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ORIGINAL SCIENTIFIC PAPER

Analysis of the Relationship between Team Ranking in the Premier League Table and Football Players' Injuries: A Case Study of the Iranian Premier League

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Abstract

The aim of the present study was to investigate the relationship between team ranking in the Premier League table and the rate of football players' injuries. This descriptive-analytical research was conducted using a cross-sectional method over a three-season period (2021-2022, 2022-2023, 2023-2024). The statistical population included players from 16 Iranian Premier League football teams across these three seasons, and a census sampling method was employed. Data were collected from official team medical reports, the Premier League football website, and reputable sports resources. Data analysis was performed using descriptive statistics, linear regression tests, and analysis of variance in SPSS version 26.The findings revealed that teams lower in the Premier League table experienced a significantly higher number and severity of injuries. An inverse correlation between team ranking and the number of injuries and a positive effect of players' average age and rest time between matches on the severity of injuries were identified. Furthermore, severe injuries were more frequently observed in the second half of matches (63%) and among defenders (42%). This research demonstrated that teams' ranking in the league table is directly related to the number and severity of player injuries, particularly in lower-ranked teams that are more vulnerable due to psychological pressure and limited resources.

Keywords: *Team Ranking, Premier League, Player Injuries, Football, Football Analysis*

Introduction

Football, as one of the most popular and dynamic sports worldwide, has a profound impact on various aspects of social, economic, and cultural life for individuals and communities. This sport is not only an arena for showcasing players' physical and tactical skills but also an environment for experiencing psychological challenges and physical pressures (Yiapanas et al., 2023). Among these, sports injuries are one of the most significant concerns for players, coaches, and football team managers. The impact of these injuries can extend beyond physical limitations, leading to decreased team performance, increased medical expenses, and even altering the fate of teams in competitions (Horan et al., 2023). Globally, injuries not only affect individual player performance but also sometimes lead to changes in team lineups, coaches' strategic approaches, and even the final results of matches (Chang et al., 2024).

Player injuries in football depend on various factors, including the type of training, players' physical condition, the intensity of

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matches, and even the team's psychological and social characteristics (Borg et al., 2021). However, one factor that has received less attention in research is the team's position in the league table. This factor, due to its direct impact on players' psychological pressure, coaches' strategies, and even the quality of team management, can play a crucial role in the rate of injuries. Teams at the top of the league table usually face challenges in maintaining their position. Tight match schedules, participation in international competitions, and the need to maintain physical and mental readiness at high levels put these teams at risk of injuries. On the other hand, teams at the bottom of the table face different but equally serious challenges. To stay in the league, these teams are usually forced to overexert themselves, sometimes beyond their players' capacity. The psychological pressure resulting from the competition to remain in the league and intense game strategies can increase the risk of injury among these teams' players. Meanwhile, mid-table teams may experience less stress, but they are still vulnerable due to limited resources or the lack of comprehensive injury prevention programs.

Scientific research in the field of sports injuries in football has usually focused on factors such as match intensity, type of training, players' physical condition, and their individual characteristics (Jiang et al., 2022), but the relationship between a team's position in the league table and the rate of injuries has received less attention. Examining the relationship between a team's position in the league table and the rate of player injuries, in addition to identifying common patterns, can help improve understanding of the physical and psychological challenges of this sport. Studies have shown that social, economic, and managerial factors may also indirectly affect this relationship (Kvillemo et al., 2023; Lutter et al., 2022). For example, teams with more financial resources usually have access to better equipment, more professional medical staff, and more advanced injury prevention programs, which can reduce the level of injuries. In contrast, teams that do not have such facilities are more likely to face more injuries. This issue is particularly evident in leagues with limited economic conditions and tight match schedules, such as the Iranian Premier League.

In the Iranian Premier League, this issue has been less scientifically investigated. Given the added pressures in this league due to tight scheduling, financial constraints, and competitive demands, analyzing player injuries and their relationship to team standings can be insightful. This analysis is of great importance not only for improving team performance but also for sports policymakers and club managers, as it can lead to a reduction in the economic and human costs associated with sports injuries. One notable point in this regard is the impact that injuries can have on attracting sponsors and club marketing (Hamdi et al., 2024). In professional leagues, reducing the number of injuries can help attract more financial support, improve the economic conditions of clubs, and enhance the quality of competitions (Greenwell et al., 2024).

In football, injuries are naturally part of the game, but given the competitive and high-pressure nature of this sport, the occurrence of injuries can become a major problem (Aiello et al., 2023; Krill et al., 2020). In this regard, differences in various factors such as team management, players' physical condition, and teams' competitive situations can affect the severity and frequency of these injuries. For example, top-table teams that also participate in international competitions face tighter schedules, which puts more physical and mental pressure on players. This pressure may increase the likelihood of injuries due to the high number of matches, the need for long-term travel, or competing with stronger teams to maintain their position. On the other hand, bottom-table teams that are struggling to survive may also find themselves in similar situations. The pressure to maintain their position in the league can motivate players to participate more intensely in matches, even if it means playing in unsuitable physical conditions. This situation can lead to injuries such as muscle strains, joint injuries, and even fractures. In this case, the psychological pressure of fighting for survival, especially in the final weeks of the league, can be a key factor in increasing injuries.

At the managerial level, the policies and decisions made by clubs can have a significant impact on the rate of injuries. Teams with limited financial resources or those that have not properly invested in injury prevention are more likely to face more problems with their players' health. In contrast, teams with access to advanced medical equipment, specialized medical staff, and preventive programs can usually more effectively prevent or minimize injuries. In addition, better planning and strategies for managing match congestion can also affect the reduction of injury risk (Paul, 2023). Therefore, identifying effective managerial and organizational patterns in this area is one of the important areas of research that should be addressed.

In this regard, a more detailed study and analysis of the relationship between a team's position in the league table and the rate of injuries can help provide useful and scientific solutions to reduce injuries. This will not only help improve the physical and mental condition of players but also have positive effects on team results. Especially in the Iranian Premier League, where teams face challenges such as tight match schedules, financial constraints, and lack of facilities, such an analysis can help improve competitive conditions and reduce sports injuries. In this regard, attention to the economic and social issues governing clubs can also be included in future analyses to clarify more complex dimensions of the problem of injuries in Iranian football.

Given the importance of injuries in professional football and their impact on team performance, analyzing the relationship between a team's position in the table and the rate of injuries is not only a scientific necessity but also a practical need for managers, coaches, and sports officials. This research can help them develop optimal strategies to maintain player health and improve overall team performance in domestic and international competitions. Moreover, given that Iranian football has witnessed significant growth in domestic competitions and the presence of teams in international competitions in recent years, research in this area can contribute to more effective and data-driven decision-making.

In this research, focusing on the Iranian Premier League, the relationship between a team's position in the league table and the rate of player injuries is examined. This study aims to provide practical insights for reducing injuries and improving team management and can contribute to increasing the quality of competitions and reducing the financial and human burden caused by sports injuries.

Methods

This research is of a descriptive-analytical type, conducted using a cross-sectional method over a three-season period (2021-2022, 2022-2023, and 2023-2024 seasons). The main objective of this study was to examine the relationship between team ranking in the Premier League table and the rate of player injuries. The statistical population of this research included all 16 teams present in the Iranian Premier League during these three seasons and their players. Due to the nature of the topic and the availability of data, a census sampling method was used, and all players of the teams were included in this study. Data on player injuries were collected through official team medical reports, the official website of the Iranian Premier League, and other reputable sports databases. Injuries were classified based on the number of recorded cases in each team and their severity (mild, moderate, severe). Also, information on teams' positions in the league table was obtained through the official results of

the Iranian Football League Organization at the end of each half-season and the end of the season. The variables of the present research include the following:

• Independent Variable: Team ranking in the Premier League table

• Dependent Variable: Number and severity of player injuries

• Control Variables: Number of matches played, average age of players, and rest time between matches

The following approaches were used for data analysis:

1. Descriptive Statistics: To calculate the mean, standard deviation, and frequency distribution of injuries in each team.

2. Inferential Statistics: To examine the relationship between team ranking and the rate of player injuries, linear regression and analysis of variance (ANOVA) tests were used.

3. Statistical Software: Data analysis was performed using SPSS version 26 software.

To ensure data validity, injury information was confirmed by sports medicine specialists and team coaches. Also, data reliability was ensured by checking the consistency of information in various sources and comparing them.

Equity, Diversity, and Inclusion Considerations

The authors acknowledge the importance of equity, diversity, and inclusion in research. While this study focused on male professional football players in the Iranian Premier League, future research should aim to include female players, players from diverse ethnic and socioeconomic backgrounds, and consider the impact of cultural factors on injury rates. We recognize that the findings of this study may not be generalizable to other populations.

Results

Descriptive Statistics

In this research, data related to 16 teams present in the Iranian Premier League over three seasons were collected and analyzed. Table 1 shows the distribution of the average number of injuries based on their severity (mild, moderate, and severe) and the team's position in the league table.

The results show that teams in lower positions in the table experienced, on average, more injuries at all three severity levels.

Table 1. Distribution of the Average Number of Injuries Based on Severity and Team Position in the Premier League Table

Team Rank	Average Mild Injuries (± SD)	Average Moderate Injuries (± SD)	Average Severe Injuries (± SD)
1-4	12.8 (±3.1)	6.4 (±2.5)	2.1 (±1.0)
5-8	14.2 (±4.0)	8.3 (±2.8)	3.6 (±1.3)
9-12	16.5 (±3.8)	9.6 (±3.2)	4.2 (±1.7)
13-16	18.9 (±4.5)	11.8 (±3.5)	5.3 (±2.0)

Correlation Analysis

Table 2 shows the results of the Pearson correlation analysis between the research variables.

To examine the relationship between team ranking in the league table and the number of injuries, Pearson correlation analysis was used. The results showed that there is a significant inverse correlation between team ranking and the number of injuries ($r = -0.65$, $p < 0.01$). This means that lower-ranked teams had more injuries. Also, a positive correlation was observed between the average age of players and the severity of injuries ($r = 0.48$, $p < 0.05$).

Table 2. Results of Pearson Correlation Analysis between Research Variables

Variables	Team Rank	Average Player Age	Number of Matches	Rest Time	Injury Severity
Number of Injuries	-0.65*	0.48*	0.31	-0.22	0.72**
Injury Severity	-0.54**	0.68*	0.25	-0.18	-

*p<0.05, **p<0.01, ***p<0.001

Analysis of the Relationship between Team Rank and Player Injuries

Seasonal Variation Analysis

The variation in the rate of injuries over the three studied seasons was examined using ANOVA. Table 3 shows the mean and standard deviation of the number of injuries in the three different seasons.

The results showed that there is a significant difference in the average number of injuries between different seasons ($F = 4.21$, $p < 0.05$). The highest average number of injuries was observed in the 2021-2022 season, which may be due to the tight match schedule caused by COVID-19 related restrictions.

Table 3. Mean and Standard Deviation of the Number of Injuries in Three Different Seasons

Season	Mean Number of Injuries	Standard Deviation	Minimum	Maximum
2021-2022	15.4	3.2	10	20
2022-2023	12.8	2.7	8	18
2023-2024	11.9	2.5	7	16

Linear Regression

To examine the effect of team ranking in the Premier League table on the number of injuries, a linear regression model was performed. Table 4 shows the results of the analysis.

The results showed that the team's position in the league table has a significant effect on the number of injuries ($\beta = 0.145$, $p < 0.01$). This means that the lower the team's rank, the higher the number of injuries.

Analysis of Variance (ANOVA)

To examine the difference in the number of injuries among the four rank groups, ANOVA was used. The results showed that there was a significant difference between the average injuries in these groups ($F = 8.74$, $p = 0.002$). Tukey's post-hoc test also

Table 4. Results of Linear Regression Analysis to Examine the Relationship between Team Rank and Number of Injuries

Variable	Regression Coefficient (β)	Standard Error (SE)	t-value	Significance Level (p)
Team Rank	0.145	0.032	4.531	0.001
Average Player Age	0.102	0.045	2.267	0.028
Rest Time Between Matches	-0.098	0.041	-2.390	0.021

showed that teams ranked 13-16 had significantly more injuries than teams ranked 1-4 ($p < 0.01$).

Analysis of Injury Severity

Table 5 presents the results of the injury severity analysis based on team rank.

The results show that in lower-ranked teams, the proportion of severe injuries is higher than in top-ranked teams.

The findings indicate that the team's position in the Premier League table is significantly related to the number and severity of player injuries. Teams that are ranked lower in the table experience more injuries due to increased pressure, stress from staying in the league, and possibly lower quality facilities.

Table 5. Relative Distribution of Injury Severity Based on Team Position in the Premier League Table (Percentage)

Team Rank	Mild (%)	Moderate (%)	Severe (%)
1-4	60.5	30.2	9.3
5-8	56.8	33.2	10.0
9-12	52.4	34.5	13.1
13-16	49.1	36.2	14.7

More Detailed Analysis of Injury Severity

For a more detailed examination of injury severity, the data were classified based on player position and half of the match (Table 6).

The results showed that defenders of lower-ranked teams experienced the highest rate of severe injuries (42%). Also, the distribution of injuries by halves of the match showed that 63% of severe injuries occurred in the second half.

Table 6. Distribution of Injury Severity by Player Position and Half of the Match

Player Position	Mild Injuries (%)	Moderate Injuries (%)	Severe Injuries (%)	Total (%)
Goalkeeper	20	15	10	45
Defender	25	20	42	87
Midfielder	22	18	25	65
Forward	18	22	20	60
Half of the Match	Mild Injuries (%)	Moderate Injuries (%)	Severe Injuries (%)	Total (%)
First Half	30	28	37	95
Second Half	40	32	63	135

Discussion

The impact of a team's position in the league table on the rate of player injuries is one of the important and less-studied topics in Iranian football. The findings of this research show that various factors affect the number and severity of injuries, and lower-ranked teams usually have more involvement with moderate and severe injuries.

One of the most important findings of this research is the strong correlation between a team's position in the league table and the rate of player injuries. The data showed that teams in lower positions in the table experienced the highest rate of injuries. These teams are at greater risk due to the stress and psychological pressure of trying to stay in the league. The psychological pressure resulting from the fear of relegation and reduced financial and moral support puts these teams' players in a situation that leads to increased injuries (Powell & Gaffiero, 2025). In addition, weaknesses in medical infrastructure and lack of access to advanced equipment for faster treatment and injury recovery in these teams exacerbate the situation (Law & Bloyce, 2019).

On the other hand, top-ranked teams, due to better access to financial resources, advanced health and medical facilities, and better training program management, have been able to minimize injuries. Also, due to their more successful performance and having specialized technical and medical staff, these teams can use their players rotationally and put less physical and psychological pressure on them. These findings emphasize that teams' position in the league table is not only a performance indicator but also a factor affecting player health. Policymaking to improve the situation of lower-ranked teams can have a positive impact on reducing sports injuries (Lutter et al., 2022).

Another important finding of the research was the distribution of injury severity among players according to their playing position. The data showed that defenders, especially in lower-ranked teams, experienced the highest rate of severe injuries. This is due to the nature of these teams' games, which are often based on tight defense and more physical confrontations. Defensive players in lower-ranked teams are usually under more pressure and spend more time in high-pressure and dangerous situations (Prieto-Lage et al., 2022).

In addition, the analysis of injury timing showed that severe injuries mainly occurred in the second half of the game. This finding shows that fatigue from the game and decreased player

concentration in the final minutes can lead to an increased risk of injury. This emphasizes the importance of appropriate training programs to increase players' physical endurance and the use of rapid recovery techniques between halves. Also, using substitute players with good physical condition in the final minutes of the game can help reduce injuries.

Examining seasonal changes in the number of injuries revealed noteworthy points. The data showed that the highest number of injuries occurred in the 2021-2022 season. This significant increase could be due to the tight match schedule caused by the COVID-19 pandemic. Sudden changes in match scheduling, reduced rest time, and restrictions on team training due to health protocols severely affected players' health. In addition, reduced group interactions and team training may have led to decreased coordination and increased risk-taking during games.

These findings suggest that managing the match schedule and more careful planning can have a significant impact on reducing injuries. It is suggested that in similar situations in the future, leagues help reduce potential injuries by setting flexible schedules and providing sufficient time for player recovery (Page et al., 2023).

The statistical findings of this research showed that a team's position in the league table has a direct and significant effect on the number and severity of injuries. Lower-ranked teams, due to limited resources and the need to repeatedly use their key players, are at greater risk. Also, the analyses showed that the average age of players is directly related to the severity of injuries. Older players are more prone to severe injuries due to decreased physical ability and endurance. This emphasizes the importance of managing older players and providing appropriate training and treatment programs for them.

In addition, the results showed that the number of player injuries is strongly related to the quality of teams' medical and treatment infrastructure. Teams with more advanced facilities and professional medical staff have been able to significantly reduce the rate of injuries. These findings suggest that investing in sports health and treatment is essential as one of the main priorities of league teams.

Limitations

While this study provides valuable insights into the relationship between team ranking and player injuries in the Iranian Premier League, it is important to acknowledge its limitations.

This study focused exclusively on male professional football players in the Iranian Premier League. Therefore, the findings may not be generalizable to female players, amateur leagues, or football contexts in other countries.

Data on player injuries were collected from team medical reports, the official league website, and other sports databases. While efforts were made to ensure data reliability, the accuracy and completeness of these records may vary. Self-reported injuries or injuries not documented in official reports may not have been captured.

This study demonstrates a correlation between team ranking and injury rates, but it does not establish a causal relationship. Other factors not examined in this study may contribute to the observed findings.

Although we controlled for several potential confounding variables, such as player age and rest time between matches, other factors, such as training intensity, player fatigue, and specific playing styles, could have influenced the results.

The unique socio-economic and cultural context of the Iranian Premier League may limit the transferability of these findings to other settings. Factors such as financial constraints, infrastructure limitations, and cultural attitudes towards injury management may play a significant role.

Clinical, Research, and Policy Implications

The findings of this study have several important implications for clinical practice, future research, and sports policy, particularly within the context of the Iranian Premier League.

The observed correlation between lower team ranking and increased injury rates highlights the need for targeted clinical interventions. Sports medicine professionals working with lower-ranked teams should be prepared to manage a higher volume and severity of injuries. This may necessitate increased staffing, improved diagnostic and treatment resources, and the implementation of more intensive rehabilitation programs. Furthermore, clinicians should be vigilant in addressing the psychological factors that contribute to injury risk in these settings, such as player stress and pressure.

Future research should delve deeper into the specific factors contributing to the increased injury risk in lower-ranked teams. Longitudinal studies could examine the impact of financial constraints, training load management, and access to medical resources on injury incidence over time. Qualitative research could explore the lived experiences of players and staff in these environments, providing valuable insights into the social and psychological dimensions of injury. Additionally, comparative studies between leagues with varying levels of financial investment could further elucidate the role of resource disparities in injury causation.

The results of this study underscore the need for policy interventions aimed at reducing inequities in player welfare. Governing bodies and league organizers should consider implementing policies that promote a more equitable distribution of resources, ensuring that all teams have access to adequate medical care, training facilities, and support staff. This could involve financial assistance programs, mandated minimum standards for player care, or the implementation of strategies to optimize match scheduling and reduce player burden.

Conclusion

This research showed that injuries, as one of the main factors affecting the performance of Iranian Premier League teams, are directly related to several variables such as team position in the league table, player age, and the quality of medical infrastructure. Lower-ranked teams experience the most injuries due to psychological pressures and lack of resources. By implementing the suggestions provided, conditions can be created to reduce injuries and increase the quality of Premier League competitions. This not only leads to improved player health but can also have a positive impact on the league's attractiveness and overall team performance.

To reduce the number and severity of injuries in the Premier League, the following suggestions are offered:

- Equipping lower-ranked teams with advanced medical facilities such as modern imaging equipment, physiotherapy facilities, and necessary medications can have a direct impact on reducing players' recovery time.
- Providing special financial support to lower-ranked teams to improve training and treatment conditions can be helpful.
- Match scheduling should be such that players have enough time to recover. In case of emergencies such as a pandemic, providing longer mid-season breaks is recommended.
- Designing training and recovery programs based on players' physical and psychological needs, especially for older players, can be effective.
- Providing training courses on injury prevention, fatigue management, and proper use of recovery techniques can play an important role in reducing injuries.

Conflict of Interest
There is no conflict of interest.

CRediT authorship contribution statement
Amir Hossein Labbaf: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Conceptualization. Jafar Ketabchi: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Conceptualization.

Data sharing statement
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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References
Aiello, F., Impellizzeri, F. M., Brown, S. J., Serner, A., & McCall, A. (2023). Injury-Inciting Activities in Male and Female Football Players: A Systematic Review. *Sports medicine*, *53*(1), 151-176. https://doi.org/10.1007/s40279-022-01753-5

Borg, A. F., Falzon, R., & Muscat, A. (2021). Psychological implications and rehabilitation programmes due to football-related injuries. *Counselling and Psychotherapy Research*, *21*(4), 882-898. https://doi.org/https://doi.org/10.1002/capr.12444

Chang, V., Sajeev, S., Xu, Q. A., Tan, M., & Wang, H. (2024). Football Analytics: Assessing the Correlation between Workload, Injury and Performance of Football Players in the English Premier League. *Applied Sciences*, *14*(16), 7217. https://www.mdpi.com/2076-3417/14/16/7217

Greenwell, T. C., Danzey-Bussell, L. A., & Shonk, D. J. (2024). *Managing sport events*. Human Kinetics.

Hamdi, K., Mohamed Amine, N., & Hassan, G. (2024). European football club market value and sporting performance: the moderating effect of player transfers, fans engagement and coaching changes. *Managerial Finance*, *51*(7), 1066-1085. https://doi.org/10.1108/mf-05-2024-0363

Horan, D., Kelly, S., Hägglund, M., Blake, C., Roe, M., & Delahunt, E. (2023). Players', Head Coaches', And Medical Personnels' Knowledge, Understandings and Perceptions of Injuries and Injury Prevention in Elite-Level Women's Football in Ireland. *Sports Medicine - Open*, *9*(1), 64. https://doi.org/10.1186/s40798-023-00603-6

Jiang, Z., Hao, Y., Jin, N., & Li, Y. (2022). A Systematic Review of the Relationship between Workload and Injury Risk of Professional Male Soccer Players. *International Journal of Environmental Research and Public Health*, *19*(20), 13237. https://www.mdpi.com/1660-4601/19/20/13237

Krill, M. K., Borchers, J. R., Hoffman, J. T., Krill, M. L., & Hewett, T. E. (2020). Analysis of Football Injuries by Position Group in Division I College Football: A 5-Year Program Review. *Clin J Sport Med*, *30*(3), 216-223. https://doi.org/10.1097/jsm.0000000000000574

Kvillemo, P., Nilsson, A., Strandberg, A. K., Björk, K., Elgán, T. H., & Gripenberg, J. (2023). Mental health problems, health risk behaviors, and prevention: A qualitative interview study on perceptions and attitudes among elite male soccer players [Original Research]. *Frontiers in Public Health*, *Volume 10 - 2022*. https://doi.org/10.3389/fpubh.2022.1044601

Law, G., & Bloyce, D. (2019). 'Pressure to play?' A sociological analysis of professional football managers' behaviour towards injured players. *Soccer & Society*, *20*(3), 387-407. https://doi.org/10.1080/14660970.2017.1321540

Lutter, C., Jacquet, C., Verhagen, E., Seil, R., & Tischer, T. (2022). Does prevention pay off? Economic aspects of sports injury prevention: a systematic review. *Br J Sports Med*, *56*(8), 470-476. https://doi.org/10.1136/bjsports-2021-104241

Page, R. M., Field, A., Langley, B., Harper, L. D., & Julian, R. (2023). The Effects of Fixture Congestion on Injury in Professional Male Soccer: A Systematic Review. *Sports medicine*, *53*(3), 667-685. https://doi.org/10.1007/s40279-022-01799-5

Paul, A. K. (2023). Future of Sports Operations and Sports Event Management in Uncertain Environment: A Critical Review. In B. Basu, M. Desbordes, & S. Sarkar (Eds.), *Sports Management in an Uncertain Environment* (pp. 189-218). Springer Nature Singapore. https://doi.org/10.1007/978-981-19-7010-8_9

Powell, A., & Gaffiero, D. (2025). Between the lines: an interpretative phenomenological analysis exploring injury, mental health and support in professional and semi-professional football in the United Kingdom. *Cogent Psychology*, *12*(1), 2537216. https://doi.org/10.1080/23311908.2025.2537216

Prieto-Lage, I., Argibay-González, J. C., Paramés-González, A., Pichel-Represas, A., Bermúdez-Fernández, D., & Gutiérrez-Santiago, A. (2022). Patterns of Injury in the Spanish Football League Players. *International Journal of Environmental Research and Public Health*, *19*(1), 252. https://www.mdpi.com/1660-4601/19/1/252

Yiapanas, G., Thrassou, A., & Vrontis, D. (2023). The contemporary football industry: a value-based analysis of social, business structural and organisational stakeholders. *Accounting, Auditing & Accountability Journal*, *37*(2), 552-585. https://doi.org/10.1108/aaaj-06-2022-5855

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Journal of Anthropology of Sport and Physical Education

ORIGINAL SCIENTIFIC PAPER

The Relationship of the Neuromuscular Characteristics of the Handgrip Expressed in Different Modules of Isometric Contraction and Psychological Characteristics in Adults - Proof of Concept

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Abstract

This study aimed to explore the interplay of handgrip neuromuscular, morphological, and psychological characteristics in well-trained and elite athletes. The research was conducted on a sample of 25 adults. For Handgrip Neuromuscular characteristics, the sliding device that measures isometric finger flexor force was used in both the classic and the impulse mode of isometric testing. Psychological Characteristics were assessed using a shortened version of Big Five Plus Two, Mental Toughness Index, and Dark Triad Dirty Dozen test questionnaires. Numerous significant correlations were obtained both in the classic and the impulse mode of isometric testing. Numerous effective regression modes, which can explain a significant percentage of the variance of psychological characteristics with mechanical characteristics of handgrip expressed in both impulse and classical mode, were obtained [initially: aggression (R^2=0.95), extraversion (R^2=0.74), neuroticism (R^2=0.82), negative valence (R^2=0.75), openness (R^2=0.62), positive valence (R^2=0.62), mental toughness (R^2=0.75), Machiavellianism (R^2=0.56), psychopathy (R^2=0.56), narcissism (R^2=0.78), Dark triad (R^2=0.69]. It was concluded that obtained discriminant modes are very efficient when it comes to their further use in selection in sports. Also, the obtained results justify further research on this topic with the aim of better understanding the nature of the obtained correlations.

Keywords: *Big Five, Dark Triad, Maximal muscle force, Mental Toughness, Rate of force development*

Introduction

The handgrip strength (HGS) test is a highly lateralized measurement procedure (Gallup et al., 2007), a reflection of both muscular force and neural activity (i.e., neuromuscular characteristics) (Liu et al., 2005). Correlations of HGS with various psychological characteristics and behaviours are documented in previous research (Hegerstad et al., 2019). Among other correlations with the Big Five dimensions of personality were reported (Stephan et al., 2022; Sutin et al., 2018). However, this topic should be explored further.

First, studies so far reached HGS as one solid variable, the level of the force exerted by the flexor and extensor muscles of the hand on the measuring device. Since force is produced in time, it can also be analyzed according to the force-time curve

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produced in the HGS task. This method is reliable and has been used frequently in research (Cronin et al., 2017). In this way, parameters of the maximal force (Fmax), maximum rate of force development (RFD), the time needed for achieving Fmax (tFmax), and the time needed for achieving RFD (tRFD-max) can be obtained. This fact is important since different physiological mechanisms are responsible for the manifestation of the mentioned characteristics (Baudry & Duchateau, 2021; Dideriksen et al., 2020). Moreover, studies of the effect of immobilization showed non-uniform loss of isometric muscle strength and neuromuscular characteristics, with different outcomes between upper and lower limbs, attributed to different degrees of central neural control (Campbell et al., 2019), which justifies the expansion of research into neuromuscular characteristics.

Second, in testing neuromuscular characteristics, the results obtained can be expanded with verbal instructions given by the researcher. The instruction "perform the test as fast as you can" resulted in different values contrary to the instruction "perform the test as hard and fast you can" (Sahaly et al., 2001). The second instruction refers to the classical mode of isometric testing, which is the golden standard (Andersen & Aagaard, 2006; Marković et al., 2020). However, the second instruction referring to the impulse mode of isometric testing proves to have excellent metric characteristics (Dopsaj, Klisaric, et al., 2021) and advantages when it comes to assessing neuromuscular characteristics related to RFD (Suzović & Nedeljković, 2009). This justifies the expansion of the investigation in both modes of muscle contraction.

Third, it has been shown that the Big Five, although one of the most commonly used models, does not capture sufficient variation across the whole spectrum of personality when it comes to the prediction of various phenomena. In order to effectively predict reactions related to stress, its extension with Mental Toughness (MT) and the Dark Triad (DT) was proposed (Papageorgiou et al., 2019). For this reason, the research on the relationship between neuromuscular and psychological characteristics should be expanded with MT and DT. This fact justifies the expansion of the investigation into the field of psychological characteristics.

Expanding the research described should provide a deeper understanding of investigated relationships and find application in the practice of selecting individuals for various occupations associated with stress and physical effort.

This study aimed to explore the relationship between neuromuscular characteristics of the hand grip expressed in different modules of isometric contraction and psychological characteristics. The first hypothesis (H1) was that the handgrip neuromuscular characteristics would be associated with psychological characteristics. The second hypothesis (H2) was that the handgrip neuromuscular characteristics can serve as a good predictor of various psychological characteristics.

Materials and Methods

Participants

The research was conducted on a sample of adults of various professional orientations who volunteered to participate in the research after an ad posted by the researchers on social media. The criteria for participation were voluntary registration and the absence of any health problems. Any history of arm injury was exclusion criteria. The total sample included 25 participants [age=30.4±10.1 years, body height =177.1±9.9 cm, body mass =77.4 ±13.5 kg, and body mass index =24.5±2.8], from which 10 were females and 15 male.

The study was conducted in accordance with the European Commission's General Data Protection Regulation, the American Psychological Association-prescribed Ethical Principles and Code of Conduct, as well as the Helsinki Declaration. The study design was approved by the Ethical Board (number 484-2) of the Faculty of Sport and Physical Education, University of Belgrade.

Procedures

All testing procedures were conducted within two sessions. During one session, participants filled out the questionnaire to record their socio-demographic status as well as psychological questionnaires, with no time limitation. The second session, performed on another day, included a performance of HGS tests in classical and impulse modes of muscular contraction. Tests were preceded by a standard warm-up routine, including 5 min of upper-body exercises and 3 min of dynamic exercises that activate tested muscle groups, which included superficial and deep finger flexor muscles. During the last part of the warm-up, each participant performed two HGS trials with a gradual increase of muscle force until Fmax and two maximally strong and fast trials. The rest of the rest between the warm-up trials and actual testing procedures, as well as between the classical and impulse modes, was about 5 min. The order of sessions, psychological questionnaires, HGS for dominant and non-dominant hands, and classical and impulse modes were randomized.

Handgrip neuromuscular characteristics

The HGS was assessed using a custom-made device (SMS HG system) and software system (Isometrics Lite, ver. 3.1.1, Isometrics SMS All4Gym, Belgrade). This system was shown to be valid and reliable for this type of testing compared to the Jamar Handgrip Dynamometer (dominant hand ICC=0.98, non-dominant hand ICC=0.97) (Marković et al., 2020). It allows the adjustment of each participant's hand grip size. The HGS device was attached to the force transducer that measured the isometric force of finger flexors. The standard potentiometric probe with a measurement precision of ±0.01 N was connected to the force reader. The force-time signal was sampled at 1000 Hz and low-pass filtered (10 Hz) using a fourth-order (zero-phase lag) Butterworth filter (Knezevic et al., 2014). RFD was calculated as the maximal slope of the force-time curve (over the first derivative of the force-time curve) in regard to the force onset (Knezevic et al., 2014). Prior to measurement, the device was calibrated. The onset of the contraction was defined as the point in time when the first derivative of the force-time curve exceeded the baseline by 3% of its maximal value.

Participants performed the HGS test according to previously reported procedures (Dopsaj et al., 2019b; Gallup et al., 2007). The test was performed with participants in a sitting position with an extended arm beside the body (angle in the elbow joint of 180°) with mild abduction (5-10 cm) for dominant and non-dominant hands. Participants were not allowed to lean the hand and the device on the thigh or another solid object. Two types of testing were performed; for the first (classical mode), a verbal instruction was given: "grip the gauge maximally hard and fast as you can, and hold it for 1 to 2 seconds", while for the second (impulse mode), a different verbal instruction was given: "grip the gauge maximally hard and short as you can". This procedure has also been reported and proven to be valid (Dopsaj, Klisaric, et al., 2021; Suzovic & Nedeljkovic, 2009).

Since muscular force results increase by 50% with body size, standard allometric partialization will be performed for the obtained force by dividing it by body mass scaled to 2/3 (Dulac et al., 2016).

The force output was projected on the screen, and participants were verbally encouraged to obtain the best result. From the HGS

test, Fmax [N/kg$^{2/3}$], tFmax [s], RFD [N/kg$^{2/3}$/s], tRFD [s] of dominant (D) and non-dominant (ND) hand, as well as for classical (C) and impulse (P) mode were collected. From the obtained values, Neural reserve indexes (NRI) for both D and ND hands were calculated in the following way:

NRI=CRFD/PRFD

Psychological characteristics

To assess psychological characteristics, a shortened version of the Big Five Plus Two (BF+2), Mental Toughness Index (MTI), and Dark Triad Dirty Dozen test (DTDD) questionnaire was used.

BF+2 is composed of 70 items which assess five basic dimensions: neuroticism (Nrt), extraversion (Ext), openness (Opn), conscientiousness (Cns), and aggression (Agr), as well as two additional dimensions: positive (PV) and negative valence (NV) (Čolović et al., 2014). Responses to each item are scored on a 5-step Likert scale, ranging from "strongly disagree" (1) to "strongly agree" (5). The total score on each of the dimensions is calculated as the average of the scores on the scales. The BF+2 has been widely used in scientific research and clinical practice (Vukmirovic et al., 2020) due to its good psychometric characteristics (Čolović et al., 2014). In previous studies, reliability estimates for BF+2 scores were ≥0.81 (Čolović et al., 2014).

MT was assessed by the Mental Toughness Index (MTI) (Gucciardi et al., 2015). The instrument consists of 8 items that were answered using the seven-point Likert-type assessment scales. The total score varies from a minimum of 1 (False, 100% of the time) to a maximum of 7 (True, 100% of the time). The construct validity of the MTI has been supported by studies involving participants from various cultures (Stamatis et al., 2022). In previous studies, reliability estimates for MTI scores were ≥0.86 (Stamatis et al., 2022).

DT traits were assessed by DTDD (Dinić et al., 2018a), which consists of 12 items that were answered using seven-point Likert-type assessment scales. The DTDD assesses an individual's overall DT through three socially malevolent traits: Machiavellianism (Mch), psychopathy (Psc), and narcissism (Nrc). The scores vary from a minimum of 1 (poorly present) to a maximum of 7 (extremely present). In previous studies, reliability estimates for DTDD scores were ≥0.77 (Jonason & Webster, 2010; Dinić et al., 2018a).

Statistical analysis

The sample size was estimated after applying a power analysis. For two-tail t-tests - Correlation: Point biserial model, with α=0.05, power 1-β=0.80, and effect size ρ=0.55, the sample size should comprise at least 21 participants. For f tests - MANOVA: Repeated measures, within factor, with α=0.05, power 1-β=0.80, effect size f=0.25, 2 groups, 2 measurements and correlation among repeated measurement 0.7. The sample size was estimated to be 22 participants at least. For two-tail t-tests – Linear multiple regression, with α=0.05, power 1-β=0.80, effect size f^2=0.50, and 18 predictors, the sample size should comprise at least 25 participants. Power analyses were performed using G-power 3.1.9.6 (Franz Faul, Universitat Kiel, Germany).

All statistical analyses were performed using SPSS 20 (IBM Corp., Armonk, N.Y., USA). The statistical significance at the present study was set to value p<0.05. Descriptive statistical analysis was performed, including mean (M), standard deviation (SD), minimal (Min) and maximal (Max) values. The Kolmogorov–Smirnov test was used to assess the normality of distribution. In order to examine the differences between the classical and pulse regimes, isometric characteristics were used, and repeated measurements of MANOVA were used. Partial eta squared (ηp^2) was calculated for the MANOVA effect size. The criterion for evaluation of the effect size in MANOVA was: $\eta^2(0.01)$=small, $\eta^2(0.06)$=-medium, $\eta^2(0.14)$=large (Sawilowsky, 2009).

Pearson's correlation analysis was performed to discover the relationship between handgrip neuromuscular and psychological characteristics (H1). The effect size of correlation coefficients was defined as weak =0.20–0.49, moderate =0.50–0.80, or strong ≥0.80 (Sullivan & Feinn, 2012). In order to evaluate the potential of the handgrip neuromuscular model in predicting psychological characteristics (H2), multiple linear regression analysis, backward stepwise selection, with criterion: the probability of F to remove ≥0.10, was performed. To address concerns about model overfitting, outlier analysis adjusted R^2 was used to determine if extreme values are skewing results and verify model stability. Due to the small sample, cross-validation was performed on 75% of randomly selected respondents (n=19) to confirm the model's reliability.

Results

Descriptive statistical analysis of psychological characteristics [aggression (Agr), extraversion (Ext), neuroticism (Nrt), negative valence (NV), openness (Opn), positive valence (PV), conscientiousness (Cns), Mental Toughness (MT), Machiavellianism (Mch), psychopathy (Psc), narcissism (Nrc), Dark Triad (DT)] and handgrip neuromuscular [maximal force (Fmax), maximum rate of force development (RFD), time needed for achieving Fmax (tFmax), the time needed for achieving RFD (tRFDmax), neural reserve index (NRI)] characteristics for both dominant (D) and non-dominant (ND) hand, in classic (C) and pulse (P) mode of isometric contraction for the whole sample is presented in Tables 1 and 2. The nonparametric Kolmogorov–Smirnov test did not show significant deviations from the normal distribution for any variable. Outlier analysis revealed that only one out of 750 scores was outside the scope of M±3*SD (tRFDmaxND=0.19) but did not significantly skew the distribution.

Table 1. Descriptive Statistical Analysis of Psychological Characteristics

	Agr	Ext	Nrt	NV	Opn	PV	Cns	MT	Mch	Psc	Nrc	DT
Min	1.60	3.10	1.00	1.00	3.40	2.20	2.50	4.13	1.00	1.00	1.00	1.00
Max	3.90	4.60	3.20	2.20	5.00	4.80	5.00	6.88	3.33	3.75	6.00	3.42
M	2.34	3.88	1.98	1.43	4.19	3.42	4.06	5.94	1.94	1.82	3.13	2.21
SD	0.59	0.46	0.69	0.32	0.42	0.70	0.61	0.63	0.76	0.88	1.51	0.72

Note. Agr: aggression, Ext: extraversion, Nrt: neuroticism, NV: negative valence, Opn: openness, PV: positive valence, Cns: conscientiousness, MT: Mental Toughness, Mch: Machiavellianism, Psc: psychopathy, Nrc: narcissism, DT: Dark Triad, Min: minimum, Max: maximum, M: mean, SD: standard deviation

Analysis of variance revealed significant differences with large effect size between classic and impulse mode of isometric contraction for FmaxND (F=22.3, p<0.001, η_p^2=0.48), RFDND (F=10.1, p<0.01, η_p^2=0.30), tFND (F=52.8, p<0.001, η_p^2=0.69), FmaxD (F=20.6, p<0.001, η_p^2=0.46), RFDND (F=10.3, p<0.01, ηp2=0.30), tFND (F=74.5, p<0.001, η_p^2=0.76).

Table 2. Descriptive statistical analysis of Handgrip Neuromuscular Characteristics in Classic (C) and Impulse (P) mode of Isometric Contraction

	CFmaxND	CRFDND	CtFmaxND	CtRFDND	CFmaxD	CRFDD	CtFmaxD	CtRFDD	NRID
Min	14.60	77.62	0.34	0.09	15.71	82.84	0.37	0.09	0.73
Max	32.59	220.48	1.88	0.19	36.27	249.93	1.39	0.17	1.10
M	22.86	152.02	0.85	0.12	24.71	163.09	0.77	0.12	0.95
SD	5.62	44.81	0.40	0.02	6.29	48.07	0.27	0.02	0.08
	PFmaxND	PRFDND	PtFmaxND	PtRFDND	PFmaxD	PRFDD	PtFmaxD	PtRFDD	NRIND
Min	13.50	100.11	0.20	0.09	11.45	94.89	0.15	0.10	0.71
Max	29.91	219.68	0.41	0.13	31.54	241.57	0.43	0.14	1.14
M	21.27	160.39	0.27	0.11	22.75	171.32	0.26	0.11	0.94
SD	4.92	38.33	0.06	0.01	6.00	43.88	0.08	0.01	0.10

Note. C: classical mode of isometric contraction, P: impulse mode of isometric contraction, D: dominant hand, ND: non-dominant hand, Fmax: maximal force, RFD: maximum rate of force development, tFmax: time needed for achieving Fmax, tRFDmax: the time needed for achieving RFD, NRI: neural reserve index, Min: minimum, Max: maximum, M: mean, SD: standard deviation

The correlation analysis (Table 3) revealed a weak positive association of NV with CFmaxND, CRFDND, and CRFDD; Psc with CFmaxND, CRFDND, CFmaxD, and PFmaxDL and DT with PFmaxND, NRID; as well as weak negative association of Agr with CFmaxND CRFDND, PFmaxND, PRFDND, NRIND; Ext with CRFDND, CFmaxD, PFmaxND, and PFmaxD. The correlation analysis also revealed a strong positive association of NV with CFmaxD, PFmaxND, PRFDND, and Psc with CRFDD, PFmaxND, PRFDND, and PRFDD.

Table 3. Correlation Analysis of Handgrip Neuromuscular with Psychological Characteristics

	Agr	Ext	Nrt	NV	Opn	PV	Cns	MT	Mch	Psc	Nrc	DT
CFmaxND	-0.42*	-0.36	0.11	0.47*	-0.01	-0.29	-0.03	0.20	0.33	0.45*	0.26	0.39
CRFDND	-0.48*	-0.40*	0.12	0.43*	-0.01	-0.26	0.05	0.22	0.23	0.44*	0.21	0.32
CtFmaxND	-0.10	0.13	-0.33	-0.10	0.20	0.04	0.14	0.19	-0.14	-0.16	-0.28	-0.25
CtRFDND	0.19	0.20	-0.22	-0.19	-0.16	-0.01	-0.13	0.12	0.03	-0.15	-0.14	-0.10
CFmaxD	-0.36	-0.42*	0.14	0.50*	-0.05	-0.23	0.01	0.15	0.15	0.49*	0.14	0.31
CRFDD	-0.36	-0.35	0.12	0.41*	-0.06	-0.24	0.05	0.12	0.12	0.54**	0.19	0.32
CtFmaxD	-0.09	-0.13	0.07	0.08	0.20	-0.13	-0.01	-0.24	-0.08	-0.05	0.00	-0.04
CtRFDD	0.14	0.36	-0.06	-0.18	0.10	0.23	-0.20	0.07	-0.14	-0.33	-0.07	-0.12
PFmaxND	-0.42*	-0.42*	0.18	0.53**	-0.02	-0.26	-0.07	0.19	0.25	0.52**	0.26	0.40*
PRFDND	-0.41*	-0.38	0.18	0.50*	-0.01	-0.20	0.00	0.20	0.26	0.50*	0.26	0.39
PtFmaxND	0.20	0.25	0.18	0.20	0.10	0.13	-0.09	0.09	0.07	-0.08	-0.03	-0.01
PtRFDND	0.10	0.36	-0.15	-0.24	0.05	0.13	0.01	-0.12	-0.22	-0.19	-0.09	-0.17
PFmaxD	-0.36	-0.41*	0.14	0.39	-0.09	-0.29	0.02	0.18	0.14	0.47*	0.12	0.25
PRFDD	-0.40*	-0.36	0.12	0.39	-0.15	-0.28	0.03	0.15	0.10	0.50*	0.10	0.25
PtFmaxD	-0.12	-0.06	0.15	0.07	0.10	-0.06	0.01	0.22	-0.09	-0.01	-0.07	-0.10
PtRFDD	0.31	0.28	0.13	-0.23	0.22	0.34	-0.12	0.06	0.06	-0.22	0.08	0.01
NRIND	-0.48*	-0.35	-0.13	0.09	-0.03	-0.35	0.14	0.23	0.07	0.16	0.02	0.03
NRID	0.03	-0.17	0.09	0.29	0.30	0.01	0.08	-0.09	0.20	0.37	0.40	0.41*

Note. Agr: aggression, Ext: extraversion, Nrt: neuroticism, NV: negative valence, Opn: openness, PV: positive valence, Cns: conscientiousness, MT: Mental Toughness, Mch: Machiavellianism, Psc: psychopathy, Nrc: narcissism, DT: Dark Triad, C: classical mode of isometric contraction, P: impulse mode of isometric contraction, D: dominant hand, ND: non-dominant hand, Fmax: maximal force, RFD: maximum rate of force development, tFmax: time needed for achieving Fmax, tRFDmax: the time needed for achieving RFD, NRI: neural reserve index, *p<0.05, **p<0.01

Table 4. The resulting models of multiple linear regression analysis of Handgrip Neuromuscular Characteristics (standardized coefficients) as predictors of Psychological Characteristics

	Agr	Eks	Nrt	NV	Opn	PV	Cns	MT	Mch	Psc	Nrc	DT
R2	0.94	0.18	0.74	0.71	0.46	0.46	0.14	0.46	0.44	0.29	0.70	0.55
Adjusted R2	0.90	0.14	0.58	0.47	0.19	0.32	0.06	0.35	0.21	0.26	0.55	0.40
F	23.10***	5.01*	4.48*	2.96*	1.71	0.28	1.78	4.24*	1.90	9.34*	4.63*	3.64*

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Table 4. The resulting models of multiple linear regression analysis of Handgrip Neuromuscular Characteristics (standardized coefficients) as predictors of Psychological Characteristics

	Agr	Eks	Nrt	NV	Opn	PV	Cns	MT	Mch	Psc	Nrc	DT
CFmaxND	1.4***	-	-	-	-0.9	-1.5**	-	-	0.7	-	-	-
CRFDND	-4.1***	-	-2.3**	-	5.8	-	-	-	-	-	-1.5*	-1.3
CtFmaxND	-0.3**	-	-5 0.8***	-0.4*	0.3	-	-	0.4*	-	-	-	-
CtRFDND	-	-	-0.4	0.3	-	-	1.1	0.5*	0.6	-	-	-
CFmaxD	-	-	-	3.0**	-	-	-	-	-	-	-2.7**	-1.4*
CRFDD	0.7**	-	-	-7.2*	-1.1*	1.3	-	-	-4.6	0.53**	8.1**	2.8**
CtFmaxD	0.3*	-	0.9**	0.6	-	-	-	-0.6**	-	-	-	-
CtRFDD	-0.6***	-	-	-	-	-	-	-	-	-	-	-
PFmaxND	-	-0.4*	2.1**	-	-	-	-1.1	-	-	-	-	-
PRFDND	0.7*	-	-	-	-3.1	1.7*	-	-	-	-	3.5***	2.5**
PtFmaxND	0.1	-	0.4*	0.4*	-	-	-	-	0.2	-	-0.3	-
PtRFDND	-1.4***	-	-0.7*	-	-	-	-	-	-0.5	-	-	-
PFmax_D	_	-	-	-2.4*	-	-1.4*	-	-	-	-	-	-
PRFDD	_	-	-	4.5*	-	-	-	-	3.5	-	-6.2*	-1.9*
PtFmaxD	_	-	-	0.5	0.3	-	-	-	-	-	-	-
PtRFDD	0.8***	-	0.5**	-0.3	-	0.8**	-	-	-	-	0.7**	0.5*
NRIND	_	-	-	-	-1.9	-	-	0.7**	-	-	-	
NRID	_	-	-0.3	1.1*	0.9**	-	-	-	1.4	-	-1.2	-

Note. Agr: aggression, Ext: extraversion, Nrt: neuroticism, NV: negative valence, Opn: openness, PV: positive valence, Cns: conscientiousness, MT: Mental Toughness, Mch: Machiavellianism, Psc: psychopathy, Nrc: narcissism, DT: Dark Triad, R2:coefficient of determination, F: F statistic, C: classical mode of isometric contraction, P: impulse mode of isometric contraction, D: dominant hand, ND: non-dominant hand, Fmax: maximal force, RFD: maximum rate of force development, tFmax: time needed for achieving Fmax, tRFDmax: the time needed for achieving RFD, NRI: neural reserve index, *p<0.05, **p<0.01, ***p<0.001

The multiple linear regression analysis started with all handgrip neuromuscular variables as predictors for Agr (R^2=0.95), Ext (R^2=0.74), Nrt (R^2=0.82), NV (R^2=0.75), Opn (R^2=0.62), PV (R^2=0.62), MT (R^2=0.75), Mch (R^2=0.56), Psc (R^2=0.56), Nrc (R^2=0.78), DT (R^2=0.69), where only a Agr model was significant (p<0.05). Performing backward stepwise selection resulted in more efficient models (Table 4).

Cross-validation on 75% of randomly selected respondents revealed the following models Agr (R^2=0.96), Ext (R^2=0.41), Nrt (R^2=0.79), NV (R^2=0.76), MT (R^2=0.45), Psc (R^2=0.37), Nrc (R^2=0.78), DT (R^2=0.70), where Agr, Ext, Nrt, Psc, Nrc, and DT models were significant (p<0.05).

Discussion

This study aimed to investigate the relationship between neuromuscular characteristics of the hand grip expressed in different modules of isometric contraction and psychological characteristics. Our findings have illuminated numerous significant associations, thereby corroborating the first hypothesis. Numerous effective regression models, which can explain a significant percentage of the variance of psychological characteristics (over 90% in Agr), supporting the second hypothesis, were also documented.

Before discussing explored relationships and comparing the morphological characteristics to the general population (Dopsaj, Pajic, et al., 2021), it could be stated that participants come from an average, physically prepared and healthy population. According to descriptive indicators (Table 2), all handgrip neuromuscular variables are also near average (Dopsaj et al., 2019b, 2019a). A similar can be concluded by comparing the psychological characteristics of the sample (Table 1) to the general population (Dinić et al., 2018b).

The results of the MANOVA confirm the findings of previous studies (Dopsaj, Klisaric, et al., 2021; Suzovic & Nedeljkovic, 2009) in the manifestation of neuromuscular characteristics in the classic and impulse mode of isometric contraction, which supports the conclusions of the difference in physiological mechanisms responsible for their manifestation.

The observed correlations (Table 3) also mainly align with prior research (Stephan et al., 2022) when it comes to the existence and direction of relationships between handgrip neuromuscular and psychological characteristics. The most significant deviation is a negative correlation with Ext, which could be explained by the documented inconsistency of findings of previous studies (Stephan et al., 2022). Namely, the difference in correlations is documented when they are examined separately for women and men or altogether. In our study, the sample is composed of persons of both sexes. However, unlike the previous research, allometric partialization enabled the partialisation of the effect of the body mass on the production of muscle force (Dulac et al., 2016). Therefore, the obtained correlation is a valid description of the observed relationship and not the sampling artefact.

Another novelty of our research is the association between neuromuscular characteristics with MT and elements of DT. Namely, while MT, Mch and Nrc (similar to Opn, Nrt, Cns and PV) do not significantly correlate with neuromuscular characteristics, Psc positively correlates with Fmax and RFD (similar to NV). DT positively correlates with PFmaxND as well as with the ability to generate more force in less or the same time in im-

pulse compared to the classical mode of isometric contraction for the dominant hand (NRID). We believe that NRID can also be described as an indicator of the possibility of creating more nerve impulses when needed, as well as efficient execution of the movements while maintaining neural reserve. In our opinion, this link is lacking (since bigger NRID indicate smaller reserve) ability to efficiently execute movements and tendencies of benevolent behaviour and can be potentially described as a lack of impulse control, both in the sense of motor control and behaviour in general. Adding to this negative correlation of Agr and Ext with Fmax and RFD, the hypothetical psychological profile of persons able to generate a large amount of force quickly (and vice versa) can be hypothetically described as non-aggressive introverts with a negative self-image prone to anti-social behaviour, emotional coldness, impulsive and manipulative. On the other hand, the ability to control impulses and maintain neural reserve could be a corrective mechanism which prevents the manifestation of the listed tendencies through aggression.

The difference in a relationship can be observed when comparing the non-dominant to the dominant hand, RFD to Fmax, and the impulse mode to the classical one. This result opens some new possibilities for explaining the relationships that were obtained. Although all mentioned variables represent a complex neuromuscular characteristic, because of its dependence on the speed of recruitment of motor units, RFD primarily reflects the ability of the nervous system to produce and transport impulses quickly (Baudry & Duchateau, 2021; Dideriksen et al., 2020), this is especially true for non-dominant hand in impulse mode of contraction. The possibility that some relationship between HGS and psychological characteristics can also be explained by the peculiarities of the functioning of the nervous system and not exclusively with the muscular strength factors is worth additional studies.

Regression models (Table 4) have a surprisingly high coefficient of determination, which raises concerns about overfitting. Outlier analysis showed that this cannot be attributed to skewed distributions of the scores due to extreme values. Adjusted R^2 scores showed that initial models are mainly unsteady. The exception is the Agr model, which initially showed good stability. After performing stepwise regression analyses, models gained much more stability regarding adjusted R^2.

Regarding cross-validation, the total sample that is not too large limits its performance. Therefore, one should not rush to say that even six models have been validated. Namely, although some models showed similarity in the total sample and on a sample of 75% of randomly selected respondents, cross-validation still showed that there is model instability and that some of the original models were not statistically significant in the repeated procedure. At this moment, it is difficult to judge whether any of the arguments mentioned above represent the reality of things and which are artefacts of sampling. Such findings call for caution in the interpretation of the obtained models. However, they also show that new research on this topic is justified. Furthermore, the obtained results show that conducting this research was justified and that the relationship between the handgrip and psychological characteristics was not exhausted by previous research.

However, obtained regression models (Table 4), with surprisingly high coefficient of determination, speak in favour of the justification of this research as well as the promising possibility that the results of future studies will bring numerous opportunities for practical application in addition to the theoretical value. What regression analysis brings in relation to the correlation is primarily a synergistic effect of subtle differences in the manifestation of measured neuromuscular characteristics when the psychological characteristics in question are predicted. It can be clearly noticed that the duration of the excitation has its share in explaining the variance of some psychological characteristics, not only the intensity of the excitation, as it could be concluded on the basis of correlation analysis. Regression analysis also showed unique connection patterns with neuromuscular characteristics specific to individual psychological characteristics. In this way, a more apparent connection of motor behaviour with a broader domain of behaviour government is established.

Since the HGS test is already in use as a robust and straightforward marker of overall body strength and health status (Cronin et al., 2017), and since explored psychological characteristics are also associated with health outcomes and life expectancy (Ziegler et al., 2015), obtained relationship can be used in practice to increase its prognostic and preventive value. Given the ease of HGS test conduction from one and all, which demonstrated direct and indirect relationships with health, it can be a very effective screening tool.

This study has certain limitations which should be taken into account when making conclusions. A convenience sampling method instead of a random one represents a limitation of its representativeness when it comes to the generalization of findings. Also, although it meets the criteria of a power analysis, this sample is not too large to claim that the findings can apply to other samples or even the general population. By applying stepwise regression, an attempt was made to increase the generability of the obtained results, but the scope of this method is still limited. In the end, correlational design limits the possibility of concluding the nature of the observed relationship.

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References

Andersen, L. L., & Aagaard, P. (2006). Influence of maximal muscle strength and intrinsic muscle contractile properties on contractile rate of force development. *European Journal of Applied Physiology*, *96*(1), 46–52. https://doi.org/10.1007/s00421-005-0070-z

Baudry, S., & Duchateau, J. (2021). Changes in corticospinal excitability during the preparation phase of ballistic and ramp contractions. *The Journal of Physiology*, *599*(5), 1551–1566. https://doi.org/10.1113/JP281093

Campbell, M., Varley-Campbell, J., Fulford, J., Taylor, B., Mileva, K. N., & Bowtell, J. L. (2019). Effect of Immobilisation on Neuromuscular Function In Vivo in Humans: A Systematic Review. *Sports Medicine*, *49*(6), 931–950. https://doi.org/10.1007/s40279-019-01088-8

Čolović, P., Smederevac, S., & Mitrović, D. (2014). Velikih Pet Plus Dva: Validacija Skraćene Verzije. *Primenjena Psihologija*, *7*(3–1), 227. https://doi.org/10.19090/pp.2014.3-1.227-254

Cronin, J., Lawton, T., Harris, N., Kilding, A., & McMaster, D. T. (2017). A Brief Review of Handgrip Strength and Sport Performance. *Journal of Strength and Conditioning Research*, *31*(11), 3187–3217. https://doi.org/10.1519/JSC.0000000000002149

Dideriksen, J. L., Del Vecchio, A., & Farina, D. (2020). Neural and muscular determinants of maximal rate of force development. *Journal of Neurophysiology*, *123*(1), 149–157. https://doi.org/10.1152/jn.00330.2019

Dinić, B. M., Petrović, B., & Jonason, P. K. (2018a). Serbian adaptations of the Dark Triad Dirty Dozen (DTDD) and Short Dark Triad (SD3). *Personality and Individual Differences*, *134*(June), 321–328. https://doi.org/10.1016/j.paid.2018.06.018

Dinić, B. M., Petrović, B., & Jonason, P. K. (2018b). Serbian adaptations of the Dark Triad Dirty Dozen (DTDD) and Short Dark Triad (SD3). *Personality and Individual Differences*, *134*(June), 321–328. https://doi.org/10.1016/j.paid.2018.06.018

Dopsaj, M., Klisaric, D., Kapeleti, M., Ubovic, M., Rebic, N., Piper, D., Trikos, B., Rajkovic, A., Nikolic, D., Nikolic, M., Vasiljevic, M., & Bozovic, B. (2021). RELIABILITY AND DIFFERENCES BETWEEN THE CLASSIC AND THE IMPULSE MODEL OF ISOMETRIC TESTING IN FUNCTION OF MAXIMAL AND EXPLOSIVE STRENGTH: PILOT RESEARCH. *PHYSICAL CULTURE*, *75*(2). https://doi.org/doi: 10.5937/fizkul75-39013

Dopsaj, M., Nenasheva, A., Tretiakova, T., Syromiatnikova, Y., Surina-Marysheva, E., Marković, S., & Dopsaj, V. (2019a). HANDGRIP MUSCLE FORCE CHARACTERISTICS WITH GENERAL REFERENCE VALUES AT

CHELYABINSK AND BELGRADE STUDENTS. *Human Sport Medicine*, *19*(2), 27–36. https://doi.org/10.14529/hsm190204

Dopsaj, M., Nenasheva, A. V., Tretiakova, T. N., Syromiatnikova, Y. A., Surina-Marysheva, E. F., Marković, S., & Dopsaj, V. (2019b). Handgrip muscle force characteristics with general reference values at Chelyabinsk and Belgrade students. *Human Sport Medicine*, *19*(2), 27–36. https://doi.org/10.14529/hsm190204

Dopsaj, M., Pajic, Z., Kocic, A., Erak, M., Pajkic, Aleksandar, Vicentijevic, A., Milosevic, M., & Bozovic, B. (2021). Profile for Body Fat Percentage of Serbian Working Population, Aged from 18 to 65, Measured by Multichannel Bioimpedance Method. *Int. J. Morphol*, *39*(6), 1694–1700.

Dulac, M., Boutros, G. E. H., Pion, C., Barbat-Artigas, S., Gouspillou, G., & Aubertin-Leheudre, M. (2016). Is handgrip strength normalized to body weight a useful tool to identify dynapenia and functional incapacity in post-menopausal women? *Brazilian Journal of Physical Therapy*, *20*(6), 510–516. https://doi.org/10.1590/bjpt-rbf.2014.0184

Gallup, A. C., White, D. D., & Gallup, G. G. (2007). Handgrip strength predicts sexual behavior, body morphology, and aggression in male college students. *Evolution and Human Behavior*, *28*(6), 423–429. https://doi.org/10.1016/j.evolhumbehav.2007.07.001

Gucciardi, D. F., Hanton, S., Gordon, S., Mallett, C. J., & Temby, P. (2015). The Concept of Mental Toughness: Tests of Dimensionality, Nomological Network, and Traitness. *Journal of Personality*, *83*(1), 26–44. https://doi.org/10.1111/jopy.12079

Hegerstad, C., Dillern, T., Giske, R., & Shalfawi, S. (2019). BASES Conference 2019 – Programme and Abstracts, The relationship between mental toughness and physical performance test in police college students. *Journal of Sports Sciences*, *37*(sup1), 27. https://doi.org/10.1080/02640414.2019.1671688

Jonason, P. K., & Webster, G. D. (2010). The dirty dozen: A concise measure of the dark triad. *Psychological Assessment*, *22*(2), 420–432. https://doi.org/10.1037/a0019265

Knezevic, O. M., Mirkov, D. M., Kadija, M., Nedeljkovic, A., & Jaric, S. (2014). Asymmetries in explosive strength following anterior cruciate ligament reconstruction. *The Knee*, *21*(6), 1039–1045. https://doi.org/10.1016/j.knee.2014.07.021

Liu, J. Z., Yang, Q., Yao, B., Brown, R. W., & Yue, G. H. (2005). Linear correlation between fractal dimension of EEG signal and handgrip force. *Biological Cybernetics*, *93*(2), 131–140. https://doi.org/10.1007/s00422-005-0561-3

Marković, S., Dopsaj, M., & Veljković, V. (2020). Reliability of Sports Medical Solutions Handgrip and Jamar Handgrip Dynamometer. *Measurement Science Review*, *20*(2), 59–64. https://doi.org/10.2478/msr-2020-0008

Papageorgiou, K. A., Benini, E., Bilello, D., Gianniou, F., Clough, P. J., & Costantini, G. (2019). Bridging the gap: A network approach to Dark Triad, Mental Toughness, the Big Five, and perceived stress. *Journal of Personality*, *87*(6), 1250–1263. https://doi.org/10.1111/jopy.12472

Sahaly, R., Vandewalle, H., Driss, T., & Monod, H. (2001). Maximal voluntary force and rate of force development in humans—Importance of instruction. *European Journal of Applied Physiology*, *85*(3–4), 345–350. https://doi.org/10.1007/s004210100451

Sawilowsky, S. S. (2009). New Effect Size Rules of Thumb. *Journal of Modern Applied Statistical Methods*, *8*(2), 597–599. https://doi.org/10.22237/jmasm/1257035100

Stamatis, A., Morgan, G. B., Moreno, P. J. F., Pineda, L. T. B., Sanchez, A. I. A., & Torres, S. S. (2022). Multicultural Invariance and Validation of the Mental Toughness Index in North American and Mexican Athletes. *Nuevas Tendencias En Educación Física, Deporte y Recreación*, *43*, 643–650.

Stephan, Y., Sutin, A. R., Canada, B., Deshayes, M., Kekäläinen, T., & Terracciano, A. (2022). Five-factor model personality traits and grip strength: Meta-analysis of seven studies. *Journal of Psychosomatic Research*, *160*, 110961. https://doi.org/10.1016/j.jpsychores.2022.110961

Sullivan, G. M., & Feinn, R. (2012). Using Effect Size—Or Why the *P* Value Is Not Enough. *Journal of Graduate Medical Education*, *4*(3), 279–282. https://doi.org/10.4300/JGME-D-12-00156.1

Sutin, A. R., Stephan, Y., & Terracciano, A. (2018). Facets of conscientiousness and objective markers of health status. *Psychology & Health*, *33*(9), 1100–1115. https://doi.org/10.1080/08870446.2018.1464165

Suzovic, D., & Nedeljkovic, A. (2009). Short pulse contractions: Relationship between maximal forces and rate of force development. *Physical Culture*, *63*(1), 17–34.

Vukmirovic, M., Rajovic, N., Pavlovic, V., Masic, S., Mirkovic, M., Tasic, R., Randjelovic, S., Mostic, D., Velickovic, I., Nestorovic, E., Milcanovic, P., Stanisavljevic, D., & Milic, N. (2020). The Burnout Syndrome in Medical Academia: Psychometric Properties of the Serbian Version of the Maslach Burnout Inventory—Educators Survey. *International Journal of Environmental Research and Public Health*, *17*(16), 5658. https://doi.org/10.3390/ijerph17165658

Ziegler, M., Cengia, A., Mussel, P., & Gerstorf, D. (2015). Openness as a buffer against cognitive decline: The Openness-Fluid-Crystallized-Intelligence (OFCI) model applied to late adulthood. *Psychology and Aging*, *30*(3), 573–588. https://doi.org/10.1037/a0039493

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ORIGINAL SCIENTIFIC PAPER

Effects of a Model of Supplementary Exercises for the Development of Motor Skills in Elementary School Students

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Abstract

The aim of this research was to evaulate the effects of supplementary exercise models on the development of motor skills in elementary school students. The study involved a sample of 120 students divided into experimental and control groups, with 60 students in each group. Students in the experimental group, in addition to the regular curriculum, implemented a supplementary exercise model aimed at developing motor skills, while students in the control group followed the regular physical education curriculum. The research variables included: segmental speed, repetitive strength, explosive power and sprint speed, evaluated through tests such as hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20-meter sprint (S20), 40-meter sprint (S40), and 60-meter sprint (S60). Based on the T-test results, the experimental group showed no statistically significant differences only in wall taps with feet (WTF) and standing long jump (SLJ), while all other tests indicated statistically significant differences in motor skills between initial and final measurements. In the control group, there were no statistically significant differences between initial and final measurements in motor skills.

Keywords: *model, supplementary exercises, motor skills, students, elementary school*

Introduction

The objectives of physical education, stemming from its goals, and operational tasks concerning gender and age of students, are categorized into three thematic areas. One of these areas is the development of physical abilities, where elementary school students, in all physical education classes and extracurricular activities, are provided with time necessary for optimal development of physical abilities: strength, speed, endurance, flexibility, and appropriate motor habits (Momčilović, 2020). However, it is important to note that changes in physical abilities during growth and development partly do not depend on children's physical activity (Malina & Katzmarzyk, 2006).

Elementary school represents a period of intensive growth and development during which significant changes occur in the students' bodies. It is a period when the body is more susceptible to external influences, although it follows the basic trends of natural developmental changes, and physical education plays a crucial role in the development of not only motor skills but also the overall psychosomatic status of elementary school students (Malacko, 2002; Horvat and Vuleta, 2002; Višnjić, 2006; Pržulj, 2006; Pržulj, 2007). Active participation in class and spending more time in physical exercise allows students to improve their motor skills (Corbin, Pangrazi, & Welk, 1994; Silverman, 2005; Pavlović, 2017; Šekeljić and Stamatović, 2014).

During the maturation process, motor skills are not acquired spontaneously but through physical exercise, where the precise load (volume and intensity) is determined individually for each person (Hardy et al., 2010). Properly dosed physical load enables optimal development of motor skills (Metvejev,

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2000; Željaskov, 2004; Pržulj, 2006; Milanović, 2014).

The development and maintenance of achieved levels of motor skills can be significantly influenced by physical exercise, and to better understand these transformations, it is necessary to continuously monitor and study the transformation processes of motor skills (Metcalfe & Clark, 2002). Developing and perfecting motor skills and monitoring physical development to achieve good physical health in children and adolescents are fundamental prerequisites (Mikkelsson et al., 2006).

Different models of transformational processes and the effects of specifically programmed educational processes, their positive influence on the development and enhancement of motor skills in elementary school children, are of great importance for improving physical education and are the subject of numerous studies (Kurelić et al., 1975; De Vris, 1976; Heimar and Medvedev, 1997; Metvejev, 2000; Branković, 2001; Višnjić, 2004; Markuš and Markuš, 2006; Duraković, 2007; Pržulj, 2009; Milanović, 2014).

Methods

The sample consisted of 120 elementary school students in Niš, aged 13 and 14 years (±6 months), enrolled in three regular physical education classes.

The entire sample was divided into two homogeneous subsamples. The first subsample, consisting of 60 participants, constituted the experimental group. These students were involved in the regular physical education classes where 60% of the class time was dedicated to implementing pre-planned program content, while the remaining 40% was reserved for supplementary exercises aimed at developing students' motor skills.

The second subsample, also comprising 60 participants, served as the control group. These students participated in regular physical education classes where 100% of the class time adhered strictly to the prescribed curriculum.

Motor skill variables in this study included: segmental speed, repetitive strength, explosive power, and sprint speed. Motor skill assessments utilized in this research were: hand tapping (HTP), foot tapping (FTP), and wall taps with feet (WTF) for segmental speed; sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), and squats (SQT) for repetitive strength; standing long jump (SLJ), standing triple jump (STJ), and vertical jump "Sergeant" (VJS) for explosive power; and 20m sprint (S20), 40m sprint (S40), and 60m sprint (S60) for sprint speed.

The motor skill variables were adopted from the research by Kurelić, Momirović, Stojanović, Šturm, and Viskić-Štalec (1975).

The experimental treatment lasted for three months with three classes per week, i.e., 36 instructional sessions in total. The experiment was conducted during regular physical education classes in elementary schools in Niš. The parents were informed about the testing, they confirmed that their children were healthy and gave their consent for them to participate in the tests. All procedures and tests were conducted according to the WMA Declaration of Helsinki.

During the experimental procedure, two measurements of motor skills were conducted: initial measurements at the beginning of the experiment and final measurements at the end of the experiment for all participants in both the experimental and control groups.

Results

The research results are the following:

Table 1. Basic statistical parameters for the assessment of motor skills of the control group during the initial measurement

Variables	N	Mean	Min.	Max.	Std.dev.	Skewn.	Kurtos.
HTP	60	31.10	26.00	38.00	15.62	0.025	1.015
FTP	60	22.84	18.00	29.00	11.14	0.152	-0.608
WTF	60	14.15	10.00	18.00	10.18	0.220	-1.507
SSB	60	11.22	8.00	16.00	15.51	0.204	-1.004
MPU	60	8.73	5.00	13.00	2.47	0.520	-1.108
SQT	60	11.35	9.00	17.00	11.24	0.207	-2.005
SLJ	60	179.68	168.0	230.00	8.82	0.100	0.105
STJ	60	498.32	425.00	595.00	7.02	0.024	-1.120
VJS	60	22.64	19.00	32.00	5.00	0.715	2.206
S20	60	4.42	3.84	4.88	2.02	0.129	0.100
S40	60	6.49	5.95	6.90	7.00	0.414	-0.104
S60	60	8.60	8.05	9.10	1.12	0.712	1.406

Notes: Arithmetic mean (Mean), minimum (Min), maximum (Max), standard deviation (Std. dev.), skewness (Skewn.), kurtosis (Kurtos.), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

Table 1. shows the results for the participants from the control group regarding their motor skills assessment during the initial measurement, and it indicates that there is no statistically significant deviation of the results from the normal distribution. The results of the tests that assess the participants' motor skills indicate that the distribution is positive. This is confirmed by the results of the distribution asymmetry (skewness) which does not exceed 1.00, which means that the tests are not difficult (up to +1.00) or easy (up to -1.00), but rather correspond to the surveyed participants and the value is below one. The homogeneity (kurtosis) indicates that there is a good sensitivity of the tests, because the obtained values are below 2.75. The results obtained regarding the motor skills do not deviate from the results of similar studies conducted in our country on this population of examinees, thus it is possible to apply the multivariate analysis methods in this research as well. Generalization of the results on the population from which the sample of these respondents was derived is thus possible.

Table 2. Basic statistical parameters for the assessment of motor skills of the control group during the final measurement

Variables	N	Mean	Min.	Max.	Std.dev.	Skewn.	Kurtos.
HTP	60	31.70	28.00	40.00	1.24	0.445	-2.524
FTP	60	23.64	19.12	31.00	15.42	0.025	-2.112
WTF	60	15.30	12.00	20.00	5.31	0.169	0.302
SSB	60	12.18	9.00	17.00	12.14	0.024	2.025
MPU	60	9.00	6.00	15.00	13.14	0.502	0.236
SQT	60	12.26	10.00	18.00	11.55	0.200	0.300
SLJ	60	189.32	164.00	240.00	11.36	0.203	0.225
STJ	60	515.25	430.00	610.00	10.10	0.506	-2.436
VJS	60	24.10	20.00	32.00	15.52	0.042	1.562
S20	60	4.34	3.72	4.76	1.30	0.160	0.303
S40	60	6.35	5.84	6.75	11.10	0.014	2.016
S60	60	8.52	7.90	8.86	3.12	0.124	1.236

Notes: Arithmetic mean (Mean), minimum (Min), maximum (Max), standard deviation (Std. dev.), skewness (Skewn.), kurtosis (Kurtos.), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

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Table 3. Basic statistical parameters for the assessment of motor skills of the experimental group during the initial measurement

Variables	N	Mean	Min.	Max.	Std.dev.	Skewn.	Kurtos.
HTP	60	30.62	27.00	37.00	15.75	-0.317	-1.047
FTP	60	23.45	19.00	30.00	12.23	-0.338	1.104
WTF	60	13.73	9.00	17.00	11.34	-0.004	1.675
SSB	60	10.82	7.00	14.00	17.05	0.236	0.359
MPU	60	8.37	5.00	12.00	6.06	-0.173	2.611
SQT	60	11.56	8.00	15.00	15.22	-0.508	1.365
SLJ	60	182.18	162.00	240.00	7.05	0.281	-0.762
STJ	60	505.43	470.00	590.00	3.77	0.311	0.400
VJS	60	22.83	19.00	31.00	4.72	-0.119	0.403
S20	60	4.20	3.72	4.94	3.31	0.350	2.200
S40	60	6.54	5.86	6.93	3.50	0.340	0.320
S60	60	8.56	8.15	8.97	0.45	0.046	1.055

Notes: Arithmetic mean (Mean), minimum (Min), maximum (Max), standard deviation (Std. dev.), skewness (Skewn.), kurtosis (Kurtos.), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

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Table 4. Basic statistical parameters for the assessment of motor skills of the experimental group during the final measurement

Variables	N	Mean	Min.	Max.	Std.dev.	Skewn.	Kurtos.
HTP	60	36.82	28.00	41.00	12.22	-0.075	-2.300
FTP	60	28.43	21.00	32.00	11.83	0.223	-1.241
WTF	60	15.67	11.00	19.00	15.31	0.342	1.09
SSB	60	17.14	10.00	20.00	10.97	0.587	0.334
MPU	60	14.26	8.00	17.00	15.17	0.622	-0.245
SQT	60	16.72	11.00	19.00	3.68	0.100	2.049
SLJ	60	194.85	175.00	250.00	10.55	0.602	2.500
STJ	60	590.83	510.00	640.00	2.47	0.084	0.122
VJS	60	31.28	23.00	33.00	2.54	0.405	1.352
S20	60	3.86	3.50	4.76	10.45	0.270	1.079
S40	60	5.85	5.44	6.24	12.85	0.522	1.508
S60	60	7.90	7.63	8.56	17.35	0.800	-0.100

Notes: Arithmetic mean (Mean), minimum (Min), maximum (Max), standard deviation (Std. dev.), skewness (Skewn.), kurtosis (Kurtos.), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

population from which the sample of these respondents was derived is thus possible.

Table 4. shows the results for the participants from the experimental group regarding their motor skills assessment during the final measurement, and it indicates that there is no statistically significant deviation of the results from the normal distribution. The results of the tests that assess the participants' motor skills indicate that the distribution is positive. This is confirmed by the results of the distribution asymmetry (skewness) which does not exceed 1.00, which means that the tests are not difficult (up to +1.00) or easy (up to -1.00), but rather correspond to the surveyed participants and the value is below one. The homogeneity (kurtosis) indicates that there is a good sensitivity of the tests, because the obtained values are below 2.75. The results obtained regarding the motor skills do not deviate from the results of similar studies conducted in our country on this population of examinees, thus it is possible to apply the multivariate analysis methods in this research as well. Generalization of the results on the population from which the sample of these respondents was derived is thus possible.

Table 5. Significance of differences between means of the control group

Tests	Mean(i)	Mean(f)	T-value	p
HTP	31.10	31.70	-1.25	0.218
FTP	22.84	23.64	-1.24	0.205
WTF	14.15	15.30	-1.21	0.200
SSB	11.22	12.18	1.75	0.405
MPU	8.73	9.00	1.24	0.205
SQT	11.35	12.26	-1.15	0.262
SLJ	179.68	189.32	-1.77	0.158
STJ	498.32	515.25	1.52	0.378
VJS	22.64	24.10	-1.17	0.354
S20	4.42	4.34	-1.23	0.263
S40	6.49	6.35	1.52	0.234
S60	8.60	8.52	-1.56	0.206

Notes: initial mean (Mean (i)), final mean (Mean (f)), T-test value (T-value), and significance level (p), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

Table 5. presents the results of the T-test for motor skills between initial and final measurements of the control group. After analyzing the obtained results, it is concluded that there is no statistically significant difference in motor skill tests.

Table 6. presents the results of the T-test for motor skills between initial and final measurements of the experimental group. After analyzing the obtained results, it is concluded that there is a statistically significant difference in hand tapping (HTP $p<0.001$), foot tapping (FTP $p<0.001$), sit-ups on a Swedish bench (SSB $p=0.006$), mixed pull-ups (MPU $p= 0.005$), squats (SQT $p=0.003$), standing triple jump (STJ $p<0.001$), Sergeant jump (VJS $p=0.001$), 20-meter sprint (S20 $p<0.001$), 40-meter sprint (S40 $p<0.001$), and 60-meter sprint (S60 $p<0.001$).

Table 6. Significance of differences between means of the experimental group

Tests	Mean(i)	Mean(f)	T-value	p
HTP	30.62	36.82	6.53	<0.001
FTP	23.45	28.43	5.55	0.000
WTF	13.73	15.67	1.52	0.120
SSB	10.82	17.14	1.36	0.006
MPU	8.37	14.26	1.26	0.005
SQT	11.56	16.72	1.17	0.003
SLJ	182.18	194.85	1.82	0.090
STJ	505.43	590.83	11.29	<0.001
VJS	22.83	31.28	3.12	0.001
S20	4.20	3.86	10.47	<0.001
S40	6.54	5.85	10.84	<0.001
S60	8.56	7.90	5.15	<0.001

Notes: initial mean (Mean (i)), final mean (Mean (f)), T-test value (T-value), and significance level (p), hand tapping (HTP), foot tapping (FTP), wall taps with feet (WTF), sit-ups on a Swedish bench (SSB), mixed pull-ups (MPU), squats (SQT), standing long jump (SLJ), standing triple jump (STJ), vertical jump "Sergeant" (VJS), 20m sprint (S20), 40m sprint (S40), 60m sprint (S60).

Discussion

The paper presents basic statistical parameters and the results of the T-test for motor skills between initial and final measurements of the experimental and control groups.

The results of the T-test for motor skills between initial and final measurements of the control group indicate that there is no statistically significant difference in motor skill tests: hand tapping (HTP p=0.218), foot tapping (FTP p=0.205), wall taps with feet (WTF p=0.200), sit-ups on a Swedish bench (SSB p=0.405), mixed pull-ups (MPU p=0.205), squats (SQT p=0.262), standing long jump (SLJ p=0.158), standing triple jump (STJ p=0.378), Sergeant jump (VJS p=0.354), 20-meter sprint (S20 p=0.263), 40-meter sprint (S40 p=234), and 60-meter sprint (S60 p=0.206).

Based on this, questions about the current lesson plan and program and the adequate selection of contents, methods and forms of work in regular physical education arise. Then, questions about the intensity and the scope of the student activities during the physical education classes, as well as, those about the better quality of the teachers' training. Also, there is the question of the student motivation during the regular physical education classes. Programmed classes and the implementation of various exercising models carry a more fun and more interesting content which is welcomed by students with greater motivation and stronger engagement which leads to heightened intensity and work scope and thus to development of motor skills. We believe that the improvement of the material conditions and provision of more diverse apparatuses, sports requisites and better equipment in school gyms and fitness rooms can bring about better effects in regular physical education classes. (Popović, 2004; Milanovic, 2007; Milanović, 2016; Momčilović, V., Momčilović, Z., 2017, 2024; Momčilović, V., Zdravković, V., 2020; Momčilović Z., Momčilović V., 2024).

The results of the T-test for motor skills between initial and final measurements of the experimental group indicate that there is a statistically significant difference in the following tests: hand tapping (HTP p<0.001), foot tapping (FTP p<0.001), sit-ups on a Swedish bench (SSB p=0.006), mixed pull-ups (MPU p=0.005), squats (SQT p=0.003), standing triple jump (STJ p<0.001), Sergeant jump (VJS p=0.001), 20-meter sprint (S20 p<0.001), 40-meter sprint (S40 p<0.001), and 60-meter sprint (S60 p<0.001). There were no statistically significant differences found in wall taps with feet (WTF p=0.120) and standing long jump (SLJ p=0.090).

The results of this study are one in a series indicating that experimental programs and supplementary exercise models for developing motor skills in elementary school children yield excellent results (Milenković, 2002; Dragić, 2003; Stamatović & Šekeljić, 2006; Pržulj, 2009; Bakhtjari, S., Shafinja, P., Ziaee, V., 2011; Korjenić et al., 2012; Milanović, S., 2016; Momčilović, V., Momčilović, Z., 2017, 2024; Momčilović, V., Momčilović, Z., & Cenić, S., 2018; Momčilović, V., Zdravković, V., 2020; Mekić, R., et all., 2023; Momčilović Z., Momčilović V., 2024).

The results of determination of the effects of the explosive strenght experimental model on motor and functional skills transformation during the regular physical education classes in elementray school students have shown that, under the experimental program influence, the experimental group of students achieved better results in motor and functional abilities measurements. Also, the results have shown that there are statistically significant effects on the final testing. (Momčilović, V., Momčilović, Z., & Cenić, S., 2018). The multivariate analysis of covariance in the field of motor skills indicates that there is statistically significant difference at the multivariate level between participants of experimental and control group. Existing difference occurs under the impact of experimental treatment which had an effect on the development of the motor skills of the experimental group. Furthermore, s statistically significant effect was determined at the reliability level of 99%, for acrobatic agility, 20m running with flying start, 50m running with standing start, pushups, standing long jump and standing triple jump. Only for one of the tests, i.e., squats, was the difference not statistically significant.

In the research about the effects of the combined physical education and sports gymnastics classes on the antropological status of elementary school students (Mekić, R., et all., 2023), in addition to the positive effects on morphological characteristics, the obtained results clearly show the positive effects of the gymnastics program on the students' motor skills in most of the tested anthropological and teoanthropological views on physical activity variables. Statistically significant changes at the final measurement in relation to the initial measurement were observed in the following variables: hand tapping, standing long jump, polygon backwards, trunk lifting, while in the

case of the variables deep bend various, stand up with a pull-up and running for 3 minutes, although there have been changes compared to the initial measurement, these changes are not at a statistically significant level.

The results of the research (Milanović, S., 2016) point to the fact that additional exercise treatment led to significant changes in motor skills of the examinees. The statistically significant differences in the levels of motor skills were observed between the experimental and the control groups in the following motor skills tests: arial agility , bat coordination, ground agility, standing long jump, standing triple jump, standing medicine ball throw, trunk lifts on the decline bench, mixed grip pull-ups, squats, 20-meter sprint from a high start, 40-meter sprint from a high start, 60-meter sprint from a high start, hand tapping, leg tapping and wall leg tapping.

Determining the impact of the selected excercises on the motor skills of the girls in the third grade od elementary schools has shown that selected excercises can be used to improve motor skills in the third grade elementary school students. (Bakhtjari, S., Shafinja, P., Ziaee, V., 2011). The results have shown statistically significant differences between the experimantal and the control groups in locomotor skills, manipulative skills and overall motor skills. In fact, the selected excercises impacted the motor skill development in examinees and led to the improvement in their motor skills development.

Conclusion

Based on the results of this research, we can conclude that the effects of supplementary exercise models on the development of motor skills in elementary school students have been identified, with statistically significant differences in motor skills observed in the experimental group after the experimental treatment.

Through the work on this study and previous research, it is evident that various supplementary exercise models, experimental programs, alternative curricula, and different teaching concepts contribute to positive transformative processes in the motor skills of elementary school students.

Starting from one of the primary objectives of physical education, which is the systematic monitoring of physical development and abilities of elementary school children, we can assert that the findings from this and similar studies are valuable for healthcare professionals, physical education teachers, sports professionals, and all other experts in the field of child education and development. These findings hold exceptional societal significance.

For systematic monitoring of physical development and abilities in children, longitudinal studies are of greater importance. With appropriate methodology and measurement techniques, these studies can contribute to transforming and modifying educational curricula effectively.

The limitation of this research is that the scope could have been larger and the research instrument could have included a greater number of variables in motor, morphological and functional space with the aim to better observe the anthropological dimensions of the students and to determine the impact of the programmed physical education classes more precisely. In addition, more detailed and complex statistical procedures and analyses could be used which would present the research results more precisely and completely.

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References

Bakhtjari, S., Shafinja, P., Ziaee, V. (2011). Effects of Selected Exercises on Elementary School Third Grade Girl Students' Motor Development. Asian J. Sports Med. 2(1):51–56.

Branković, N. (2001). Razvojne karakteristike motoričkih sposobnosti učenica na kraju šestomesečnog izvoĐenja nastave fizičkog vaspitanja. U S. Vučković (Ur.). Zbornik radova "Fis-komunikacije" (str. 205-207). Niš: Fakultet fizičke kulture.

Clark, J. E., & Metcalfe, J. S. (2002). The Mountain of Motor Development: A Metaphor. In J. E. Clark, & J. Humphrey (Eds.), Motor Development: Research and Reviews (pp. 163-190). Reston, VA: NASPE Publications.

Corbin, C. B., Pangrazi, R. P., & Welk, G. J. (1994). Toward an understanding of appropriate physical activity levels for youth. Physical Activity and Fitness Research Digest, 1(8), 1–8.

Dragić, B. (2003). Efekti alternativnog nastavnog plana i programa fizičkog vaspitanja na morfološke karakteristike, motoričke sposobnosti i socijalne karakteristike učenika VI razreda osnovne škole. Doktorska disertacija, Niš: Fakultet fizičke kulture.

Duraković, M. (2008). *Kinatropologija*, *Biološki aspekti tjelesnog vježbanja*. Zagreb: Kineziološki fakultet Sveučilišta.

Hardy, L. L., King, L., Farrell, L., Macniven, R., & Howlett, S. (2010). Fundamental movement skills among Australian preschool children. Journal of Science and Medicine in Sport, 13(5), 503-508.

Heimar, S. i Medved, R. (1997). *Funkcionalna dijagnostika treniranosti sportaša, Međunarodno savetovanje,* Zbornika radova (23-44). Zagreb: Fakultet za fizičku kulturu Sveučilišta u Zagrebu.

Horvat, T. i Vuleta, D. (2002). Razlike u nekim motoričkim sposobnostima između učenika 5–8. razreda O.Š. „Josipa Račića" i učenika 5–8 razreda u OŠ u Hrvatskoj. U V. Findak (ur.). Zbornik radova 11. ljetne škole kineziologa Republike Hrvatske Programiranje rada u području edukacije, sporta, sportske rekreacije i kineziterapije. Zagreb: Hrvatski kineziološki savez.

Korjenić, A. , Jeličić, M. , Basinac, I., & Begović, D. (2012). Efekti programirane nastave odbojke na nivo motoričkih sposobnosti i usvojenost elemenata odbojkaške igre. Sportske nauke i zadravlje, 2 (2), 93-99. doi:10.7251/ssh1202093k

Kurelić, N., Momirović, K., Stojanović, M., Šturm, J., Radojević, Đ., Viskić-Štalec, N. (1975) Struktura i razvoj morfoloških i motoričkih dimenzija omladine. Beograd: Fakultet za fizičku kulturu / FFK - Institut za naučna istraživanja

Malacko, J. (2002). Sportski trening. Novi Sad: Fakultet fizičke kulture.

Malina, R.M., katzmarzyk, P.T. (2006). Physical activity and fitness in international growth standard for preadolescent and adolescent children. Food and Nutrition Bulletin. Vol 27, 4. 295-313.

Markuš, D. & Markuš, J. (2006). Uticaj posebno programiranog treninga na promene nekih motoričkih sposobnosti članova gimnastičke sekcije. U V. Findak (Ur). 15. letnja škola kineziologa republike hrvatske (str. 168-173.). Rovinj: Hrvatski kineziološki savez.

Mekić R, Bjelica B, Murić B, Kahrović I, Radenković O, Petković E, Aksović N. (2023). Influence of combined teaching of physical education and sports gymnastics on the anthroplological status of elementary school students. 10th INTERNATIONAL SCIENTIFIC CONFERENCE "ANTHROPOLOGICAL AND TEO-ANTHROPOLOGICAL VIEWS ON PHYSICAL ACTIVITY", BOOK OF PROCEDEEINGS pp. 56-62, Kopaonik, Serbia.

Mikkelsson, L., Kaprio, J., Kautianinen, H., Kujala, U., Mikkelsson, M., Nupponen, H. (2006). School fitness tests as predictors of adult healtrelated fitness. Am J Hum Biol, 18, 342-349.

Milanović R. S.. (2016). Efekti dopunskog metodičkog oblika rada na razvoj antropoloških obeležja školske dece. Uzdanica, XIII/2, str. 149–160.

Milanović, I. (2007). Efekti programirane nastave fizičkog vaspitanja u mlađem školskom uzrastu. Fizička kultura, 61(1–2), 43–70.

Milanović, S. (2014). Efekti dopunskog metodičkog oblika rada na razvoj antropoloških obeležja školske dece. *Međunarodna interdisiplinarna naučno-stručna onferencija"Vaspitno-obrazovni i sportski horizonti"*. Subotica: Visoka škola strukovnih studija za obrazovanje vaspitača i trenera.

Milenković, V. (2002). Efekti primene eksperimentalnog programa sa akcentom na sportsku gimnastiku na neke motoričke sposobnosti učenika sedmog razreda osnovne škole. U R. Popović (Ur.) Zbornik radova "Fis-komunikacije", (str. 291-300), Niš: Fakultet fizičke kulture.

Momčilović Z., Momčilović V. (2024) Intercorrelations of motor abilities of young school-age students. *11th International Scientific Conference "ANTHROPOLOGICAL AND TEO-ANTHROPOLOGICAL VIEW ON PHYSICAL ACTIVITY"*, Book of Proceedings pp. 62-68, Kopaonik, Serbia, March, 21 – 22, 2024.

Momčilović, V. (2020). Motoričke sposobnosti učenika IV razreda osnovne škole gradske i seoske sredine u Vranju. Vranje: Pedagoški fakultet u Vranju.

Momčilović, V., Momčilović, Z. (2017). Efekti dodatnog programa vežbi koordinacije u redovnoj nastavi fizičkog vaspitanja na neke motoričke sposobnosti, Zbornik radova VII međunarodne konferencije „Sportske nauke i zdravlje", Panevropski univerzitet „APERION", Banja Luka, 186-191.

Momčilović, V., Momčilović, Z. (2024). Transformation processes in the motor skills of young schoolchildren. 14th International Conference on "Sports Science and Health", Book of Proceedings pp. 63-71, Banja Luka, 14-15. 3. 2024.

Momčilović, V., Momčilović, Z., & Cenić, S. (2018). Effect of experimental model of explosive strength in regular physical education classes. Facta Universitatis Series: Physical Education and Sport, 16(3), 569-576.

Momčilović, V., Zdravković, V. (2020). The influence of integration of physical and music education on class teaching students motor skills development, Facta Universitatis Series: Teaching, Learning and Teacher Education Vol. 4, No 1, 35 – 45.

Pavlović, S. (2017). Prediktori fizičke aktivnosti učenika na času fizičkog vaspitanja (Predictors of physical activity of student in physical education class). Unpublished Doctoral dissertation, Novi Sad: Faculty of Sport and Physical Education. In Serbian.

Popović, S. (2003–2004). Efikasnost nastave fizičkog vaspitanja u zavisnosti od organizacione forme rada u nastavnom procesu. Fizička kultura, 57 58(1-4), 26–40.

Pržulj, D. (2006):. *Osnovi antropomotorike*, Udžbenik. Pale: Fakultet fizičke kulture.

Pržulj, D. (2007): *Kondiciona priprema sportista*, Udžbenik. Pale: Fakultet fizičke kulture.

Pržulj, D. (2009). Razvoj motoričkih sposobnosti u funkciji pliometrijskog metoda treninga kod sportista. *Sport i zdravlje*, 4 (1), 58-62.

Šekeljić, G., & Stamatović, M. (2014). Teorija i metodika fizičkog vaspitanja (Theory and methodic of physical education). Užice: Faculty of Pedagogy. In Serbian.

Silverman, S. (2005). Thinking long term: physical education's role in movement and mobility. Quest, 57(1), 138-147.

Stamatović, M., & Šekeljić, G. (2006). Uticaj različitih koncepcija nastave fizičkog vaspitanja na motorički status učenika mlađeg školskog uzrasta. U G. Bala (Ur.) Antropološki status i fizička aktivnost dece i omladine, Zbornik radova, (str. 301-310), Novi Sad: Fakultet sporta i fizičkog vaspitanja.

Višnjić, D. (2006). *Nastava fizičkog vaspitanja*: od V do VIII razreda osnovne škole: priručnik za studente, nastavnike i profesore. Beograd: Zavod za udžbenike i nastavna sredstva.

Željaskov, C (2004). *Kondicioni tzrening frhunskioh sportista (teorija, metodika i praksa),* Udžbenik. Beograd: Sportska akademija.

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SYSTEMATIC REVIEW

Analysis of different physical activity modalities as therapeutic intervention in women with osteoporosis: A scoping systematic review

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Abstract

Osteoporosis represents a growing public health concern characterized by progressive bone mass reduction and increased fracture risk, particularly among the elderly. Physical activity emerges as one of the most important non-pharmacological preventive measures, achieving multidimensional benefits through simultaneous preservation of bone density, enhancement of muscle strength, and improved balance capabilities. Accordingly, the aim of this systematic literature review is a comprehensive critical analysis of current scientific research examining the therapeutic potential of physical activities in the treatment of osteoporosis in women.This systematic review was conducted according to PRISMA-ScR guidelines, searching four electronic databases from January 2015 to May 2025, where two independent researchers applied PICOS criteria and the PEDro scale for quality assessment. Finally, 18 studies met the criteria and were included in the final analysis.The analysis demonstrates that physical activity achieves significant therapeutic effects in women with osteoporosis through improvement of muscle strength, postural stability, and bone density maintenance, with positive outcomes achieved regardless of specific exercise modality - including aerobic and anaerobic training, Pilates, yoga, and vibration therapies. Implementation of regular physical activity represents a fundamental component of the multidisciplinary approach in osteoporosis treatment among women, enabling individualized application of various modalities according to specific needs and capabilities of patients.

Keywords: *physical activity, osteoporosis, women, importance, impact*

Introduction

Epidemiological studies indicate a growing trend of metabolic disorders, among which obesity and type 2 diabetes stand out, while osteoporosis occupies a special place as a "silent killer," yet often represents a neglected public health issue (Alswat, 2017; Li et al., 2024; Yang et al., 2025). This metabolic disorder is frequently associated with bone fractures, which can result in disability and, in extreme cases, death (Lyu et al., 2025). This bone tissue disorder, whose name derives from the Latin words "osteo" meaning bone, and "porosis" meaning pore, is defined as a condition of reduced bone density accompanied by compromised structural integrity. According to the World Health Organization's definition, osteoporosis represents a condition in which the degradation of bone mass and microstructure leads to increased bone fragility and consequent increased risk of fractures (World Health Organization, 2020). This metabolic condition, which impacts approximately 200 million individuals globally, weakens the body's structural framework that normally provides physical support, facilitates movement, and shields essential organs (Anthamatten & Parish, 2019). Although often perceived as exclusively a problem in postmenopausal women, osteoporosis represents a clinical entity that manifests in both sexes through different temporal patterns and intensities (Lorentzon & Cummings, 2015). Existing literature indicates a fourfold higher prevalence in women, while men are exposed to the risk of more complex complications, making aging the main predisposing factor through complex biopsychosocial mechanisms (Bijelic et al., 2017). At age 60, approximately 10% are affected by osteoporosis, at age 70, around 20%, at age 80, nearly 40%, while

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at age 90, as many as 2/3 of all women are affected (Sarafrazi et al., 2021). It is estimated that the prevalence of osteoporosis will increase by 1/3 in people aged 50-60 years, and by as much as 1/2 in people older than 80 years (Kanis, 2007). By 2050, it is projected that the number of individuals with osteoporosis will increase threefold, including both men and women (Lorentzon et al., 2022).

Bone Mass Loss by Gender

The process of bone mass reduction represents an integral part of physiological aging, whereby gender-specific patterns of loss can be quantified through analysis of annual rates, identification of risk factors, and monitoring of bone metabolism biomarkers (Drake et al., 2015).

A longitudinal study by Jones et al. (1994), which included 769 participants of both sexes over 60 years of age, assessed annual bone mass loss. The results demonstrated that men recorded annual bone mass loss at the femoral neck level of 0.82%, while women showed a statistically significantly greater loss of 0.96% annually. Analysis of age cohorts reveals that the period of accelerated bone mass decline in men manifests between the ages of 74 and 79, in contrast to women, in whom this critical period occurs earlier, between the ages of 65 and 69. These results indicate a universal tendency of bone mass loss in both women and men, but in women, bone mass loss manifests at a younger age and a faster rate compared to men.

The physiology of bone tissue is based on a continuous process of remodeling (formation and resorption), whose homeostasis is disrupted by aging (Gennari et al., 2008). In the female population, resorptive mechanisms progressively surpass formative activity, resulting in a net reduction of bone substance (Noirrit-Esclassan et al., 2021). This complex process is regulated by the coordinated activity of osteoblasts that mediate bone synthesis and osteoclasts responsible for resorption, while their functions are modulated by a wide spectrum of bioactive substances, including estrogen hormones, parathyroid hormone, calcitriol, and multiple additional regulatory factors (Gennari et al., 2008). The initial decades of life are characterized by predominantly formative processes; however, in the third decade of life, a gradual reduction of the trabecular bone component begins (Armada et al., 2018). The critical period of bone mass loss occurs in the sixth decade, as a consequence of menopause, which brings with it lower levels of estrogen hormones (Pedro et al., 2017).

Menopause is a natural reproductive transition that occurs due to primary ovarian insufficiency, characterized by a progressive decline in ovarian function (Ji & Yu, 2015). This physiological phenomenon is characterized by a dramatic reduction in estradiol production and total estrogens (Boschitsch et al., 2017). In menopause, the physiological cycle of bone remodeling is significantly disrupted due to estrogen deficiency. Osteoclastic resorption activity increases, while osteoblastic activity decreases. Consequently, the amount of resorbed bone exceeds that of deposited bone, resulting in bone mass loss.

The pattern of bone degradation in the female population manifests through two phases (Noirrit-Esclassan et al., 2021):

The initial phase begins in the trabecular component of bones simultaneously with the onset of menopause, resulting from estrogen deficiency that leads to disproportionate elevation of bone resorption relative to bone formation.

The secondary phase occurs 4-8 years after the initial phase and is characterized by slower but constant degradation of both trabecular and cortical bone architecture. This second phase is primarily associated with chronological aging and represents the only pattern of bone degradation present in the male population.

Prevention and Treatment

The foundations of contemporary understanding of estrogen's role in osteoporosis prevention were established in the early 1940s through revolutionary research by Albright and Reifenstein. Such discoveries led to the formal adoption of estrogen therapy in 1960 as a standard approach in preventing bone loss in women (Prior, 2018). Contemporary scientific literature abounds with evidence regarding the efficacy of estrogen therapy in preserving bone mass during menopause and the postmenopausal period (Prior, 2018; Zhao et al., 2017). Parallel to hormonal approaches, significant risk factors that negatively affect healthy bone structure formation have been identified, particularly tobacco consumption and excessive alcohol intake, which necessitate their complete elimination (Chan et al., 2018). Adequate supplementation with calcium and vitamin D represents a fundamental component of bone health preservation, whereby women over 50 years of age are recommended a daily calcium intake of 1200 mg (Alswat, 2017; Qaseem et al., 2017). According to AACE and ACE guidelines, optimal serum vitamin D3 levels are maintained through supplementation of 1000-2000 international units daily. Although the principle "exercise preserves bones" is widely accepted, reality indicates alarmingly low participation of the elderly population in regular physical activities (Anthamatten & Parish, 2019). Physical activity as therapy falls under non-pharmacological measures, which have always been promoted and recommended to women not only during and after menopause but throughout their entire lives. Solid empirical evidence supports the fundamental role of physical activity in increasing bone mass (Howe et al., 2011; Hsu et al., 2014). Considering that falls constitute the predominant mechanism of fractures in the geriatric population, their association with deteriorated balance and muscle tissue atrophy requires focused attention (Souto Braz et al., 2022). High levels of functional strength in the lower extremities and preserved postural control represent an imperative for independent functional status and competent performance of activities of daily living in older age (Chen & Jiang, 2014). Physical activity achieves multidimensional benefits through simultaneous preservation of bone mass, optimization of muscle performance, and improvement of balance abilities (Otero et al., 2017). Clinical studies consistently demonstrate that aerobic training and strength training, implemented as standalone interventions without pharmacological support, generate measurable effects in attenuating bone loss in women with verified osteoporosis (Borba-Pinheiro et al., 2016; Linhares et al., 2022).

The primary objective of this systematic literature review is a comprehensive critical analysis of current scientific research examining the therapeutic potential of physical activities in the treatment of osteoporosis in women. Specifically, the review focuses on evaluating the efficacy of different modalities of physical activity, including outdoor and indoor exercises, in the context of osteoporosis management in the female population. This approach aims to systematically assess evidence regarding physical activity as a significant therapeutic modality, expanding perspectives beyond conventional pharmacological paradigms in the treatment of this bone pathology.

This systematic review seeks to answer the following fundamental research questions:

− What is the efficacy of different types of physical activities in improving bone mineral density in women with osteoporosis?

− Are there significant differences in therapeutic effects between physical activities performed outdoors versus those in indoor environments?

− What are the optimal parameters of physical activities (intensity, frequency, duration) for achieving maximum therapeutic benefits in women with osteoporosis?

− What is the impact of physical activities on functional outcomes such as balance, muscle strength, and fall risk in women with osteoporosis?

− Can physical activities as a standalone intervention pro-

vide clinically significant results compared to combined therapeutic approaches?

This systematic review enables:

− Synthesis of existing evidence: Integration of fragmented research into a coherent picture of the role of physical activities in osteoporosis treatment in women, enabling a better understanding of the therapeutic potential of non-pharmacological interventions.

− Identification of best practices: Definition of evidence-based recommendations for implementing physical activities as a therapeutic modality, including optimal exercise protocols and specific populations that benefit most from such interventions.

− Mapping research gaps: Systematic identification of areas where there is insufficient quality research, which can guide future scientific efforts and research priorities.

− Support for clinical decision-making: Providing a solid scientific foundation for healthcare professionals to integrate physical activities into multidisciplinary therapeutic plans for women with osteoporosis.

− Treatment paradigm change: Contributing to the shift in focus from exclusively medicinal to holistic approaches that include physical activity as a central component of osteoporosis therapy.

− Informing public policies: Generating evidence that can inform the creation of public health strategies and programs for prevention and treatment of osteoporosis in women through physical activity promotion.

Methodology

For this research, PRISMA-ScR guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews) were employed, which represent a standardized methodological framework for conducting scoping studies. Implementation of these guidelines ensured a systematic and transparent approach in the process of identifying, selecting, and synthesizing relevant scientific publications (Page et al., 2021).

Search Strategy

The relevant literature was identified using a systematic approach across appropriate electronic databases. Standardized MeSH terms (Medical Subject Headings) and relevant keywords directly related to the research questions were applied to formulate the search strategy. The search encompassed the following scientific databases: PubMed, Web of Science, ResearchGate, and Google Scholar. The chronological framework of the research was established for the period from January 2015 to May 2025. The tabular overview presents specific combinations of search terms in detail (Table 1).

Table 1. Search strategy

Database	Search strategy
PubMed	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
Web of Science	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise" OR "walking" OR "aerobic exercise" OR "resistance exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
ResearchGate	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")
Google Scholar	("osteoporosis" OR "bone loss") AND ("physical activity" OR "outdoor physical activity" OR "exercise" OR "walking" OR "aerobic exercise" OR "resistance exercise" OR "balance exercise") AND ("significance" OR "impact" OR "effect") AND ("women" OR "older women")

Table 2. Picos methodological framework

PICOS Element	Inclusion criteria	Exclusion criteria
Population (P)	Women, older (+35 years); No serious contraindications for physical activity; Diagnosis of osteoporosis confirmed by DXA scan; Women with primary or secondary osteoporosis; Women who have the ability to move independently.	Studies that do not specify the group of respondents; Men; Women under 35; People with contraindications to physical exercise; Persons who do not have the ability to move independently.
Intervention/ Exposure (I)	Structured outdoor or indoor physical activities including walking, brisk walking, running, cycling, swimming, yoga, Nordic walking, gym, aerobic activities, combined physical activities, supervised activities, individually tailored activities; Different levels of intensity, frequency and duration.	Works involving physical activity; Only pharmacological treatments included; Surgical interventions; Supplementation as the only treatment; Interventions without defined physical activities.
Comparison (C)	No specific comparison required (may include comparisons between women and men; comparisons between control and experimental groups; comparisons of different physical activity programs in terms of modality, frequency, intensity, duration)	Comparisons with inappropriate interventions not relevant to our research question.
Outcomes (O)	Primary outcomes: Bone mineral density. Secondary outcomes: Mental health, Motor skills (primarily strength and balance); Risk of falls; Quality of life.	Studies not measuring relevant osteoporosis outcomes; Studies that focus on subjective measures without objective measures; Studies with invalid measuring instruments.
Study design (S)	Randomized controlled studies, Prospective cohort studies, Longitudinal interventional studies, Original research, professional papers published between January 2015 and May 2025 in English with full text available, Ethically approved studies.	Studies published before January 2015, papers in other languages, letters to the editor, commentaries, conference abstracts, studies without full text available, review papers.

The selection of adequate studies was realized through an independent assessment approach by two researchers (SD and MD), who utilized pre-established inclusion and exclusion criteria, formulated based on the PICOS methodological framework (population, intervention, comparators, outcomes, and study design). The evaluation was conducted with strict adherence to methodological standards, thereby ensuring high precision and transparency of the selection procedure. Specific parameters used for the selection of scientific papers are comprehensively presented in Table 2, which enables complete reproduction of the research approach.

Study Selection and Selection Process

The selection of relevant studies was realized through a two-stage procedure. Initially, two independent researchers (SD and MD) conducted an evaluation of the titles and abstracts of identified publications by applying previously established inclusion and exclusion criteria (Table 2). In the second phase, a comprehensive analysis of complete texts of previously selected studies was performed.

In the initial search, a total of 1170 records were identified (1147 from Google Scholar, 17 from PubMed, 4 from Web of Science, 2 from ResearchGate). During this phase, 1142 articles were eliminated following title and abstract screening due to failure to satisfy the inclusion requirements. Identification and removal of duplicates (n=4) were performed through manual review and comparison of bibliographic information, including paper title, authors, year of publication, and journal. This process was independently conducted by two researchers (SD and MD).

Following the initial selection, evaluation of articles at the full-text level was performed. Artilces for which no full-text was available (n=2), studies without clearly defined types of physical activity (n=2), as well as research with imprecisely described participant characteristics (gender, health status, mobility capacity; n=2) were excluded from further analysis. Eighteen studies that satisfied all predefined criteria were included in the final scoping review (Figure 1).

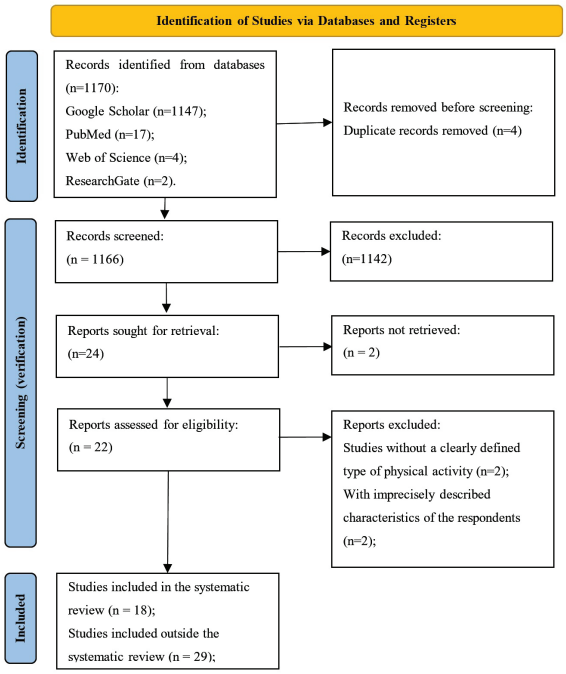

FIGURE 1. Flow diagram of study selection

Methodological Quality

The methodological quality of included studies was independently assessed using the PEDro scale (Physiotherapy Evidence Database), which contains 11 criteria. The evaluation was performed using a binary scoring system (+/- or 1/0) for each criterion (Table 3). Studies with a score ≥6 were classified as high-quality, those with a score of 4-5 as moderate quality, while studies with a score <4 were considered low-quality.

Table 3. Physiotherapy Evidence Database (PEDro) score of the included studies

No.	Author(s)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	Angin et al. (2015)	+	+	+	+	-	-	-	+	+	+	+	8/11
2	Kemmler et al. (2016)	-	+	+	+	-	-	+	+	+	+	+	8/11
3	Motorwala et al. (2016)	-	-	-	+	+	+	+	+	-	-	+	6/11
4	Otero et al. (2017)	-	-	+	+	-	-	+	+	+	+	+	7/11
5	Wen et al. (2017)	-	-	-	+	+	-	+	+	+	-	+	6/11
6	Arazi et al. (2018)	+	+	-	+	-	-	-	+	-	+	+	6/11
7	Dizdar et al. (2018)	+	+	-	+	-	-	-	-	+	+	+	6/11
8	Miko et al. (2018)	-	+	+	+	-	-	+	+	+	+	+	8/11
9	Watson et al. (2018)	-	+	+	+	-	-	+	+	+	+	+	8/11

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Table 3. Physiotherapy Evidence Database (PEDro) score of the included studies

No.	Author(s)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
10	Razzak et al. (2019)	-	-	+	+	-	-	+	+	-	+	+	6/11
11	Khan et al. (2019)	-	+	+	+	-	-	+	+	+	+	+	8/11
12	Conradsson & Halvarsson (2019)	+	+	-	+	-	-	-	+	-	+	+	6/11
13	de Oliveira et al. (2019)	+	+	-	+	-	-	+	-	-	+	+	6/11
14	Yu et al. (2019)	+	-	+	+	-	-	-	+	+	+	+	7/11
15	Filipović et al. (2020)	+	+	-	+	-	-	-	-	+	+	+	6/11
16	ElDeeb et al. (2020)	+	+	-	+	-	-	+	-	+	+	+	7/11
17	Solakoglu et al. (2022)	+	+	+	+	-	-	+	+	+	+	+	8/11
18	Bittar et al. (2023)	+	+	-	+	-	-	-	+	+	+	+	7/11

Legend: + indicates one point, – indicates no point. (1) Eligibility criteria; (2) Randomization; (3) Concealment of allocation; (4) Between-group homogeneity; (5) Blinded subjects; (6) Blinded trainers; (7) Blinded testers; (8) Dropout rate < 15%; (9) Intention-to-treat; (10) Statistical between-group comparisons; (11) Point and variability estimates; (12) Total scores.

Results

Results of Included Studies

The systematic review encompassed a total of 18 studies focused on physical interventions in women with osteoporosis.

This review encompassed 18 research studies involving 1087 participants in total. The majority of research (88.9%) represents randomized controlled trials, indicating a high level of evidence. Experimental pre-post studies and retrospective cohort studies each comprised 5.6%. The average sample size was 60.4 participants per study, with a range from 30 to 100 participants. A detailed analysis is provided in Figure 2.

Aerobic exercise and combined training protocols were the most commonly examined interventions, each representing 22.2% of the studies. Strength and resistance training, along with balance-focused exercises, accounted for 16.7% each. Pilates and yoga interventions were each featured in 11.1% of the research. Figure 3 presents a comprehensive breakdown of these findings.

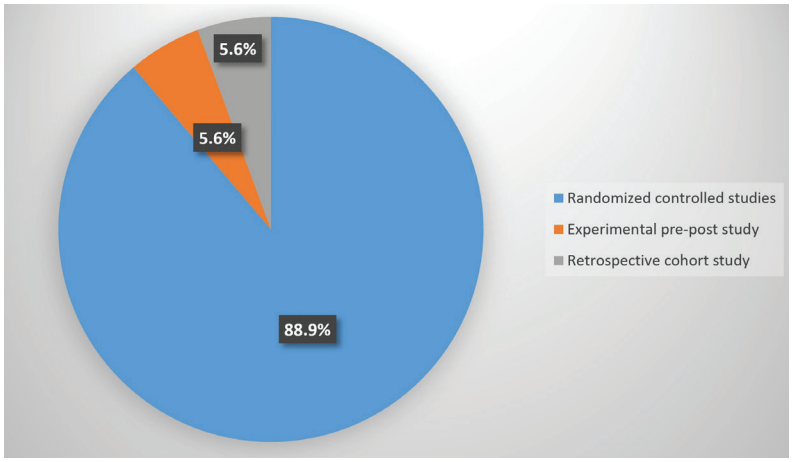

FIGURE 2. Overview of study types

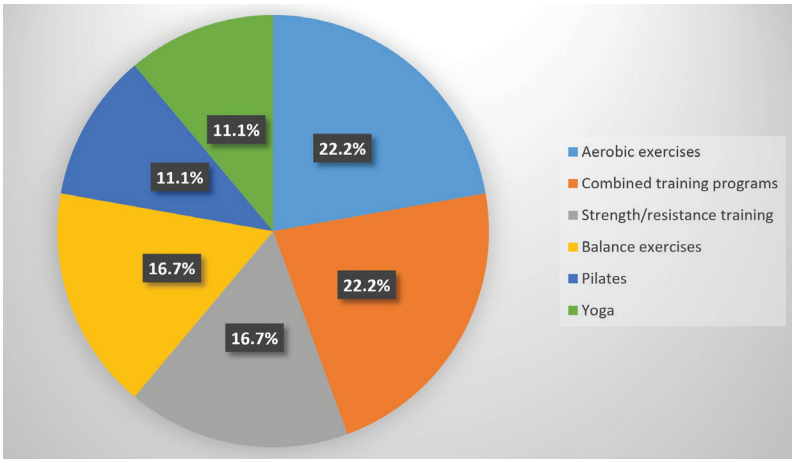

FIGURE 3. Overview of represented interventions

The largest number of studies (38.9%) conducted 12-week programs, while 24-week programs were represented in 16.7% of cases. A detailed analysis is provided in Figure 4.

Positive effects on bone mass were recorded in 61.1% of studies, while 22.2% of studies showed maintenance of bone density. The osteoanabolic exercise program particularly stood out, yielding the best results regarding increased bone mass density. A detailed analysis is provided in Figure 5.

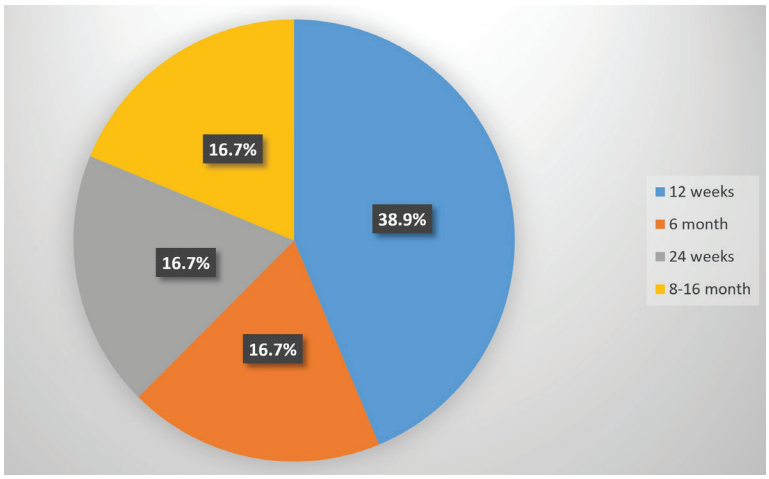

FIGURE 4. Overview of intervention duration

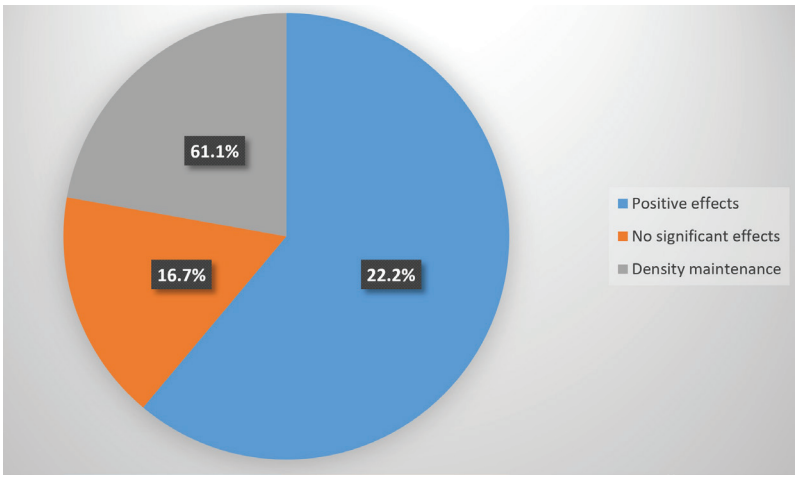

FIGURE 5. Overview of effects

A complete methodological review of the research is presented in Table 4, which provides a comprehensive taxonomic overview of individual research characteristics. The table integrates key metadata, including: authors and year of publication, research design typology, demographic structure of participants, specificities of applied physical interventions, and predominant research outcomes. This detailed overview enables systematic evaluation and critical analysis of methodological approaches and results.

Table 4. Characteristics of studies included in the review

No.	Author(s)	Study type	Number of respondents	Activities	Conclusion
1	Angin et al. (2015)	A randomized control trial	41	Clinical Pilates program for the experimental group.	Pilates increases bone mass, relieves pain, improves physical performance and quality of life.
2	Kemmler et al. (2016)	A randomized control trial	55	16 years of practice, at least 2 sessions per week.	At least 2 sessions of weekly exercise maintain bone density.
3	Motorwala et al. (2016)	Experimental pre-post study	30	Yoga, 6 month.	Helps maintain bone mass density.
4	Otero et al. (2017)	A randomized control trial	65	Low intensity strength and balance exercises.	This program improved strength and balance, reduced the number of falls.
5	Wen et al. (2017)	A randomized control trial	48	The experimental group attended a 10-week step aerobics program, 90 min 3 sessions per week.	It had no positive effects on bone mass, but it improved the muscles of the lower extremities.

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Table 4. Characteristics of studies included in the review

No.	Author(s)	Study type	Number of respondents	Activities	Conclusion
6	Arazi et al. (2018)	A randomized control trial	40	Combined training (aerobic and resistance training) 3 sessions of 90-110 min during 10 weeks, with milk consumption 500 ml per day.	Significant changes in bone mass increase; improvement of biochemical markers in the experimental group.
7	Dizdar et al. (2018)	A randomized control trial		The participants were randomly divided into three groups: balance and coordination, muscle strengthening, and aerobic exercises. The exercise programs were performed for 12 weeks, 60 min a day, 3 times a week.	Aerobic exercises were effective for physical performance, strengthening exercises were effective in reducing pain, and balance and coordination in reducing falls.
8	Miko et al. (2018)	A randomized control trial	100	12 months of balance exercise program 3 times a week for at least 30 min.	It increased stability, reduced falls and improved aerobic capacity.
9	Watson et al. (2018)	A randomized control trial		High intensity resistance and impact training for 8 months.	This program has been shown to be very effective in delaying bone loss.
10	Razzak et al. (2019)	A randomized control trial	94	Two groups. The first group had aerobic exercises, and the second group had resistance exercises, for 12 weeks.	Aerobic exercise has a greater effect on estradiol and lean mass.
11	Khan et al. (2019)	A randomized control trial	93	Three groups, one had aerobic exercises, the second anaerobic exercises and the third osteoanabolic exercises. The duration of the experiment is 12 weeks.	Bone mass density improved in all three groups, but the most in the group with osteoanabolic exercises.
12	Conradsson, & Halvarsson (2019)	A randomized control trial	95	Balance and gait training for the experimental group lasting 12 weeks, 3 sessions per week.	Improved balance in the experimental group and reduced falls.
13	de Oliveira et al. (2019)	A randomized control trial	51	Group 1: Whole-body vibration (WBV) training; Group 2: Pilates exercises. Duration: 6 months, 3 sessions per week.	Both groups showed improvement in bone mass.
14	Yu et al. (2019)	Retrospective cohort study	80	24-week aerobic dance.	It results in a reduction of fractures and improves balance.
15	Filipović et al. (2020)	A randomized control trial	96	12-week supervised exercise program (resistance, balance and aerobic training)	There was an improvement in the functional condition of women.
16	ElDeeb et al. (2020)	Randomized controlled study	43	Whole-body vibration (WBV) training 2 times a week for 24 weeks, vitamin D and calcium	In the experimental group, the work of the hip and leg muscles improved, and falls were reduced.
17	Solakoglu et al. (2022)	A randomized control trial	32	Two groups, one conservative exercise (30 min a day, 12 weeks), and the other yoga (32 min, exactly 12 weeks).	There was an improvement in functioning in both groups, while balance improved more in the yoga group.
18	Bittar et al. (2023)	A randomized control trial	30	Group 1 (n=10): Walking on a treadmill for 20 minutes at 60% VO2max; Group 2 (n=10): Treadmill walking for 20 minutes at 40% VO2max with blood flow restriction; Group 3 (n=10): Only blood flow restriction without exercise (20 minutes). The experiment lasted 24 weeks.	There were no differences between groups ($p = 0.87$), but a significant increase in all groups after 24 weeks ($p = 0.002$).

Methodological Quality Assessment of Included Studies

Evaluation of methodological quality using the standardized PEDro (Physiotherapy Evidence Database) instrument established that all 18 included studies are high-quality research, which indicates a satisfactory methodological standard of the analyzed included studies (Table 3).

Discussion

Multidimensional benefits of physical activity in osteoporosis

The findings of this scoping systematic review confirm the multidimensional benefits of physical activity in the therapeutic approach to women with osteoporosis. The results indicate a complex spectrum of positive effects that manifest through improvement in neuromuscular control, functional capabilities, and quality of life. The most significant recorded effects include increased muscle strength and improved postural stability, which directly contribute to reducing the risk of falls, one of the key factors influencing fracture frequency in this population. Additionally, regular physical activity demonstrates a positive impact on maintaining existing bone mass density, which represents a fundamental therapeutic goal in osteoporosis management.

Heterogeneity of physical activity modalities and their applicability

The heterogeneity of applied physical activity modalities in the analyzed studies - including Pilates, aerobic and anaerobic exercises, osteoanabolic exercises, resistance training, balance training, vibration therapy, yoga exercises, and coordination activities - indicates the broad applicability of different approaches in osteoporosis therapy. It is important to emphasize that positive effects manifested independently of specific intervention characteristics, including duration (6-16 months), frequency, intensity, and training volume. Such findings suggest that the key factor for therapeutic success is the implementation of regular physical activity itself, while the choice of specific modality can be adapted to individual preferences, physical capabilities, and available resources of patients.

The pathophysiological basis of osteoporosis and the need for an integrated approach

Considering that osteoporosis predominantly affects women in perimenopause and postmenopause due to progressive reduction in estrogenic activity, early implementation of an integrated therapeutic approach represents an imperative (Li et al., 2024; Yang et al., 2025). Physiological changes that characterize the menopausal period, primarily the drastic decline in serum estrogen levels, lead to accelerated bone tissue resorption and disruption of the balance between bone formation and degradation processes (Noirrit-Esclassan et al., 2021). This pathophysiological basis of osteoporosis requires a comprehensive approach that combines pharmacological and non-pharmacological therapy, representing the gold standard in contemporary treatment of this condition (Anthamatten & Parish, 2019; Prior, 2018).

Synergistic effect of combined pharmacological and non-pharmacological therapy

The synergistic effect of an adequately designed physical activity program, which involves carefully titrated training intensity and frequency, in combination with targeted pharmacotherapy - including hormone replacement therapy, vitamin D, and calcium supplementation - represents the most effective approach in preventing bone loss and slowing disease progression (Alswat, 2017; Qaseem et al., 2017; Borba-Pinheiro et al., 2016; Souto Braz et al., 2022).

The efficacy of the integrated therapeutic strategy was confirmed in a randomized controlled trial conducted by Arazi et al. (2020), where the impact of a combined intervention on 40 participants with osteoporosis was evaluated. A ten-week program that encompassed combined aerobic training and resistance training with a frequency of three sessions per week (minimum 90 minutes per session), along with simultaneous calcium supplementation through daily intake of at least 500 ml of milk, resulted in significant improvement in bone mass density and normalization of key biochemical parameters of bone metabolism. Such findings represent direct confirmation of the hypothesis that synchronous application of pharmacological measures through structured training and adequate nutritional status can achieve a synergistic effect on bone tissue, which surpasses the benefits achieved by isolated application of any of the mentioned modalities.

Modality-specific efficacy and individualization of treatment

However, it is important to note that the therapeutic benefits of physical activity are not universally applicable to all exercise modalities. Kemmler et al. (2016) demonstrated in their longitudinal study that through long-term exercise with a minimal frequency of two sessions per week, progression of bone mass loss can be successfully inhibited. Nevertheless, this generalization requires a more cautious approach when considering specific types of physical activity. The research by Wen et al. (2017) is illustrative, which evaluated the impact of step aerobics on 48 women with osteoporosis through a ten-week protocol of 90 minutes per session, with a frequency of three times per week. Results showed that this modality, despite adequate duration and intensity, did not achieve significant changes in bone mass density, but primarily contributed to improvement in lower extremity muscle strength. These findings suggest that the efficacy of physical activity in osteoporosis treatment depends on the specificity of biomechanical characteristics of the applied modality, indicating the need for an individualized approach in therapeutic protocol selection.

Secondary therapeutic benefits: fall prevention and functional status

Parallel to the analysis of direct effects on bone tissue, growing attention is directed toward secondary therapeutic benefits of physical activity, particularly in the context of fall prevention and functional status improvement. Otero et al. (2017) demonstrated through the implementation of a strength and balance exercise program in 65 women with osteoporosis that improvement in neuromuscular control and postural stability results in a significant reduction in fall incidence, which directly contributes to improved quality of life in participants. Such results were confirmed in a more extensive study conducted by Miko et al. (2018), where a twelve-month balance training program with a frequency of three sessions per week (minimum 30 minutes per session) in a larger sample of women resulted not only in increased postural stability and fall reduction, but also in unexpected improvement in aerobic capacity. Synergistic effects of combined modalities were further elaborated in research by Conradsson and Halvarsson (2019), where a twelve-week program that integrated balance training with a progressive walking protocol achieved significant improvement in body stability and fall reduction in women with osteoporosis.

Comparative analysis of different types of physical activity

The complexity of the therapeutic effects of combined interventions is particularly evident in the study by Filipović et al. (2020), where a multidimensional approach that encompassed balance training, resistance exercises, and aerobic activities resulted in comprehensive improvement of participants' functional status, surpassing the narrowly focused benefits of individual

modalities. An additional dimension in understanding the differential efficacy of physical activity is provided by the comparative findings of Razzak et al. (2019), who, through a randomized study on 94 women with osteoporosis over twelve weeks, compared the impact of aerobic exercises with resistance exercises. Results indicated the superiority of aerobic activities in terms of estradiol stimulation and maintenance of lean body mass, which represent key determinants in bone tissue homeostasis and suggest hormonally mediated mechanisms of therapeutic action.

Systematic analysis of differential efficacy of various physical activity modalities was further elaborated through research by Dizdar et al. (2018), who comparatively evaluated three distinct approaches: coordination and balance exercises, muscle strength training, and aerobic activities. Findings demonstrated modality-specific adaptations, where aerobic exercises primarily influenced improvement in physical performance, muscle strengthening exercises resulted in significant pain reduction, while coordination and balance exercises optimized postural control with consequent reduction in fall risk. This differential nature of therapeutic responses was further confirmed in the study by Khan et al. (2019), where comparative analysis of aerobic training, anaerobic training, and osteoanabolic protocols over twelve weeks showed that all three modalities induced improvement in bone mass density, with osteoanabolic treatments achieving the most pronounced benefits on bone tissue.

Temporal dimension of therapeutic effects and long-term approach

The temporal dimension of therapeutic effects represents an additional critical factor in the optimization of intervention protocols, which was explicitly demonstrated in the longitudinal study by Bittar et al. (2023). Their comparative analysis of three different intervention programs over twenty-four weeks revealed that significant positive effects on bone mass manifest only after an extended implementation period, whereby after twelve weeks the effects proved marginal, while after twenty-four weeks uniform improvement was evidenced in all experimental groups. Such findings suggest that intervention duration is a crucial determinant of therapeutic success, indicating the need for a long-term approach in implementing physical activity as a therapeutic modality in osteoporosis.

Alternative approaches: holistic modalities

Exploration of alternative approaches to physical activity has provided significant insights into the therapeutic potential of holistically oriented modalities. Angin et al. (2015) evaluated the efficacy of clinical Pilates through a randomized controlled trial on 41 participants, demonstrating that this integrative approach simultaneously induces increased bone mass density, pain reduction, improved physical performance, and quality of life optimization. A comparative perspective is provided by research from de Oliveira et al. (2019), where a six-month comparative analysis of Pilates exercises and Whole-body vibration (WBV) training with a frequency of three sessions per week showed that both modalities achieve benefits on bone mass, with Pilates demonstrating superiority in pain relief and physical performance improvement. An integrated approach combining technological innovations with pharmacological interventions was elaborated in the study by El-Deeb et al. (2020), where a twenty-four-week implementation of WBV training (twice weekly) with vitamin D and calcium supplementation resulted in improved hip and lower extremity muscle function, balance optimization, and proportionally reduced number of falls, confirming the synergistic potential of pharmacological and non-pharmacological therapeutic approaches.

An additional dimension in the spectrum of alternative modalities is represented by yoga as a traditional approach that integrates physical, mental, and spiritual components. Motorwala et al. (2016) demonstrated through a six-month intervention on 30 participants that yoga successfully maintains bone mass density, while a comparative study by Solakoglu et al. (2022) between the yoga approach and conservative training over twelve weeks showed that both modalities improve functional status, with yoga achieving superior results in postural balance optimization. These findings suggest that the complexity of yoga techniques that integrate isometric contractions, proprioception, and breathing control may provide additional benefits compared to conventional training.

High-impact activities and biomechanical characteristics

Specific biomechanical characteristics of high-impact activities were further investigated through the study by Watson et al. (2018), where an eight-month program of resistance training and high-impact activities demonstrated exceptional efficacy in slowing bone mass loss in women. A complementary approach through rhythmic activity was evaluated in research by Yu et al. (2019) on 80 participants, where a twenty-four-week aerobic dance intervention resulted in a significant reduction in fracture incidence and improved postural stability.

Clinical significance and implications for practice

Comprehensive analysis of available literature unequivocally confirms the central role of physical activity in the therapeutic approach to women with osteoporosis, demonstrating that regular implementation of structured exercise programs represents a fundamental component of contemporary multidisciplinary treatment of this condition. The key insight emerging from the analyzed studies relates to the convergence of positive effects of different physical activity modalities, whereby benefits manifest through a spectrum of physiological adaptations that encompass optimization of bone homeostasis, improvement of neuromuscular function, and reduction of fracture risk.

Particularly significant is the observation that therapeutic success is not limited to specific types of activities, but is achieved through a broad range of approaches - from conventional aerobic and anaerobic modalities to holistically oriented methods such as Pilates and yoga. This flexibility in therapeutic protocol selection enables individualized treatment application that can be adapted to the specific needs, preferences, and functional capabilities of each patient, which represents a key advantage in clinical practice.

The temporal dimension of therapeutic effects indicates the necessity of a long-term approach to physical activity implementation, whereby optimal results are achieved through continuous application over extended periods. The synergistic potential of combined interventions that integrate pharmacological and non-pharmacological modalities represents the gold standard in osteoporosis treatment, enabling maximization of therapeutic benefits through complementary mechanisms of action.

Study Limitations

This systematic analysis has several limitations that should be considered when interpreting the results. The first major limitations relate to the heterogeneity of methodologies among the analyzed studies - different intervention durations, exercise frequency, and intensity complicate direct comparison of efficacy between different physical activity programs.

The limited number of participants in individual studies reduces the statistical power of findings, while short-term follow-up in most studies does not allow assessment of the long-term sustainability of therapeutic effects. Methodological differences in outcome measurement, including different techniques for assess-

ing bone density and functional parameters, limit the possibility of precise quantification of effect sizes.

Strict inclusion criteria, limiting the sample to mobile women over 40 years old without contraindications to exercise, create a homogeneous sample that does not accurately represent the heterogeneous real-world population of women with osteoporosis in clinical practice. This limitation restricts the generalizability of the findings to more complex cases with comorbidities and functional limitations.

Conclusion

The systematic review's findings indicate that organized physical activity interventions constitute an important treatment approach for osteoporotic women. Literature analysis indicates consistent benefits of different types of physical activity on bone health, functional capacity, and fall prevention. Crucially, positive effects are achieved through diverse approaches - from strength training and aerobic exercises to alternative methods such as yoga, enabling treatment adaptation to individual patient characteristics. The findings emphasize the importance of long-term adherence to exercise programs and their integration with conventional therapeutic modalities to achieve optimal clinical outcomes.

Future research should focus on standardizing exercise protocols through the development of consensus recommendations for different stages of osteoporosis. Longitudinal designs with 2-3 year follow-up are necessary to assess long-term efficacy.

Priority should be given to investigating dose-response relationships between exercise modalities and therapeutic outcomes and developing personalized algorithms that integrate genetic and hormonal biomarkers.

Important areas include comparative cost-effectiveness studies of different programs and the implementation of digital technologies for adherence monitoring. Molecular research into the mechanisms of physical activity's action on bone tissue may identify new therapeutic targets and deepen understanding of the pathophysiological basis of osteoporosis.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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References

Alswat, K. A. (2017). Gender disparities in osteoporosis. *Journal of clinical medicine research*, *9*(5), 382-387. https://doi.org/10.14740/jocmr2970w

Angın, E., Erden, Z., & Can, F. (2015). The effects of clinical pilates exercises on bone mineral density, physical performance and quality of life of women with postmenopausal osteoporosis. *Journal of Back and Musculoskeletal Rehabilitation*, *28*(4), 849-858. https://doi.org/10.3233/BMR-150604

Anthamatten, A., & Parish, A. (2019). Clinical update on osteoporosis. *Journal of midwifery & women's health*, *64*(3), 265-275. https://doi.org/10.1111/jmwh.12954

Arazi, H., Samadpour, M., & Eghbali, E. (2018). The effects of concurrent training (aerobic-resistance) and milk consumption on some markers of bone mineral density in women with osteoporosis. *BMC Women's Health*, *18*, 1-9. https://doi.org/10.1186/s12905-018-0694-x

Armada, L., de Castro Brasil, S., Armada-Dias, L., Bezerra, J., Pereira, R. M., Takayama, L., Dos Santos, M. M. R., Gonçalves, S. L., & Nascimento-Saba, C. C. (2018). Effects of aging, gender, and hypogonadism on mandibular bone density. *Journal of investigative and clinical dentistry*, *9*(2), e12310. https://doi.org/10.1111/jicd.12310

Bijelic, R., Milicevic, S., & Balaban, J. (2017). Risk factors for osteoporosis in postmenopausal women. *Medical archives*, *71*(1), 25-28. https://doi.org/10.5455/medarh.2017.71.25-28

Bittar, S. T., Santos, H. H. D., Oliveira, V. M. A. D., Brito, A. T. D. S., Machado, R. M., Alves, J. M. V. M., & Cirilo-Sousa, M. S. (2023). Effect of walking with blood flow restriction in elderly women with osteoporosis/osteopenia. *Fisioterapia em Movimento*, *36*, e36116. https://doi.org/10.1590/fm.2023.36116

Borba-Pinheiro, C. J., Dantas, E. H. M., de Souza Vale, R. G., Drigo, A. J., de Alencar Carvalho, M. C. G., Tonini, T., Meza, A. I. E., & de Figueiredo, N. M. A. (2016). Resistance training programs on bone related variables and functional independence of postmenopausal women in pharmacological treatment: A randomized controlled trial. *Archives of gerontology and geriatrics*, *65*, 36-44. https://doi.org/10.1016/j.archger.2016.02.010

Boschitsch, E., Durchschlag, E., & Dimai, H. P. (2017). Age-related prevalence of osteoporosis and fragility fractures: real-world data from an Austrian Menopause and Osteoporosis Clinic. *Climacteric*, *20*(2), 157-163. https://doi.org/10.1080/13697137.2017.1282452

Chan, D. C., Chang, C. B., Han, D. S., Hong, C. H., Hwang, J. S., Tsai, K. S., & Yang, R. S. (2018). Effects of exercise improves muscle strength and fat mass in patients with high fracture risk: A randomized control trial. *Journal of the Formosan Medical Association*, *117*(7), 572-582. https://doi.org/10.1016/j.jfma.2017.05.004

Chen, M. S., & Jiang, B. C. (2014). Resistance training exercise program for intervention to enhance gait function in elderly chronically ill patients: multivariate multiscale entropy for center of pressure signal analysis. *Computational and mathematical methods in medicine*, *2014*(1), 471356. https://doi.org/10.1155/2014/471356

Conradsson, D., & Halvarsson, A. (2019). The effects of dual-task balance training on gait in older women with osteoporosis: a randomized controlled trial. *Gait & posture*, *68*, 562-568. https://doi.org/10.1016/j.gaitpost.2019.01.005

de Oliveira, L. C., de Oliveira, R. G., & de Almeida Pires-Oliveira, D. A. (2019). Effects of whole-body vibration versus pilates exercise on bone mineral density in postmenopausal women: a randomized and controlled clinical trial. *Journal of Geriatric Physical Therapy*, *42*(2), E23-E31. https://doi.org/10.1519/JPT.0000000000000184

Dizdar, M., Irdesel, J. F., Dizdar, O. S., & Topsaç, M. (2018). Effects of balance-coordination, strengthening, and aerobic exercises to prevent falls in postmenopausal patients with osteoporosis: a 6-month randomized parallel prospective study. *Journal of aging and physical activity*, *26*(1), 41-51. https://doi.org/10.1123/japa.2016-0284

Drake, M. T., Clarke, B. L., & Lewiecki, E. M. (2015). The pathophysiology and treatment of osteoporosis. *Clinical therapeutics*, *37*(8), 1837-1850. https://doi.org/10.1016/j.clinthera.2015.06.006

ElDeeb, A. M., & Abdel-Aziem, A. A. (2020). Effect of whole-body vibration exercise on power profile and bone mineral density in postmenopausal women with osteoporosis: a randomized controlled trial. *Journal of Manipulative and Physiological Therapeutics*, *43*(4), 384-393. https://doi.org/10.1016/j.jmpt.2019.12.003

Filipović, T. N., Lazović, M. P., Backović, A. N., Filipović, A. N., Ignjatović, A. M., Dimitrijević, S. S., & Gopčević, K. R. (2020). A 12-week exercise program improves functional status in postmenopausal osteoporotic women: randomized controlled study. European *Journal of Physical and Rehabilitation Medicine*, *57*(1), 120-130. https://doi.org/10.23736/s1973-9087.20.06149-3

Gennari, L., Khosla, S., & Bilezikian, J. P. (2008). Estrogen and fracture risk in men. *Journal of Bone and Mineral Research*, *23*(10), 1548-1551. https://doi.org/10.1359/jbmr.0810c

Howe, T. E., Shea, B., Dawson, L. J., Downie, F., Murray, A., Ross, C., Harbour, T. R., Caldwell, M. L., & Creed, G. (2011). Exercise for preventing and treating osteoporosis in postmenopausal women. *Cochrane database of systematic reviews*, (7). https://doi.org/10.1002/14651858.CD000333.pub2

Hsu, W. H., Chen, C. L., Kuo, L. T., Fan, C. H., Lee, M. S., & Hsu, R. W. W. (2014). The relationship between health-related fitness and quality of life in postmenopausal women from Southern Taiwan. *Clinical interventions in aging*, *9*, 1573-1579.

Ji, M. X., & Yu, Q. (2015). Primary osteoporosis in postmenopausal women. *Chronic diseases and translational medicine*, *1*(01), 9-13.

Jones, G., Nguyen, T., Sambrook, P., Kelly, P. J., & Eisman, J. A. (1994). Progressive loss of bone in the femoral neck in elderly people: longitudinal findings from the Dubbo osteoporosis epidemiology study. *Bmj*, *309*(6956), 691-695. https://doi.org/10.1136/bmj.309.6956.691

Kanis, J. A. (2007). Assessment of osteoporosis at the primary health care level. WHO Collaborating Centre for Metabolic Bone Diseases. *WHO Collaborating Centre for Metabolic Bone Diseases*.

Kemmler, W., von Stengel, S., & Kohl, M. (2016). Exercise frequency and bone mineral density development in exercising postmenopausal osteopenic women. Is there a critical dose of exercise for affecting bone? Results of the Erlangen Fitness and Osteoporosis Prevention Study. *Bone*, *89*, 1-6. https://doi.org/10.1016/j.bone.2016.04.019

Khan, A. A., Farhad, A., Siddiqui, P. Q. R., & Ansari, B. (2019). Effects of osteoanabolic exercises on bone mineral density of osteoporotic females: A randomized controlled trial. *International Journal of Health Sciences*, *13*(1), 9.

Li, J., Xu, J., Jiang, Z., Duan, M., Yin, Y., Xiang, Z., Wang, X., Sheng, J., Liu, T., & Xu, H. (2024). Axillaridine A suppresses osteoclastogenesis and alleviates ovariectomy-induced bone loss via inhibition of RANKL-mediated RANK signaling pathways. *Food Science and Human Wellness*, *14*(16), 9250397 https://doi.org/10.26599/FSHW.2024.9250397

Linhares, D. G., Borba-Pinheiro, C. J., Castro, J. B. P. D., Santos, A. O. B. D., Santos, L. L. D., Cordeiro, L. D. S., Drigo, J. A., Nunes, M. A. R., & Vale, R. G. D. S. (2022). Effects of multicomponent exercise training on the health of older women with osteoporosis: a systematic review and meta-analysis. *International Journal of Environmental Research and Public Health*, *19*(21), 14195. https://doi.org/10.3390/ijerph192114195

Lorentzon, M., & Cummings, S. R. (2015). Osteoporosis: the evolution of a diagnosis. *Journal of internal medicine*, *277*(6), 650-661. https://doi.org/10.1111/joim.12369

Lorentzon, M., Johansson, H., Harvey, N. C., Liu, E., Vandenput, L., McCloskey, E. V., & Kanis, J. A. (2022). Osteoporosis and fractures in women: the burden of disease. *Climacteric*, *25*(1), 4-10. https://doi.org/10.1080/13697137.2021.1951206

Lyu, Q., Ma, L., Liu, H., & Shao, H. (2025). Association of the weight-adjusted waist index with mortality in osteoporotic patients. *Journal of Bone and Mineral Metabolism*, 1-8. https://doi.org/10.1007/s00774-025-01594-y

Miko, I., Szerb, I., Szerb, A., Bender, T., & Poor, G. (2018). Effect of a balance-training programme on postural balance, aerobic capacity and frequency of falls in women with osteoporosis: A randomized controlled trial. *Journal of Rehabilitation Medicine (Stiftelsen Rehabiliteringsinformation)*, *50*(6). https://doi.org/10.2340/16501977-2349

Motorwala, Z. S., Kolke, S., Panchal, P. Y., Bedekar, N. S., Sancheti, P. K., & Shyam, A. (2016). Effects of Yogasanas on osteoporosis in postmenopausal women. *International journal of yoga*, *9*(1), 44-48. https://doi.org/10.4103/0973-6131.171717

Noirrit-Esclassan, E., Valera, M. C., Tremollieres, F., Arnal, J. F., Lenfant, F., Fontaine, C., & Vinel, A. (2021). Critical role of estrogens on bone homeostasis in both male and female: from physiology to medical implications. *International Journal of Molecular Sciences*, *22*(4), 1568. https://doi.org/10.3390/ijms22041568

Otero, M., Esain, I., González-Suarez, Á. M., & Gil, S. M. (2017). The effectiveness of a basic exercise intervention to improve strength and balance in women with osteoporosis. *Clinical interventions in aging*, *12*, 505-513.

Pedro, R. E., Carli, J. P. D., Linden, M. S., Lima, I. F., Paranhos, L. R., & Costa, M. D. (2017). Influence of age on factors associated with peri-implant bone loss after prosthetic rehabilitation over osseointegrated implants. *The journal of contemporary dental practice*, *18*(1), 3-10.

Prior, J. C. (2018). Progesterone for the prevention and treatment of osteoporosis in women. *Climacteric*, *21*(4), 366-374. https://doi.org/10.1080/13697137.2018.1467400

Qaseem, A., Forciea, M. A., McLean, R. M., Denberg, T. D., & Clinical Guidelines Committee of the American College of Physicians*. (2017). Treatment of low bone density or osteoporosis to prevent fractures in men and women: a clinical practice guideline update from the American College of Physicians. *Annals of internal medicine*, *166*(11), 818-839. https://doi.org/10.7326/M15-1361

Razzak, Z. A., Khan, A. A., & Farooqui, S. I. (2019). Effect of aerobic and anaerobic exercise on estrogen level, fat mass, and muscle mass among postmenopausal osteoporotic females. *International journal of health sciences*, *13*(4), 10.

Sarafrazi, N., Wambogo, E. A., & Shepherd, J. A. (2021). Osteoporosis or low bone mass in older adults: United States, 2017–2018.

Solakoglu, O., Karatekin, B. D., Yumusakhuylu, Y., Mesci, E., & Icagasioglu, A. (2022). The effect of yoga asana "Vrksasana (Tree Pose)" on balance in patients with postmenopausal osteoporosis: A randomized controlled trial. *American Journal of Physical Medicine & Rehabilitation*, *101*(3), 255-261. https://doi.org/10.1097/PHM.0000000000001785

Souto Braz, R. R., Campos, S. L., Villela, D. W., Antonino, G. B., Araújo Batista, P. K., Guerino, M. R., Rodrigues, M. T. F., Alves, P. F. K., Duarte, T. V. J., Silva, A. D., Lima, F. D., Silva, F.F.A., Oliveira, V. C. K., Santos, D. K. E., Leite, S. W., Lucena, C. L., Ferreira, L. P. A., Monte-Silva, K., Araújo, R. G. M., & Taiar, R. (2022). Effectiveness of whole-body vibration combined with multicomponent training on the risk of falls and quality of life in elderly women with osteoporosis: Study protocol for a randomized controlled clinical trial. *Biology*, *11*(2), 266. https://doi.org/10.3390/biology11020266

Watson, S. L., Weeks, B. K., Weis, L. J., Harding, A. T., Horan, S. A., & Beck, B. R. (2018). High-intensity resistance and impact training improves bone mineral density and physical function in postmenopausal women with osteopenia and osteoporosis: the LIFTMOR randomized controlled trial. *Journal of Bone and Mineral Research*, *33*(2), 211-220. https://doi.org/10.1002/jbmr.3284

Wen, H. J., Huang, T. H., Li, T. L., Chong, P. N., & Ang, B. S. (2017). Effects of short-term step aerobics exercise on bone metabolism and functional fitness in postmenopausal women with low bone mass. *Osteoporosis International*, *28*, 539-547. https://doi.org/10.1007/s00198-016-3759-4

WHO, C. O. (2020). World health organization. *Air Quality Guidelines for Europe*, (91). https://doi.org/10.1097/CM9.0000000000002014

Yang, B., Tan, M., & Xiong, F. (2025). Global trends in osteoimmunology and osteoporosis research: A bibliometric analysis from 2013 to 2022. *Medicine*, *104*(18), e42367. https://doi.org/10.1097/MD.0000000000042367

Yu, P. A., Hsu, W. H., Hsu, W. B., Kuo, L. T., Lin, Z. R., Shen, W. J., & Hsu, R. W. W. (2019). The effects of high impact exercise intervention on bone mineral density, physical fitness, and quality of life in postmenopausal women with osteopenia: A retrospective cohort study. *Medicine*, *98*(11), e14898. https://doi.org/10.1097/MD.0000000000014898

Zhao, J. G., Zeng, X. T., Wang, J., & Liu, L. (2017). Association between calcium or vitamin D supplementation and fracture incidence in community-dwelling older adults: a systematic review and meta-analysis. *Jama*, *318*(24), 2466-2482. https://doi.org/10.1001/jama.2017.19344

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Journal of Anthropology of Sport and Physical Education

SHORT REPORTS

East African women runners' perceptions of differences in sport. A short report from a pilot study

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Abstract

The present manuscript brings some discussions about the perception of women runners in East Africa about the differences in treatment for them and men in situations related to sport. The academic literature reveals that the fight for women's rights in this context has intensified and gained a voice in recent years. The women interviewed for this short report pilot point out that, at least in the road running scenario, their perceptions regarding treatment do not show significant distinctions. However, in dialogue with the literature, one realizes the possible hypothesis that they are living the result of years of struggles experienced by their ancestors.

Keywords: *sport, road running, woman, track and field*

Introduction

The presence of women in the sports field has always been surrounded by barriers and difficulties. Sport is a genderyfied field, that is, it is considered a space for men and masculinity, creating and recreating the ideological support of the superiority of men to the detriment of women based on the fragility and incapacity of women (Njororai, 2015). In Brazil (1941), this myth of the weaker sex was represented by law, through the prohibition of the practice of sports incompatible with its maternal nature and care for the home by the Decree-law 3.199 (Brasil, 1941). Farias (2008) points out that athletics was among the sports, as it was considered harmful and dangerous for women's bodies due to constant shocks and repetitive movement of the hips and lower limbs. Over the years, some practices have become more socially accepted, such as athletics, in which Brazilian women have participated in the Olympic Games.

In this context, Moura (2022) argues that Brazilian women's participation in sports was conditioned not only by biological determinism, but also by the cultural construction of gender and political issues of various actors who reaffirmed the supposed male hegemony over certain bodily practices. Despite advances over the years, women still face barriers in the 21st century that limit their participation, professional development, and visibility in a wide range of sports. Despite the history of difficulties with the sport practiced by women, Brazil has become a fertile ground for the entry and home of foreign athletes, who come in search of better financial conditions, mainly coming from the African continent, in which the sport is presented as national identity. In the international environment, these women present themselves as heroines of their countries in the face of medal conquests (Njororai, 2015). Although they also face cultural patterns in their countries of origin and challenging the male world, what would it be like to come to another country, enter a different culture and practice a sport that for years has been forbidden to them?

In this way, we also present the concept of intersectionality, which seeks to understand the dynamics of society based on the interaction of two or more social markers or axes of subordination, creating inequalities for women, races, ethnicities, class, etc (Crenshaw, 2002). This concept helps us understand how these athletes, due to their gender, race and immigration status, face specific challenges that may remain invisible in some analyses. Even Brazilian female athletes already navigate their careers under the marks of prejudice, lack of investment

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and masculinized expectations (Moura, 2018), which can be intensified in the case of black, migrant women who enter Brazilian sports culture. Because of the restlessness imposed by the aforementioned questioning, the present manuscript seeks to carry out some discussions on the perception of women runners from East Africa who migrated to Brazil about the differences in the treatment aimed at them and men in situations related to sport.

Methods

The present study is characterized as qualitative, in which it seeks to analyze from the perspective of women runners from East Africa who migrated to Brazil the differences perceived by them concerning the treatment intended for men and women. For this, semi-structured interviews were used as a research instrument.

In semi-structured interviews, although there is a script, it allows the interviewee's speech to become more flexible (Jovchelovicht & Bauer, 2002). According to Sparkes and Smith (2014), semi-structured interviews have the benefit of providing a deeper knowledge about the experiences and meanings of the participant's social conditions. Therefore, for this research, semi-structured interviews were conducted with women athletes from East Africa who work in road running in Brazil, in 2020. The interview was based on open-ended questions about the perception of women runners in East Africa about the differences they perceive. The present study was evaluated and approved by the Ethics Committee of the State University of Maringá, Brazil, under the registration number CAAE: 24963419.6.0000.0104. Furthermore, the study complied with the research standards established by the Declaration of Helsinki. All participants signed an informed consent form prior to agreeing to take part in the study.

Table 1. Profiles of (the) interviewed athletes

Athlete	Age	Origin	practice time	World Ranking Position *
Woman 1	32 years	Uganda	10 years	593
Woman 2	28 years	Kenya	6 years	609

*World Ranking Road Running (2020)

Results and discussions

In this pilot study, two road running race athletes from East Africa who resided in Brazil at the time of the interviews were interviewed. One athlete is of Kenyan origin and another Ugandan. Both are not among the best in the world ranking of the sport. This fact shows that they have a median income in the context of road running at an international level.

Considering that gender differences in sport are not restricted to symbolic aspects, but also appear through unequal access to participation and training structures, especially for women from the global south (Adriaanse & Schofield, 2014; Knijnik, 2015; Moura, 2022), the questions directed to athletes were from three fronts: a) perception of difference in treatment between men and women; b) whether there is a difference in remuneration between men and women; c) if there are perceived differences in the migratory process between men and women.

Answers to questions about a general perception of treatment point out that there are no significant differences between men and women. The same happens when addressing the issue of remuneration, as can be seen in the interviewee's speech "no differences because we receive the same salary" (Woman 2). When asked about the immigration process, one of the athletes reports that she feels that women receive fewer opportunities than men.

Sometimes, in some races, the selections might be:"we want two men and one lady". We do not know what happens, but we only accept it the way they choose (Woman 2).

In this regard, the study by Njororai (2015) shows that since Kenya's sports boom, which occurred in the 1960s, women have remained the shadow of men representatives on the international stage. However, in recent decades women have gained visibility, even being responsible for the largest number of medals in the country.

Regarding salary conditions, it is important to note that in the case of the women interviewed, their financial gains are the result of sports performance, that is, their remuneration comes from the prizes provided by the competitions. And in the Brazilian context of street racing, most events pay the same price for men and women with the same classification. However, the two realities are different, in Brazil, this is a particularity of road running events, and cannot be extended to other sports. An example of this was the need to create articles on parity in awards in the new law that regulates sports in Brazil. Since 2023, sports institutions, whether public or private, that receive federal funding must, obligatorily, guarantee equality in awards between men and women (Brazil, 2023).

Even so, as highlighted by Henne & Pape (2018), the apparent parity in prize money does not eliminate structural asymmetries, given that women tend to have lower access to sponsorships, contracts with sports brands, and media visibility, compromising their long-term economic security in comparison to men. Regarding the African context, more specifically in Kenya, a study shows that there is a limitation of financial resources for women, as well as a lack of administrative support, as well as marginalized media coverage (M'mbaha & Chepyator-Thomson, 2019).

By weaving connections between opportunities and obtaining awards, it is clear that the limited opportunities for women in street racing directly impacts their earning potential. If they do not participate in competitions, they cannot access cash prizes, which makes it difficult to maintain an athletic career, especially when living outside their country. This scenario highlights how inequality of opportunities manifests itself in a structural way, impacting not only sports participation, but also women's economic autonomy and permanence in sports. This is reinforced by Cooky & Messner (2018), who point out that the limitation of competition opportunities directly impacts women's long-term participantion in high-performance sports.

Furthermore, these findings should be viewed from an intersectional perspective (Crenshaw, 1989), recognizing that the challenges faced by these East African women runners are not solely due to gender, but are compounded by racial identity and immigration status. The combination of these factors creates unique barriers to participation, mobility, and economic stability within the sport. Collins (2015) emphasizes that intersectionality is not simply the addition of social markers, but rather the understanding that systems of oppression operate simultaneously to maintain inequalities even when formal rules appear to guarantee equality. For example, women living in Brazil may have greater access to road running competitions than East African women, as the latter rely on invitation and selection to participate. Thus, their experiences exemplify how structural inequalities operate at multiple and intersecting levels.

Conclusion

The present manuscript aimed to reflect on women in sport. For this, the perception of women runners of East African origin who migrated to Brazil was evidenced. From the results exposed, it can be understood that there have been advances in the guarantee of similar conditions in relation to male and female athletes, this when questioning the athletes' general perception of the treatment and also of their financial gains. However, when asked about the recruitment and migration process, it appears that the opportunities for women are still less than those for men, even when women are considered the country's main references in the world athletics scene.

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References

Adriaansem J.; Schofield, T. (2014). The impact of gender quotas on gender equity in sport governance. *Journal os Sport Management Review*, v. 28, p. 485-497.

Brazil. (1941). Decreto-Lei nº 3.199, de 14 de abril de 1941 [Decree-law n. 3.199 of april 14, 1941]. Rio de Janeiro, RJ. Retrieved from: http://www6.senado.gov.br/legislacao/ListaPublicacoes.action?id=152593

Brazil. (2023). Law No. 14,597, of June 14, 2023: Establishes the General Sports Law and provides other measures. Official Gazette of the Union.

Collins, P. H. (2015). Intersectionality's Definitional Dilemmas. *Annual Review of Sociology*, 41, 1–20.

Cooky, C., & Messner, M. A. (2018). No Slam Dunk: Gender, Sport, and the Unevenness of Social Change. Rutgers University Press

Crenshaw, K. (2002). Documento para o encontro de especialistas em aspectos da discriminação racial relativos ao gênero. *Estudos Feministas*, 10, 171–188.

Farias, C. M. de (2008). Projeção e emancipação das mulheres brasileiras no esporte, 1932 - 1968. XIII Encontro de História, ANPUH. Rio de Janeiro.

Henne, K. & Pape, M. (2018). Dilemmas of gender and global sports governance - an invitation to southern theory. *Sociology of Sport Journal*, 35(3), 216-225.

Knijnik, J. D. (2015). Femininities and Masculinities in Brazilian Women's Football: Resistance and Compliance. *Journal of International Women's Studies*, 16(3), p. 53-70.

M'mbaha, J. M., & Chepyator-Thomson, J. R. (2019). Factors influencing career paths and progress of Kenyan women in sport leadership. *Qualitative Research in Sport, Exercise and Health*, *11*(3), 316-333.

Moura, G. X. (2018). *De in-goal a in-goal: a trajetória de mulheres no Rugby no Brasil.* Dissertação (Mestrado em Educação Física) – Centro de Ciências da Saúde. Universidade Estadual de Maringá, Maringá.

Moura, G. X. (2022). *Por que não se importam com elas? O Esporte de mulheres na agenda governamental do Brasil*. Tese (Doutorado em Educação Física) – Centro de Ciências da Saúde. Universidade Estadual de Maringá, Maringá.

Njororai, W. W. S. (2015). Women athletes emerging from the shadow of men in Kenya: evidence from the Commonwealth, Olympic and World Athletics Championships. *Sport in Society*, *19*(7), 1066-1082.

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Original scientific papers are the results of empirically- or theoretically-based scientific research, which employ scientific methods, and which report experimental or observational aspects of anthropology of sport and physical education from five major fields of anthropology: cultural, global, biological, linguistic and medical. Descriptive analyses or data inferences should include rigorous methodological structure as well as sound theory. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Original scientific papers should be:

- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

Review papers should provide concise in-depth reviews of both established and new areas, based on a critical examination of the literature, analyzing the various approaches to a specific topic in all aspects of anthropology of sport and physical education from five major fields of anthropology: cultural, global, biological, linguistic and medical.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Review papers should be:
- Up to 6000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 100.

Editorials are written or commissioned by the editors, but suggestions for possible topics and authors are welcome. It could be peer reviewed by two reviewers who may be external or by the Editorial Board.

☐Open Submissions ☑Indexed ☑Peer Reviewed

Editorials should be:
- Up to 1000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 10.

Short reports of experimental work, new methods, or a preliminary report can be accepted as two page papers. Your manuscript should include the following sections: Introduction, Methods, Results, and Discussion.

☑Open Submissions ☑Indexed ☑Peer Reviewed

Short reports should be:
- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Peer review - fair review provides authors who feel their paper has been unfairly rejected (at any journal) the opportunity to share reviewer comments, explain their concerns, and have their paper reviewed for possible publication in JASPE.

☑Open Submissions ☑Indexed ☐Peer Reviewed

Peer review - fair review should be:
- Up to 1500 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 15.

Invited papers and award papers include invited papers from authors with outstanding scientific credentials. Nomination of invited authors is at the discretion of the JASPE editorial board. JASPE also publishes award papers selected by the scientific committee of the publisher's conferences.

☐Open Submissions ☑Indexed ☐Peer Reviewed

Invited papers and award papers should be:
- Up to 3000 words (excluding title, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References);
- A structured abstract of less than 250 words;
- Maximum number of references is 30;
- Maximum combined total of 6 Tables/Figures.

1.3. Submission

JASPE only accepts electronic submission to the e-mail of the Journal Office: **office.jaspe.mne@gmail.com; vasileva.jaspe@gmail.com**.

Submitted material includes:

- A manuscript prepared according to the Guidelines for the Authors;
- A signed form that states the study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere, that states that all of the authors are in agreement with submission of the manuscript to JASPE, and that, for studies that use animal or human individuals, authors must include information regarding their institution's ethics committee, and which identifies the official approval number;
- A signed form that there is no conflict of interest.

Name the files according to the family name of the first author. Authors submitting revised versions of the manuscript can use the identification number of their manuscript as provided by the Journal Office. *See* example:

- ✓ FAMILY NAME-manuscript.doc – (main manuscript file)
- ✓ FAMILY NAME-statement.PDF – (authorship statement)
- ✓ FAMILY NAME-declaration.PDF – (declaration of potential conflict of interest)
- ✓ FAMILY NAME-fig1.tiff – (Figure 1)

1.4. Peer Review Process

A manuscript submitted for publication will be submitted to the review process as long as it fits the following criteria:

- The study was not previously published, nor has been submitted simultaneously for consideration of publication elsewhere;
- All persons listed as authors approved its submission to JASPE;
- Any person cited as a source of personal communication has approved the quote;
- The opinions expressed by the authors are their exclusive responsibility;
- The author signs a formal statement that the submitted manuscript complies with the directions and guidelines of JASPE.

The editors-in-chief and associate editors will make a preliminary analysis regarding the appropriateness, quality, originality and written style/grammar of the submitted manuscript. The editors reserve the right to request additional information, corrections, and guideline compliance before they submit the manuscript to the ad-hoc review process.

JASPE uses ad-hoc reviewers, who volunteer to analyze the merit of the study. Typically, one or two expert reviewers are consulted in a double-blind process. Authors are notified by e-mail when their submission has been accepted (or rejected). Minor changes in the text may be made at the discretion of the editors-in-chief and/or associate editors. Changes can include spelling and grammar in the chosen language, written style, journal citations, and reference guidelines. The author is notified of changes via email. The final version is available to the author for his or her approval before it is published.

1.5. Open Access License and Publisher Copyright Policies

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The editors of JASPE consider plagiarism to be a serious breach of academic ethics. Any author who practices plagiarism (in part or totality) will be suspended for six years from submitting new submissions to JASPE. If such a manuscript is approved and published, public exposure of the article with a printed mark ("plagiarized" or "retracted") on each page of the published file, as well as suspension for future publication for at least six years, or a period determined by the editorial board. Third party plagiarized authors or institutions will be notified, informing them about the faulty authors. Plagiarism will result in immediate rejection of the manuscript.

JASPE only publishes studies that have been approved by an institutional ethics committee (when a study involves humans or animals). Fail to provide such information prevent its publication. To ensure these requirements, it is essential that submission documentation is complete. If you have not completed this step yet, go to JASPE website and fill out the two required documents: Declaration of Potential Conflict of Interest and Authorship Statement. Whether or not your study uses humans or animals, these documents must be completed and signed by all authors and attached as supplementary files in the originally submitted manuscript.

1.6. After Acceptance

After the manuscript has been accepted, authors will receive a PDF version of the manuscripts for authorization, as it should look in printed version of JASPE. Authors should carefully check for omissions. Reporting errors after this point will not be possible and the Editorial Board will not be eligible for them.

Should there be any errors, authors should report them to the Office e-mail address **jaspe@ucg.ac.me.** If there are not any errors authors should also write a short e-mail stating that they agree with the received version.

1.7. Code of Conduct Ethics Committee of Publications

JASPE is hosting the Code of Conduct Ethics Committee of Publications of the **COPE** (the Committee on Publication Ethics), which provides a forum for publishers and Editors of scientific journals to discuss issues relating to the integrity of the work submitted to or published in their journals.

2. MANUSCRIPT STRUCTURE

2.1. Title Page

The first page of the manuscripts should be the title page, containing: title, type of publication, running head, authors, affiliations, corresponding author, and manuscript information. *See* example:

Analysis of Dietary Intake and Body Composition of Female Athletes over a Competitive Season

Original Scientific Paper

Diet and Body Composition of Female Athletes

Svetlana Nepocatych[1], Gytis Balilionis[1], Eric K. O'Neal[2]

[1]Elon University, Department of Exercise Science1, Elon, NC 27215
[2]University of North Alabama, Department of Health, Physical Education and Recreation, Florence, AL 35632

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100 Campus Dr.

2525 CB

Elon, NC 27244

United States

E-mail: snepocatych@elon.edu

Word count: 2,946

Word count: 4259

Abstract word count: 211

Number of Tables: 3

2.1.1. Title

Title should be short and informative and the recommended length is no more than 20 words. The title should be in Title Case, written in uppercase and lowercase letters (initial uppercase for all words except articles, conjunctions, short prepositions no longer than four letters etc.) so that first letters of the words in the title are capitalized. Exceptions are words like: "and", "or", "between" etc. The word following a colon (:) or a hyphen (-) in the title is always capitalized.

2.1.2. Type of publication

Authors should suggest the type of their submission.

2.1.3. Running head

Short running title should not exceed 50 characters including spaces.

2.1.4. Authors

The form of an author's name is first name, middle initial(s), and last name. In one line list all authors with full names separated by a comma (and space). Avoid any abbreviations of academic or professional titles. If authors belong to different institutions, following a family name of the author there should be a number in superscript designating affiliation.

2.1.5. Affiliations

Affiliation consists of the name of an institution, department, city, country/territory (in this order) to which the author(s) belong and to which the presented / submitted work should be attributed. List all affiliations (each in a separate line) in the order corresponding to the list of authors. Affiliations must be written in English, so carefully check the official English translation of the names of institutions and departments.

Only if there is more than one affiliation, should a number be given to each affiliation in order of appearance. This number should be written in superscript at the beginning of the line, separated from corresponding affiliation with a space. This number should also be put after corresponding name of the author, in superscript with no space in between.

If an author belongs to more than one institution, all corresponding superscript digits, separated with a comma with no space in between, should be present behind the family name of this author.

In case all authors belong to the same institution affiliation numbering is not needed.

Whenever possible expand your authors' affiliations with departments, or some other, specific and lower levels of organization.

2.1.6. Corresponding author

Corresponding author's name with full postal address in English and e-mail address should appear, after the affiliations. It is preferred that submitted address is institutional and not private. Corresponding author's name should include only initials of the first and middle names separated by a full stop (and a space) and the last name. Postal address should be written in the following line in sentence case. Parts of the address should be separated by a comma instead of a line break. E-mail (if possible) should be placed in the line following the postal address. Author should clearly state whether or not the e-mail should be published.

2.1.7. Manuscript information

All authors are required to provide word count (excluding title page, abstract, tables/figures, figure legends, Acknowledgements, Conflict of Interest, and References), the Abstract word count, the number of Tables, and the number of Figures.

2.2. Abstract

The second page of the manuscripts should be the abstract and key words. It should be placed on second page of the manuscripts after the standard title written in upper and lower case letters, bold.

Since abstract is independent part of your paper, all abbreviations used in the abstract should also be explained in it. If an abbreviation is used, the term should always be first written in full with the abbreviation in parentheses immediately after it. Abstract should not have any special headings (e.g., Aim, Results…).

Authors should provide up to six key words that capture the main topics of the article. Terms from the Medical Subject Headings (MeSH) list of Index Medicus are recommended to be used.

Key words should be placed on the second page of the manuscript right below the abstract, written in italic. Separate each key word by a comma (and a space). Do not put a full stop after the last key word. *See* example:

Abstract

Results of the analysis of

Key words: *spatial memory, blind, transfer of learning, feedback*

2.3. Main Chapters

Starting from the third page of the manuscripts, it should be the main chapters. Depending on the type of publication main manuscript chapters may vary. The general outline is: Introduction, Methods, Results, Discussion, Acknowledgements (optional), Conflict of Interest (optional), and Title, Author's Affiliations, Abstract and Key words must be in English (for both each chosen language of full paper). However, this scheme may not be suitable for reviews or publications from some areas and authors should then adjust their chapters accordingly but use the general outline as much as possible.

2.3.1. Headings

Main chapter headings: written in bold and in Title Case. *See* example:

- ✓ **Methods**

Sub-headings: written in italic and in normal sentence case. Do not put a full stop or any other sign at the end of the title. Do not create more than one level of sub-heading. *See* example:

- ✓ *Table position of the research football team*

2.3.2 Ethics

When reporting experiments on human subjects, there must be a declaration of Ethics compliance. Inclusion of a statement such as follow in Methods section will be understood by the Editor as authors' affirmation of compliance: "This study was approved in advance by [name of committee and/or its institutional sponsor]. Each participant voluntarily provided written informed consent before participating." Authors that fail to submit an Ethics statement will be asked to resubmit the manuscripts, which may delay publication.

2.3.3 Statistics reporting

JASPE encourages authors to report precise p-values. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Use normal text (i.e., non-capitalized, non-italic) for statistical term "p".

2.3.4. 'Acknowledgements' and 'Conflict of Interest' (optional)

All contributors who do not meet the criteria for authorship should be listed in the 'Acknowledgements' section. If applicable, in 'Conflict of Interest' section, authors must clearly disclose any grants, financial or material supports, or any sort of technical assistances from an institution, organization, group or an individual that might be perceived as leading to a conflict of interest.

2.4. References

References should be placed on a new page after the standard title written in upper and lower case letters, bold.

All information needed for each type of must be present as specified in guidelines. Authors are solely responsible for accuracy of each reference. Use authoritative source for information such as Web of Science, Medline, or PubMed to check the validity of citations.

2.4.1. References style

JASPE adheres to the American Psychological Association 6th Edition reference style. Check "American Psychological Association. (2009). Concise rules of APA style. American Psychological Association." to ensure the manuscripts conform to this reference style. Authors using EndNote® to organize the references must convert the citations and bibliography to plain text before submission.

2.4.2. Examples for Reference citations

One work by one author
- ✓ In one study (Reilly, 1997), soccer players
- ✓ In the study by Reilly (1997), soccer players
- ✓ In 1997, Reilly's study of soccer players

Works by two authors
- ✓ Duffield and Marino (2007) studied
- ✓ In one study (Duffield & Marino, 2007), soccer players
- ✓ In 2007, Duffield and Marino's study of soccer players

Works by three to five authors: cite all the author names the first time the reference occurs and then subsequently include only the first author followed by et al.
- ✓ First citation: Bangsbo, Iaia, and Krustrup (2008) stated that
- ✓ Subséquent citation: Bangsbo et al. (2008) stated that

Works by six or more authors: cite only the name of the first author followed by et al. and the year
- ✓ Krustrup et al. (2003) studied
- ✓ In one study (Krustrup et al., 2003), soccer players

Two or more works in the same parenthetical citation: Citation of two or more works in the same parentheses should be listed in the order they appear in the reference list (i.e., alphabetically, then chronologically)
- ✓ Several studies (Bangsbo et al., 2008; Duffield & Marino, 2007; Reilly, 1997) suggest that

2.4.3. Examples for Reference list

Journal article (print):

Nepocatych, S., Balilionis, G., & O'Neal, E. K. (2017). Analysis of dietary intake and body composition of female athletes over a competitive season. *Montenegrin Journal of Sports Science and Medicine, 6*(2), 57-65. doi: 10.26773/mjssm.2017.09.008

Duffield, R., & Marino, F. E. (2007). Effects of pre-cooling procedures on intermittent-sprint exercise performance in warm conditions. *European Journal of Applied Physiology, 100*(6), 727-735. doi: 10.1007/s00421-007-0468-x

Krustrup, P., Mohr, M., Amstrup, T., Rysgaard, T., Johansen, J., Steensberg, A., Bangsbo, J. (2003). The yo-yo intermittent recovery test: physiological response, reliability, and validity. *Medicine and Science in Sports and Exercise, 35*(4), 697-705. doi: 10.1249/01.MSS.0000058441.94520.32

Journal article (online; electronic version of print source):

Williams, R. (2016). Krishna's Neglected Responsibilities: Religious devotion and social critique in eighteenth-century North India [Electronic version]. *Modern Asian Studies, 50*(5), 1403-1440. doi:10.1017/S0026749X14000444

Journal article (online; electronic only):

Chantavanich, S. (2003, October). Recent research on human trafficking. *Kyoto Review of Southeast Asia, 4*. Retrieved November 15, 2005, from http://kyotoreview.cseas.kyoto-u.ac.jp/issue/issue3/index.html

Conference paper:

Pasadilla, G. O., & Milo, M. (2005, June 27). *Effect of liberalization on banking competition*. Paper presented at the conference on Policies to Strengthen Productivity in the Philippines, Manila, Philippines. Retrieved August 23, 2006, from http://siteresources.worldbank.org/INTPHILIPPINES/Resources/Pasadilla.pdf

Encyclopedia entry (print, with author):

Pittau, J. (1983). Meiji constitution. In *Kodansha encyclopedia of Japan* (Vol. 2, pp. 1-3). Tokyo: Kodansha.

Encyclopedia entry (online, no author):

Ethnology. (2005, July). In *The Columbia encyclopedia* (6th ed.). New York: Columbia University Press. Retrieved November 21, 2005, from http://www.bartleby.com/65/et/ethnolog.html

Thesis and dissertation:

Pyun, D. Y. (2006). *The proposed model of attitude toward advertising through sport.* Unpublished Doctoral Dissertation. Tallahassee, FL: The Florida State University.

Book:
Borg, G. (1998). *Borg's perceived exertion and pain scales*: Human kinetics.

Chapter of a book:
Kellmann, M. (2012). Chapter 31-Overtraining and recovery: Chapter taken from Routledge Handbook of Applied Sport Psychology ISBN: 978-0-203-85104-3 *Routledge Online Studies on the Olympic and Paralympic Games* (Vol. 1, pp. 292-302).

Reference to an internet source:
Agency. (2007). Water for Health: Hydration Best Practice Toolkit for Hospitals and Healthcare. Retrieved 10/29, 2013, from www.rcn.org.uk/newsevents/hydration

2.5. Tables

All tables should be included in the main manuscript file, each on a separate page right after the Reference section.

Tables should be presented as standard MS Word tables.

Number (Arabic) tables consecutively in the order of their first citation in the text.

Tables and table headings should be completely intelligible without reference to the text. Give each column a short or abbreviated heading. Authors should place explanatory matter in footnotes, not in the heading. All abbreviations appearing in a table and not considered standard must be explained in a footnote of that table. Avoid any shading or coloring in your tables and be sure that each table is cited in the text.

If you use data from another published or unpublished source, it is the authors' responsibility to obtain permission and acknowledge them fully.

2.5.1. Table heading

Table heading should be written above the table, in Title Case, and without a full stop at the end of the heading. Do not use suffix letters (e.g., Table 1a, 1b, 1c); instead, combine the related tables. *See* example:

- ✓ **Table 1.** Repeated Sprint Time Following Ingestion of Carbohydrate-Electrolyte Beverage

2.5.2. Table sub-heading

All text appearing in tables should be written beginning only with first letter of the first word in all capitals, i.e., all words for variable names, column headings etc. in tables should start with the first letter in all capitals. Avoid any formatting (e.g., bold, italic, underline) in tables.

2.5.3. Table footnotes

Table footnotes should be written below the table.

General notes explain, qualify or provide information about the table as a whole. Put explanations of abbreviations, symbols, etc. here. General notes are designated by the word *Note* (italicized) followed by a period.

- ✓ *Note.* CI: confidence interval; Con: control group; CE: carbohydrate-electrolyte group.

Specific notes explain, qualify or provide information about a particular column, row, or individual entry. To indicate specific notes, use superscript lowercase letters (e.g. $^{a, b, c}$), and order the superscripts from left to right, top to bottom. Each table's first footnote must be the superscript ^{a}.

- ✓ ^{a}One participant was diagnosed with heat illness and n = 19.^{b}n =20.

Probability notes provide the reader with the results of the texts for statistical significance. Probability notes must be indicated with consecutive use of the following symbols: * † ‡ § ¶ || etc.

- ✓ *P<0.05,†p<0.01.

2.5.4. Table citation

In the text, tables should be cited as full words. *See* example:

- ✓ Table 1 (first letter in all capitals and no full stop)
- ✓ ...as shown in Tables 1 and 3. (citing more tables at once)
- ✓ ...result has shown (Tables 1-3) that... (citing more tables at once)
- ✓ ....in our results (Tables 1, 2 and 5)... (citing more tables at once)

2.6. Figures

On the last separate page of the main manuscript file, authors should place the legends of all the figures submitted separately.

All graphic materials should be of sufficient quality for print with a minimum resolution of 600 dpi. JASPE prefers TIFF, EPS and PNG formats.

If a figure has been published previously, acknowledge the original source and submit a written permission from the copyright holder to reproduce the material. Permission is required irrespective of authorship or publisher except for documents in the public domain. If photographs of people are used, either the subjects must not be identifiable or their pictures must be accompanied by written permission to use the photograph whenever possible permission for publication should be obtained.

Figures and figure legends should be completely intelligible without reference to the text.

The price of printing in color is 50 EUR per page as printed in an issue of JASPE.

2.6.1. Figure legends

Figures should not contain footnotes. All information, including explanations of abbreviations must be present in figure legends. Figure legends should be written bellow the figure, in sentence case. *See* example:

- ✓ **Figure 1.** Changes in accuracy of instep football kick measured before and after fatigued. SR – resting state, SF – state of fatigue, *p>0.01, †p>0.05.

2.6.2. Figure citation

All graphic materials should be referred to as Figures in the text. Figures are cited in the text as full words. *See* example:

- ✓ Figure 1
  - × figure 1
  - × Figure 1.
  - ✓ ….exhibit greater variance than the year before (Figure 2). Therefore…
  - ✓ ….as shown in Figures 1 and 3. (citing more figures at once)
  - ✓ ….result has shown (Figures 1-3) that... (citing more figures at once)
  - ✓ ….in our results (Figures 1, 2 and 5)... (citing more figures at once)

2.6.3. Sub-figures

If there is a figure divided in several sub-figures, each sub-figure should be marked with a small letter, starting with a, b, c etc. The letter should be marked for each subfigure in a logical and consistent way. *See* example:

- ✓ Figure 1a
- ✓ …in Figures 1a and b we can…
- ✓ …data represent (Figures 1a-d)…

2.7. Scientific Terminology

All units of measures should conform to the International System of Units (SI).

Measurements of length, height, weight, and volume should be reported in metric units (meter, kilogram, or liter) or their decimal multiples.

Decimal places in English language are separated with a full stop and not with a comma. Thousands are separated with a comma.

Percentage	Degrees	All other units of measure	Ratios	Decimal numbers
✓ 10%	✓ 10º	✓ 10 kg	✓ 12:2	✓ 0.056
× 10 %	× 10 º	× 10kg	× 12 : 2	× .056

Signs should be placed immediately preceding the relevant number.		
✓ 45±3.4	✓ p<0.01	✓ males >30 years of age
× 45 ± 3.4	× p < 0.01	× males > 30 years of age

2.8. Latin Names

Latin names of species, families etc. should be written in italics (even in titles). If you mention Latin names in your abstract they should be written in non-italic since the rest of the text in abstract is in italic. The first time the name of a species appears in the text both genus and species must be present; later on in the text it is possible to use genus abbreviations. *See* example:

- ✓ First time appearing: *musculus biceps brachii*

Abbreviated: *m. biceps brachii*

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SportMont
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ISSN 1451-7485

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SMJ covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

Prospective authors should submit manuscripts for consideration in Microsoft Word-compatible format. For more complete descriptions and submission instructions, please access the Guidelines for Authors pages at the SMJ website: http://www.sportmont.ucg.ac.me/?sekcija=page&p=51. Contributors are urged to read SMJ's guidelines for the authors carefully before submitting manuscripts. Manuscripts submissions should be sent in electronic format to sportmont@ucg.ac.me or contact following Editors:

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Summer issue – June 2026

Montenegrin Journal of Sports Science and Medicine

MONTENEGRIN JOURNAL OF SPORTS SCIENCE AND MEDICINE

ISSN 1800-8755

CALL FOR CONTRIBUTIONS

Montenegrin Journal of Sports Science and Medicine (MJSSM) is a print (ISSN 1800-8755) and electronic scientific journal (eISSN 1800-8763) aims to present easy access to the scientific knowledge for sport-conscious individuals using contemporary methods. The purpose is to minimize the problems like the delays in publishing process of the articles or to acquire previous issues by drawing advantage from electronic medium. Hence, it provides:

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- Peer review by expert, practicing researchers;
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- Worldwide media coverage.

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MJSSM covers all aspects of sports science and medicine; all clinical aspects of exercise, health, and sport; exercise physiology and biophysical investigation of sports performance; sport biomechanics; sports nutrition; rehabilitation, physiotherapy; sports psychology; sport pedagogy, sport history, sport philosophy, sport sociology, sport management; and all aspects of scientific support of the sports coaches from the natural, social and humanistic side.

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MONTENEGRIN SPORTS ACADEMY

Founded in 2003 in Podgorica (Montenegro), the Montenegrin Sports Academy (MSA) is a sports scientific society dedicated to the collection, generation and dissemination of scientific knowledge at the Montenegrin level and beyond.

The Montenegrin Sports Academy (MSA) is the leading association of sports scientists at the Montenegrin level, which maintains extensive co-operation with the corresponding associations from abroad. The purpose of the MSA is the promotion of science and research, with special attention to sports science across Montenegro and beyond. Its topics include motivation, attitudes, values and responses, adaptation, performance and health aspects of people engaged in physical activity and the relation of physical activity and lifestyle to health, prevention and aging. These topics are investigated on an interdisciplinary basis and they bring together scientists from all areas of sports science, such as adapted physical activity, biochemistry, biomechanics, chronic disease and exercise, coaching and performance, doping, education, engineering and technology, environmental physiology, ethics, exercise and health, exercise, lifestyle and fitness, gender in sports, growth and development, human performance and aging, management and sports law, molecular biology and genetics, motor control and learning, muscle mechanics and neuromuscular control, muscle metabolism and hemodynamics, nutrition and exercise, overtraining, physiology, physiotherapy, rehabilitation, sports history, sports medicine, sports pedagogy, sports philosophy, sports psychology, sports sociology, training and testing.

The MSA is a non-profit organization. It supports Montenegrin institutions, such as the Ministry of Education and Sports, the Ministry of Science and the Montenegrin Olympic Committee, by offering scientific advice and assistance for carrying out coordinated national and European research projects defined by these bodies. In addition, the MSA serves as the most important Montenegrin and regional network of sports scientists from all relevant subdisciplines.

The main scientific event organized by the Montenegrin Sports Academy (MSA) is the annual conference held in the first week of April.

Annual conferences have been organized since the inauguration of the MSA in 2003. Today the MSA conference ranks among the leading sports scientific congresses in the Western Balkans. The conference comprises a range of invited lecturers, oral and poster presentations from multi- and mono-disciplinary areas, as well as various types of workshops. The MSA conference is attended by national, regional and international sports scientists with academic careers. The MSA conference now welcomes up to 200 participants from all over the world.

It is our great pleasure to announce the upcoming 24th Annual Scientific Conference of Montenegrin Sports Academy “Sport, Physical Activity and Health: Contemporary Perspectives” to be held in Budva, Montenegro, from 16 to 19 April, 2026. It is planned to be once again organized by the Montenegrin Sports Academy, in cooperation with the Faculty of Sport and Physical Education, University of Montenegro and other international partner institutions (specified in the partner section).

The conference is focused on very current topics from all areas of sports science and sports medicine including physiology and sports medicine, social sciences and humanities, biomechanics and neuromuscular (see Abstract Submission page for more information).

We do believe that the topics offered to our conference participants will serve as a useful forum for the presentation of the latest research, as well as both for the theoretical and applied insight into the field of sports science and sports medicine disciplines.

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from Montenegrin Sports Academy

We have expanded the quality of our journals considerably over the past years and can now claim to be the market leader in terms of breadth of coverage.

As we continue to increase the quality of our publications across the field, we hope that you will continue to regard MSA journals as authoritative and stimulating sources for your research. We would be delighted to receive your comments and suggestions, mostly due to the reason your proposals are always welcome.

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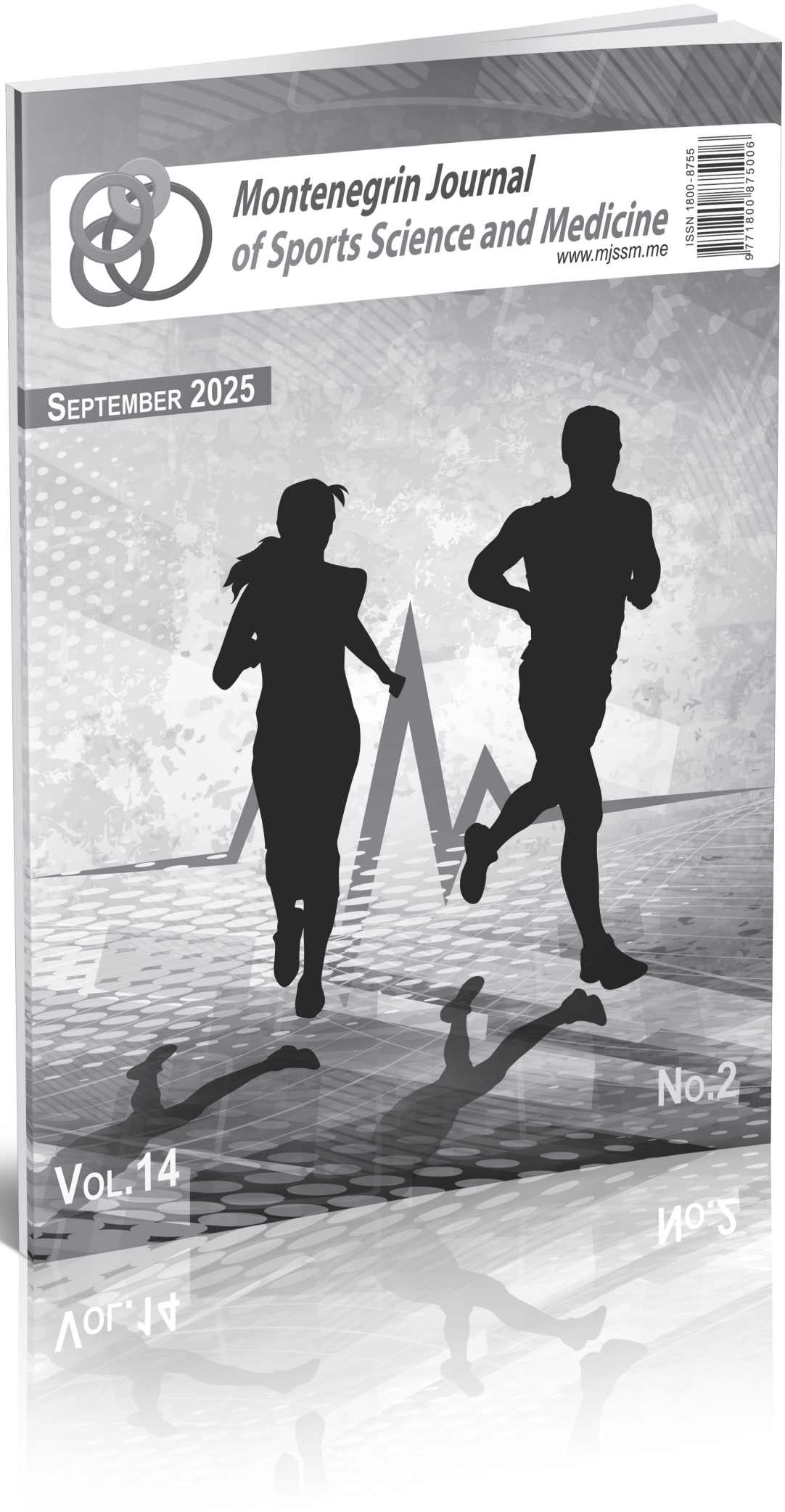
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