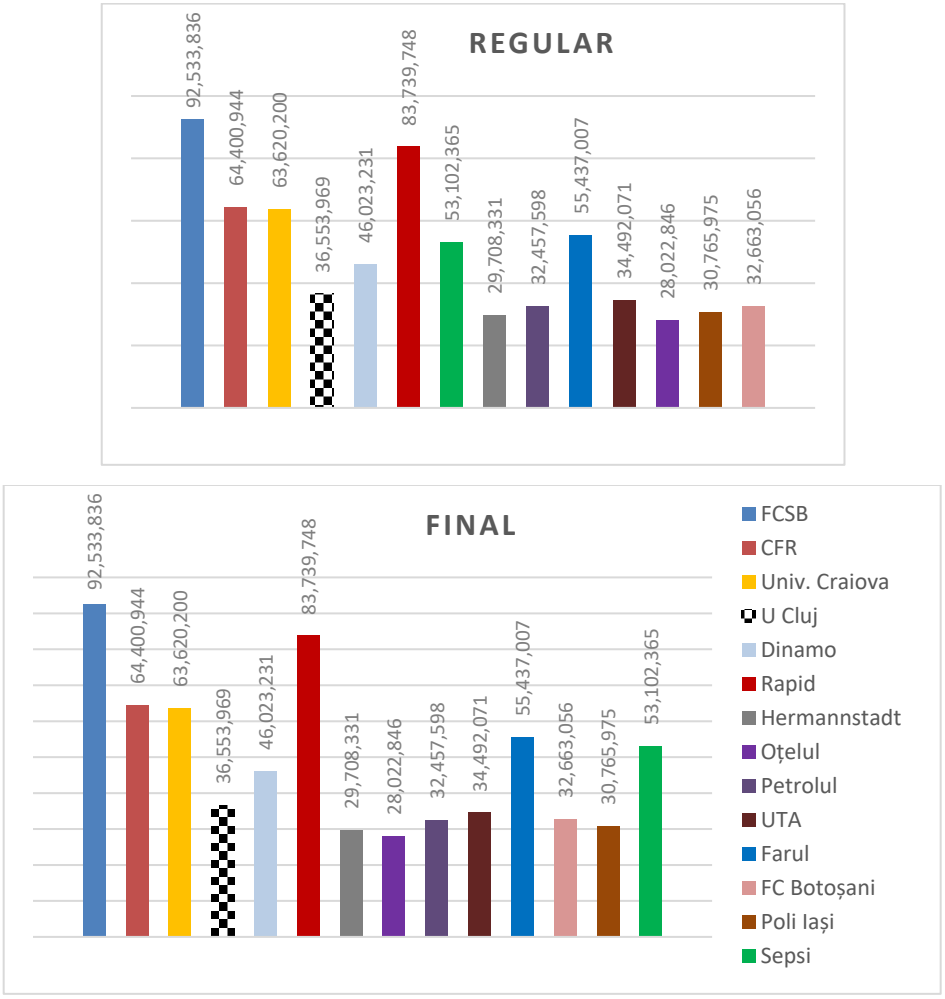


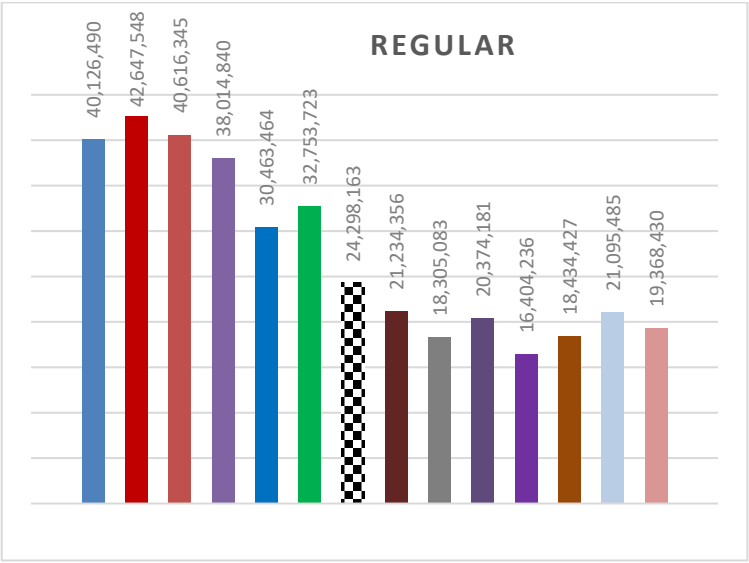
Figure 2. Total Budgets for 2024-2025 competition season

Considering the value of the Kendall coefficient (τ) that we calculated, a positive correlation is identified in both seasons, although the intensity of the relationship varies significantly. Such a direct relationship indicates that clubs with higher budgets tend to occupy better positions in the standing of the competition. The correlation is relatively strong at the end of the analyzed regular season of the 2023-2024 championship with $\tau = 0.78$ (value associated with a moderately strong correlation almost inferior borderline), while in the following edition the intensity is average (with a value of $\tau = 0.56$). Considering the final rankings, the correlations are much lower: $\tau = 0.582$ for the first analyzed year and an almost insignificant $\tau = 0.385$ for the following year. In summary, we would assess the intensity as moderate, but at the upper limit of the range for the regular season and weak to moderate for the entire season. If we exclude what happened in the play-out of the last season (and in the analysis of which the correlation measured by the Kendall coefficient is not significant), the intensity can be considered moderate at a general level.

A clearer determination could be obtained by using other methods, such as Spearman's rank correlation coefficient. The calculated values for this are $\eta = 0.877$ for the regular season of the first year and $\eta = 0.758$ for the end of that championship, respectively $\eta = 0.763$ and $\eta = 0.53$ for the following season. The connections measured in this way are stronger in all analyzed situations (with a relevant deviation only for final ranking from the last season).

When we analyze the sports performance from the two seasons (at the end of the regular season and complementarily at the end of the championship) in relation to the variable wage expenditures (ordinal approach), the results is not significantly different. For the regular season, the Kendall rank correlation coefficient (τ) calculated based on this data provides values ranging from $\tau = 0.714$ in the 2023-2024 championship (see figure 3) to $\tau = 0.473$ in the following edition (see figure 4). The values of the coefficient at the end of the championships are even lower $\tau = 0.516$ in 2023-2024 and $\tau = 0.297$ in 2024-2025 (the coefficient isn't significant, too). Under such conditions, the correlation is also one of moderate intensity ($\tau < 0.7$), with only one of the calculated values exceeding at borderline the limit of the interval.

If we consider the Spearman coefficient, its values are significant and indicate a strong correlation for the first season: $\eta = 0.873$ (regular) and $\eta = 0.732$ (final). For the next championship edition, the correlation is much lower: medium level ($\eta = 0.684$) for the regular season, and medium to low ($\eta = 0.486$) when considering the final standing.



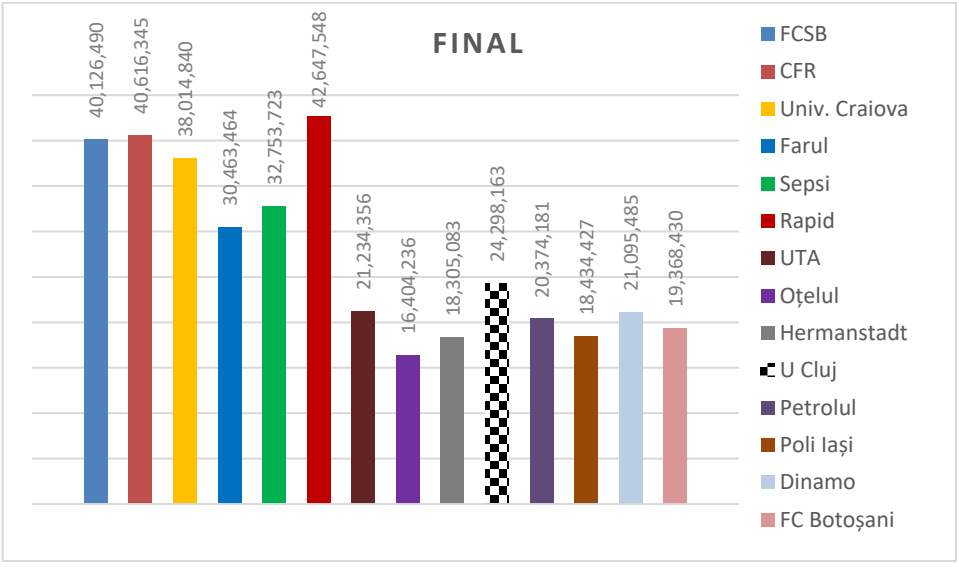


Figure 3. Wages Expenses for 2023-2024 competition season

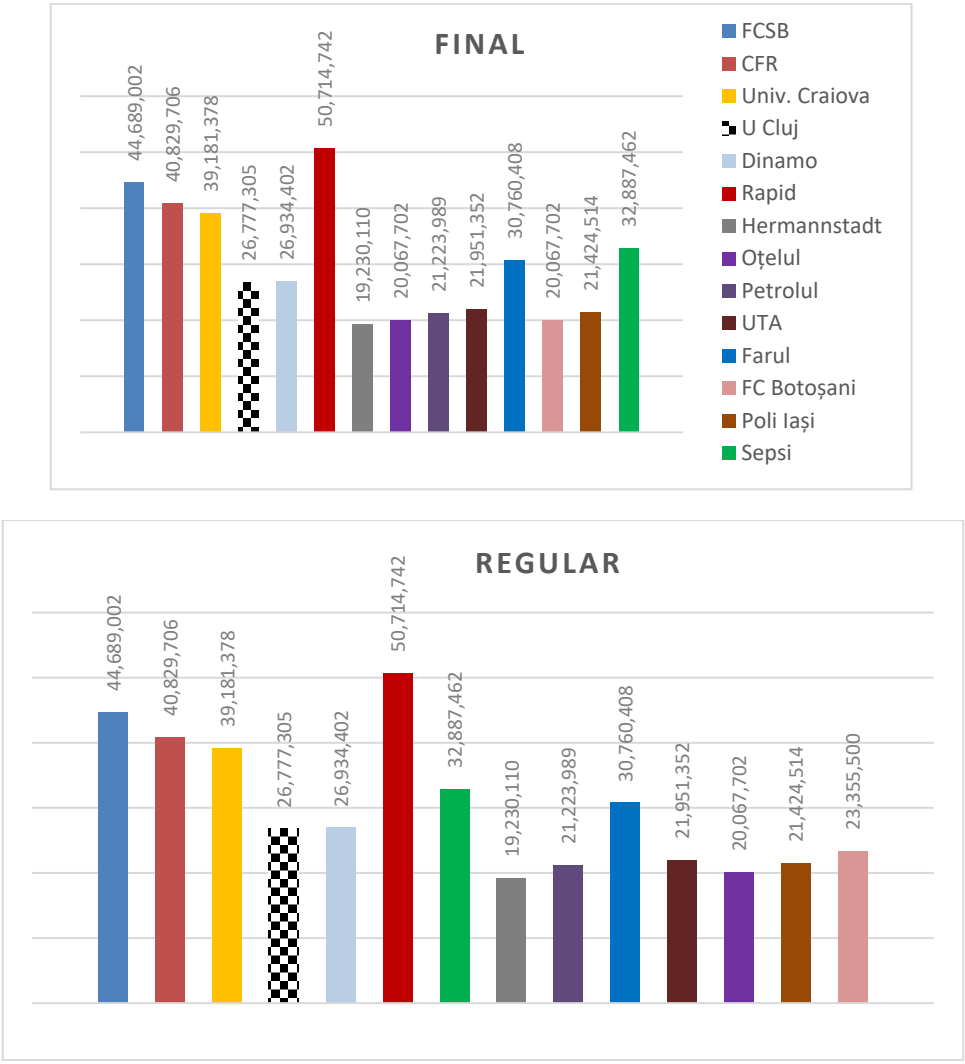


Figure 4. Wages Expenses for 2024-2025 competition season

Correlating all this information, the result indicates a positive (direct) but relatively moderate (medium intensity) correlation between the level of salary expenditures and sports performance. Teams that offer higher salaries will normally achieve a better position in championship, but this correlation seems to be less intense than in the case of total expenditures.

CONCLUSION

The statistical analysis conducted indicates a positive relationship exists between money spent by a club and its standing position, particularly when we look at the total spendings. Somewhat surprisingly from the perspective of economic literature on this topic, where rather the expenses on wages and not the total ones appear to be more strongly correlated with sports performances. The explanation may be related to the smaller differences between the salary budgets of the teams in the Romanian championship compared to the differences existing in other championships for which the respective studies were conducted. Such a moderate connection also may suggest that although the salary budget is an important factor in ensuring sports competitiveness, it is not sufficient on its own. The results obtained also depend on other internal factors (the quality of training, player motivation, the homogeneity and stability of the team and coaching staff) and external factors (the schedule of matches in relation to the team's own situation and that of the opponents – the interval and distances between matches, injuries, suspensions). At the same time, there are aspects related to other categories of expenses: transfers, training conditions (facilities, training camps) and travel (means of transport, accommodation conditions)

The analyzed correlations appear stronger when measured using the Spearman coefficient. But in this case too, it is observed that the playoff and playout diminish the intensity of all these correlations. The way they are organized (separating teams into two groups, halving the points obtained during the regular season, having only one match in the playout) largely explains these discrepancies. The correlations seem to deteriorate significantly especially due to the playout. Middle-level teams generally seem to have a higher chance of failing at this stage of the championship, likely explicable by the demoralization of those who missed the playoffs (U Cluj in the first analyzed season, Farul and Sepsi in the last season).

One aspect that must be considered is that the budgets of all clubs are showing a tendency to increase, so a higher budget level of a club that is likely to improve performance should be seen as one that registers a larger increase than that of other competitors. For example, in 2024 alone, the revenue of the clubs in the Super League increased overall by 81 million lei (approximately 16 million euros) compared to the previous year, reaching a level of 570 million lei (approximately 114 million euros) in 2024 (FRF, 2025). This would mean that only clubs that have raised their budget by more than the average increase of 16.5% have recorded a comparatively higher budget. In addition, it is necessary to take into account that the absolutes gaps compared to clubs with higher budgets, the recovery of these differences, as well as the still remaining differences represent explanations and obstacles in improving performance, even in the context of

superior budget increases. Precisely in order to consider the general evolutions and the comparative situation, the ranking correlation was used as a working method.

According to our knowledge, this is the first paper that studies such correlations with focus on the Romanian football championship. Among the limitations of the research are the lack of detailed data regarding the players' individual contracts or unofficial funding sources, which could have influenced the interpretation of the correlations between performance and budgets. Additionally, the analysis focused on a single national league and a very limited time frame, which reduces the applicability of generalizations. Any of its conclusions apply only to a specific case: Romanian football. Further research also needs to include more clubs and assess long-term impacts of financial investments.

Reality highlights the fact that, although there is a statistical link between budget and performance, it is not absolute. Sports success does not solely depend on financial investments, but is also influenced by other factors: sports strategy, management quality, team homogeneity, infrastructure, team cohesion, or even hazard. As in all businesses calculated spending is essential, but blind investment does not guarantee success.

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The Effectiveness of Blazepod-Based Neurocognitive Training on Reaction Time and Agility in Young Competitive Athletes

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ABSTRACT. *Introduction*: Reaction speed and cognitive-motor coordination are critical components of athletic performance, particularly in sports requiring rapid decision-making and stimulus-response adaptation. While BlazePod technology has gained popularity in applied settings, empirical validation in youth athletic populations remains limited. *Objective*: This study aimed to evaluate the effects of a six-week BlazePod-based neurocognitive training program on reaction time, agility, and cognitive-motor performance in adolescent athletes. *Methods*: Thirty-five athletes (aged 15–19) were randomly assigned to experimental (n = 18) or control (n = 17) groups. The experimental group received additional BlazePod training (3 sessions/week, 15–20 minutes), while the control group continued standard sport-specific routines. All participants completed five tests at pre- and post-intervention: Simple Reaction Time, Choice Reaction Time, Agility T-Test, Go/No-Go, and Stroop Response Time. *Results*: Statistically significant improvements were observed in all variables within the experimental group ($p < .001$), with large effect sizes (Cohen's $d > 2.0$). The control group showed smaller but significant gains. Gender-based analysis confirmed training effectiveness across both sexes. *Conclusions*: BlazePod-based training significantly enhances both motor and cognitive performance in youth athletes. The results support its integration into sport training to improve reactivity, executive function, and decision-making under pressure.

Keywords*: reaction time, neurocognitive training, agility, BlazePod, adolescent athletes*

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INTRODUCTION

Reaction speed is a critical component of athletic performance, particularly in dynamic sports where rapid responses to external stimuli can determine competitive success (Mero, Luhtanen, & Komi, 1992). It encompasses the ability to perceive a stimulus, process information, and execute a motor response within minimal time. While this skill has traditionally been viewed as a stable trait, recent findings indicate that it can be developed through targeted neuromotor and cognitive training (Williams & Ford, 2008).

Over the past decade, cognitive-motor training—a method combining physical execution with simultaneous cognitive demands—has gained traction in the domains of sports science and performance psychology. Studies show that such dual-task approaches not only enhance physical response times but also improve executive functions such as attentional control, inhibition, and decision-making under pressure (Voss et al., 2010; Faubert & Sidebottom, 2012). These cognitive traits are especially vital in team sports, where athletes must constantly scan, interpret, and respond to complex visual information in real time (Mann, Williams, Ward, & Janelle, 2007).

One emerging tool in this space is the BlazePod system, a visual stimulus-based technology that uses wireless LED pods to elicit reactive responses under configurable cognitive and motor conditions. It enables the creation of both simple and complex reaction-based tasks, adaptable to varying ages and performance levels. Unlike conventional agility drills, BlazePod-based protocols engage visual perception, working memory, and motor control simultaneously, aligning closely with the demands of real sport environments (De Fazio, R., Mastronardi, V. M., De Vittorio, M., & Visconti, P. 2023). While visual cue systems like Fitlight and BlazePod have grown in popularity among practitioners, empirical validation of their effectiveness, particularly in youth populations, remains limited.

Recent studies using similar technology have found improvements in reaction time and coordination in elite athletes (Gabbett & Benton, 2009; Silvestri, F., et. al., 2023, Campanella, M., et. al, 2024), but relatively few have explored their effects in adolescent athletes, a population undergoing rapid neuromuscular and cognitive development. This is a significant omission, as adolescence is considered a sensitive period for optimizing neural adaptations through targeted training stimuli (Malina et al., 2015; Lloyd & Oliver, 2012). Furthermore, the literature remains scarce on how these technologies affect more complex cognitive-motor tasks such as inhibitory control (e.g., Go/No-Go) and interference processing (e.g., Stroop tasks), which are fundamental to performance in unpredictable environments (Verburgh et al., 2014; Scharfen & Memmert, 2019).

Moreover, while the benefits of cognitive training in older adults and clinical populations are well documented (Barha et al., 2017), fewer controlled trials have investigated sport-specific cognitive training in adolescents using ecologically valid, field-based tools like BlazePod. Most existing studies have focused on virtual or computer-based platforms, which may not fully capture the speed, pressure, and movement complexity of real-time sport demands (Voss et al., 2010; Broadbent, Causer, Ford, & Williams, 2015).

Given this context, the current study aims to examine the effects of a six-week BlazePod-based neurocognitive training program on reaction time, agility, and cognitive-motor performance in young athletes. By integrating simple and choice reaction drills, change-of-direction tasks, and executive function tests (e.g., Go/No-Go, Stroop), this study seeks to provide evidence on the practical and cognitive benefits of using light-based stimulus tools in youth athletic development. Furthermore, it aims to address the existing gap in the literature regarding field-based, technology-assisted cognitive training during a critical developmental stage.

METHODS

The purpose of this study was to evaluate the effectiveness of BlazePod-based neurocognitive training on reaction time, agility, and cognitive-motor integration in young athletes aged 15 - 19. To assess performance changes, participants underwent a six-week intervention with pre-test and post-test measurements across five standardized tasks: Simple Reaction Time, Choice Reaction Time, Agility (T-Test), Go/No-Go, and Stroop-like Reaction Time. Descriptive statistics and inferential tests were used to compare scores between the initial test (IT) and final test (FT) phases. Table 1 presents the descriptive outcomes for all performance tests.

Participants

The study included 35 adolescent athletes (M = 16, F = 19), aged between 15 and 19 years (M = 16.7 years, SD = 1.2). All participants were engaged in competitive sports, training at least four times per week for a minimum of two years prior to the study. The athletes represented various disciplines, including football, basketball, and handball. Participants were randomly assigned to two groups: the experimental group (n = 18; 8 males, 10 females), which received BlazePod-based neurocognitive training, and the control group (n = 17; 8 males,

9 females), which continued standard sport-specific training without additional intervention. There were no significant differences between groups at baseline in age, training experience, or test performance. Inclusion criteria included: age between 15 and 19 years, active participation in organized competitive sport and no reported cognitive, neurological, or musculoskeletal impairments. Exclusion criteria were: missing more than two training sessions during the 6-week period, incomplete testing data and withdrawal of consent. All participants and their guardians provided written informed consent prior to enrollment.

Participants were randomly assigned to either the experimental group (BlazePod-based training) or the control group (standard training). Both groups continued their regular sport-specific practices throughout the study period.

Study Design

The study followed a pre-test/post-test experimental design over a 6-week intervention period. All participants completed a battery of five tests at two time points: prior to the intervention (pre-test) and after six weeks (post-test). The experimental group underwent additional BlazePod-based training sessions, while the control group maintained regular drills without BlazePod integration.

Intervention protocol

The experimental group participated in three sessions per week, each lasting 15–20 minutes, using BlazePod visual cue technology. Drills targeted neuromotor reactivity, decision-making speed, and cognitive-motor coordination. The protocol was progressive in complexity and intensity, with tasks adapted weekly to increase cognitive load and movement dynamics.

Performance tests and measurements

Five validated tests were administered to assess both motor and cognitive-motor functions:

1. Simple Reaction Time Test: Measured the basic motor response speed to a single visual stimulus using the BlazePod system. Participants were instructed to tap the pod immediately upon illumination.

2. Choice Reaction Time Test: Assessed response selection and decision-making. Participants responded only to specific colors among multiple BlazePod stimuli, testing both speed and accuracy.
3. Agility T-Test: Evaluated multidirectional speed and change-of-direction ability. BlazePods were used to prompt movement in various directions, simulating reactive agility tasks.
4. Go/No-Go Task: Measured inhibitory control and motor response regulation. Participants were required to respond to specific stimuli (e.g., color X) and withhold responses to others, delivered via BlazePod cues.
5. Stroop-like Reaction Test: Adapted to measure executive functioning and attentional control. Participants responded only when the pod color and the written color name were incongruent.

All tests were administered indoors on a flat surface, under standardized conditions. Performance data were automatically recorded via the BlazePod app and manually verified for accuracy.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and approved by the institutional ethics committee. Written informed consent was obtained from all participants and their legal guardians. Participants were informed of their right to withdraw at any time without penalty.

Statistical Analysis

Descriptive statistics (mean, standard deviation, minimum, maximum, and coefficient of variation) were calculated for each performance test at pre- and post-intervention. Paired-samples *t*-tests were used to assess within-group changes for both experimental and control groups. Independent-samples *t*-tests were applied to compare post-test results between groups. Effect sizes were calculated using Cohen's *d*. Additional between-group analyses were conducted by gender. Statistical significance was set at $p < .05$. Analyses were performed using IBM SPSS v.26.

RESULTS

In the following, there are presented the outcomes of the six-week intervention, including descriptive and inferential statistics across all performance measures. Analyses were conducted to assess pre- to post-intervention changes

within the experimental and control groups, focusing on both motor and cognitive-motor performance domains. The descriptive statistics for this study are shown in table 1, for all five performance assessments conducted at baseline (initial test) and after the six-week BlazePod-based intervention (final test). The data reveal consistent and statistically significant improvements across all variables, indicating the effectiveness of the training protocol in enhancing both motor and cognitive performance in young athletes.

In the Simple Reaction Time test, the average response time decreased substantially, from approximately 277 ms to 221 ms, reflecting a notable improvement in basic neuromotor responsiveness. Similarly, Choice Reaction Time, which requires faster decision-making under cognitive load, improved by over 80 ms on average. These changes suggest that the training not only enhanced raw reaction speed but also improved cognitive processing efficiency under time-constrained conditions.

Performance gains were also evident in the Agility T-Test, where the average completion time decreased by nearly 1.5 seconds. This result implies better physical coordination and faster change-of-direction ability, likely influenced by the dynamic, stimulus-based demands of BlazePod exercises. Interestingly, the coefficient of variation for agility more than doubled post-intervention, suggesting that while most participants improved, individual responses varied - perhaps due to differences in baseline fitness or neuromuscular maturity.

The most cognitively demanding tests - Go/No-Go and Stroop Response Time - also showed strong improvements. The Go/No-Go task, which measures inhibitory control, improved by over 100 ms, while Stroop performance improved by nearly the same margin. Both tests also saw a marked increase in post-test variability, indicating that although overall group performance improved, individual adaptation levels differed considerably - an expected outcome in cognitive training.

Overall, the descriptive data indicate that the BlazePod intervention produced significant and practically meaningful improvements in both simple motor tasks and more complex cognitive-motor functions. The observed changes support the integration of cognitive-stimulus training in youth athletic development, especially for enhancing decision-making speed, attentional control, and physical reactivity in sport-specific environments.

Table 1. Descriptive statistics for all tests

Test	Phase	Min	Max	X	p	SD	CV%
Simple Reaction Time (ms)	IT	239.1	315.9	277.1	0.000	19.890	7.180
	FT	134.2	293.7	220.5	0.000	41.810	18.960
Choice Reaction Time (ms)	IT	325.0	464.8	398.4	0.000	31.940	8.020
	FT	204.7	432.8	318.3	0.000	67.490	21.200
Agility (T-Test) (s)	IT	9.8	12.2	10.7	0.000	0.610	5.620
	FT	6.0	11.8	9.3	0.000	1.398	14.970
Go/No-Go (ms)	IT	516.2	661.7	600.5	0.000	38.070	6.340
	FT	401.8	640.8	498.2	0.000	68.160	13.680
Stroop Response Time (ms)	IT	531.2	757.2	647.9	0.000	51.030	7.875
	FT	420.5	732.3	552.9	0.000	82.640	14.950

Note: IT – initial test, FT – final test, Min – minimum, Max – maximum, X – mean, p – significance threshold, SD – standard deviation, CV% - variation coefficient

Table 2 presents the inferential statistics for the experimental group, reflecting the changes from pre- to post-intervention across all five measured variables. All improvements were statistically significant, with 95% confidence intervals excluding zero and effect sizes (Cohen's *d*) ranging from –2.30 to –4.00, indicating very large effects.

The most pronounced gains were observed in Choice Reaction Time, Go/No-Go, and Stroop Response Time, which are cognitively demanding tasks. These findings suggest that the BlazePod-based intervention was especially effective in enhancing neurocognitive processing and inhibitory control. Improvements in Simple Reaction Time and Agility were also substantial, demonstrating strong benefits in both fundamental motor response and change-of-direction speed.

These results provide compelling evidence that six weeks of BlazePod - integrated training significantly enhanced both motor and cognitive performance in young athletes, with high practical relevance.

Table 2. Inferential statistics for the experimental group

Test	ΔX	ΔSD	CI Lower	95% Higher	p	d
Simple Reaction Time (ms)	-87.1	25.8	-100.002	-74.287	0.000	-3.371
Choice Reaction Time (ms)	-124.6	31.2	-140.207	-109.171	0.000	-3.996
Agility (T-Test) (s)	-2.5	1.1	-3.075	-1.980	0.000	-2.295
Go/No-Go (ms)	-181.1	45.4	-203.751	-158.582	0.000	-3.989
Stroop Response Time (ms)	-189.5	57.4	-218.168	-161.009	0.000	-3.299

Note: ΔX – mean differences, ΔSD – SD differences, p – paired t test value, d – Cohen's d value, CI – confidence interval

In Table 3 you can find summarized the inferential statistics for the control group across all five performance tests, comparing pre- and post-intervention scores. Although the participants in this group did not receive the BlazePod-based training, the results indicate statistically significant improvements in each test. However, the magnitude of these changes, while meaningful, was consistently lower than that observed in the experimental group.

The control group showed modest reductions in Simple and Choice Reaction Time, with average improvements of approximately 24 ms and 33 ms, respectively. While statistically significant, the effect sizes for these changes ($d \approx$ -1.5 to -1.8) were smaller compared to the experimental group, where improvements exceeded 80 ms with effect sizes above -3.0. These findings suggest that some natural improvement may have occurred over time, possibly due to familiarization with the testing procedures or general training outside the study.

In the Agility T-Test, participants improved by less than half a second on average, and although this change reached statistical significance, the smaller effect size (d = -1.22) indicates a limited practical impact. Similar trends were observed in the Go/No-Go and Stroop tests, where reductions in response times were noticeable but less substantial than those observed in the trained group.

While the consistent direction of improvement across all measures may reflect general performance maturation or test-retest learning effects, the relatively lower effect sizes and narrower confidence intervals suggest that the control group's gains were less robust and potentially less functionally meaningful. These outcomes reinforce the conclusion that targeted neurocognitive training, such as that provided by BlazePod, yields greater and more impactful benefits than standard physical or technical training alone.

Table 3. Inferential statistics for the control group

Test	ΔX	ΔSD	CI Lower	95% Higher	p	d
Simple Reaction Time (ms)	-24.2	15.6	-32.297	-16.162	0.000	-1.544
Choice Reaction Time (ms)	-32.8	17.8	-42.049	-23.715	0.000	-1.844
Agility (T-Test) (s)	-0.3	0.2	-0.508	-0.207	0.000	-1.221
Go/No-Go (ms)	-46.4	32.6	-63.195	-29.664	0.000	-1.424
Stroop Response Time (ms)	-54.5	39.1	-74.704	-34.402	0.000	-1.392

Note: ΔX – mean differences, ΔSD – SD differences, p – paired t test value, d – Cohen's d value, CI – confidence interval

Table 4 presents the results of the independent *t*-tests comparing post-intervention performance between the experimental and control groups, separated by gender. Across all five performance measures, statistically significant differences were observed for both males and females, with large effect sizes in each comparison

(Cohen's *d* ranging from -1.36 to -4.67). These results provide strong evidence that the BlazePod-based training was effective across genders, though the magnitude of change varied slightly between males and females depending on the task.

In the Simple Reaction Time and Choice Reaction Time tasks, both males and females in the experimental group outperformed their control counterparts. Males showed slightly greater gains in Simple Reaction Time (Cohen's $d = -3.31$), while females demonstrated stronger effects in Choice Reaction Time (Cohen's $d = -3.50$). This may reflect sex-based differences in baseline cognitive processing or responsiveness to cognitive training stimuli.

For the Agility T-Test, male participants in the experimental group outperformed those in the control group by a substantial margin ($d = -2.13$), while females also showed a significant, albeit slightly smaller, difference ($d = -1.36$). These findings indicate that BlazePod training contributed meaningfully to physical agility in both sexes, with possibly more pronounced neuromuscular responsiveness among males.

The most notable differences emerged in the cognitive-motor tasks. In the Go/No-Go test, males in the experimental group showed an exceptionally large improvement compared to controls ($d = -4.67$), while females also demonstrated a strong effect ($d = -3.44$). Similarly, in the Stroop Response Time test, both genders improved significantly, with males showing a slightly stronger effect. These results suggest that the intervention was particularly effective in enhancing executive functioning and inhibitory control across both sexes.

Overall, the gender-specific post-test comparisons confirm that BlazePod training produced large and consistent benefits in reaction time, agility, and cognitive-motor performance, regardless of sex. While some differences in effect size were observed, the general trend indicates that both male and female athletes responded positively and significantly to the intervention.

Table 4. Post-Test Independent t-Tests by Gender

Test	Gender	X (Exp)	SD (Exp)	X (Ctrl)	SD (Ctrl)	p	d
Simple Reaction Time (ms)	M	180.2	30.8	259.9	14.5	0.000	-3.311
	F	197.9	26.5	249.5	26.6	0.000	-1.941
Choice Reaction Time (ms)	M	251.3	39.1	365.5	44.7	0.000	-2.716
	F	275.9	36.0	383.6	24.4	0.000	-3.495
Agility (T-Test) (s)	M	8.2	1.1	10.2	0.6	0.000	-2.131
	F	8.2	1.1	9.8	1.3	0.006	-1.357
Go/No-Go (ms)	M	414.9	38.7	586.4	35.7	0.000	-4.669
	F	442.0	40.6	563.1	29.9	0.000	-3.441
Stroop Response Time (ms)	M	450.8	67.7	628.6	47.8	0.000	-3.096
	F	482.6	51.9	603.0	42.7	0.000	-2.556

Note: X – mean, SD – standard deviation, p – significance threshold, d – Cohen's d value

DISCUSSIONS

The aim of this study was to assess the effectiveness of a six-week BlazePod-based neurocognitive training intervention on motor and cognitive-motor performance in young athletes. The findings revealed statistically and practically significant improvements in all tested domains within the experimental group, while the control group demonstrated smaller gains, likely attributable to test-retest familiarity or natural development. The results provide compelling evidence supporting the integration of visual-cognitive technology into youth athletic training programs.

The most substantial improvements were observed in tasks involving cognitive load and executive function, particularly in the Choice Reaction Time, Go/No-Go, and Stroop tests. This is consistent with earlier studies showing that training interventions combining physical stimuli with cognitive demands enhance both motor output and higher-level processing (Faubert & Sidebottom, 2012; Verburgh, Scherder, Van Lange, & Oosterlaan, 2014). The inclusion of BlazePod drills - which emphasize stimulus recognition, fast decision-making, and inhibitory control - likely contributed to these gains.

Our findings align with research suggesting that reaction time can be significantly improved through targeted neuromotor interventions. Voss, Kramer, Basak, Prakash, and Roberts (2010) noted that cognitive-motor training not only enhances physical responsiveness but also improves attentional flexibility and neural efficiency. This study extends those findings by demonstrating similar benefits in adolescent populations using BlazePod technology, which is both scalable and accessible in sport training contexts.

While the experimental group demonstrated very large effect sizes (Cohen's $d > 2.0$ in all variables), the control group, despite showing statistically significant changes, presented considerably smaller effect sizes (typically below 1.5). This supports the view that general sport training alone may offer marginal improvements in response time and agility but lacks the specificity required to induce meaningful cognitive-motor adaptations (Scharfen & Memmert, 2019).

Gender-based analysis revealed that both male and female athletes significantly benefitted from the intervention, although slight differences were observed in response profiles. For example, females in the experimental group showed a particularly strong improvement in the Choice Reaction Time task, while males outperformed in the Go/No-Go and Stroop tasks. This may reflect sex-based differences in cognitive control strategies or baseline executive function (Barha, Davis, Falck, Nagamatsu, & Liu-Ambrose, 2017; Blain, Longman, & Ward, 2020).

The increase in coefficient of variation across most tests post-intervention suggests that while the group as a whole improved, individual responsiveness varied. This variability is expected in adolescent populations due to developmental differences in neuromuscular and cognitive maturation (Lloyd & Oliver, 2012; Malina, Rogol, Cumming, Coelho e Silva, & Figueiredo, 2015). It also emphasizes the importance of individualized monitoring and progression in training design.

Importantly, the use of light-based visual stimuli through BlazePod is a form of externally focused attention training, which has been shown to enhance motor learning and performance compared to internally focused or conventional drills (Wulf & Lewthwaite, 2016). This principle may partly explain the superior performance outcomes in the experimental group.

Despite these promising findings, some limitations should be acknowledged. The study lacked longitudinal follow-up, which would help determine the retention of training effects. Additionally, performance was not measured in sport-specific competitive contexts, leaving open the question of ecological transferability. Future research should explore long-term benefits, dose-response relationships, and real-game applications of cognitive-motor technologies in athletic settings.

The present study provides strong empirical support for the integration of BlazePod-based cognitive-motor training in youth athletic programs. The results demonstrate not only significant improvements in reaction time and agility but also in executive function-related performance. These findings contribute to a growing body of literature advocating for the inclusion of cognitive components in physical training for athletes.

Limitations

While the results of this study offer strong support for the use of BlazePod-based neurocognitive training in youth athletic development, several limitations should be acknowledged: The study evaluated outcomes immediately after the six-week intervention without any follow-up period. As such, it is unclear whether the improvements observed in reaction time, agility, and cognitive-motor tasks are retained over time or if they diminish without continued stimulus-based training. Future research should include longitudinal follow-up to assess the persistence of these effects.

Although the tests used (e.g., reaction time, agility, inhibitory control) are highly relevant to athletic performance, the study did not assess sport-specific outcomes such as in-game decision-making, passing accuracy, or match statistics. The extent to which the cognitive and motor gains transfer to actual performance in competitive contexts remains to be determined.

The post-test results revealed increased variability (higher CV%) across most measures, suggesting that not all athletes responded equally to the intervention. Factors such as baseline cognitive capacity, motivation, maturity level, and training history were not controlled and may have influenced the degree of improvement. Future studies should consider individualized response profiling or adaptive training protocols.

Practical implications

The findings of this study hold several important practical applications for coaches, sport scientists, and athletic development programs:

BlazePod-based drills can be seamlessly integrated into warm-ups, skill circuits, or cooldowns to enhance both physical responsiveness and cognitive control. The equipment is portable, adaptable, and well-suited to team environments, making it a practical tool for daily use.

Given the substantial gains in tasks requiring executive control (Go/No-Go, Stroop), coaches can use light-based reactive tasks to simulate sport-like decision-making conditions. This is particularly relevant in invasion sports where rapid response to visual stimuli and inhibitory control are critical to performance.

Incorporating BlazePod drills into youth training may offer cognitive benefits that extend beyond physical development. As neuroplasticity is heightened during adolescence, combining physical drills with cognitive demands may support better long-term adaptation, mental sharpness, and injury resilience.

CONCLUSIONS

This study provides robust evidence that a six-week BlazePod - based neurocognitive training intervention significantly enhances both motor and cognitive-motor performance in adolescent athletes. Notable improvements were observed in reaction time, agility, and executive function tasks such as response inhibition and interference control. These findings suggest that the integration of cognitive stimuli - particularly visual-based, reactive drills - can meaningfully complement traditional athletic development programs.

The consistency of performance gains across both male and female athletes supports the versatility and applicability of this training method in diverse training contexts. Moreover, the large effect sizes and statistically significant changes observed in the experimental group, compared to the smaller improvements in the control group, highlight the added value of BlazePod-based training beyond routine sport-specific practice.

Importantly, this study fills a critical gap in the literature by demonstrating the effectiveness of light-based cognitive-motor training in a youth athletic population—a group particularly sensitive to neural and functional adaptation. Given the increasing cognitive demands in modern sport, coaches and practitioners are encouraged to incorporate tools like BlazePod to improve not only speed and coordination but also decision-making, attention, and executive control.

Future research should aim to explore the long-term retention of these performance gains, assess sport-specific transfer effects, and optimize training protocols for different athletic disciplines and developmental stages. Nonetheless, the current findings strongly support the integration of cognitive-motor technologies into holistic training frameworks aimed at maximizing youth athletic potential.

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Early Intervention in the Recovery of Psychomotor Developmental Disorders in Preterm Infants – A Systematic Review Analysis –

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ABSTRACT. Introduction: Preterm birth remains a major public health issue, being closely associated with a higher risk of psychomotor developmental disorders. Early physiotherapy interventions play a crucial role in supporting motor and cognitive development during the critical period of the first two years of life, with the potential to reduce long-term disability. **Aim:** The aim of this paper was to analyze and highlight the impact of early intervention in the recovery of psychomotor developmental disorders in preterm infants, through a systematic review of recent literature. **Materials and Methods:** This study is based on a systematic analysis of 20 scientific articles published between 2015 and 2025, identified using databases such as PubMed, Google Scholar, and Sci-Hub. **Results:** Individualized and multidisciplinary early interventions were found to be effective in improving motor, cognitive, and sensory development in preterm infants. Family-centered programs, therapies started during hospitalization or shortly after discharge, and combined interventions (such as sensory stimulation, infant massage, passive exercises, and hydrotherapy) led to significant developmental progress. Additionally, observational studies confirmed that preterm infants exhibit significant motor delays compared to full-term infants. **Conclusion:** The reviewed literature supports the effectiveness of early physiotherapy interventions in the recovery of preterm infants and emphasizes the need to implement such programs in Romanian clinical practice. Active family involvement, early initiation, and personalized approaches are essential to optimizing developmental outcomes in pre-term babies.

Keywords: *early intervention, physical therapy, preterm babies, cognitive-motor skills*

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INTRODUCTION

According to the World Health Organization (2023), premature birth is one of the most common causes of neuro-motor development problems in childhood, affecting millions of newborns globally each year. Infants born before 37 weeks of gestation often experience significant delays in motor development, even in the absence of major neurological damage.

Studies by Elbasan et al. (2017) show that, compared to full-term newborns, premature babies are more prone to visual and hearing impairments and cognitive problems. Early motor skills are essential for social interaction, exploration, and cognitive development. Studies show that early motor performance is associated with later outcomes in cognitive, motor, and language development. Therefore, early assessment of motor development and early intervention are important (Yu-Han et al., 2017).

To prevent as many complications of preterm birth as possible and support extrauterine development in the last weeks of pregnancy, premature newborns are placed in Neonatal Intensive Care Units. Although these units increase survival rates, babies are exposed to stressors and painful procedures that can cause structural and functional changes in certain regions of the brain, negatively affecting neurological and psychological development (Gonzalez et al., 2021).

Recent research highlights the importance of early identification of these deficits and the application of appropriate therapeutic interventions, especially in the first year of life, a period marked by increased brain plasticity.

PURPOSE OF THE STUDY

This paper aims to highlight the essential role of early intervention in the recovery of psychomotor development disorders in prematurely born children, through a systematic analysis of the literature published in the last decade. In the context of an increased incidence of prematurity worldwide, with direct implications for neuro-motor and cognitive development, it is imperative to identify proven therapeutic strategies that respond promptly to the needs of this category of newborns. The analysis also includes observational studies that clearly demonstrate significant motor delays in preterm infants compared to those born at term, underscoring the importance of early detection and prompt intervention.

MATERIAL AND METHODS

The study was conducted as a systematic review of the scientific literature, based on 20 original articles published between 2015 and 2024. PubMed, Google Scholar, and Sci-Hub were used as search engines. Observational and interventional studies evaluating premature infants with a corrected age of up to 24 months were selected. The inclusion criteria were original articles, pilot studies, randomized or comparative studies, published in English.

RESULTS

Table 1. Characteristics of selected studies

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
Cabral et al.	2015	Comparative cross-sectional study	P.B.G.: N=15, (31,3 weeks, 1506 g) T.B.G: N=15, (39,2 weeks, 3047 g)	Assessment of motor development (AIMS) and sensory processing (TSFI) in infants aged 4–6 months corrected age	53% of preterm infants had AIMS scores below the 5th percentile. All preterm infants with marked sensory deficits showed motor delay.	Preterm infants with sensory integration disorders (especially tactile and vestibular) showed inferior motor development. Early sensory assessment is essential.
Celik et al.	2018	Comparative study	Full-Term Baby Group (FTBG): N=30 (15M/15F); Preterm Baby Group (PTBG): N=30 (13M/17F)	Assessment of sensory processing using the TSFI and the Alberta Infant Motor Scale (AIMS)	Significant correlation between AIMS scores and total TSFI scores ($r = 0.63$, $p < 0.001$). 36.7% of preterm infants had abnormal sensory processing scores.	Assessment of sensory processing and motor development is essential for the effective implementation of early interventions.
da Silva et al.	2016	Analytical cross-sectional study	N=20 children (10 preterm, 10 full-term)	Early family-based therapeutic intervention for the preterm group; evaluation with the Motor Development Scale (MDS)	Preterm infants had significantly lower scores in fine motor skills (3.5 vs 4.7), gross motor skills (4.3 vs 5.2), spatial awareness (4.1 vs 5.6), and temporal awareness (3.6 vs 4.7).	Early intervention allowed for achieving normal motor levels in balance and body scheme. Other areas remained below the scores of full-term children.

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
De Oliveira Tobinaga et al.	2016	Quasi-experimental study	N=15 preterm newborns (average gestational age: 34.2 wks)	Single 10-minute hydro physiotherapy session in a sterilized pool with 37°C water; passive limb maneuvers, trunk rotations, and gentle sensory stimulation.	Salivary cortisol: significant decrease from 0.41 ± 0.14 to 0.29 ± 0.09 μg/dL (p=0.004); Heart and respiratory rate: significant decrease (p<0.005); O_2 saturation: significant increase (p=0.002); NIPS score unchanged.	Hydro physiotherapy has beneficial effects on reducing physiological stress in preterm infants. It can be used as a non-invasive, safe, and effective therapeutic method in neonatal care.
Elbasan et al.	2017	Controlled comparative study	Intervention Group: 78 preterm infants (24–36 wks); Control Group: 76 preterm infants with similar corrected ages.	Family-centered physiotherapy, according to NDT principles; Weekly maternal training; Assessment at 3, 6, 9, 12 months.	Significant intra-group improvements in cognitive development scores (CDS) and motor development scores (MDS) between 3 and 12 months (p<0.001). Between groups: CDS (p=0.059), MDS (p=0.334), non-significant differences.	Family-centered NDT intervention did not generate significant differences compared to the control group. Inclusion of other methods is recommended for a stronger impact on motor and cognitive development.
Fan et al.	2021	Randomized controlled trial	N=73 preterm infants (28–31 wks); EI-SC (early intervention-standard care): N=37; SC-EI: N=36; Reference Group: N=33.	Home-based early intervention program for 30 days, including intellectual stimulation, body massage, and skin-to-skin contact, evaluated with TIMP, DQ, and anthropo-metric measurements.	TIMP: significant increase in EI-SC group (53.1±8.8 to 83.5±11.9) vs. SC-EI (50.5±8.6 to 76.0±13.4), p=0.044; Significant increases in weight, length, and head circumference in EI-SC vs. SC-EI (p<0.05); at T2, both groups > reference group (p<0.05).	Post-discharge, home-based early intervention is effective in the short term in promoting motor development and physical growth in preterm infants. This model offers a feasible and accessible alternative in areas with limited medical resources.
Fontana et al.	2018	Randomized controlled tria	N=57 preterm infants (25–29 weeks GA, without major comorbidities);	Early intervention consisting of PremieStart and parental training for massage and visual stimulation,	Mean age at acquisition of full oral feeding: 36.8 ± 1.6 wks (EI) vs 37.9 ± 2.4 wks (SC), p = 0.04.	Early parental intervention with massage and visual stimulation significantly improved breast milk feeding and accelerated the

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
			Early Intervention Group: N=29; Standard Care Group: N=28.	compared to standard care.	Breast milk consumption at discharge: 57.6% (EI) vs 22.9% (SC), p < 0.001. Exclusive breast milk percentage: 41.4% (EI) vs 10.7% (SC), p = 0.003.	transition to full oral feeding. Active parental participation plays an essential role in the feeding success.
Iqbal et al.	2016	Quasi-experimental study	N = 37 preterm infants	Developmental therapy applied for 6 months, at home and in hospital, evaluated with BSID-II.	54.1% improvement in motor function; 40.5% improvement in mental function; 48.6% improvement in behavior.	Early developmental therapy significantly contributes to the improvement of psychomotor functions in preterm infants. Factors such as socio-economic status or neonatal jaundice can partially influence the results.
Kepenek - Varol et al.	2019	Prospective study	N=32 preterm infants (14M/18F)	A single 40-minute therapy session based on NDT principles, including facilitation, positioning, weight transfer exercises, multiple sensory stimulation.	No statistically significant differences in total MOS scores (26.34±1.56 vs. 26.63±1.48; p=0.44) or in subcategories (p > 0.05). A weak positive correlation was noted between duration of intensive care hospitalization and repertoire of other movements (r=0.412; p=0.02).	A single physiotherapy session does not produce acute effects on spontaneous movements of preterm infants, and studies are needed to evaluate the long-term effects of interventions.
Lee et al.	2017	Controlled comparative study	N=96 Intervention Group: 32 preterm infants < 2.5 kg; Control Group: 30 preterm infants; Comparative Group: 34 preterm infants > 2.5 kg.	Neurodevelopmental therapy (NDT): 15 min, 4 times/week until post-conceptual age of 40 weeks.	Significant increase in TIMP scores in the intervention group: Pre-test: 27.2 ± 7.3 Final: 70.8 ± 6.5 vs. 53.8 ± 7.5 (control), p<0.01.	Early NDT applied in intensive care units significantly improves motor development in preterm infants, even surpassing the comparative group with low risk of delay.
Liu et al.	2021	Comparative clinical trial	Intervention Group: N=22 preterm infants (<32 wks/<1500 g);	Early combined therapy: visual, auditory, oral, motor, respiratory stimulation,	Oxygen: 22.8 ± 13.7 vs. 31.9 ± 15.9 days; Gastric tube: 23.1 ± 12.8 vs. 33.4 ± 15.4 days;	Early combined intervention significantly improves short-term clinical outcomes:

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
			Control Group: N=29 similar preterm infants.	daily 20–25 min, until discharge.	Hospitalization: 39.1 ± 10.3 vs. 47.4 ± 16.1 days; ROP: 9% vs. 34%; BPD: 23% vs. 55%; NEC: 4.5% vs. 27.6%.	respiratory function, neuromuscular development, and reduces major complications (ROP, NEC, BPD).
Øberg et al.	2022	Multicenter randomized clinical trial	N = 153 preterm infants (≤ 32 wks gestational age); Experimental Group: N=74; Control Group: N=79.	Parent-administered exercise program in neonatal intensive care units (10 min, 2×/day, for 3 wks, individualized).	No significant differences found between groups at 24 months (PDMS-2). But PDMS-2 scores correlated positively with intervention dose: +0.019/session unit (p = 0.017).	Higher intervention dose was associated with better motor scores. Short interventions only in hospital do not seem sufficient for long-term effects.
Ochandorena-Acha et al.	2022	Randomi-zed clinical trial	N=62 preterm infants (born <34 wks); Experimental Group: N=30; Control Group: N=32.	Early individualized therapeutic intervention (1 hour/wk for 11 wks), focused on motor activities and parental participation.	Experimental group achieved significantly higher TIMP scores than the control group after intervention (mean difference = 5.13, p = 0.003).	Early therapeutic interventions, personalized and family-centered, can improve early motor development and the parent-child relationship in preterm infants.
Parău et al.	2024	Prospective pilot study	N = 78 preterm infants (GA 34–36 weeks; 1500–2500 g); Intervention Group: N=36; Control Group: N=42.	Early physiotherapy intervention applied using the Bobath method, for 9 months.	Early interventions reduced motor development differences compared to full-term infants. Development is influenced by gestational age and birth weight.	Early therapy can positively influence the neuro-motor development trajectory in preterm infants.
Su et al.	2017	Prospective longitudinal study	N=342 very low birth weight preterm infants (<1500 g).	Motor assessment at 4, 6, 9, and 12 months with Alberta Infant Motor Scale; cognitive and motor assessment at 24 months with BSID-II.	3 motor trajectories: stable normal (55%), deterioration (32%), persistent delay (13%). Deterioration and persistent delay were associated with increased risk of mental and motor delay at 24 months (p < 0.05).	Motor trajectories in the first year can predict developmental outcomes at 2 years. Perinatal factors negatively influence motor trajectory. Early monitoring is essential.
Syrengelas et al.	2016	Controlled comparative study	Full-Term Baby Group (FTBG): N=1,038 (584M/454F); Preterm Baby	Assessment of motor development using the Alberta Infant Motor Scale (AIMS); comparison be-	Preterm infants had significantly lower AIMS scores compared to full-term children over	AIMS highlights that preterm infants have inferior motor development compared to full-term infants.

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
			Group (PTBG): N=403 (251M/152F).	tween preterm and full-term infants and analysis of the influence of neonatal morbidities.	18 months; Respiratory Distress Syndrome: decrease of 1.93 points (P < 0.0001) Intraventricular Hemorrhage Grade III: decrease of 0.97 points (P = 0.008) Retinopathy of Prematurity: decrease of 1.12 points (P = 0.012).	Neonatal morbidity factors negatively influence motor development and must be considered in their assessment.
Torró-Ferrero et al.	2022	Randomized multicenter clinical trial	N = 120 preterm newborns (26–34 wks GA; <2,000 g), divided into 3 groups (n = 40/group).	G.1: passive exercises; G.2: passive exercises + gentle limb compressions; G.3: control (standard NICU care).	Group 2: significant increase in bALP at 4 wks (p = 0.03); Group 1: non-significant increase; Group 3: decrease in bALP. No adverse effects.	Early physiotherapy stimulates bone remodelling in preterm infants. The intervention is safe and effective, recommended in early neonatal care.
Ustad et al.	2016	Randomized controlled multicentre study	N=153 preterm infants (gestational age ≤ 32 weeks); Intervention Group: N=74; Control Group: N=79.	3-week intervention (2×10 min/day) administered by parents under supervision, between 34–36 weeks post-menstrual age.	Significant difference in TIMP scores between groups: Δz = 0.42 (95% CI: 0.13–0.72), p = 0.005; intervention effect: d = 0.40 (moderate effect size).	Parent-administered physiotherapy before the estimated birth term improves short-term motor performance. The intervention is feasible and well-tolerated in current neonatal practice.
Valentini et al.	2019	Comparative study	Full-Term Baby Group (FTBG): N=1,218; Preterm Baby Group (PTBG): N=1,361.	Assessment using Alberta Infant Motor Scale, in the first 12 months of life.	FTBG: significantly higher AIMS scores at 9–10 months in all four postures. For sitting posture, FTBG had an intensive acquisition window between 1–7 months, compared to PTBG: 3–7 months.	General motor development trajectories in the first year of life are similar in preterm and full-term infants, but preterm infants achieve lower performance in postures requiring high postural control.
Valizadeh et al.	2017	Randomized clinical trial	76 preterm infants (4 groups: N=19/group).	G.1: passive exercises in bed (Moyer-Mileur); G.2: hydro physiotherapy; G.3: combination;	No significant differences recorded between groups in TIMP scores at 34 wks PMA (p=0.11).	Interventions with passive exercises, including hydro physiotherapy, are safe but have limited short-term effect on

Authors	Year	Methods	Subjects	Intervention	Results	Conclusions
				G.4: fetal positioning (control).	Only lower limb recoil tone was significantly influenced (p=0.04) by physical activity/ hydrotherapy.	motor performance. Muscle tone (foot recoil) was improved.

DISCUSSIONS

Several studies (Syrengelas et al., 2016; Valentini et al., 2019; Torró-Ferrero et al., 2022) have documented significant delays in motor development in premature infants, supporting the early application of personalized assessments and interventions. Furthermore, the strong correlation between sensory integration and motor performance (Celik et al., 2018; Liu et al., 2021) indicates the need to include sensory components in the treatment plan. Other research (Ochandorena-Acha et al., 2022; Øberg et al., 2022; Cabral et al., 2015) has demonstrated the effectiveness of interventions that actively involve parents, highlighting the therapeutic value of the parent-child relationship in the recovery process.

An interesting finding comes from studies that investigated interventions applied directly in neonatal intensive care units (Lee et al., 2017; Ustad et al., 2016), where significant progress in early development was noted, suggesting that the timing of therapy initiation is essential. At the same time, complementary therapies such as hydrophysiotherapy (Tobinaga et al., 2016; Fan et al., 2021) and oromotor stimulation (Varol et al., 2019) have shown promising benefits on motor functions, feeding behavior and self-regulation.

In terms of duration and frequency of interventions, these vary significantly from one study to another, but most support a positive effect when therapy is applied consistently over a period of at least 4–8 weeks. However, not all studies include long-term follow-up assessments, which limits the generalizability of the results.

Furthermore, the analysis of the articles shows that there is no single ideal protocol, but rather a clear need to adapt interventions to the specificities of each case. In a context such as Romania, where access to neonatal recovery services is uneven, it is imperative to promote integrated, child- and family-centered, and culturally adapted early intervention programs. Therefore, this approach highlights not only the effectiveness of the interventions analyzed, but also the priority directions for the development of rehabilitation services in the field of prematurity.

CONCLUSIONS

Analysis of the 20 selected scientific articles revealed that preterm infants experience significant motor development delays, particularly in postures requiring advanced postural control. However, early, structured, and individualized interventions, especially within the first months of life marked by heightened brain plasticity, consistently showed beneficial effects.

Active parental involvement emerged as a key factor in achieving better functional outcomes. Family-centered programs, whether hospital or home-based, not only support the infant's development but also help reduce parental anxiety, boost caregiver confidence, and foster a strong emotional bond.

Initiating intervention as early as the neonatal intensive care stage was another critical factor. Studies in this setting reported improvements in motor coordination, neurobehavioral organization, and early functional autonomy. Additionally, therapies such as hydrophysiotherapy and oromotor stimulation proved effective in enhancing feeding tolerance, lowering stress levels, and shortening hospital stays, highlighting their valuable potential for broader clinical application.

LIMITATIONS

While the reviewed literature consistently supports the benefits of early intervention in preterm infants, several methodological limitations must be acknowledged. Many studies involved small sample sizes, affecting statistical power and the generalizability of findings. Additionally, variations in study design, regarding the duration, intensity, and content of interventions, hinder direct comparisons. The frequent absence of long-term follow-up limits insight into the sustained impact of these interventions on child development. Moreover, few studies address cultural or contextual factors, which are essential to understanding how interventions function within health systems of differing resource levels.

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