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EDUCATIO ARTIS GYMNASTICAE

2/2026

STUDIA UNIVERSITATIS BABEŞ-BOLYAI EDUCATIO ARTIS GYMNASTICAE

2/2026
DOI:10.24193/subbeag.71(2)

ISSN (print): 1453-4223; ISSN (online): 2065-9547; ISSN-L: 1453-4223

PUBLISHED BY BABEŞ-BOLYAI UNIVERSITY

YEAR **Volume 71 (LXXI) 2026**
MONTH **JUNE**
ISSUE **2**

PUBLISHED ONLINE: 2026-06-30
PUBLISHED PRINT: 2026-07-30
ISSUE DOI: 10.24193/subbeag.71(2)

CONTENT/ SOMMAIRE/ INHALT/ CUPRINS

STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 5-15
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).11

Impact of Academic Qualifications and Teaching Level on Physical Education Teachers' Mental Health

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Article history: Received 2026 March 18; Revised 2026 May14; Accepted 2026 May 16; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. This study aimed to examine the mental health of physical education (PE) teachers in relation to their academic qualifications and teaching levels. The study sample comprised 187 PE teachers from the city of Setif, Algeria, during the 2025-2026 academic year, distributed between middle and secondary education levels. The researchers employed the modified SCL-90 scale to evaluate mental health across the seven dimensions. The findings revealed statistically significant differences in reactive sensitivity and phobia between teachers with bachelor's and master's degrees, with those possessing master's degrees exhibiting higher levels. Additionally, secondary school teachers demonstrated higher levels of obsessive-compulsive disorder symptoms than their middle-school counterparts. This study offers recommendations for the development of targeted interventions, professional development programs, and institutional changes to support teachers' mental health across various career stages and educational settings.

Keywords: *mental health, physical education, teachers, academic qualifications, teaching level.*

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INTRODUCTION

Physical education constitutes a cornerstone of school curricula, commanding substantial weekly instructional time for students. Formally defined as an academic subject featuring a planned, sequential K–12 curriculum that leverages human movement to foster knowledge, skills, and confidence in lifelong physical activity (Michael et al., 2021), physical education also well as Conceptual Physical Education (CPE) models. These integrate classroom instruction in kinesiology, health-related fitness, and self-management with structured physical activity to cultivate healthy lifestyles (Corbin, 2021). Physical education teachers serve as primary specialists bearing unique responsibilities within educational systems, including lesson preparation, objective establishment, assessment implementation, and comprehensive class management spanning preventative, instructional, and recreational domains (Németh et al., 2024). delineate five critical competency domains essential for these educators: psycho-pedagogical, personal-professional, didactic/methodological, communicative and organizational, and scientific-pedagogical. These competencies enable effective lesson organization, student guidance, and educational process planning (Németh et al., 2024). Jeremić et al. (2018) systematically analyzed physical education teachers' instructional roles through dual student-teacher perspectives, identifying three foundational functions: organized class management, emotional partnership with learners, and specialized knowledge dissemination with explanatory responsiveness. These roles underpin successful physical education learning outcomes.

Academic qualifications and teaching experience fundamentally shape physical education teachers' performance, interpersonal dynamics, social environments, and mental health. Gatt et al. (2025) investigate PE teachers' conceptualizations of mental health and well-being, revealing perceptions as a positive dynamic state characterized by emotional wellness, adaptive capacity, and constructive social relationships embodying an 'salutogenic' health paradigm transcending disease absence. In addition, Piñeiro-Cossio et al. (2021) synthesized well-being and mental health definitions within physical education and school sports contexts, noting definitional heterogeneity while consistently associating these constructs with life satisfaction, positive affect, stress resilience, relational quality, personal growth, and self-acceptance. Professional experience correlates directly with academic attainment, where master's-level educators demonstrate enhanced competency and pedagogical distinctiveness compared with bachelor's holders. Chen et al. (2025) empirically demonstrated the protective effects of professional competence against stress and emotional exhaustion while promoting work engagement moderated by age, rank, and educational level higher qualifications, yielding superior occupational mental health profiles.

Yan et al. (2022) corroborated these findings, establishing elevated academic degrees' associations with competence enhancement and job satisfaction core occupational mental health constituents. Superior academic preparation thus elevates physical education teachers' mental health resilience. The teaching level introduces additional nuances, distinguishing middle school (late childhood) from high school (adolescent) contexts, with divergent interactional and managerial demands. Chen et al. (2025) documented school environment and instructional level correlations with teacher stress, burnout, and satisfaction, including among physical education faculty. In a sample of 116 physical education teachers, Bodo et al. (2021) established educational qualification as a significant life satisfaction predictor as a cardinal mental health indicator. These converging lines of evidence underscore critical knowledge gaps regarding academic qualifications and the specific impact of teaching education teachers' mental health. Accordingly, this study addresses the pivotal research question: What is the level of mental health among physical education teachers according to their qualifications and teaching levels?

METHOD

Participants

The study involved 187 physical education and sports teachers from Sétif, who were teaching during the 2025–2026 academic year at both the middle and secondary school levels. These teachers were chosen randomly, and, on average, they were 30 years old.

Table 1. Research Participants

	N	**Percentage**
Gender		
Educational qualifications		
Bachelor's degree	89	47.17
Master's degree	92	50.82
Teaching level		
High	79	43.6
Middle	102	56.35

Instrument

Ghali (2014) revised the SCL-90 scale of Derogatis et al (1973), which initially contained 90 items. The updated version reduced the number of items to 48 and categorized them into seven dimensions. This revised version was evaluated by experts and its psychometric properties were assessed, leading to the elimination of five items, resulting in a total of 43 items. The items on the scale are phrased negatively and scored to reflect mental health, where higher scores indicate poorer mental health, and lower scores indicate better mental health and psychological wellbeing. Participants responded to the scale items using a five-point scale (1 = I do not suffer at all, 2 = I suffer a little, 3 = I suffer moderately, 4 = I suffer a lot, and 5 = I suffer severely), selecting the option that best described their experience. These five choices correspond to the five levels of mental health defined by this scale (Ghali, 2014).

Psychometric properties

To assess the internal consistency and validity of the Mental Health scale, correlation coefficients were computed between individual items, their respective dimensions (e.g., physical symptoms, reactive hypersensitivity, depression, anxiety, hostility, and phobia), and total scores. The analysis revealed strong positive correlations ($r > 0.70$) for the majority of items with their dimensions and the overall scale, with nearly all coefficients statistically significant at $p < 0.01$ (**) or $p < 0.05$ (*). These results confirm the high internal validity and reliability of the instrument.

Cronbach's alpha coefficients were calculated for each dimension and the total scale. All dimensions exhibited high internal consistency, with alpha values ranging from 0.861 to 0.903, and an overall scale of $\alpha = 0.892$. These results indicate excellent reliability (>0.80) across all subscales.

Data Analysis

Data were analyzed using the SPSS version 28 software. Various statistical tests were performed, including correlation coefficients and Cronbach's alpha for reliability, means, and standard deviations (Basu, 2021). Additionally, an independent samples t-test was conducted to assess differences between the groups (Carmona, 2014).

RESULTS

To determine whether there were statistically significant differences in the level of mental health attributable to the educational qualification variable, an independent samples t-test was used after confirming the normality of the distribution using the Smirnov test. The results are presented in the following table:

Table 2. Difference in mental health between groups (bachelor's degree, master's degree)

		N	Mean	Sd	T	df	Sig.
Physical symptoms	Bachelor's degree	89	12,8182	3,36495	-,788	178	,432
	Master's degree	92	13,2609	4,11342			
Obsessive-compulsive disorder	Bachelor's degree	89	16,1705	5,27240	-,258	178	,796
	Master's degree	92	16,3804	5,61952			
Reactive Hypersensitivity	Bachelor's degree	89	9,9886	3,59915	-2,275	178	,024
	Master's degree	92	11,3478	4,36125			
Depression	Bachelor's degree	89	12,0000	4,47214	,538	178	,591
	Master's degree	92	11,6196	4,98094			
Anxiety	Bachelor's degree	89	8,8864	3,93753	-,127	178	,899
	Master's degree	92	8,9565	3,48596			
Hostility	Bachelor's degree	89	9,5455	4,44354	-1,255	178	,211
	Master's degree	92	10,4022	4,70226			
Phobia	Bachelor's degree	89	9,3295	2,88763	-2,579	178	,011
	Master's degree	92	10,7283	4,23254			
Mental health	Bachelor's degree	89	78,7386	20,76441	-1,158	178	,248
	Master's degree	92	82,6957	24,80595			

The independent sample t-test results revealed significant differences in the mental health dimensions between PE teachers with bachelor's and master's degrees. Specifically, teachers with master's degrees reported higher scores for reactive hypersensitivity ($t = -2.275$, $p = .024$) and phobia ($t = -2.579$, $p = .011$), indicating potentially poorer mental health in these areas. Master's degree holders scored higher on reactive hypersensitivity ($M = 11.3478$, $SD = 4.36125$) and phobia ($M = 10.7283$, $SD = 4.23254$) than bachelor's degree holders did. However, no significant differences were found in the overall mental health score or in other dimensions such as physical symptoms, OCD, depression, anxiety, and hostility.

To determine whether there were meaningful differences in mental health based on teaching level, we used an independent sample t-test. Before this, we checked whether the data followed a normal distribution by using the Smirnov test. The results are presented in the following table:

Table 3. Difference in mental health between groups (high school, middle school)

		N	Mean	Sd	T	df	Sig
Physical symptoms	High school	79	12,7722	3,56244	-,858	179	,392
	Middle school	102	13,2549	3,89640			
OCD	High school	79	17,2278	6,03823	2,030	179	,044
	Middle school	102	15,5882	4,82640			
Reactive hypersensitivity	High school	79	11,1899	4,11712	1,467	179	,144
	Middle school	102	10,3039	3,96217			
Depression	High school	79	12,5190	5,19087	1,723	179	,087
	Middle school	102	11,3039	4,29549			
Anxiety	High school	79	9,2532	3,77396	1,060	179	,291
	Middle school	102	8,6667	3,62700			
Hostility	High school	79	10,3924	4,60885	1,000	179	,319
	Middle school	102	9,7059	4,56111			
Phobia	High school	79	10,0886	3,51987	,089	179	,929
	Middle school	102	10,0392	3,83553			
Mental health	High school	79	83,4430	24,18505	1,336	179	,183
	Middle school	102	78,8627	21,79656			

The independent sample t-test results presented in table 3 provide insight into the differences in mental health dimensions between high school and middle school PE teachers. The analysis revealed a statistically significant difference only in one dimension: obsessive-compulsive disorder (OCD) ($t = 2.030$, $df = 179$, $p = .044$). High school teachers showed higher average scores for OCD symptoms (17.2) than did middle school teachers (15.6), indicating that high school teachers might experience more OCD-related problems. However, it is important to note that no statistically significant differences were found in the overall mental health score or in other dimensions such as physical symptoms, reactive hypersensitivity, depression, anxiety, hostility, and phobia. Although there were slight variations in the mean scores across these dimensions, none reached statistical significance.

DISCUSSIONS

This study aimed to review the current understanding of the mental health status of PE teachers, focusing on the factors influencing it, and emphasizing the importance of conducting more studies in this field. Table 2 shows no significant overall difference in mental health based on educational qualification (Sig = 0.248). However, significant differences were observed in terms of Reactive Hypersensitivity (Sig = 0.024) and phobia (Sig = 0.011). Teachers with master's degrees scored higher on these dimensions than those with bachelor's degrees. According to Rahmani et al. (2024), teachers with master's degrees express higher levels of reactive hypersensitivity and phobia, suggesting a potential link between higher educational attainment and increased mental health challenges. This may be due to the greater responsibilities or expectations associated with advanced degrees (Rahmani et al., 2024). Fang et al. (2023) found that teachers' mental health can vary based on their educational environment, with teachers in remote or economically disadvantaged areas facing different stressors than their counterparts in urban areas (Fang et al., 2023). Advanced educational levels may be correlated with poor mental health in specific dimensions. These findings support research showing that teaching is a high-stress profession with multiple factors contributing to psychological challenges. Studies indicate that teaching often leads to emotional exhaustion and mental health issues such as depression and anxiety, exacerbated by job demands, student behaviors, and administrative pressures (Fang et al., 2023). The work environment also plays a role in achieving mental health stability among teachers, as Rahmani and others (2024) study proved that teachers often face challenging working conditions, including high levels of presenteeism and emotional labor, which are associated with psychological distress(Corpuz, 2023). In recent years, the coronavirus pandemic has managed to erase two years of human memory, with people unable to remember how it has passed; thus, its impact on mental health is negative. In addition, maintaining one's mental health, in particular, gives individuals confidence in themselves and thus improves their health, as confirmed by Frang et al. (2023), who addressed the need to include mental health examinations in routine health checks to facilitate early detection and intervention for teachers facing mental health challenges. From another perspective, sensitizing teachers to the importance of their place in life as competent shapers of generations of students gives them psychological comfort, which increases their motivation to achieve. Corpuz (2023) and Mo (2024) arrived at the same conclusion, supporting policies that promote teacher well-being and provide training in emotional regulation, coping strategies, and work-life balance as factors that can help alleviate stress and improve mental health outcomes(Corpuz, 2023). The analysis shows significant mental health

challenges for teachers with master's degrees, but this should be contextualized within the inherently stressful nature of teaching. While all teachers face emotional demands, those with higher qualifications may experience additional pressure from their career expectations. Addressing these issues requires comprehensive strategies including policy changes, enhanced support systems, and targeted interventions to support teachers' well-being.

Table 3 shows that there was no significant overall difference in mental health between middle and high school teachers (Sig = 0.181). However, there was a significant difference in Obsessive-Compulsive Disorder (OCD) symptoms (Sig = 0.044), with high school teachers reporting higher levels. No significant differences were found in the other mental health dimensions. This highlights the specific OCD-related challenges for high school teachers, while other mental health aspects remain similar across educational levels. Comparing other dimensions to OCD might reveal similar experiences, such as physical symptoms from prolonged standing under various weather conditions. However, Christian's study found higher levels of obsessive-compulsive disorder symptoms than their middle school counterparts. This may be attributed to increased stress and responsibilities associated with teaching older students, who may pose more complex educational and behavioral challenges(Fang et al., 2023). Coming to the dimension of reactive hypersensitivity, undesirable student behaviors and exaggerated teacher reactions, such as stubbornness and chaos, as well as continuous communication with parents, express the nature of similar pressures for teachers at both middle and high school levels. In contrast, Vallani et al. confirmed that obsessive-compulsive disorder symptoms affect teachers' ability to effectively manage the classroom environment, which may negatively affect their interactions with students and teaching efficiency in general (Vallani et al., 2022). Therefore, Hooker's study shows that teachers generally face high levels of stress and burnout, which may lead to mental health problems, such as depression and anxiety. These challenges are prevalent across all teaching levels, demonstrating the need for comprehensive mental health support for teachers(Christian et al., 2022). According to Salter, positive relationships between teachers and students can alleviate anxiety and promote mental health outcomes for both teachers and students. Therefore, building supportive and caring relationships within the school environment is essential for promoting mental health and well-being (Salter et al., 2024). Phobia is less common among teachers than hostility, which is closely linked to the school environment, explaining the similar results across middle and high schools. Rubies's study shows that the school environment, including student behavior and perceived safety, significantly impacts teachers' mental health. Unsafe environments or high student behavioral problems can increase teacher s' stress and mental health issues (Salter et al., 2024). Similar results across psychological dimensions

suggest that teachers face common problems, although obsessive-compulsive disorder symptoms differ between the middle and high school levels. Vallani's study recommends generalizing mental health support policies for all teachers while providing flexible, targeted interventions for specific issues, such as OCD in high school teachers. Comprehensive support systems addressing stress, anxiety, and depression are crucial for all educators (Vallani et al., 2022). While obsessive-compulsive disorder is a significant concern for high school teachers, overall teacher mental health is influenced by the school environment, student behavior, and personal demographics. Comprehensive mental health programs and supportive school policies can improve teachers' well-being across all educational levels.

CONCLUSION

This study examined the mental health of physical education teachers in relation to their educational qualifications and teaching levels. The findings highlight a complex interplay of factors influencing teachers' mental health, with significant implications for educational policy and practice. Notably, the study identified increased reactive hypersensitivity and phobia among teachers with master's degrees. The study advocates the implementation of tailored mental health support, professional development, institutional changes, and further research. Recommendations include targeted interventions for individuals with advanced degrees; programs aimed at reducing obsessive-compulsive disorder symptoms among high school teachers; differentiated support across career stages; regular mental health literacy training; comprehensive screening services; and policies addressing stressors associated with different teaching levels and qualifications.

AUTHOR CONTRIBUTIONS

Author 1, Author 2, and Author 3, Author 4 contributed to the design and implementation of the research, data collection, analysis of the results, and writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest regarding the publication of this paper.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to all the participants for their cooperation and contribution to the research.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 17-30
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).12

Prevalence and Factors Associated with Growth Plate Injuries in Children and Adolescent Basketball Players in Malang City

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Article history: Received 2026 March 03 Revised 2026 April 18. Accepted 2026 May 19; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. This study aims to determine the prevalence of growth plate injuries and factors associated with injury in children and adolescent basketball players in Malang City. The study used a quantitative descriptive design with a cross-sectional approach in 80 basketball players aged 8-17 years. Data collection was conducted using a Reported Condition Inquiry questionnaire that included the duration of training, injury history, anatomical location of injury, and mechanism of injury experienced by basketball players. The results showed an injury prevalence of 83.8% with 70% of them involving the growth plate area. The most common injury locations were the ankle (26.3%) and the knee (21.3%). The most dominant risk factors were direct contact and non-contact, each contributing 37.5% to the incidence of injury. These findings indicate that basketball players are highly susceptible to growth plate injuries due to the high physical demands of basketball and immature bone structure. This study emphasizes the importance of implementing injury prevention strategies through muscle strengthening, movement techniques, and adjusting training loads according to the developmental stage of basketball players.

Keywords: *growth plate; sports injury; basketball; injury prevalence*

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INTRODUCTION

Increased sports involvement with high levels of training intensity and complexity performed repeatedly at a young age carries a high risk of injury (Naaktgeboren et al., 2017). Regular participation among young players, coupled with the specific risks of sport factors, can increase the likelihood of suffering injuries mainly due to the immaturity of the musculoskeletal system during the period of structural and motor development (Mendhe & Borkar, 2021). The growth plate is a common site of traumatic injury and is the most fragile area of the growing long bones in children with up to 20% of childhood fractures involving growth plate damage (Sananta et al., 2020). During the growth phase, bones are relatively weaker (2-5 times) compared to tendons and ligaments (Sananta et al., 2022).

Physical fatigue can cause muscle fatigue which is identified as a potential risk factor for injury due to rapid eccentric contractions (muscle lengthening) and consequently interferes with motor performance, thus contributing to an increase in the occurrence of injuries (Schwiete et al., 2025). As a result of repeated pressure at high intensity or frequency during training, many basketball players experience physical injuries, namely damage to the growth plate bones (Apers et al., 2021). Factors that interact at the time of injury can be intrinsic (personal), extrinsic (environmental) factors and previous injuries which can cause injuries up to 50-70% (Kilic et al., 2018). Frequent jumping, landing, and sudden changes of direction are extrinsic factors for injury in players due to exposure to high levels of eccentric loading. Furthermore, a lack of adequate strength, endurance, flexibility, and other skill-related components are intrinsic factors that increase the risk of injury (Šiupšinskas et al., 2019).

Approximately 80% of young athletes experience injuries related to the musculoskeletal system (Naaktgeboren et al., 2017). This high figure indicates that the musculoskeletal system at a young age is still in a developmental phase that is vulnerable to injury. In line with this, previous research by (Dover & Kiely, 2015) indicates that growth plate injuries account for 15-30% of all childhood bone injuries, emphasizing the importance of paying special attention to the growth plate. One form of injury related to the growth plate is a pelvic apophyseal avulsion, which is described in the medical literature as “a rare injury affecting young athletes to the growth plate or cartilage that has not yet ossified (not yet become bone)”. These injuries generally occur as a result of sudden, forceful contraction or excessive passive lengthening (stretching) of the muscle. To describe the location and type of injury to the growth plate, the Salter-Harris classification is widely used in clinical practice (Sheffer et al., 2020). Understanding the characteristics of these injuries is important in determining the appropriate rehabilitation approach, including the need for mechanical loading. This is supported by the Journal of Functional Morphology and Kinesiology (Monaco et al., 2021)

who cited that mechanical loading has an important role not only during the development of the musculoskeletal system but also after the developmental phase, as well as contributing to the maintenance of articular cartilage health.

This study examines the potential risk of growth plate injuries in young people, suggesting that high-intensity exercise can contribute to a higher risk of growth plate injuries. Overall, while exercise offers numerous benefits for physical and mental health, attention should be paid to the potential risk of injury (Smith & Merwin, 2021). Training interruptions due to injury or illness can substantially reduce the opportunity to achieve high levels of performance, therefore better knowledge of injury risk factors and prevention strategies is essential (Wik et al., 2020). Coaches need to reduce repetitive training loads and control training progression in basketball players who are experiencing peak growth (PHV) (Jayanthi et al., 2022). Coaches should use a variety of exercises to prevent excessive repetitive movements that can lead to injury, by including strengthening exercises or weight training can reduce the risk of injury by up to 68%, improve performance and health parameters (Brenner, 2016).

MATERIAL AND METHODS

Participants

The research sample consisted of children and adolescent basketball players who actively train in Malang City. The purposive sampling technique involved the deliberate selection of 80 individuals based on the following criteria: basketball players in Malang City, aged 8-17 years, players who actively train regularly, with a training frequency of at least three times a week. This research passed ethical research at State University of Malang (UM) Indonesia.

Research design

This study used a quantitative descriptive design with a cross-sectional approach to describe the prevalence of growth plate injuries in adolescent basketball athletes (Wang & Cheng, 2020). The study was conducted from October to November 2025 in Malang City.

Reported Condition Inquiry

The Reported Condition Injury is a questionnaire designed to gather information about health status. It covers personal data (age, weight, and height), duration of practice (in years), mechanism of injury, anatomical location affected, and time of injury (Bastos, et al., 2014).

Objective: The purpose of this scale is to measure the prevalence rate of growth plate injuries in Malang City basketball players and to determine the risk factors for injuries that occur in the growth plate.

Structure: This research design uses a questionnaire structure consisting of V0-V7: V0: Identification, V1: Age, V2: Weight, V3: Height, V4: Training time, V5: Injury, V6: Anatomical site, V7: Mechanism of Injury

Response Method: Responses were measured using the "Reported Condition Inquiry" questionnaire.

Interpretation: Injury History: Injury, no injuries. Mechanism of injury: No injuries, running, jump, impact, specific athletic gesture. Anatomical site: No injuries, neck, shoulder, arm, dorsal, elbow, forearm, lumbar region, wrist, hip, knee, calf, ankle. Analysis of growth plate: Growth plate, not a growth plate. Growth plate symptoms: Pain in the joints, deformities (lumps, shifts, cracks), swelling in the joints. Risk factors for growth plate injury: No injuries, overuse, non-contact, direct contact.

Validity and Reliability: The validity and reliability of the instrument were tested using Pearson correlation and Crohn's Alpha using IBM SPSS Statistics. Data analysis techniques included univariate analysis in the form of frequency distributions and percentages to describe the research results.

Analysis of statistics

In this study, the collected data will be processed using IBM SPSS Statistics. Validity and reliability tests will ensure that the questionnaire items accurately and consistently measure the variables studied. The analysis results are presented in the form of descriptive statistical tables, frequencies, and percentages.

RESULTS

Table 1. Statistical analysis of physical character test results

Physical Characteristics	N	*Minimum*	*Maximum*	*Mean ± Std. Deviation*
Age (th)	80	8.0	17.0	12.55 ± 2.2098
Weight (kg)	80	20.0	93.0	48.05 ± 13.3633
Height (cm)	80	120.0	180.0	155.52 ± 10.0252
Valid N	80			

Source: Present research

Based on the descriptive analysis results in table, the average age of respondents was 12.55 years with an age range of 8 to 17 years, reflecting that respondents were in the early to middle adolescence phase. Respondents' average weight was 48.05 kg with a weight ranging from 20 kg to 93 kg, while height showed an average value of 155.52 cm with a range of 120 cm to 180 cm. These results indicate a normal variation in physical characteristics for basketball players who are in their growth period.

Table 2. Statistical analysis of training duration results

Exercise Duration	Frequency	Percentage
0 – 5.9 months	14	17.5%
6 – 11.9 months	10	12.5%
1 – 1.9 months	23	28.7%
2 – 2.9 years	12	15.0%
3 – 3.9 years	10	12.5%
> 4 years	11	13.8%
N	**80**	**100.0%**

Source: Present research

The table shows that in Malang City, the majority have training experience of 1 to 1.9 years, with a percentage of (28.7%), making this group the most dominant. Groups with a duration of less than 1 year, namely 0 to 5.9 and 6 - 11.9 months, were (17.5%) and (12.5%), respectively, indicating that quite a lot of respondents are still in the initial phase of training. Meanwhile, groups with longer training experience, namely 2 to 2.9 years, were (15.0%), 3 to 3.9 (12.5%), and more than 4 years (13.8%), indicating that a small portion have long-term training duration.

Figure 1 shows that both children and adolescents had a higher proportion of injuries compared to those who did not experience injuries. In the children group, 75% experienced injuries, while 25% did not experience injuries. Meanwhile, in the adolescent group, the percentage of injuries was higher, at 85%, with 15% experiencing no injuries. These findings indicate that the incidence of injuries is more dominant in the adolescent group than in children, thus indicating an increasing risk of injury with age.

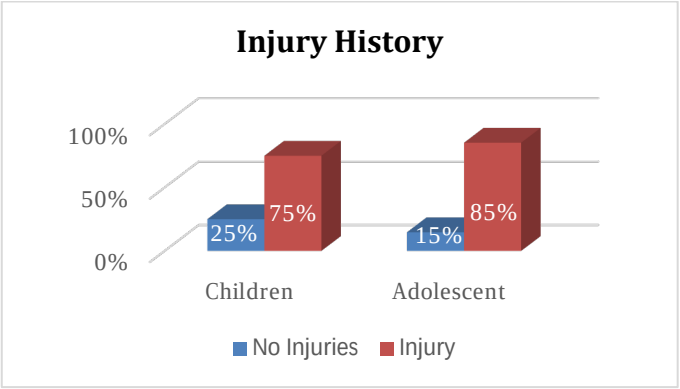

Fig. 1. Graph of injury history in children and adolescents

Figure 2 shows the differences in patterns between children and adolescents. In the children group, the most common injuries occurred during running and performing specific movements, each at 33%, while injuries from jumping were relatively low (8%), and no injuries from impacts were found. Conversely, in the adolescent group, the most dominant injuries occurred from specific movements (37%), followed by jumping (25%), running (16%), and impacts (7%). Furthermore, the percentage of non-injury in adolescents (15%) was lower than in children (25%). This suggests that in adolescents, activities with higher movement complexity and mechanical loads, such as specific movements and jumping, play a greater role in the occurrence of injuries than in children.

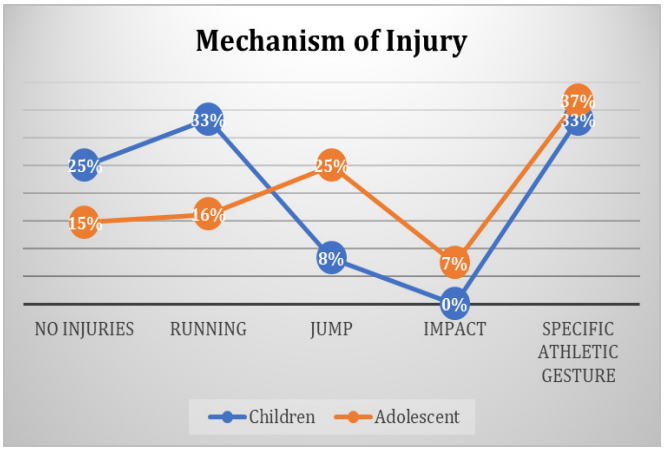

Fig. 2. Graph of mechanism injury

Figure 3 shows the distribution of injury locations between children and adolescents. In children, injuries focused on one primary area, the ankle (42%), indicating that lower extremity stability and movement control are weak points in this age group. Injuries to other body parts were relatively low, so the injury pattern in children tended to be simpler and more localized. In adolescents, injuries occurred in more body parts with a more even proportion, such as the knee (22%), ankle (24%), wrist (13%), shoulder (6%), elbow (6%), and calf (12%). This pattern reflects the increasing intensity, complexity of movements, and physical demands in adolescents, which causes the risk of injury not only to be concentrated in one joint, but also to involve various body segments.

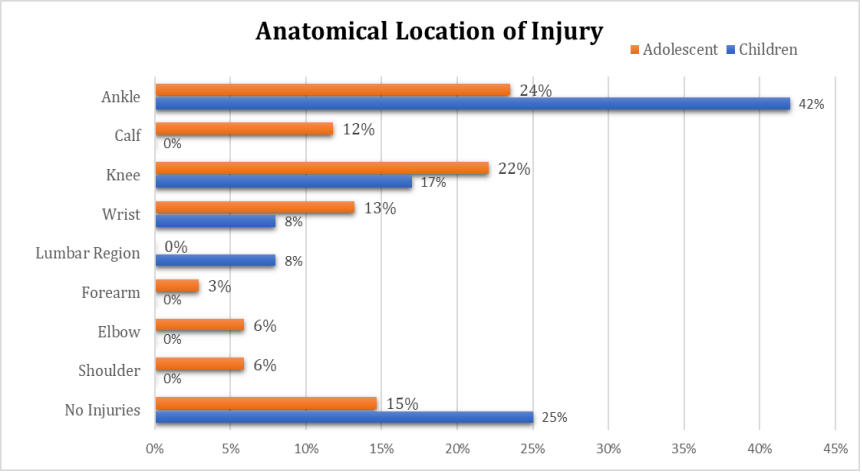

Fig. 3. Graph of anatomical site

Table 3. Statistical analysis of growth plate

Growth Plate	Frequency	Percentage
No injuries	13	16.3%
Growth plate	56	70.0%
Not a growth plate	11	13.8%
N	**80**	**100.0%**

Source: Present research

Table 3 shows that 70% of respondents experienced injuries affecting the growth plate, specifically the shoulder, elbow, wrist, knee, calf, and ankle. Meanwhile, 13.8% experienced injuries that did not involve the growth plate, and 16.3% of respondents experienced no injuries at all. The high number of

respondents in the growth plate category indicates that the growth plate area is highly susceptible to excessive stress in active basketball players because their bone structure is not yet fully mature.

Table 4. Statistical analysis of growth plate symptoms

Growth Plate Symptoms	Frequency	Percentage
Pain in the joints	23	41.1%
Deformities (lumps, shifts, cracks)	10	17.9%
Swelling in the joints	23	41.1%
N	**56**	**100.0%**

Source: Present research

Table 4 shows that of the 56 respondents who experienced growth plate injuries, 23 players (41.1%) reported joint pain and 23 players (41.1%) reported swelling at the ends of the bones. The high prevalence of these two symptoms indicates that inflammation and pain are the primary indications of growth plate injuries due to basketball activities. Meanwhile, 10 players (17.9%) reported deformities such as lumps, cracks, and bone displacement. These findings demonstrate that early detection through complaints of pain and signs of swelling is important to prevent more severe complications in the bone growth process.

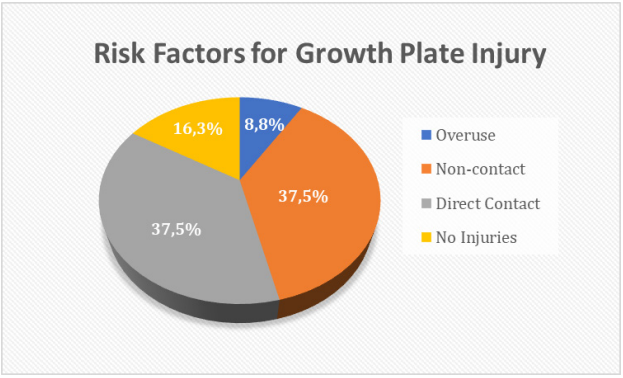

Fig. 4. Graph of risk factors for growth plate injury

Figure 4 shows that the most common risk factors for growth plate injuries are direct contact and non-contact injuries, each accounting for 37.5%.

Overuse injuries accounted for 8.8%, while 16.3% of respondents experienced no injuries. These results indicate that, in addition to physical collisions between players, sudden movements such as sprinting, sudden stops, or changes in direction are the primary causes of growth plate injuries.

DISCUSSION

The study results show that growth plate injuries are a fairly common problem among children and adolescent basketball players in Malang City. The injury rate reached 83.8% of those with a history of injury, with 70% experiencing injuries affecting the growth plate. This figure illustrates the high potential risk of skeletal injury in the 8-17 age group, a phase where bone growth is actively underway and the growth plate structure is still fragile, making it more susceptible to impact forces (Hern & Fern, 2024). The average age of respondents was 12.55 years, indicating that most players were in the peak height velocity (PHV) phase, which is a period of accelerated growth that causes an increase in height in a short time (Achmad et al., 2022).

During the growth phase, bones are relatively weaker (2-5 times) compared to tendons and ligaments, so that the growth plate becomes more susceptible to injury due to the increase in bone length which is not balanced by adaptation of the strength of the muscles and surrounding tissue (Sananta et al., 2022). Improper biomechanics, such as incorrect running, jumping, and sudden movements in basketball can put excessive stress on certain parts of the body and increase the likelihood of recurrent injuries (Forelli et al., 2024). This is reinforced by findings from the literature (Aksović et al., 2024) which is in accordance with the results of this study that the highest injury locations are at the ankle (26.3%) and knee (21.3%) which are the main centers of support in basketball movements. Injuries that occur in the knee are related to conditions such as Osgood-Schaltter which occurs due to repeated pulling of the patellar tendon on the tibial tuberosity, which is one of the active growth plate areas (Corbi et al., 2022). Ankle injuries can involve the distal epiphysis of the tibia and fibula due to rotational movements, sudden changes in direction, or landing errors. The high frequency of injuries at these two locations suggests that the loads experienced by basketball players tend to exceed the adaptive capacity of the developing bone. Growth plate injuries of these lower extremities require high vigilance and close monitoring during skeletal growth (Sabharwal & Sabharwal, 2018). Early recognition and appropriate treatment of these injuries can minimize long-term morbidity.

The respondents' training duration also reflects the high prevalence of growth plate injuries. The majority (28.7%) had a training duration of 1-1.9 years, indicating that many of them are still in the early stages of movement adaptation. Less experienced basketball players often exhibit poor motor control skills and unstable landing techniques, increasing the likelihood of growth plate injuries during intense movements (Costa e Silva et al., 2024). The high prevalence of growth plate injuries in this study indicates that children and adolescent basketball players in Malang City are at significant risk of injury due to the biological development and physical demands of their sport. This finding aligns with the literature (Emery & Pasanen, 2019) that high-intensity exercise at puberty requires close supervision to prevent serious injuries that can interfere with long-term bone growth.

Growth plate injuries in basketball players are influenced by a complex combination of risk factors, including direct contact, non-contact, and overuse (Mendhe & Borkar, 2021). The results of this study indicate that direct contact and non-contact injuries accounted for an equal percentage (37.5%), while overuse accounted for 8.8% of the total injuries. Direct contact in basketball, such as collisions during a ball grab or collisions between players, can cause sudden compression forces on bones containing active growth plates. Impacts often result in epiphyseal injuries due to shear and compression forces caused by repeated rotations or direct hits, which disrupt the growth plate. Although their frequency cannot be completely avoided in basketball, injuries due to direct contact often occur without the body's readiness or lack of ability to anticipate the impact.

Non-contact injuries were also one of the biggest risk factors identified in this study. Non-contact injuries occur when basketball players make sudden changes in direction, stop abruptly, pivot, or land after a jump (Zhang et al., 2025). These movements place significant stress on the lower extremities, particularly the knees and ankles. Because the growth plates are still open in childhood and adolescence, the high extrinsic loads from these activities can cause irritation, displacement, or damage to the growth plates. Muscle fatigue also impairs the body's ability to control movement, increasing the risk of non-contact injuries (Schwiete et al., 2025). This is supported by research data, where specific movements are the most dominant mechanism (36.3%). Epidemiological surveys show that knee injuries account for 14-33% of all injuries, with specific movements such as lay-ups, pivots, and step-backs being high-load movements on the heel and knee (Zhu et al., 2025). The characteristics of basketball require basketball players to complete many jumps, sudden stops, and runs which are potential for injury because they involve demands on strength and coordination of the knees and ankles which increase the risk of injury.

Overuse also contributes to the risk of growth plate injury. Repeated high-intensity exercise without sufficient recovery time can cause microtrauma to growing bones (Borkowski et al., 2025). The results of this study indicate that 8.8% of respondents experienced overuse injuries. The variety of movements in basketball can increase repetitive stress on the growth plates, increasing the risk of injury. Immature bone structures make them more susceptible to damage, emphasizing the importance of managing exercise, strengthening supporting muscles, and monitoring growth to prevent injuries that can disrupt growth plate development (Myers et al., 2017). High training frequency, early specialization in one sport, and relatively similar movement patterns such as repeated jumps and landings in basketball, can cause repetitive stress on the distal epiphyseal area of the tibia and fibula. In a study (Jayanthi et al., 2020) it was stated that over time, especially young basketball players, are more likely to experience overuse injuries if they have a higher level of sport specialization.

In young basketball players, as bone stiffness increases, resistance to impact decreases, and sudden overload can cause the bones to bend or bend. Swelling, hyperemia, and deformity in the physical area are symptoms of injury characterized by tenderness, because blood vessels in the area widen or experience vasodilation, causing fluid, protein, and cells to leak into the surrounding tissue. This is consistent with the results of the study, which showed that 41.1% of respondents experienced swelling at the ends of bones and 41.1% experienced pain in the joints. Due to the various injury risks experienced by basketball players, it is important that training programs take into account physical and psychological maturity, so that growing children and adolescents can adjust to their own body changes.

CONCLUSIONS

Based on the results of research that has been conducted, regarding the prevalence and factors related to growth plate injuries in children and adolescent basketball players in Malang City, it can be concluded that growth plate injuries are a fairly high problem experienced by basketball players with a prevalence of injuries reaching 83.8% and as many as 70% of which involve the growth plate area. The most common locations of injury are the ankles and knees, which are the main support areas in basketball. The most dominant risk factors come from direct contact and non-contact at 37.5%, indicating that suboptimal movement techniques and high training loads have a significant influence on the growth plate. This high number, a condition that requires special attention because it can impact the process of bone growth and the development of player performance in the future.

AUTHOR CONTRIBUTIONS

Author 1 and author 2 contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest in this research.

ACKNOWLEDGEMENTS

The authors declare no competing interests.

ETHICAL CLEARANCE

State University of Malang (UM), Research and Community Service, Institute Research Ethics Committee No.08.01.02/UN32.14.2.8/LT/2026

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 31-46
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).13

Improving Coordinative Capacity in Fourth-Grade Physical Education Lessons Through the Application of Movement Games

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Article history: Received 2026 March 18; Revised 2026 May 14; Accepted 2026 May 16; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction:* The present article aims to highlight the effectiveness of using movement games as the primary means for improving coordinative capacity in fourth-grade students during physical education lessons. In the context of school physical education, the development of coordinative capacities at early school age represents a priority, and movement games - through their playful, varied, and motivating character - prove to be an extremely valuable didactic tool for achieving this objective. *Purpose:* The purpose of the present research is to improve coordinative capacity in fourth-grade physical education lessons through the application of movement games. *Methods:* The following research methods were used in conducting the experiment: study of specialized literature, pedagogical observation method, experimental method, testing method and control probes, statistical-mathematical method, and graphical and tabular method. The research was conducted at Gymnasium School No. 51 in Bucharest, Sector 2, on a sample of 50 students (20 girls and 30 boys) belonging to the primary cycle in classes IV A (control group) and IV B (experimental group), with ages between 10 and 11 years. *Results:* The results obtained in the final evaluation revealed significantly superior performances of the experimental group compared to the control group across all four tests used to measure

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coordinative capacity, thus demonstrating the superior efficiency of applying movement games in physical education lessons compared to the exclusive use of classical exercises. *Conclusions:* Through play, a complex and integrated development of students' physical, cognitive, social, and emotional skills was achieved; play proved to be an effective method for developing coordinative capacities; activities that included movement games were attractive and highly appreciated by the children, due to the positive emotions generated by competition.

Keywords: *coordinative capacities, students, movement games, physical education lesson*

INTRODUCTION

The role of physical education in primary education is to ensure the harmonious development of the body, to improve health status, to increase morpho-functional indices, to equip students with as diverse as possible knowledge, skills, and motor abilities, and to shape their character and moral profile, expressed through qualities such as willpower, courage, self-control, punctuality, and respect for opponents. Physical education and school sports represent activities of major importance, considering the tasks and objectives they fulfill within the instructional-educational process.

Viewing the multilateral development of children and young people, society in line with its needs determines an educational ideal from which the educational goals and objectives are born. The integrated part of the educational system along with the structure and its contents of the physical education, is part of a broad framework called to meet the requirements and determinations by the complexity of the formative act, having the student's center (Savu & Pehoiu, 2018). Motor quality skill (coordinative ability) is important in physical education in secondary school because it develops fundamental motor skills, improves coordination of movements, develops confidence in one's own abilities, supports the learning of complex sports, strengthens cognitive skills, promotes an active and healthy lifestyle, forms a positive social environment within physical activities, especially those in teams, which involve coordination and collaboration, encourages teamwork, mutual respect and communication, fundamental aspects in the development of interpersonal relationships and social skills of students (Chirazi et al., 2025). Motor skills are vital and essential parts of everyday lives not only in children. But especially at this age teachers should focus on improvement in this area (Rechtik et al., 2019). Motor

coordination (MC) is an essential skill underpinning precise and controlled movements, contributing significantly to daily functioning and overall performance. The developmental trajectory of MC in children is intricately shaped by a spectrum of factors encompassing age, gender, and physical activity engagement. Delving into the complex interrelation of these variables holds the potential to unravel nuanced developmental trends and offer targeted avenues for interventions aimed at augmenting motor proficiency in the pediatric population (Canli et al., 2023). Motor skill competence is important for children's physical and social development. Regular physical education classes may not fully support the improvement of specific motor abilities. Although different training approaches are used in schools, their effectiveness in enhancing fundamental motor skills remains of practical interest (Gökşin et al., 2025).

The periods before puberty are nevertheless to be used particularly intensively for appropriate stimuli (especially with regard to coordination and speed). It is sensible to influence the maturing functions and has been proved that coordination can be trained particularly well at this age (Hirtz & Starosta, 2002). Spatio-temporal orientation, together with movement combination and coupling, and with kinesthetic, balance, motor reaction, movement transformation and rhythm differentiation form the coordinative abilities (Pehoiu, 2010). Early acquisition of spatial-temporal orientation and balancing skills is necessary for optimal motor performance, as these abilities are highly valued in sports and technical activities (Tanasă & Abalaşei, 2024).

Movement games represent an important means through which numerous general and specific competencies are developed among students in primary education. The use of movement games in physical education lessons has been investigated by numerous authors over time (Dobrescu, 2019; Stun et al., 2024; Mardiansyah et al., 2024; Topalska & Rumenov, 2025; Marwan & Rohayati, 2025; Akay et al., 2025). A global decline in levels of movement competence and physical activity in children presents the urgent need to look at how to reverse this trend. The Movement Oriented Games Based Assessment (MOGBA) is an intervention designed to improve children's complex movement skills, based on principles of motor development and assessment theories (Rossum et al., 2025).

It is necessary for active methods to be used during physical education lessons, allowing the pupils the opportunity to actively participate in the training process. Of the diversity of means that are at the teacher's disposal, the movement game is one of the most attractive solutions for stimulating the pupils to exercise. Being subordinated to the instructional objectives, through its contents and rules, the movement game is also a means and a method that needs to be promoted in the structure of the physical education lesson (Dobrescu,

2016). Alecu et. al (2025) proposes that movement games be integrated into the curriculum to foster the cognitive and socioemotional development of children by leveraging the exceptional benefits these games offer. The formative and educational potential of movement games can support the development of children's emotional intelligence, leading to better adaptation to the demands of the school and social environment. Thus, students not only develop physically but also enhance their psychological well-being, self-confidence, and self-esteem. Like other activities specific to this discipline, their practice positively influences the quality of education. We recommend that movement games serve as elements through which specific competencies can be developed in primary school students. Their structure aligns with the learning objectives designed for this age group.

PURPOSE OF THE RESEARCH

The purpose of the present research is to improve coordinative capacity in fourth-grade physical education lessons through the application of movement games.

HYPOTHESES

If we clearly define the specific concepts related to the improvement of coordinative capacities among primary school students, we will be able to identify the most effective means of intervention, such as movement games. These games not only stimulate the development of coordination, balance, and body control, but also maintain a high level of involvement and motivation among children. Through an appropriate approach to these concepts and the use of concrete and attractive methods, physical education can become an essential instrument in the harmonious development of students.

We assume that the use of the proposed movement games within physical education lessons will lead to a significant improvement in coordinative capacities among fourth-grade students. By implementing these movement games, students will develop essential motor skills in an enjoyable and efficient manner. These activities will not only improve students' physical performance but will also increase their interest and engagement in physical education lessons, thus contributing to harmonious physical development and the formation of healthy lifestyle habits.

MATERIALS AND METHODS

Study Design

During the experiment, which involved both practical and methodological aspects, the following research methods were used: the study of specialized literature, the pedagogical observation method, the experimental method, the method of tests and control trials, the statistical–mathematical method, as well as graphical and tabular methods.

Ethical Approval and Consent

The hereby study was conducted in accordance with the fundamental ethical principles set out in the Declaration of Helsinki and national regulations on the protection of minors involved in research. The research protocol was approved by the management of Secondary School No. 51, Sector 2, Bucharest, under No. 488 dated February 24, 2025.

Participants

The research was conducted at Secondary School No. 51 in Bucharest, Sector 2, on a sample of 50 students (20 girls and 30 boys) from the primary education cycle, belonging to classes IV A (control group) and IV B (experimental group), aged between 10 and 11 years.

Procedure

The main research method used was the pedagogical experiment. For its implementation, the research was carried out in several stages between February and May 2025. Before the beginning of the experiment, the initial assessment was conducted in February, while the final assessment took place in May. In the two stages of the experiment, four specific tests were used to determine the level of coordinative capacities: the "Throwing the ball at a target while standing with the back to it" test, the balance test, the "Square test", and the "Matorin test." The tests were applied uniformly to all students in both the experimental group and the control group.

"*Throwing the ball at a target while standing with one's back to it*"

Test: The materials required for this test are: a measuring tape, six tennis balls, a gymnastics hoop, a medicine ball (1 kg), and a mat. The student stands at the throwing line with their back to the target. The task consists of throwing the ball over the head (over the shoulder) and hitting the target placed

at a distance of 2 meters. After the explanation and demonstration, one trial attempt and five recorded attempts are performed. The results are evaluated as follows: ball landing on the mat - 1 point; hitting the bar of the gymnastics hoop - 2 points; between the hoop and the medicine ball - 3 points; hitting the medicine ball - 4 points. The points obtained are summed and the final score is recorded.

Balance Test

The materials required for this test are a stopwatch and a gymnastics bench. The student stands on an inverted gymnastics bench on one leg (with hands on the hips) and attempts to maintain balance on the apparatus for as long as possible. The time is recorded until the subject touches the ground with the free foot, removes the hands from the hips, or falls off the apparatus. The test result is expressed in seconds and is performed on both the right and the left leg.The results are evaluated as follows: Excellent: >50 s - 50 points; Very good: 40-49.99 s - 40 points; Good: 30-39.99 s - 30 points; Satisfactory: 20-29.99 s - 20 points; Insufficient: <20 s - 10 points.

"*Square Test*"

The materials required for this test are a measuring tape, a stopwatch, and chalk. A square with a side length of 90 cm is drawn on the ground and divided into smaller squares of 30 cm (nine small squares). Two additional squares of the same size are then drawn on opposite sides. The student is required to start from square "0" and, following the numbering, perform jumps with both feet as quickly as possible into the respective squares without skipping a square or stepping on the dividing lines, until reaching square "S". The time required to complete the course is recorded and the number of errors is noted, each error being penalized with one second. The results are evaluated as follows: 5.00-5.99 s - 50 points; 6.00-6.99 s - 40 points; 7.00-7.99 s - 30 points; 8.00-8.99 s - 20 points; 9.00-9.99 s - 10 points.

"*Matorin Test*"

The materials required for this test are chalk and a ruler. From a standing position, a jump with rotation around the longitudinal axis of the body is performed - both to the left and to the right. During the jump, the student must maintain balance, land with the feet together as in the initial position, and achieve the greatest possible rotation angle. The test is carried out on a flat surface where the teacher draws a graduated circle with chalk and measures the angle of rotation for each jump using a ruler. The results are evaluated as follows: Excellent: ≥360° - 50 points; Good: 270°-360° - 40 points; Average: 180°-270° - 30 points; Weak: <180° - 20 points.

During Module 4 of the school year, between March 3 and April 6, 2025, in order to improve coordinative capacity within physical education and sport lessons, classical exercises were used for the control group, while the experimental group performed the movement games proposed by the authors. According to the annual planning of the learning units, Module 4 included 10 lessons dedicated to the improvement of coordinative capacity, of which 8 lessons were allocated to the actual instructional activities and 2 lessons to the final assessment.

The movement games used for the experimental group and the objectives pursued are presented in Table 1.

Table 1. Movement Games Used in the Experimental Group

Lesson	Movement Game	Objectives Pursued
1	Who is more skillful?	Development of body segments
	Touch the boots with the stick	Development of precision and ambidexterity
2	Mischievous cards	Development of balance, spatio-temporal orientation, and segment coordination
	The clock	Development of precision, ambidexterity, and body segment coordination
3	The Bell Game	Development of spatio-temporal orientation
	Ball Duel	Development of balance and precision
4	Intervention team	Development of spatio-temporal orientation
	Jumps over the rope	Development of general coordination
5	The Windows	Development of spatio-temporal orientation
	Hardworking little birds	Development of spatio-temporal orientation
6	Millipede	Development of general coordination
	The Skillful Shooter	Development of ambidexterity and eye-hand coordination
7	Try it	Development of balance
	X and 0	Development of general coordination
8	Exatlon	Development of balance and general coordination

Data Analysis

In order to analyze and interpret the data obtained from the experiment, we used SPSS software, a statistical software platform that offers an easy-to-use interface and a robust range of functions that allowed us to quickly obtain valuable information from the available data. For the coefficient of variability, the following ranges were used for interpretation: less than 10% - very high homogeneity; between 10% and 15% - high homogeneity; 15%-20% - medium

homogeneity; over 20% - low homogeneity. The "p"-value in the significance test was calculated by the statistical software. If the value is less than 0.05, the difference is statistically significant. If the value is 0.05 or above, there is no significant difference.

RESULTS

In the test "Throwing the ball at a target while standing with one's back to it", the following was observed:

- At the initial testing, the mean value obtained by the experimental group - 5.6 - is approximately equal to that of the control group - 5.28. This is demonstrated by the calculated t-value (0.181) and the p-value (0.36), which is greater than 0.05, as determined by applying Student's t-test.
- At the final testing, the mean value obtained by the experimental group - 16.32 - is statistically significantly higher than that of the control group - 10.84. This is demonstrated by the calculated t-value (4.906) and the p-value (0.000), which is less than 0.05, as determined by applying Student's t-test (Table 2 and Figure 1).

Table 2. Test "Throwing the Ball at a Target While Standing with One's Back to It" - Experimental Group and Control Group - Statistical-Mathematical Indicators -

Statistical-Mathematical Indicators		**Control Group (C.G.)**		**Experimental Group (E.G.)**	
Type of testing		Initial Testing	Final Testing	Initial Testing	Final Testing
Average		5.28	10.84	5.6	16.32
Standard deviation		1.42	1.79	1.55	1.73
Coefficient of variability		27.06 %	16.56 %	27.82 %	10.63 %
Minimum value		3	8	3	12
Maximum value		8	14	8	20
Student's t-test	t calculated	8.504		7.591	
	p	0.000		0.000	
Student's t-test Initial Testing E.G+C.G	t calculated	0.181			
	p	0.36			
Student's t-test Final Testing E.G+C.G	t calculated	4.906			
	p	0.000			

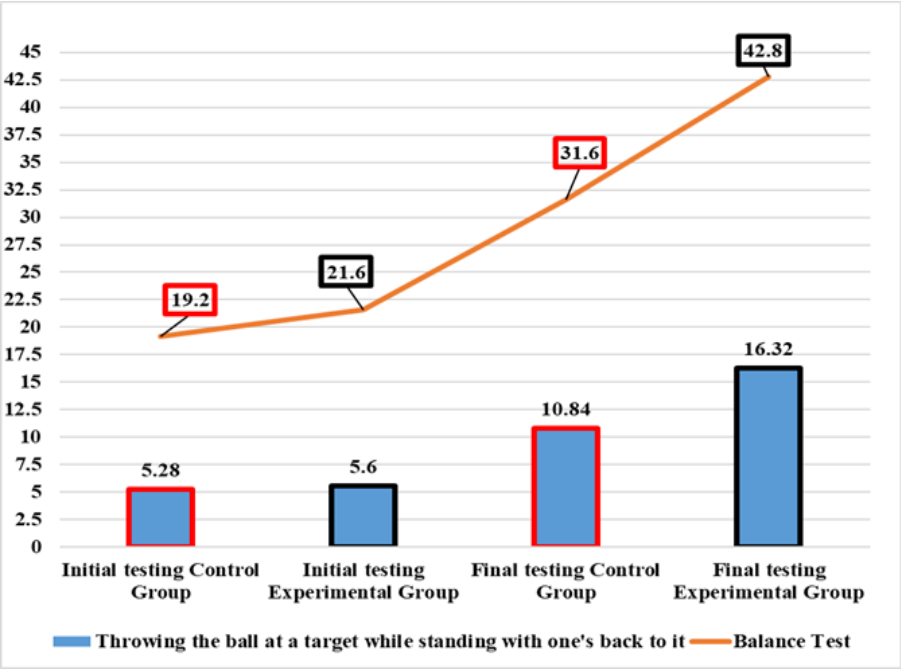

Fig. 1. Test "Throwing the ball at a target while standing with one's back to it" and Balance Test - Control group and Experimental group - Differences between initial evaluations and final evaluations (participants' performance was quantified in points)

In the balance test, the following was observed:

- At the initial testing, the mean value obtained by the experimental group - 21.6 - is approximately equal to that of the control group - 19.2. This is demonstrated by the calculated t-value (0.12) and the p-value (0.24), which is greater than 0.05, as determined by applying Student's t-test.
- At the final testing, the mean value obtained by the experimental group - 42.8 - is statistically significantly higher than that of the control group - 31.6. This is demonstrated by the calculated t-value (9.37) and the p-value (0.000), which is less than 0.05, as determined by applying Student's t-test (Figure 1 and Table 3).

Table 3. Balance Test - Control Group and Experimental Group-Statistical-Mathematical Indicators

Statistical-Mathematical Indicators		**Control Group (C.G.)**		**Experimental Group (E.G.)**	
Type of testing		Initial Testing	Final Testing	Initial Testing	Final Testing
Average		19.2	31.6	21.6	42.8
Standard deviation		7.59	8.50	6.87	6.13
Coefficient of variability		39.55%	26.91%	31.85%	14.33%
Minimum value		10	20	10	30
Maximum value		30	50	30	50
Student's t-test	t calculated	9.37		1.242	
	p	0.000		0.000	
Student's t-test Initial Testing E.G+C.G	t calculated	0.12			
	p	0.24			
Student's t-test Final Testing E.G+C.G	t calculated	9.37			
	p	0.000			

In the "In the Square" test, the following was observed:

- At the initial testing, the mean value obtained by the experimental group - 20.8 - is approximately equal to that of the control group - 18. This is demonstrated by the calculated t-value (0.06) and the p-value (0.12), which is greater than 0.05, as determined by applying Student's t-test.
- At the final testing, the mean value obtained by the experimental group - 41.2 - is statistically significantly higher than that of the control group - 26.8. This is demonstrated by the calculated t-value (9.37) and the p-value (0.000), which is less than 0.05, as determined by applying Student's t-test (Table 4 and Figure 2).

Table 4. Test In the Square - Control Group and Experimental Group - Statistical-Mathematical Indicators

Statistical-Mathematical Indicators	**Control Group (C.G.)**		**Experimental Group (E.G.)**	
Type of testing	Initial Testing	Final Testing	Initial Testing	Final Testing
Average	18	26.8	20.8	41.2
Standard deviation	7.07	8.02	6.87	6.13
Coefficient of variability	39.28%	29.92%	31.85%	14.33%
Minimum value	10	10	10	30
Maximum value	30	40	30	50

Statistical-Mathematical Indicators		Control Group (C.G.)	Experimental Group (E.G.)
Student's t-test	t calculated	7.620	3.066
	p	0.000	0.000
Student's t-test Initial Testing E.G+C.G	t calculated	0.06	
	p	0.12	
Student's t-test Final Testing E.G+C.G	t calculated	8.59	
	p	0.000	

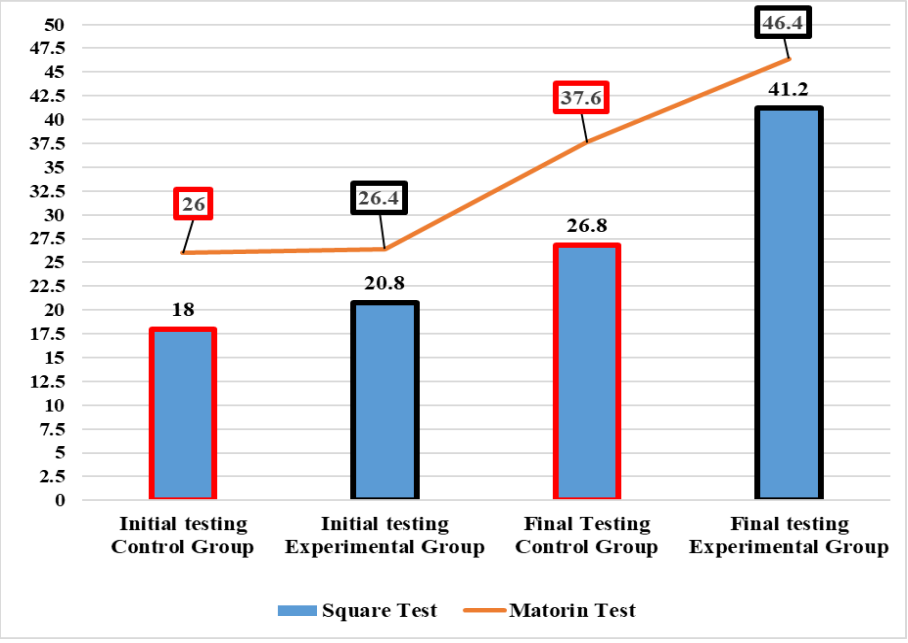

Fig. 2. Test "In the Square" and Matorin Test - Control group and Experimental group - Differences between initial evaluations and final evaluations (participants' performance was quantified in points)

In the "Matorin" test, the following was observed:

- At the initial testing, the mean value obtained by the experimental group - 26.4 - is approximately equal to that of the control group - 26. This is demonstrated by the calculated t-value (0.35) and the p-value (0.713), which is greater than 0.05, as determined by applying Student's t-test.

- At the final testing, the mean value obtained by the experimental group - 46.4 - is statistically significantly higher than that of the control group - 37.6. This is demonstrated by the calculated t-value (3.89) and the p-value (0.000), which is less than 0.05, as determined by applying Student's t-test (Figure 2 and Table 5).

Table 5. Test "Matorin" - Control group and Experimental group - Statistical-Mathematical Indicators

Statistical-Mathematical Indicators		**Control Group (C.G.)**		**Experimental Group (E.G.)**	
Type of testing		Initial Testing	Final Testing	Initial Testing	Final Testing
Average		26	37.6	26.4	46.4
Standard deviation		5	6.63	4.89	4.89
Coefficient of variability		19.23%	17.64%	18.55%	10.55%
Minimum value		20	30	20	40
Maximum value		30	50	30	50
Student's t-test	t calculated	3.917		2.682	
	p	0.000		0.000	
Student's t-test Initial Testing E.G+C.G	t calculated	0.35			
	p	0.713			
Student's t-test Final Testing E.G+C.G	t calculated	3.89			
	p	0.000			

DISCUSSIONS

The systematic integration of playful activities into physical education lessons in the primary cycle emerges as a pedagogical necessity, as also supported by Moisescu & Gürbüz (2017), who position play as the main mediator for refining coordination during the fundamental phase of motor development.

The obtained results confirm the research hypotheses and are consistent with data from the specialized literature, which emphasize the predominant role of playful activities in developing coordinative capacities at early school age (Pesce et al., 2016; Sutapa et al., 2021). The superiority of the experimental group across all four evaluation tests can be explained by the multifactorial and motivating nature of movement games, which simultaneously stimulate multiple components of coordination, in contrast to classical repetitive and less varied exercises. These movement games fostered greater emotional involvement, reduced monotony, and increased adherence to the activity - an essential aspect in the context of fourth-grade physical education lessons.

The systematic implementation of movement games can represent an efficient and accessible didactic strategy for physical education teachers, contributing to improving the quality of lessons and to the formation of higher-quality motor skills. However, the limitations of the study (relatively short duration of the intervention, small sample limited to a single school) suggest the need for future research on larger samples and over extended periods, possibly including additional variables.

CONCLUSIONS

The use of movement games brings countless benefits for children, both from the perspective of physical health (strengthening the cardiovascular system, boosting immunity, fortifying the skeletal system, balancing the endocrine system, and improving posture) and mental health. Movement games help children develop their imagination, creativity, coordination abilities, and spatial orientation.

Throughout Module 4, it became evident that play facilitated a complex and integrated development of students' physical, cognitive, social, and emotional skills; that play proved to be an effective method for developing coordinative capacities; and that activities incorporating movement games were attractive and highly appreciated by the children, thanks to the positive emotions generated by competition. The ludic method transformed the learning process into a dynamic, interactive, and enjoyable experience that stimulated students' interest and engagement. By developing cognitive, social, and emotional skills, this holistic and efficient approach contributed significantly to the improvement of coordinative capacities. Compared to the classical teaching method, the ludic approach offers a more comprehensive and better-adapted form of learning to the diverse needs of students.

Based on the above, we can affirm that hypothesis no. 1 was confirmed, according to which movement games not only stimulate the development of coordination, balance, and body control, but also maintain a high level of involvement and motivation among children.

On the basis of the data and results obtained from the scientific investigations we conducted, we arrived at the following general conclusions, which we present below:

- The movement games were correctly selected and were specific to the chosen theme (development of coordinative capacities);
- The proposed movement games were selected in accordance with the students' age group and level of preparation.

From the interpretation of the statistical data within the experiment, we concluded that:

- In the test "Throwing the ball at a target while standing with one's back to it", the experimental group exhibited high homogeneity compared to the control group, which showed medium homogeneity;
- In the balance test, the experimental group exhibited high homogeneity compared to the control group, which showed low homogeneity;
- In the "In the Square" test, the experimental group exhibited high homogeneity compared to the control group, which showed low homogeneity;
- In the "Matorin" test, the experimental group exhibited high homogeneity compared to the control group, which showed medium homogeneity;
- Across all applied tests, statistically significant differences were observed between the results obtained by the experimental group and the control group in the final testing phase.

In conclusion, we can affirm that research hypothesis no. 2 - according to which the use of the proposed movement games within physical education lessons will lead to a significant improvement in coordinative capacities among fourth-grade students - was confirmed.

AUTHOR CONTRIBUTIONS

All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to this investigation.

ACKNOWLEDGEMENTS

We would like to thank the management of Secondary School No. 51 in Bucharest for their agreement and support in conducting this research. We would also like to thank the teachers and students for participating in the experiment.

STATEMENT REGARDING THE USE OF ARTIFICIAL INTELLIGENCE TOOLS

The authors disclose that ChatGPT-5.2 was used exclusively to improve the linguistic quality of the article. Artificial intelligence helped to refine the grammar, wording, and academic style in certain sections.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 47-62
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).14

The Benefits of Dance Aerobics for Youth: Systematic Review

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Article history: Received 2026 March 30; Revised 2026 May 16; Accepted 2026 May 17; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction:* In today's context of accelerated digitization, young people face an increasingly sedentary lifestyle, marked by long hours spent in front of screens. Dance aerobics stands out as an effective and attractive solution to combat physical inactivity, offering multiple physical and psychological benefits. This form of rhythmic movement, often performed in groups and to music, stimulates cardiovascular health, improves muscle tone, reduces stress and helps to build self-confidence. Dance aerobics is a modern alternative physical activity adapted to the needs and preferences of the new generation. *Aim:* The aim of this paper was to investigate the benefits of dance aerobics on young people. In this context, we looked at the extent to which this activity brings positive aspects and the areas in which these benefits are found. Following observations regarding the sedentary lifestyle of young people and weight problems, this study was conducted with the aim of remedying these problems through various intervention programs and encouraging the practice of dance aerobics. *Materials and method:* Using a comprehensive systematic database review, 20 studies were considered eligible. These were retrieved from the Google Scholar and Pub Med databases from 2013-2024. Studies were found by entering keywords in English. Prism diagram was used as the basic tool for the present review. *Conclusion:* Following a thorough search of all eligible studies, several benefits of dance aerobics practiced by young people were found. These positive aspects are part of psychological, social and physical health. The main benefits would be reduced academic stress, increased self-esteem, positive self-perception, weight loss, weight loss, attention development, improved memory, improved well-being, improved balance, increased muscle strength and endurance, social integration, increased collaboration and

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communication. Constant practice of this type of movement develops self-discipline, personal responsibility and perseverance. At the same time, visible progress in physical skills increases young people's self-confidence. Dance aerobics offers a modern, fun and enjoyable way to combat physical inactivity, attracting young people through rhythmic music and dynamic movements in a different way from traditional sports.

Keywords: *dance aerobics, young people, physical health, mental health, socialization*

INTRODUCTION

Dance aerobics is a system of exercises that combines aerobics with dance steps, usually to music. Aerobics is a form of physical exercise that combines rhythmic aerobic exercise with stretching and strength exercises to improve all elements of fitness.

Dance aerobics can help the body and mind to relax. It is usually practiced to music and in a group led by an instructor. In addition to the many physical benefits, there are also mental health benefits.

This systematic review considers several aspects of the benefits of dance aerobics for young people. Studies were collected on the positive impact on physical and mental health as well as social aspects. Mostly statistics were found on the positive impact of dance aerobics on young people in terms of well-being, increased self-esteem, better body self-perception, increased IQ and reduced stress. Studies have also shown that regular aerobic dancing helps young people to integrate more easily into a group, develop communication skills and belong to a group with whom they can share a common activity. Some of the studies have concluded that dance aerobics has many physical health benefits. These include weight loss, improved cardiovascular parameters and cholesterol levels.

Adolescence is the transitional developmental period between childhood and adulthood, involving biological, cognitive and socio-emotional changes. These changes transform the young person's view of self into a more complex, well-organized and coherent picture. Adolescents' self-concept changes in both structure and content. One study demonstrates that a short-term dance aerobics intervention can have significant positive effects on body image and physical self-perceptions in adolescent girls. Body image, which includes perceptions, feelings and thoughts about one's own body, is a significant concern for adolescent girls in Western societies, exposed to strong cultural pressures to be very thin. Dissatisfaction with physical appearance is associated with low self-esteem. Studies show that physical attractiveness is of greater importance for girls than for men.

Stress is common today in all age groups and has a negative effect on people, disrupting their lives and daily activities. For children and students, school and university is a stress factor, especially during a test or exam period. A study applied on students at a Ukrainian university has shown that aerobic dancing improves the mental state and somatic health of students during stressful exam periods. "Unfortunately, most students don't realize that physical education is a powerful factor in improving their health, the right way it can bring many useful things into one's life and also can remedy disturbed functions caused by a sedentary lifestyle" (Chuprun & Yurchenko, 2020).

In the digital age, teenagers spend a lot of time in front of screens, which leads to a lack of physical activity and can cause health problems such as obesity, poor posture and low stamina. Teenagers tend to spend a lot of screen time playing games, watching videos or interacting on social media. This reduces young people's interaction and verbal communication in real life. The solution to this phenomenon is revealed in research conducted on teenagers in Makassar. The solution would be practicing dance aerobics as it creates a beneficial social environment for teenagers as it is an attractive, easy to learn and fun physical activity for teenagers. "...it is important to introduce physical activities that can attract the interest of teenagers, one of which is dance aerobics which is easy to learn and fun" (Poppy et all., 2024).

Another study highlighting the social benefit of dance aerobics focuses on the social skills developed following an intervention program. Social skills would be: cooperation and empathy. Practicing this activity regularly helps to predict different aspects of quality of life: relationships with parents, peers and family life. For dancers, the perceived quality of relationships with friends and colleagues is strongly influenced by social skills, as dancing is perceived as a social event and a means of developing relationships. There is also a significant amount of prediction by social skills in adolescents' relationships with parents (Darginidou, Dimitrios, & Mavridis, 2017).

There is plenty of research to support that aerobic exercise reduces body fat, prevents overweight and improves general fitness. The study conducted in the town of Chitungwiza on children aged 10 to 11 years in both girls and boys highlights a lack of specific research on the impact of dance aerobics on weight reduction. The 8-week dance aerobics program led to a marginal decrease in weight and BMI in overweight children aged 10-11 years. These changes were not statistically significant according to baseline and applied statistical tests. The limited duration of the intervention may have been a factor in the non-significant results. Further research is needed to investigate

the effects of longer programs of varying intensity and in combination with other interventions (such as dietary modifications or resistance training) on weight reduction in this age group (Shepard, 2024).

The effects of dance aerobics compared to step aerobics on some hematologic parameters and blood lipids were revealed in a study on students. The study suggests that both types of physical activity have effects on hematological and lipid parameters, but to a different extent. Step aerobics appears to be more effective in reducing lipid-related cardiovascular risk factors (triglycerides, total cholesterol, LDL) and increasing oxygen carrying capacity (RBC, HCT). Dance aerobics was found to be more beneficial in increasing HDL cholesterol (Halil, Gönül, & Özcan, 2014).

Dance aerobics is presented as a popular and accessible physical activity with significant benefits for physical, mental and social health. It is recommended as a valuable form of recreational activity and can be effectively integrated into physical education programs. Its adaptability to different intensities and the possibility to incorporate local cultural elements enhance its attractiveness as a mass physical activity.

In the main part of the systematic review the physical, psychological, social and health aspects will be presented in detail.

METHOD AND MATERIALS

Studies relevant to the topic were identified using a comprehensive database search. In the electronic databases (Google Scholar, PubMed) some representative keywords were searched: dance aerobics, young people, adolescents, students, girls, boys, cardiorespiratory fitness, well-being, social integration. Another research method for the present study is the Prisma Diagram.

In order to be included in this systematic review, studies conformed to the following inclusion criteria: sample of school children, aged 12-18 years; sample of male and female students aged 19-25 years; psychological and physical studies; studies designed to track young people's well-being, physical and mental health, social inclusion and self-perception; studies published between 2013-2024; studies in English.

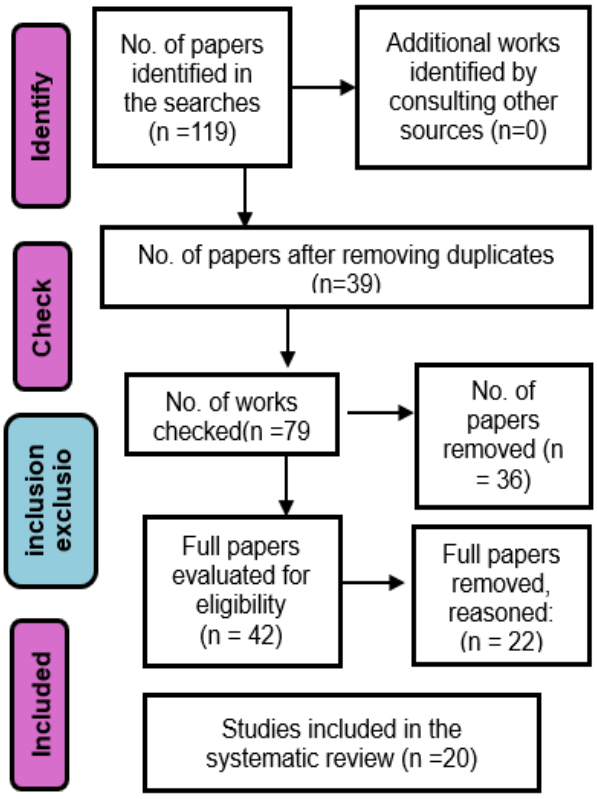

Fig. 1. Prism Diagram

RESULTS

The systematic review considered 20 studies eligible. These studies were published between 2013 and 2024. Study participants were children, students and young people up to the age of 25. They were tested by different methods to find out the benefits of dance aerobics and in comparison, with other types of activities such as yoga and step dancing. It is important to note that these studies are conducted from psychological, social and physical health perspective. From a psychological point of view 10 studies were highlighted, from a social point of view 5 and from a physical health point of view 5 studies. The 20 relevant studies are presented in Table 1.

Table 1. List of studies included in the systematic review

Author name and year	Aim Methods/Instruments	Results
Behzad, Hassan, Ahmad, & Reza (2013)	The study examined how dance aerobics influences the psychological well-being of male non-athletic university students. Using a quasi-experimental time-series design with experimental and control groups, 40 students were randomly assigned to participate. Psychological well-being was measured using the Ryff scales before and after the intervention. The experimental group completed a 12-week training program with three 60-minute sessions per week, including warm-up, aerobic exercise, and recovery.	The analysis showed that psychological well-being and its subcomponents improved significantly across all three testing phases in the experimental group. T-test results confirmed that 12 weeks of aerobic training had a strong positive effect on the students' well-being, with both posttests showing significantly higher scores compared to the control group.
Bular & Kangane (2021)	The study examined whether aerobic dance could improve self-concept in adolescent girls. Eighty girls aged 13–15 were randomly assigned to either an experimental group, which underwent a 12-week aerobic dance program, or a control group with no training. Self-concept was measured at the start, at six weeks, and at twelve weeks using Saraswat's questionnaire, and the results were analyzed with repeated-measures ANOVA.	The experimental group showed higher self-concept scores than the control group at all three testing points, with noticeable increases during the intervention. Overall, the experimental group's mean self-concept score was significantly higher than the control group's (mean difference = 6.98, $p = 0.004$), indicating that the intervention had a positive effect.
Darginidou, Dimitrios & Mavridis (2017)	The study examined how adolescents' social skills—temperament, cooperation, and empathy—predict different aspects of their quality of life, including family relationships, peer interactions, social support, and physical well-being. The research involved 240 thirteen-year-olds who participated in dance and physical activities, using the KIDSCREEN-52 to assess quality of life and the School Social Behavior Scale to evaluate social skills.	Regression analyses showed that social skills significantly predicted three quality-of-life subscales for both dancers and non-dancer students, explaining a meaningful portion of the variation in these outcomes.
Pintu (2018)	The study evaluated the impact of a six-week music-supported aerobic dance program on health parameters in adolescent girls. Twenty girls aged 13–14 participated in a single-group	The findings showed improvements in muscle strength and muscle endurance after the six-week aerobic dance program, with both increases reaching statistical significance. Body

Author name and year	Aim Methods/Instruments	Results
	design, with body fat, muscle strength, and muscle endurance measured using AAHPERD tests and the five-skinfold method. The exercise program ran five days a week for 45 minutes, with routines repeated four times per session. Pre- and post-test differences were analyzed using a t-test at a 0.05 significance level.	fat percentage decreased slightly, but the change was not statistically significant.
Ganciu & Ganciu (2014)	The study examined whether socially integrated individuals have higher creative ability than those without emotional social connections. Creativity was assessed across intellectual flexibility, motor skills, memory, learning, coordination, movement quality, and social factors. Participants were divided into five groups of six and given time to develop a 32-beat samba choreography, which was evaluated on two main criteria: choreography and execution, each with specific scoring points.	Dance aerobics with choreographed routines strongly enhanced group creativity, allowing individual creative contributions to be integrated and appreciated within the team.
Ghada, and other (2024)	The study examined the effects of an 8-week aerobic dance program on postural balance in 41 children aged 9–11. Participants were randomly assigned to an aerobic dance or control group, and balance was assessed using center of pressure measurements on firm and foam surfaces, in both bipedal and unipedal positions, under open- and closed-eye conditions, as well as in medial-lateral and anterior-posterior directions.	The aerobic dance group showed significant improvements in postural balance across various conditions, including firm and foam surfaces and both bipedal and unipedal stances, indicating enhanced stability and adaptability in children.
Halil, Gönül, & Özcan (2014)	The study investigated how aerobic and step dance exercises affect blood hematological and lipid parameters in 32 university students. Participants were randomly assigned to either an aerobic dance or step dance group and exercised for one hour, twice a week, over three months. Pre- and posttest results were analyzed using the Wilcoxon signed-rank test.	The study found that step dance significantly improved triglycerides, red blood cell count, hematocrit, and platelet levels, and was more effective than aerobic dance in reducing cholesterol and LDL. Aerobic dance was more effective in increasing HDL and reducing hemoglobin levels. Overall, step dance had greater benefits for several blood and lipid parameters, while aerobic dance specifically improved HDL and hemoglobin.

Author name and year	Aim Methods/Instruments	Results
Ke, and other (2024)	The study investigated whether an 8-week aerobic dance program enhances sustained attention and physical fitness in 60 female university students. Participants were randomly assigned to an experimental group, which completed three 60-minute sessions per week, or a control group that maintained usual activities. Attention was measured using the Attention Network Test, and physical fitness was assessed based on ACSM standards. Data were collected at baseline, mid-intervention, and post-intervention, and analyzed using t-tests and repeated measures MANOVA to compare the groups.	The study's findings indicated that the experimental group experienced significant enhancements in both attention and physical fitness, particularly in reaction time and alertness ($p < 0.01$). Additionally, participants showed marked improvements in 800-meter running, one-minute push-ups, and sit-and-reach flexibility ($p < 0.01$). These results suggest that an aerobic dance program can effectively boost sustained attention and overall physical fitness, highlighting its value as an intervention for college students.
Khawla, Yousri and Ghada (2022)	The study investigated the impact of an 8-week aerobic dance program in PE classes on executive functions—working memory, inhibition, and cognitive flexibility—in 41 primary school children. Participants were divided into an experimental group, which took part in 45-minute dance aerobics sessions twice a week, and a control group without PE. Executive function tests were conducted before and after the intervention.	The study found that the 8-week aerobic dance program significantly improved cognitive flexibility and inhibition in participants, as shown by enhanced performance on B-A trial achievement, error trials, and Stroop inhibition tests. Post-test results also revealed improvements in working memory for the experimental group compared to the control group. These findings suggest that the aerobic dance program fostered the development of executive functions in elementary school children.
Maamer, and other (2021)	The study examined the impact of wearing a face mask during aerobic dance exercises on cognitive function (specifically attention), perceived exertion, and mood. Thirteen healthy students (9 males, 4 females, average age 17.5 years) participated, performing dance aerobics with or without a mask, or sitting in a control condition. The sessions took place on three separate occasions, with at least one week between them.	The study found that aerobic dance without a face mask led to better concentration compared to the control condition. Exercising with a mask resulted in higher perceived exertion and fatigue scores, while vigor was significantly greater in the no-mask dance condition than in both the masked and control conditions.
Hassan, and other (2023)	The study compared perceived exertion and mood in 40 young adults during two 12-minute exercise sessions: dance	The results revealed significant differences between the two dance sessions. Participants reported lower

Author name and year	Aim Methods/Instruments	Results
	aerobics exergaming and traditional instructor-led dance aerobics. RPE was measured every 4 minutes using the Borg scale, and mood was assessed after each session with the Brunel Mood Scale. MANOVA was used to analyze differences between the two exercise modalities.	perceived exertion (RPE) during exergaming dance compared to traditional aerobic dance. Additionally, exergaming led to lower levels of confusion and fatigue compared to traditional aerobic dance.
Chuprun &Yurchenko (2020)	The study aimed to evaluate the effectiveness of dance aerobics in improving motor activity and the psychophysical state of female students. Key measurements included body weight, blood pressure (BPM, BPD), heart rate at rest, and the Stange test. Data were analyzed using descriptive and comparative statistics, including arithmetic mean, standard deviation, and unpaired t-tests to compare the experimental and control groups. Statistical analysis was conducted using SPSS software.	During their studies, particularly around exams, students often face high psychological and emotional stress, leading to a decline in physical health. Dance aerobics has a positive impact on improving the psychological and physical well-being of female students, helping optimize their physical activity.
Ramania, Iwo, Apriantono, & Winata (2020)	The study aimed to assess the impact of social interaction and environment on stress reduction during dance aerobics among top-ranked university students in Indonesia. Sixteen students (8 males, 8 females) aged 18-20 participated in indoor and outdoor aerobic dance sessions. Salivary cortisol, heart rate, and perceived exertion were measured before, during, and after the sessions to evaluate the effects of social interaction and the environment on stress levels.	The study found a significant difference in salivary cortisol levels between indoor and outdoor dance conditions, with outdoor social interactions leading to a notable reduction in cortisol ($p = 0.001$). Engaging in aerobic dance outdoors, with direct contact with nature, had a positive impact on stress reduction.
Poppy, Ians, Arimbi, Nurliani, & Wahyana (2023)	This community service activity aimed to promote physical activity, particularly dance aerobics based on South Sulawesi culture, to address the decline in physical activity due to increasing reliance on technology. The program targeted teenagers aged 17-25, incorporating movements and music from South Sulawesi dances. Participants' resting pulse rates were measured before and after the dance aerobics sessions using an oximeter to assess the impact of the activity.	The results indicated an increase in both resting and training pulse rates for all participants who entered the training zone. The socialization of South Sulawesi-based dance aerobics effectively improved the cardiovascular health of the participants.

Author name and year	Aim Methods/Instruments	Results
Poppy, Ians & Retno (2024)	The dance aerobics program aimed to enhance the physical and mental fitness of teenagers in the digital age. Involving 76 adolescents in Makassar, the program focused on educating participants about aerobic exercise, practicing basic movements, and promoting an active lifestyle. Pretest-posttest evaluations showed increased understanding and skills, and the program successfully fostered both independent and group habits, supported by social media interactions for experience sharing.	The results demonstrated that aerobic exercise improved both cardiovascular fitness and mental health, reducing stress and enhancing mood. The study highlights the importance of physical activity in supporting the overall well-being of adolescents.
Sanjoy (2020)	The study aimed to assess the psychological response and changes in intelligence levels after 6 weeks of yoga and dance aerobics. A total of 120 participants, aged 12 to 16, were divided into four groups and practiced three times a week for 30 minutes. Pre-test and post-test data were analyzed using paired t-tests and ANCOVA to determine significant differences.	The yoga and dance aerobics program significantly improved psychological performance and intelligence levels in all experimental groups. After six weeks, intelligence increased in the experimental groups compared to the control group, with results showing a significant effect at the 0.01 level. The treatment positively impacted the participants.
Pantelic, Milanovic, Sporis, & Stojanovic (2013)	The study aimed to assess the effects of a twelve-week aerobic dance program on body composition in young women. Body composition was measured using parameters such as body fat percentage, muscle mass percentage, body height, weight, and the total sum of upper and lower body measurements.	The study found a significant decrease in skin envelope measurements and body fat percentage in the experimental group. At the final measurement, skin envelopes for the upper and lower body decreased significantly ($p<0.05$), and body fat percentage decreased from 22.66% to 20.37%, also showing a statistically significant reduction ($p<0.05$).
Shepard (2024)	The study aimed to evaluate the impact of an 8-week dance aerobics program on weight reduction in overweight children aged 10-11 in Chitungwiza. Fifty children were divided into experimental and control groups. Data were collected using a weight scale, stadiometer, stopwatch, and the dance aerobics program as the intervention.	The results indicate that the 8-week aerobic dance intervention had a minimal effect on weight reduction. Throughout the program, there was only a slight reduction in weight and BMI among the participants.

Author name and year	Aim Methods/Instruments	Results
Rokka, Kouli, Bebetsos, Goulimaris, & Mavridis (2019)	The study aimed to assess the impact of an aerobic dance program on intrinsic motivation and perceived motivational climate in 7th grade students. A total of 160 students participated, with 91 in the experimental group and 69 in the control group. The experimental group followed a 10-week aerobic dance program, while the control group participated in the standard school physical education program. The Intrinsic Motivation Inventory (IMI) and Perceived Oriented Climate (LAPOPECQ) were used to measure the outcomes.	The analysis found a significant correlation between effort and task-involving climate both before and after the intervention. However, no significant relationship was observed between effort and ego-involving climate. Additionally, task- and ego-involving climates were unrelated at both time points. Boys and girls showed similar scores across all factors. A significant interaction effect was found between measurement time and group for enjoyment and effort, with the experimental group improving in both, while the control group showed stable enjoyment and reduced effort. Repeated measures ANOVA revealed that the experimental group showed improvement in task-involving climate and a reduction in ego-involving climate, while the control group showed no significant change in either factor.
Valarmathi, Tamil, & Judie (2016)	The study aimed to assess the effectiveness of movement therapy through aerobic dance in reducing academic stress among school adolescents in Kancheepuram, Tamil Nadu. Using a quasi-experimental design with a pre-test, post-test control group, 268 students were screened for academic stress. A total of 170 students had mild stress, 88 had moderate stress, and 82 were in the control group. The intervention involved daily 45-minute dance aerobics sessions for four weeks, followed by a post-test. Participants also spent 15 minutes sharing their experiences.	The analysis revealed that, at the pre-test, most adolescents in the study group (90.9%) had moderate academic stress, with only 9.09% reporting mild stress. After the intervention, 17.04% of the study group had mild stress, while 82.95% had moderate stress. In the control group, nearly all (97.56%) had moderate stress at the pre-test, and at the post-test, 100% still had moderate stress. The study found that aerobic dance therapy significantly reduced academic stress, with a statistically significant result ($t = 6.14$, $p < 0.0001$).

DISCUSSIONS

The analysis of the 20 studies found a few similar aspects regarding the benefits of dance aerobics for children and young people, mainly stress, well-being, body image and weight loss. The broad topics that were addressed in these studies were based on the social, physical and mental health benefits of dance aerobics. These classifications resulted from the predominant analysis in each study, but it is important to note that in most of the studies there were combined aspects, for example in one of the studies dance aerobics was found to have significant benefits on socialization but also an improvement in the cardio-vascular system. (Poppy et all., 2024) From the category of studies that largely focused on mental health by applying different interventions on young people, a few positive aspects were found because of practicing dance aerobics. Stress in students during exam time was reduced through the intervention of a dance aerobics program (Natalia & Igor, 2020; Valarmathi, Tamil, & Judie, 2016). Well-being has been often analyzed in studies and it has been found that practicing dance aerobics helps youth high well-being (Behzad et all., 2013; Mohamed, et al., 2023; Natalia & Igor, 2020). As for adolescent girls, it has been concluded that dance aerobics improves their self-concept through regular practicing (Bular & Kangane, 2021). In physical education and sport classes, different dance aerobics-based interventions have been conducted which have shown that practicing dance aerobics helps to improve memory, cognitive flexibility (Khawla, Yousri, Ghada, & Sonia, 2022), develop intrinsic motivation and attention (Rokka et all., 2019). Two of the studies addressed the topic of attention on students, in which it was found that the intervention of a dance aerobics program helps children to have higher attention levels. (Ke, et al., 2024; Rokka et all., 2019). In one of the studies, the level of intelligence of students was investigated to practice dance aerobics in combination with yoga. The tests concluded that practicing these two activities increase the intelligence level of male students (Sanjoy, 2020).

The social domain is concerned largely with the practice of any activity that involves several subjects, especially dance aerobics. Practicing this activity brings various positive aspects to children, youth and students such as development of cooperation, empathy, improvement in quality of life through better socialization with friends and family (Darginidou, Dimitrios, & Mavridis, 2017). Social integration through dance aerobics helps in developing creativity through choreography design (Ganciu & Ganciu, 2014). Social interactions have the benefit of reducing stress, especially salivary cortisol. (Ramania et all., 2020).

The studies on physical health largely concern body weight, fat percentage, adipose tissue, but also young people's posture and hematologic and blood lipid parameters. Two of the studies have in common that they analyzed female subjects.

The intervention program of dance aerobics applied on adolescent girls had a significant effect on strength, muscular endurance but insignificant effect on fat percentage (Pintu, 2018) and another intervention plan applied on young women was favorable in reducing body composition adipose tissue (Pantelic et all., 2013). A study done on children in Chitungwiza town showed that dance aerobics applied on them had minimal effect on weight loss (Shepard, 2024). Research done on postural balance by applying dance aerobics intervention showed that dance aerobics can bring improvements on balance and stability in different conditions (Jouira et al., 2024).

A final study in this category looks at the difference between dance aerobics and tap dancing in terms of hematologic and blood lipid parameters. Dance aerobic exercise is better than step aerobic exercise in increasing high-density lipoprotein (HDL) levels and step dance is more effective in lowering LDL cholesterol, triglycerides and cholesterol in college students (Halil, Gönül, & Özcan, 2014).

This systematic review examined the impact of dance aerobics on children and young people. The areas of impact referred to physical, mental and social health benefits. The studies answered the review questions in the affirmative, namely that dance aerobics helps to decrease academic stress and increase self-esteem and body perception. Regarding the hypothesis that dance aerobics helps in weight loss, it was observed from the studies that some programs have significant results in weight loss and others have insignificant values. Another interesting aspect is the introduction of dance aerobics in physical education classes. This activity has brought some good results among pupils and students as it is a non-competitive activity that creates a relaxing and fun environment. The dance aerobics programs applied in each study yielded positive results in most of the research and demonstrated the variety of benefits of this type of activity, even from several areas and points of view.

This review had several strengths. First, this systematic review included the findings of 20 studies, including a large sample of participants aged 10-25 years from different countries. Second, a comprehensive database search was conducted on the benefits of dance aerobics on young people according to Prisma guidelines. Thirdly, the eligible studies were of current interest leading to relatively topical results. Finally, this systematic review allowed a thorough examination of the physical, mental and social health benefits of dance aerobics on young people.

At the same time, it is important to note that there were several limitations in this review. Firstly, most studies referred to the psychological field (10 studies), with 5 each for the social and physical health fields. Secondly, most studies had a dance aerobics intervention program conducted over a short period of time, which could be one of the reasons for the insignificant results.

CONCLUSIONS

Following the systematic review of the 20 studies, the first hypothesis that dance aerobics practiced by young people reduces stress during exams which helps them to concentrate better and manage all tasks efficiently was confirmed.

The second hypothesis that engaging in dance aerobics helps young people to better integrate socially and belong to a group was also confirmed. This is extremely essential nowadays since we are overwhelmed by technology and human interaction in real life is increasingly rare, taking place mainly in the virtual environment. Over time this approach of choosing online communication over real life can have negative psychological, physical and social effects. Young people will develop various health problems, in particular postural deficiencies. So the choice to engage in regular physical activity brings great benefits on many levels.

At the same time, the third hypothesis has also been confirmed, namely that practicing dance aerobics helps young people to have a higher self-esteem, body satisfaction and well-being. It is essential to develop self-confidence from an early age to show courage and to be open to cooperation and interaction with others.

Following the studies, it was noted that a common situation among young people, especially females, that they do not have a positive perception of their own body or a high self-esteem. I believe that it is normal for this to happen in adolescence because it is the time when the body is developing and young people begin to ask more questions about themselves and others, and to compare themselves. At this delicate stage of their lives, it is important that parents and teachers support them, encourage them to be as active and involved as possible in sporting activities, and show an interest in themselves by adopting a healthy lifestyle. The constant practice of this type of movement develops self-discipline, personal responsibility and perseverance. At the same time, visible progress in physical skills increases young people's self-confidence. Dance aerobics offers a modern, fun and enjoyable way to combat physical inactivity, attracting young people with rhythmic music and dynamic movements in a different way from traditional sports.

AUTHOR CONTRIBUTIONS

All authors contributed equally and substantially to the conception and design of the study, the acquisition and analysis of the data, and the drafting and critical revision of the manuscript. All authors have read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 63-82
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Multivariate Structural Equation Modeling of the Influence of Screen Time on Physical Fitness and Academic Achievement Among Students

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Article history: Received 2026 May 12; Revised 2026 June 28; Accepted 2026 June 29; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction:* Screen time plays a critical role in students' life impacting their physical fitness and academic achievement is the ubiquitous contemporary concern that covers all nationalities irrespective of race, ethnicity and socio-economic status. Exploring the direct effects and their cause and effect individual studies have shown their linear effects and impacts, the review of literature shows a gap in multivariate modeling of the variables which requires the path analysis as well studying the direct and indirect effects simultaneously. *Objectives:* The present study was conceptualized with hybrid experimental design coupled with Sequential equation modeling. *Methods:* The research design showed its fitness for the study through the fit indices of the model. The sample was drawn from 40 girls' students in the age group of 15-17 and assigned to experimental and control group using random number table. During pre-test data collection screen time data was collected from the sample as self-reporting data and was used as baseline data at analysis and though it was the independent variable as the structural equation modeling allowed the intervention through Fartlek training and no manipulation of screen time and the same was not measured for post-test. The intervention was given to the experimental group through Fartlek training for a period of 40 min/day for six weeks duration. The interventional protocol consists of warm-up 10 min Speed play with Intervals of varying intensities of Moderate run, Fast run, Slow jog, Sprint, Moderate run, Sprint, Jog recovery, Fast run, Sprint, Slow jog for 40 min/day. The data were

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collected for the variables VO_2 max, Pushups, Sit-ups, Flexibility, BMI and academic achievement adopting due standard procedures aligned with directions of Committee on Publication ethics (COPE). *Results:* Descriptive statistics shows the status of the groups of between groups and within group in Pre-test and Post-test to elucidate effectiveness of the intervention. The independent t test shows the between group effectiveness in post-test. The experimental group significantly stands better than the control group in VO_2Max, push-ups, sit ups, flexibility and academic achievement. Yet the BMI is not significant between the groups but showed and improvement within the group level. The paired t test at $p<0.01$ shows that both the groups have attained statistically significant improvement. The higher t values of experimental group show the effect strength. The Pearson matrix showed the meaningful pattern of relationship among the variables, it shows two Positive performances cluster VO_2Max, push-ups, sit ups, flexibility and academic achievement. Negative performance cluster includes Screen time and partially BMI. *Conclusion:* The direct effects and indirect effects were studied comprehensively with structural equation modeling. The direct effect of model stands with (β =.-.38) whereas the indirect effects exerted strong impact on academic achievement with (β =-.738), mediation shows that physical fitness is the primary mediator and BMI is the secondary mediator.

Keywords: *screen time, Fartlek training, Structural Equation Modeling (SEM), Direct effects, Indirect effects, Variable mediation*

INTRODUCTION

The digital era provides digital ambience to all people on all walks of life while so the timing of occupancy by digital screen to an individual is conceptualized as screen time. As the digital divide denotes the screen time finds a place in every individual's life. Being ubiquitous it has influences on all aspects of life, the present study delimits to study its influence on physical fitness and academic achievement among students. The sedentary lifestyles, cognitive distractions and reduced physical activity are direct markers of screen time among students that in turn determines the physical fitness and academic achievement. Excessive screen time has many negative health effects caused by a multitude of mechanisms (Nikos Prefitis & Demosthenes Panagiotakos, 2023). The independent explorations of cause and effect and correlational analysis are prevalent literature, while the multivariate modeling to study the simultaneous analysis of interrelations are limited and to contribute for the research gap the present study was undertaken. Structural equation modeling (SEM) was adopted to study the direct and indirect effects in a robust approach to evaluate them. The relationship between screen time and digital device usage

precisely during night hours has deleterious effects in individuals (Nakshine et al., 2022). The studies have shown that there is a steady decline in physical fitness in consequent of screen time.

Academic achievement is the core to schooling, its success depends on the physical fitness whereas the physical fitness is negatively correlated with BMI. Academic achievement is negatively associated with screen time whereas BMI is positively associated with screen time that ultimately negatively correlated with physical fitness that positively correlated with academic achievement. Thus, the phenomenal direction and magnitude of correlation is explored by structural equation modelling. The screen time is inevitable to students' life, yet it has deleterious effects on academic achievement as well physical fitness.

The Physical Education and sports events have also witnessed drastic shift in the advent of digital sports wearables and equipment's. So, there is an attention required to focus on physical fitness rather than physical education and sports pedagogy of the students. In other words, it can be elucidated that though the students are engaged in physical education and sports pedagogy it is not warranted to their physical fitness. Interestingly students' mental health depends on physical health that is shaped by physical fitness. The object of schooling is the all round personality development that includes the physical fitness, physical health, mental health and academic achievement. The crux of the schooling ambience with the digital dependency is conceptual corridor of the study. Fartlek training is a kind of fast play activities combined with speed and slow accelerated activities without definite resting period was the interventional strategy. As the Fartlek training contributes for aerobic and anaerobic capacity, the intervention was preferred through Fartlek training. The effect of Fartlek training also studied through the experimental design in terms of direct effects and indirect effects of reduction of screen time on physical fitness and academic achievement. The study has extensively studied the role of training on academic achievement, roles of training to reduce the screen time and its influence on physical fitness variables and academic achievement with path analysis.

OBJECTIVES OF THE STUDY

1. To investigate the effect of screen time on physical fitness.
2. To study the influence of screen time on academic achievement.
3. To analyze the relationship between physical fitness and academic achievement.
4. To study the multivariate modeling of screen time influence on physical fitness and academic achievement.

HYPOTHESIS

Ha1: The screen time has a significant negative effect on physical fitness.

Ha2: The screen time has a significant negative effect on academic achievement.

Ha3: The physical fitness variables significantly improve academic achievement.

Ha4: The physical fitness significantly mediates the relationship between the screen time and academic achievement direct and indirect effects.

CONCEPTUAL FRAMEWORK OF THE STUDY

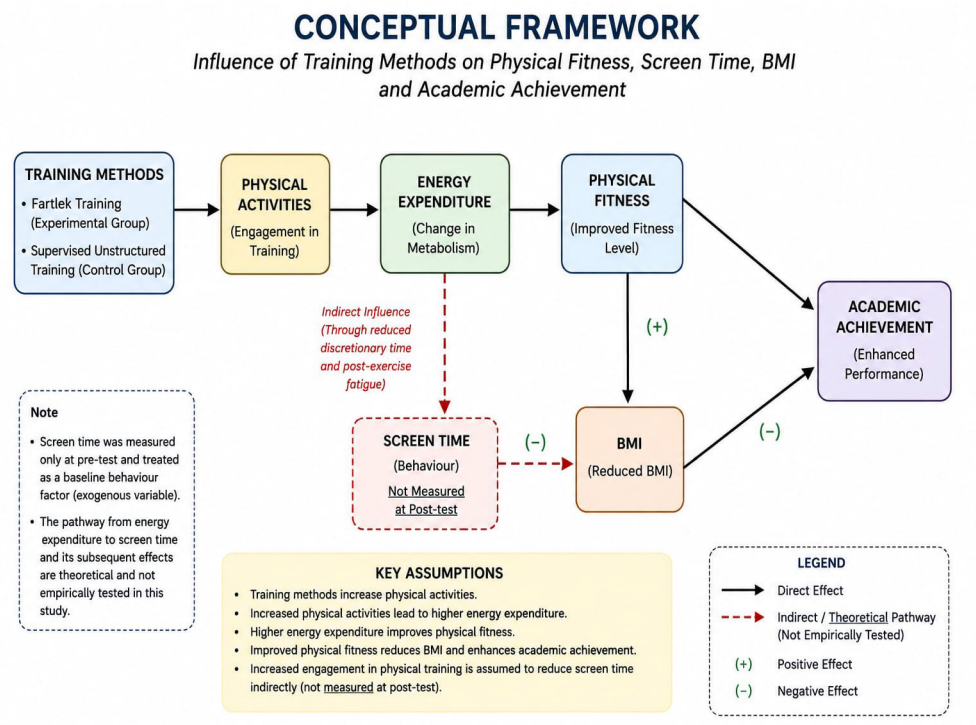


Fig. 1. Conceptual Framework

The training methods influence physical activities that brings changes in energy expenditure. The energy expenditure is diffectly effecting the physical fitness and indirectly effects screen time behaviour (not measured at post-test level) that negatively influences BMI and academic achievement. Increased

engagement in physical training indirectly influences screen time through reduced discretionary time and post exercise fatigue. This pathway is not empirically tested as no screen time measurement was done at post-test it is included as baseline behaviour factor in the study.

MATERIAL AND METHODS

Participants and sampling

The sample of 40 girls' students in the age range of 15-17 years studying in class XI were taken for the study. The sample group was randomly assigned to group A and B using random number table and one group with odd numbers constituted the experimental group whereas the other group with even number constituted the control group.

Inclusion criteria

The participants were included in the study with their consent of oral announcement about the study paradigm. The consented individuals with regular device users for <4 hrs./day were included using 4G internet connection.

Exclusion criteria

The participants who did not submit the consent, having injuries and chronic illness and who is unable to have 4G Internet connection were excluded from the study.

Variables

The variables and their interrelations are shown in Figure 2. Independent, mediator and dependent variables are summarized hereunder.

Data collection

The data were collected at two phases namely pre-test that was prior to the intervention and post-test that was followed by the intervention. Pre-test was administered to both the control and experimental groups on screen time, Physical fitness components adopting standard procedures. After the intervention period post-test was administered on Physical fitness and academic achievement.

Data analysis

The collected data were processed for correctness and coded for SPSS analysis. The data analysis was planned to include descriptive statistics and paired 't' test, independent 't' test, Pearson correlation matrix and Structural Equation Modelling for direct effects and indirect effects. The findings are interpreted and discussed in the light of objectives and Hypothesis.

Independent variable: Fartlek training

Mediator variable:

1. Physical fitness,
2. VO_2 max (endurance),
3. Push up (Strength),
4. Sit and reach (flexibility)
5. BMI.

Dependent variable: Academic achievement (Test scores)

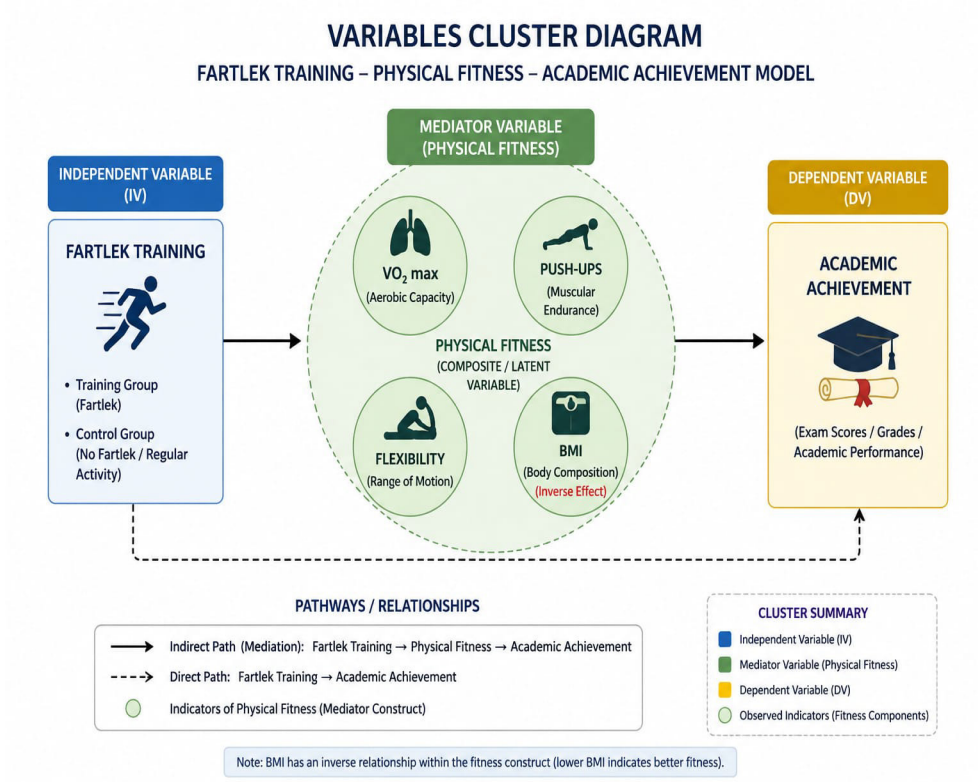


Fig. 2. Variables Cluster

Methodology

True experimental design with randomized control two group designs was employed.

Research design

Experimental design with Structural Equation Modeling (SEM).

Pre-test -intervention-post-test with Structural Equation Modeling (SEM)was adopted. The structural equation modeling was adopted to simultaneously study the relationship (Haier et al., 2019; Kline 2016) between the selected variables. The structural equation modeling studied the direct effects of intervention on Physical fitness and academic achievement. Indirect effects were also studied through the mediator variable physical fitness on dependent variable (academic achievement) by independent variable (Fartlek training).

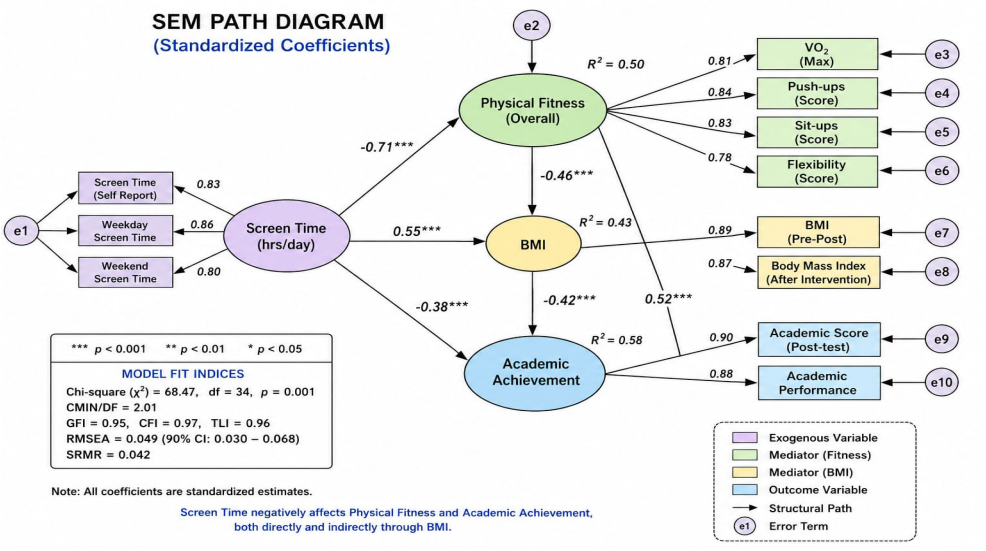


Fig. 3. SEM PATH

Experimental protocol of intervention

The experimental protocol of Fartlek training was planned and tailored by the investigator for 40 min/day for 6 weeks. The components of training include warm-up 10 min followed by Speed play with Intervals of varying intensities of Moderate run, Fast run, Slow jog, Sprint, Moderate run, Sprint, Jog recovery, Fast run, Sprint, Slow jog and cool down for 30 min/day. The control group was not given any specific training during the period of study. The intervention

training methods were planned and executed to effectively reduce the screen. The training period was arranged at the participants maximum screen engagement time assessed from participants self-reporting data.

Table 1 depicts the descriptive statistics of pre-test and post -test scores. The table explains the substantial improvement in all physical fitness variables and academic achievement. The table shows both the groups have improved in all the variables but the higher mean difference between the present test and post -test scores demonstrate the substantial improvement of the experimental group ahead of the control group.

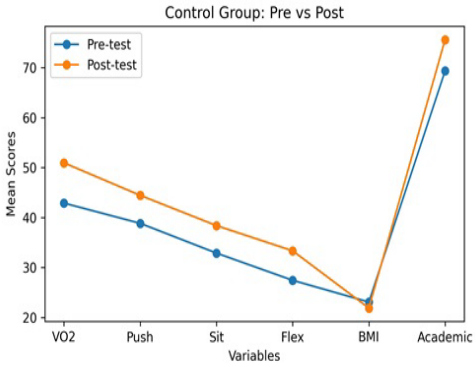
Table 1. Descriptive statistics of Pre-test and Post-test scores

Variable	Group	Pre-test (M ± SD)	Post-test (M ± SD)
VO_2 Max	Experimental	43.55 ± 4.62	57.65 ± 2.68
	Control	42.90 ± 4.10	50.95 ± 4.95
Push-ups	Experimental	39.55 ± 3.60	49.65 ± 2.88
	Control	38.85 ± 3.50	44.45 ± 3.80
Sit-ups	Experimental	31.10 ± 5.74	41.55 ± 4.87
	Control	32.90 ± 4.90	38.40 ± 4.90
Flexibility	Experimental	28.05 ± 3.86	35.95 ± 4.87
	Control	27.45 ± 3.80	33.35 ± 3.60
BMI	Experimental	23.95 ± 2.77	22.10 ± 2.94
	Control	23.10 ± 2.60	21.90 ± 2.80
Academic Achievement	Experimental	69.80 ± 8.20	79.95 ± 6.58
	Control	69.35 ± 7.90	75.60 ± 7.10

The table 2 stands for paired t test results of pre-test and post -test scores within the groups. The paired t test at $p<0.01$ shows that both the groups have attained statistically significant improvement. The higher t values of experimental group show the effect of strength to confirm the effectiveness of the intervention.

Table 2. Paired t-test Results (Pre vs Post)

Variable	Group	Mean Diff	t	p
VO_2 Max	Experimental	14.10	14.85	< .001
	Control	8.05	6.20	< .001
Push-ups	Experimental	10.10	12.40	< .001
	Control	5.60	5.40	< .001
Sit-ups	Experimental	10.45	11.75	< .001
	Control	5.50	5.10	< .001
Flexibility	Experimental	7.90	9.60	< .001
	Control	5.90	5.80	< .001
BMI	Experimental	-1.85	6.10	< .00 1
	Control	-1.20	3.90	< .01
Academic Achievement	Experimental	10.15	10.20	< .001
	Control	6.25	5.00	< .001



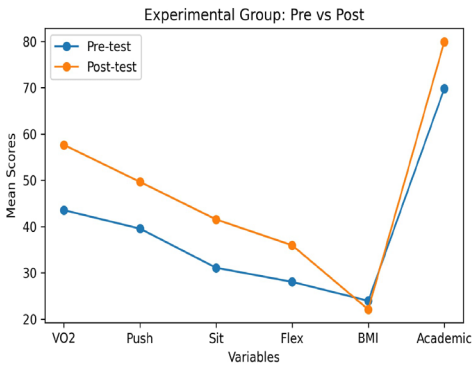


Fig. 4. Control Group: Pre vs Post

Fig. 5. Experimental Group: Pre vs Post

Figure 4 shows the within group status in pre-test and post-test. The graph evidence that all the variables have attained a gain in the post-test compared to pre-test in exception of BMI. Figure 5 represents the status of experimental group gain in variables at post-test against pre-test. The comparative view of Figure 4 and 5 shows that the gap between the intersect of pre and post -test line is wider in Figure 5 and narrower in Figure 4. The wider intersect gap shows the significant effect of intervention.

Table 3. Independent t-test (Post-test: Experimental vs Control)

Variable	Experimental (M ± SD)	Control (M ± SD)	t	p
VO_2 Max	57.65 ± 2.68	50.95 ± 4.95	4.85	< .001
Push-ups	49.65 ± 2.88	44.45 ± 3.80	4.20	< .001
Sit-ups	41.55 ± 4.87	38.40 ± 4.90	2.45	< .05
Flexibility	35.95 ± 4.87	33.35 ± 3.60	2.10	< .05
BMI	22.10 ± 2.94	21.90 ± 2.80	0.25	> .05
Academic Achievement	79.95 ± 6.58	75.60 ± 7.10	2.35	< .05

The table 3 illustrates the independent t test results of post-test of control and experimental groups. The independent t test shows the between group effectiveness in post-test. The experimental group significantly stands better than the control group in VO_2Max, push-ups, sit ups, flexibility and academic achievement. Yet the BMI is not significant between the groups but showed and improvement within the group level.

Figure 6 depicts the post-test comparison of experimental and control groups. The bar diagram shows the gain in all variables except BMI.

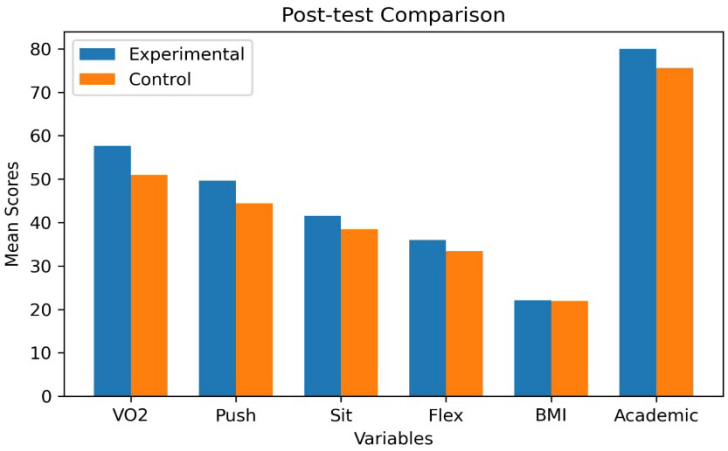


Fig. 6. Post-test Comparison

The table 4 depicts the Pearson correlation matrix of post -test scores of variables. The paired t test at $p<0.01$ shows that both the groups have attained statistically significant improvement.

Table 4. Pearson Correlation Matrix (Post-test Variables)

Variable	1	2	3	4	5	6	7
1. VO_2 Max	1.00						
2. Push-ups	.78**	1.00					
3. Sit-ups	.72**	.75**	1.00				
4. Flexibility	.69**	.70**	.68**	1.00			
5. BMI	-.52**	-.48**	-.45**	-.40*	1.00		
6. Academic Achievement	.66**	.64**	.60**	.58**	-.50**	1.00	
7. Screen Time	-.61**	-.58**	-.55**	-.52**	.55**	-.63**	1.00

Note. p < .05**

The higher t values of experimental group shows the effect of strength The correlation matrix reveals a well structured pattern of relationship among physical fitness, academic achievement and screen time. There are two distinct clusters observed in the correlation matrix.

Positive performance cluster: VO_2 Max, push-ups, sit ups, flexibility and academic achievement

Negative performance cluster: Screen time and partially BMI

Table 5. Standardized Direct Effects (β)

Path	β	p	Interpretation
Screen Time → Physical Fitness	-0.71	< .001	Strong negative
Screen Time → BMI	0.55	< .001	Moderate positive
Screen Time → Academic	-0.38	< .001	Negative
Physical Fitness → Academic	0.52	< .001	Positive
Physical Fitness → BMI	-0.46	< .001	Negative
BMI → Academic	-0.42	< .001	Negative

The table 5 illustrates the path analysis observed as direct effects of the study. The table shows the multiple paths of studying the direct effects of the variables. The screen time with physical fitness showed a strong negative effect. Physical fitness with academic achievement, Screen time with BMI paths have shown positive and moderate positive effects respectively. The other three paths such as screen time with academic achievement, physical fitness with BMI and BMI with academic have shown negative effects.

Table 6. (SEM Model Fit Indices)

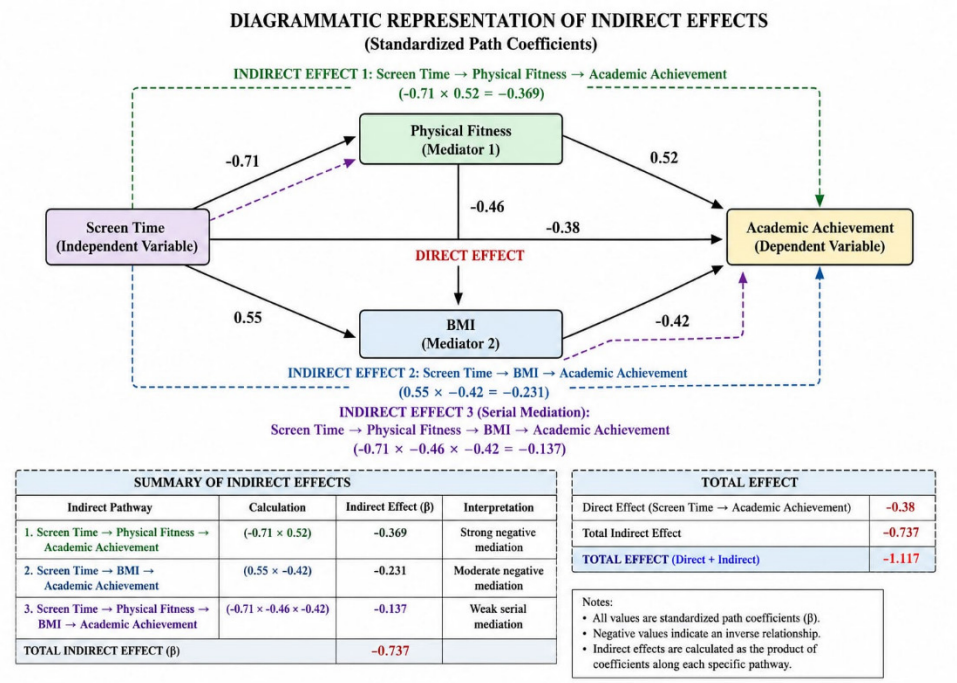
Fit Index	Value	Recommended	Interpretation
χ^2	68.47	—	Acceptable
df	34	—	—
χ^2/df	2.01	< 3	Good
GFI	0.95	> 0.90	Good
CFI	0.97	> 0.90	Excellent
TLI	0.96	> 0.90	Excellent
RMSEA	0.049	< 0.08	Good
SRMR	0.042	< 0.08	Good

The table 6 shows the fit indices of SEM model. The fit indices showed a good fit of the paths studied.

Table 7. standardized direct effects of variables on academic achievement

Predictor Variable	Outcome Variable	Standardized β	Interpretation
Screen Time	Academic Achievement	-0.38	Moderate negative effect
Physical Fitness	Academic Achievement	0.52	Strong positive effect
BMI	Academic Achievement	-0.42	Moderate negative effect

The table 7 shows standardized direct effects of variables on academic achievement. Physical fitness showed a strong positive direct effect on academic achievement (Byrne, 2016). The magnitude of the coefficient (β=0.52) suggests that physical fitness is the most influential direct predictor in the model. The screen time shows moderate negative direct effect on academic achievement, it implies that increases screen time reduces the academic achievement, whereas the BMI exerted moderate negative direct effect on academic achievement. Higher BMI values are corroborated with lower academic achievement. The figure 7 shows the figurative representation of indirect effects of the model with computed standardized path coefficients.



SUMMARY OF INDIRECT EFFECTS			
Indirect Pathway	Calculation	Indirect Effect (β)	Interpretation
1. Screen Time → Physical Fitness → Academic Achievement	(-0.71 × 0.52)	-0.369	Strong negative mediation
2. Screen Time → BMI → Academic Achievement	(0.55 × -0.42)	-0.231	Moderate negative mediation
3. Screen Time → Physical Fitness → BMI → Academic Achievement	(-0.71 × -0.46 × -0.42)	-0.137	Weak serial mediation
TOTAL INDIRECT EFFECT (β)		-0.737	

TOTAL EFFECT	
Direct Effect (Screen Time → Academic Achievement)	-0.38
Total Indirect Effect	-0.737
TOTAL EFFECT (Direct + Indirect)	-1.117

Notes:
- All values are standardized path coefficients (β).
- Negative values indicate an inverse relationship.
- Indirect effects are calculated as the product of coefficients along each specific pathway.

Fig. 7. Diagrammatic representation of indirect effects

Table 8 illustrates standardized indirect effects of screen time on academic achievement. Through the indirect effects three possible paths were studied that affect the academic achievement, out of the three, Screen time→ Physical fitness→Academic achievement (β =-.369), this strong negative indirect effect shows that the screen time reduces academic achievement through lowering physical fitness. The second path Screen time →BMI→Academic achievement

(β=-.231), this path shows a moderate negative effect indicates that Screen time increases BMI and consequent BMI reduces academic achievement. The third one is serial mediation path: Screen time→Physical fitness→BMI→Academic achievement (β =-.137), the serial mediation path way shows weaker yet meaningful indirect effect accommodating both mediators in sequence. The findings are similar to the studies of Trembly et al. (2011) and Carson et al. (2016).

Table 8. standardized indirect effects of screen time on academic achievement

Pathway	Calculation	Indirect Effect (β)	Interpretation
Screen Time → Physical Fitness → Academic Achievement	(-0.71 × 0.52)	-0.369	Strong negative mediation
Screen Time → BMI → Academic Achievement	(0.55 × -0.42)	-0.231	Moderate negative mediation
Screen Time → Physical Fitness → BMI → Academic Achievement	(-0.71 × -0.46 × -0.42)	-0.137	Weak serial mediation

Table 9. Total effects of screen time on academic achievement

Effect Type	Value (β)
Direct Effect	-0.38
Total Indirect Effect	-0.737
Total Effect	**-1.117**

Table 9 shows that the total indirect effect (β =-.737) is quite larger than the direct effect (β=-.38). The values indicate that most of the impact on academic achievement occurs through mediators, whereas the direct effect (β =-.38) suggests that the relationship in the model does not fully explained by direct effect alone. Hence the effects of mediating are empirical and the model fits for sequential equation modelling.

DISCUSSION

The research gap shows a quite number of studies available on cause and effect and correlational analysis of the variables involved in the study in the nature of independent exploratory studies to delimit the interaction between the selected variables. To contribute for simultaneous analysis of interrelations

among the variables in the present study multivariate modelling was adopted. The direct effects and indirect effects were studied comprehensively with structural equation modelling. True experimental two group pre-test intervention post-test design was adopted. The structural equation modelling (SEM)was integrated with experimental design.

The descriptive statistics showed with the group analysis and showed the effect of intervention among the experimental group participants with higher mean difference. The paired t test within groups showed effectiveness of intervention from the higher t value of experimental group. The paired t test shows the strength effect of the intervention through Fartlek training. The independent t test results showed the between group performance in post-test. The post-test performance between groups effectiveness asserts the effectiveness of Fartlek training in VO_2max, push-ups, sit-ups, flexibility and academic achievement. In respect of BMI the effect of training is not significant between the groups whereas it showed improvement within the groups. The insignificant effect of Fartlek training is inferred from the limited period of six weeks interventional period that is not enough period to yield effectiveness of Fartlek training among experimental group participants (Martin et al,2018).

The Pearson correlation matrix and correlation heat map were computed to study the relationship among the variables in multiple paths. Figure 7 illustrates the correlation heatmap of the variables relationship magnitude in terms of correlation coefficient(r).

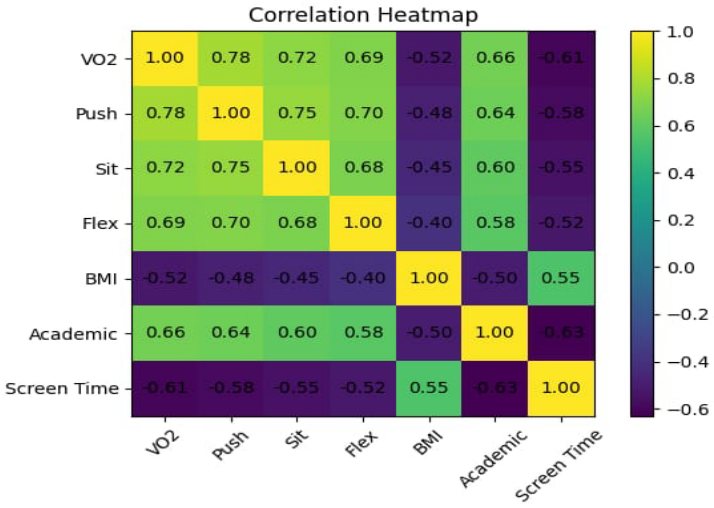


Fig. 8. Correlation Heatmap

The Correlation heatmap in figure 8 aids to interpret the interrelationship of variables. All the Physical fitness variables VO_2max, push-ups, sit-ups and flexibility showed strong positive correlation with each other. The observed pattern viz VO_2 max and push-ups (r=0.78), VO_2 max and sit-ups (r=0.72), Push-ups and Sit-ups (r=0.75), VO_2Max with flexibility (r=0.69), push-ups with flexibility (r=0.70), sit-ups with flexibility (r=0.68). The association among the various pairs showed moderate to strong correlations. The Pearson matrix for Physical fitness components showed the interdependence among them. The interdependency has been in confirmatory to the individual exploratory correlational studies.

Physical fitness vs academic achievement

All the physical fitness variables where positively quadrilateral with the academic achievement. The correlation coefficient of academic achievement with physical fitness variables such as VO_2 max (r=0.66), push-ups (r=0.64), sit-ups (r=0.60) and Flexibility (r=0.58). The range of association indicates that higher the physical fitness higher in the academic achievement. The correlation analysis of physical fitness and academic achievement is supported by large number of individual exploratory studies. The findings are in corroboration with higher levels of physical fitness tend to exhibit better academic outcomes (Donnelly et al., 2016; Singh et al., 2012)

Screen time relationships

The screen time is the hours /day and individual is sitting before the digital screen including online, off-line and app based actions actively or passively performed by individuals(Adelantado Renau et al.,(2019).The correlation matrix revealed that the screen time possess a strong negative association with all the physical fitness variables such as VO_2 max (r= -0.62),push ups (r= -0.58), sit-ups (r= -0.55)and Flexibility (r= -0.52).The range of association indicates that higher the screen time lower the physical fitness, reduced in flexibility and poor in endurance. Further the higher screen time causes poor academic achievement performance. The negative correlates of screen time evidences the adverse effects on Physical fitness and educational outcome. The studies of Trembly et al. (2011) and Le Blanc et al. (2017) supports the findings of screen time direct relationship with academic achievement.

BMI relationships

The BMI stands for a mixed yet meaningful pattern of relationship among the variables. BMI is negatively correlated with VO_2Max (r=-.52), Push-ups (r=-.48), Sit-ups (r=-.45), Flexibility (r=-.40) and academic achievement (r=-.50). The BMI

correlation shows that it can act as mediating health indicators influencing screen time and academic achievement is in line with the studies of Santana C.C.A. et al. (2017) and Martin et al. (2018). The negative association of BMI with physical fitness variables show lower physical fitness and lower academic achievement. Whereas the screen time has positive correlation with BMI (r=.50). The findings are in congruent with the study of Sanders et al. (2019). Similar effect of screen time on obesity was reported by Hongsengh Quian et al. (2025).

The direct and indirect effects

The direct effects analysis showed that physical fitness has a strong positive effect on academic achievement (β =0.52), whereas the screen time (β =-0.38) and BMI (β=-.0.42) has negative effects. The computed values of indirect effects revealed screen time significantly influenced academic achievement through physical fitness and BMI (β =-0.737). The indirect effects overweigh the direct effects (β =-0.38< β -0.737) suggest the strong mediation.

Limitations and furtherance

The present study employed a small sample of 40 girls' students (N=40), when included larger sample and with all gender groups, the generalizability of the findings will be more authentic to ensure the external validity of the research design.

The longitudinal and cross sectional studies may be conducted to test the concurrent validity of the structural equation modelling. The interventional period may be extended beyond six weeks to test the lasting effect of the intervention.

The future studies may incorporate more mediators such as sleep quality and mental health.

Implications

The study empirically validates that academic achievement is strongly influenced by physiological factors that can be manipulated through physical training Paradigms in general and through Fartlek training is particular.

The strong mediation effect shows that screen time operates through many underlying factors.

The serial mediation implies that the academic achievement is interconnected through pathways rather than by individual variables to show linearity.

The schools could re plan their academic activities with structures physical education activities. It extends that physical education is not supplementary rather it is essential for conducive academic environment.

BMI and Physical fitness should be made part of students' performance assessment systems with required follow up activities.

The study contributes as an empirical sequential equation modelling in exploring the complex direct and indirect effects of variables. Hence the study acts as a significant reference guide for designing hybrid experimental designs.

CONCLUSION

The study contributes for design hybrid approach to experimental research that allows to study the direct and indirect effects of modeling. The structural equation modeling path indicates that screen time has direct effects with academic achievement; also it has indirect effects through meditation model. The homogeneity between the groups were established prior to the intervention. The screen time was measured for baseline analysis and not manipulated through the model is empirical from the structural equation modeling hybridization with experimental design. The higher t values of experimental group shows the effect strength. The correlation matrix reveals a well-structured pattern of relationship among physical fitness, academic achievement and screen time. The structural equation modeling shows that total indirect effect (β =-0.737) is quite larger than the direct effect (β =-0.38). The values indicate that most of the impact on academic achievement occurs through mediators, whereas the direct effect (β =-0.38) is marginal. The direct effects shows that the relationship can not be exhaustively explained by the direct effects alone rather the indirect effects play a significant relationship and so the selection of research design with Sequential Equation Modelling is aptly justified by the observed results. The BMI has not attained statistically significant effect through the training intervention is due to the limitation of training duration. The requirement of minimum 12 weeks intervention was studied by Zhen Li et al. (2025) supports the limitation of limited period of intervention on BMI. The other mediating and dependent variables have shown typical effect of intervention to confirm the soundness of the study that substantiates the generalizability of the findings.

AUTHORS CONTRIBUTION STATEMENT

Asha Devi contributed to conceptualization of the paper and field work done by her on implementation of the intervention and measurement of variables and drafted the manuscript. Uma provided the hybrid experimental design with Sequential

Equation Modelling to test the variables simultaneously. Suresh Kumar assisted in data analysis, interpretation and revised the manuscript. All authors reviewed the paper and approved the final version for submission.

CONFLICT OF INTEREST

The authors declare that no conflict of interests.

ACKNOWLEDGMENTS

The authors extend their acknowledgements to the participants to co-operate with the study design and measurements. The authors are grateful to the lab technicians to assist in measuring the variables and processing the measurements into ready reference variable data.

ETHICAL STATEMENT

The procedures followed for the study adheres to the ethical established by the Committee on Publication Ethics (COPE) ensuring transparency, integrity and respect for participants.

FUNDING

The researchers have not raised any financial support from any funding agency in Public, Commercial or Not -for -profit sectors specific to this research study.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 83-99
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).16

Effects of the Use of Plyometric Exercises on the Development of Explosive Strength in High School Students During Physical Education Lessons

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Article history: Received 2026 May 05; Revised 2026 June 22; Accepted 2026 June 25; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction*: Explosive strength represents a fundamental component of motor capacity, playing a decisive role in achieving motor performance both in sports activities and in physical education lessons. In the current context, plyometric training is recognized as one of the most effective methods for developing this motor quality, especially among adolescents. The aim of the study was to analyse the effects of a plyometric exercise program on the development of explosive strength in 10th grade students during physical education lessons. *Materials and methods*: The research was conducted on a sample of students aged 15–16 years, divided into an experimental group and a control group. The experimental group followed a structured plyometric exercise program integrated into physical education lessons, while the control group followed activities according to the regular school curriculum. Evaluation was carried out in two stages (initial and final testing), using specific tests for assessing explosive strength. Statistical analysis included the calculation of arithmetic mean and comparative analysis of results. *Results:* Results highlighted meaningful improvements in explosive strength parameters in the experimental group compared to the control group. *Conclusions:* Integrating plyometric exercises into physical education lessons represents an effective and accessible method for developing explosive strength and increasing the attractiveness of the educational process.

Keywords: *plyometric training, explosive strength, physical education, high school students, motor performance.*

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INTRODUCTION

Physical education and sport represent essential components in the harmonious development of children and adolescents, generating benefits at the somatic, functional, psychological, cognitive, and social levels. In the context of contemporary society, characterized by decreasing levels of physical activity and increasing sedentary behaviours among young people, physical education lessons play a crucial role in promoting active lifestyles and supporting health-related fitness (World Health Organization, 2020; Donnelly et al., 2016).

Among the motor qualities developed through physical education, muscular strength occupies a central position due to its contribution to the execution of motor skills and sports-specific movements. Explosive strength, understood as the ability of the neuromuscular system to generate maximal force in the shortest possible time, is particularly important during adolescence, when significant physiological and neuromuscular adaptations occur (Suchomel et al., 2016; Lloyd et al., 2011).

The development of explosive strength is closely related to the efficiency of the stretch-shortening cycle (SSC), a neuromuscular mechanism that enables the storage and subsequent release of elastic energy during movement. This mechanism contributes to improved jumping, sprinting, and change-of-direction performance and represents the physiological basis of plyometric training methods (Komi, 2000; Markovic & Mikulic, 2010).

Plyometric exercises consist of rapid eccentric-concentric muscle actions designed to enhance power production and neuromuscular efficiency. Numerous studies have demonstrated that appropriately designed plyometric programs can significantly improve strength, power, speed, and overall athletic performance in children and adolescents without negatively affecting their development when properly supervised (Faigenbaum et al., 2007; Behm et al., 2017; Ramírez-Campillo et al., 2020).

Considering the educational value of plyometric exercises and their applicability within school settings, investigating their effectiveness during physical education lessons may provide valuable information for optimizing teaching strategies aimed at improving students' motor performance and physical fitness.

Research Objectives

- Determining the initial level of explosive strength in high school students.
- Designing and implementing a plyometric exercise program adapted to the students' age and level.

- Comparing the evolution of explosive strength parameters between the experimental and control groups.
- Evaluating the effectiveness of plyometric exercises in physical education lessons.
- Analysing the impact of these exercises on student motivation and involvement.

Research Hypothesis

It is assumed that the systematic use of plyometric exercises during physical education lessons leads to a statistically significant increase in explosive strength parameters among high school students compared to traditional methods included in the school curriculum.

MATERIALS AND METHODS

Participants

The study was designed as a pedagogical experiment aimed at investigating the effects of plyometric exercises on the development of explosive strength in high school students. The research sample consisted of 40 students from the Agricultural High School of Beclean, Romania, divided into two groups: an experimental group (n = 20) and a control group (n = 20).

Table 1. Structure of the Research Groups

Variables	Experimental Group	Control Group	Total
Participants	20	20	40
Boys	14	13	27
Girls	6	7	13
Urban area	3	7	10
Rural area	17	13	30
Intervention duration	8 months	8 months	8 months

Participants were enrolled in grades X–XII and had a mean age ranging between 16 and 17 years. Prior to the intervention, the two groups were assessed and found to be comparable in terms of age, gender distribution, physical development, and initial motor performance, ensuring similar baseline conditions for the experiment.

The inclusion criteria were: (a) regular attendance in physical education classes; (b) absence of musculoskeletal injuries, chronic diseases, or medical contraindications to physical exercise; (c) participation throughout the entire duration of the study; and (d) submission of informed consent forms signed by both the students and their legal guardians.

The exclusion criteria included: (a) medical restrictions preventing participation in physical activity; (b) absence from more than 20% of the intervention sessions; (c) injuries occurring during the research period that limited participation in training or testing procedures; and (d) incomplete participation in the assessment protocol.

The participants were not involved in specialized strength or plyometric training programs outside the school curriculum and presented a relatively homogeneous level of physical preparation corresponding to their age and educational level. All students followed the standard physical education curriculum prescribed by the national educational framework.

The experimental group participated in a structured plyometric exercise program integrated into physical education lessons, while the control group continued to follow the traditional physical education program. The intervention was implemented over a period of eight months.

The study was approved by the management of the Agricultural High School of Beclean; All participants and their legal caretakers were informed about the objectives, procedures, benefits, and potential risks associated with the study. Written informed consent was obtained prior to participation.

The research was conducted in accordance with the ethical principles of the Declaration of Helsinki and respected the standards regarding voluntary participation, confidentiality, anonymity, and the protection of personal data. Meantime, the groups were formed using a quasi-experimental design based on existing class structures, while maintaining comparable baseline characteristics."

The distribution of participants according to gender and area of residence is presented in Table 1.

Procedure

The research was conducted during the 2024–2025 school year and was structured over five instructional intervals according to the official organization of the school year.

The didactic intervention consisted of the systematic integration of plyometric exercises into physical education lessons, particularly within the stages dedicated to the development of motor abilities.

• Level 0 – intended for beginners, focusing on the consolidation of general motor skills and neuromuscular coordination.

• Level 1 – intended for subjects with good general strength but low explosive strength.

• Level 2 – involved increased intensity and complexity, introducing variations of execution angles and auxiliary materials.

• Level 3 – integrated work with external weights and different contact surfaces.

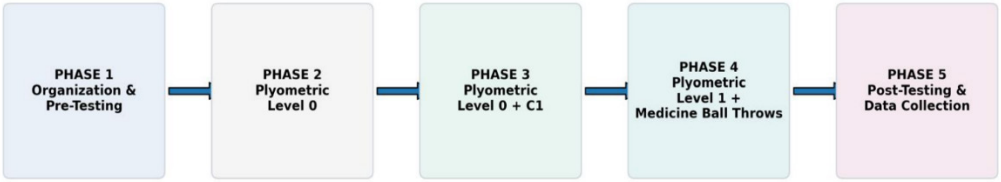

Fig. 1. Experimental design and progression of the plyometric intervention program implemented during the intervention period.

This hierarchy allowed not only a logical progression of the effort, but also a differentiated approach, adapted to the individual pace of development of the students.

Plyometric exercises were the core of the intervention, being represented by jumps on the spot and from the move, oriented towards the development of muscle reactivity and intersegmental coordination.

The scientific foundation of the intervention is based on the mechanism of the stretch-shortening cycle, considered essential in the manifestation of explosive force. This mechanism involves a rapid and efficient succession of three distinct but interdependent phases:

- The eccentric phase, in which the muscles are subjected to rapid stretching, causing the accumulation of elastic energy at the level of the musculotendinous components.

- The transition phase (damping), characterized by an extremely short interval, in which the accumulated energy is transferred, and the myotatic reflex contributes to facilitating the muscle response.

- The concentric phase, in which the muscles are rapidly shortened, and the momentum is generated, expressed by the manifestation of explosive force.

The effectiveness of this mechanism depends essentially on reducing the duration of the transition phase and on the ability of the neuromuscular system to harness the accumulated elastic energy.

The intervention program was progressively organized from simple exercises to more complex motor structures, focusing on the efficient development of the neuromuscular mechanisms involved in explosive strength production. The training protocol was implemented over a period of 8 weeks, with a frequency of two sessions per week, integrated into the regular physical education lessons. Each session lasted approximately 20–25 minutes and was performed following the warm-up phase.

The program included the following exercises:

- Multiple one-leg jumps over short distances (2–3 sets × 8–10 repetitions per leg), designed to improve unilateral lower-limb power, dynamic balance, and neuromuscular coordination.
- Two-leg jumps on coordination ladders (3 sets × 10–12 repetitions), emphasizing rapid ground contact, lower-limb reactivity, and movement rhythm.
- Lateral and zig-zag jumps over floor markings (3 sets × 8–10 repetitions), aimed at enhancing multidirectional explosive force, agility, and spatial orientation.
- Forward-backward jumps over a line (3 sets × 15–20 seconds), focusing on stretch-shortening cycle efficiency and quick force production.
- Explosive medicine ball throws from the chest and overhead (2–3 sets × 8–10 repetitions using 1–2 kg medicine balls), targeting upper-body explosive strength and whole-body force transfer.

Training volume and exercise complexity were progressively increased throughout the intervention period by manipulating the number of repetitions, sets, movement speed, and task difficulty. Recovery intervals ranged between 60 and 90 seconds between sets to ensure adequate performance quality and minimize fatigue accumulation.

The exercises were selected according to the age-specific characteristics of the participants and respected the principles of progressive overload, exercise variability, and safety. Particular attention was paid to correct landing mechanics, body alignment, and movement execution to reduce injury risk and maximize training adaptations.

The plyometric exercises were incorporated into the main part of the physical education lesson following a standardized warm-up. The training load was progressively increased throughout the intervention period by manipulating exercise complexity, number of repetitions, and movement intensity. Particular attention was paid to proper landing mechanics, postural control, and injury prevention.

Table 2. Structure of the Plyometric training program implemented during the intervention period

Training Phase	Duration	Frequency	Session Duration	Main Exercises	Sets × Repetitions	Rest Between Sets	Main Objective
Level 0	Weeks 1–8	2 sessions/ week	15–20 min	Forward-backward jumps; ladder drills; two-leg jumps; low-amplitude jumps	2–3 × 8–10	60–90 s	Neuromuscular adaptation, movement technique, and coordination development
Level 0 + C1	Weeks 9–16	2 sessions/ week	15–20 min	Single-leg jumps; lateral jumps; zig-zag jumps; multidirectional jumps	3 × 8–12	60–90 s	Improvement of reactive strength and SSC efficiency
Level 1 + Medicine Ball Throws	Weeks 17–32	2 sessions/ week	15–20 min	Multiple jumps; advanced plyometric drills; chest passes; overhead medicine-ball throws	3–4 × 10–12	90–120 s	Development of explosive strength, power output, and neuromuscular efficiency

Table 3. General characteristics of the intervention program

Variable	Description
Total intervention duration	8 months
Weekly frequency	2 physical education lessons per week
Estimated total sessions	Approximately 64 sessions
Plyometric work per lesson	15–20 minutes
Training progression	Gradual increase in complexity, volume and intensity
Recovery strategy	Active recovery through walking and mobility exercises
Safety procedures	Teacher supervision and emphasis on proper landing mechanics
Training environment	School gymnasium and outdoor sports facilities

Materials: The selected assessment battery targeted three complementary manifestations of explosive strength.

1. Standing long jump, evaluated horizontal propulsion, capacity and the ability to generate force in the direction of movement.

2. Vertical jump, assessed vertical propulsion and lower-limb power production, reflecting the participants' ability to rapidly overcome body weight.

3. One-hand distance throw; measured explosive force transfer through the upper body and the efficiency of force generation and transmission along the kinetic chain.

Together, these tests provided a comprehensive assessment of explosive strength by examining its expression in horizontal, vertical, and throwing movements. This multidimensional approach allowed for a more accurate evaluation of the adaptations induced by the plyometric training program.

Data analysis

To provide a comprehensive overview of the intervention effects, the mean values obtained in the three performance tests (standing long jump, vertical jump, and medicine ball throw) were analyzed for both the experimental and control groups, separately for boys and girls. Overall, all groups demonstrated positive progress between the initial and final assessments; however, the magnitude of improvement was consistently greater in the experimental groups.

In order to compare the data obtained in the two tests, statistical-mathematical calculations were used, for processing the data using the arithmetic mean (which represents the average value of performances)

RESULTS

Table 4. Mean values recorded in the experimental and control groups (boys)

Group	Standing Long Jump (m) Initial	Standing Long Jump (m) Final	Vertical Jump (m) Initial	Vertical Jump (m) Final	Medicine Ball Throw (m) Initial	Medicine Ball Throw (m) Final
Experimental	1.934	2.126	0.315	0.395	6.692	6.829
Control	1.908	2.033	0.394	0.433	6.150	6.225

Note: All values are expressed as arithmetic means.

Table 5. Mean values recorded in the experimental and control groups (girls)

Group	Standing Long Jump (m) Initial	Standing Long Jump (m) Final	Vertical Jump (m) Initial	Vertical Jump (m) Final	Medicine Ball Throw (m) Initial	Medicine Ball Throw (m) Final
Experimental	1.718	1.815	0.295	0.356	4.700	4.838
Control	1.652	1.715	0.275	0.305	4.578	4.635

Note: All values are expressed as arithmetic means.

Table 6. Progress rates in boys following the intervention

Test	Experimental Group (%)	Control Group (%)	Difference Between Groups (%)
Standing Long Jump	9.93	6.55	3.38
Vertical Jump	25.39	9.89	15.50
Medicine Ball Throw	2.04	1.21	0.83

Note: All values are expressed as arithmetic means.

Table 7. Progress rates in girls following the intervention

Test	Experimental Group (%)	Control Group (%)	Difference Between Groups (%)
Standing Long Jump	5.64	3.81	1.83
Vertical Jump	20.67	10.90	9.77
Medicine Ball Throw	2.93	1.24	1.69

Note: All values are expressed as arithmetic means

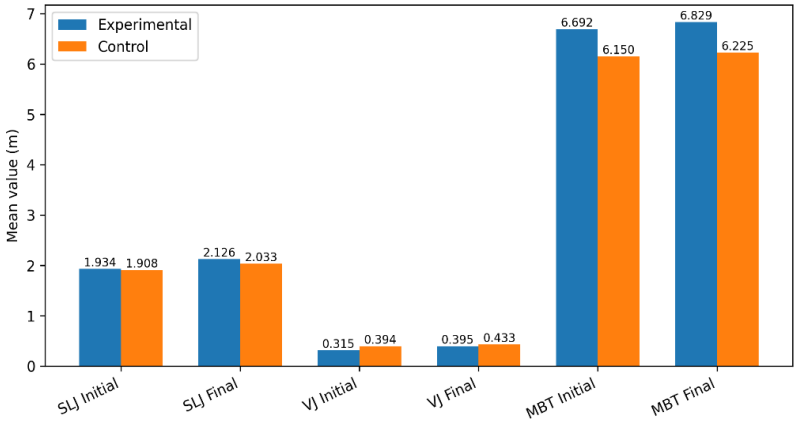

Fig. 1. Boys- mean values

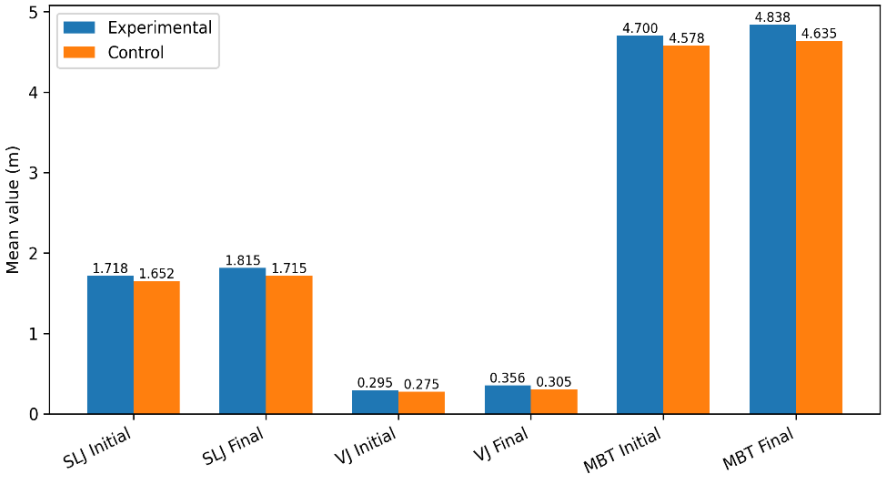

Fig. 2. Girls- mean values

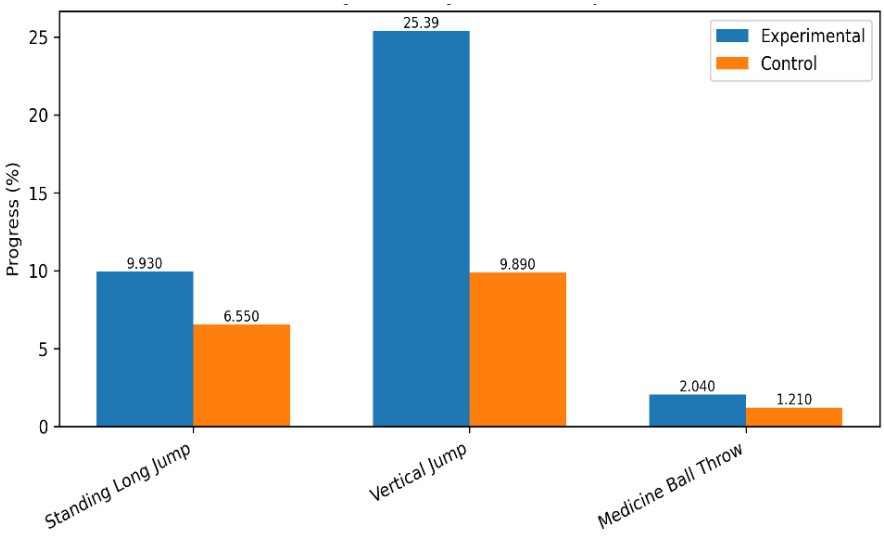

Fig. 3. Progress Rates- boys
Abbreviations: SLJ = Standing Long Jump; VJ=Vertical Jump; MBT = Medicine Ball Throw.

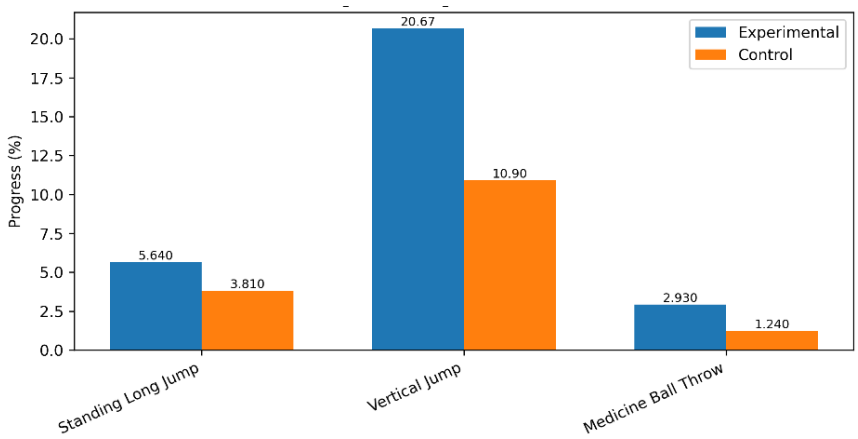

Fig. 4. Progress Rates- girls

At the long jump from the spot, the assessment of the results presented in the previous figures is presented as follows: BOYS – experimental group (X1 = 1.934 m, X2 = 2.126 m), control group (X1 = 1.908 m, X2 = 2.082 m), GIRLS – experimental group (X1 = 1.756 m, X2 = 1.806 m), control group (X1 = 1.652 m, X2 = 1.735 m).

The vertical jump reveals the following averages performed by the subjects of the two groups: BOYS – experimental group (X1 = 0.315 cm, X2 = 0.379), control group (X1 = 0.375 cm, X2 = 0.442), GIRLS – experimental group (X1 = 0.295 cm, X2 = 0.356), control group (X1 = 0.275 cm, X2 = 0.305 cm).

The results of the weight throw show the following averages: BOYS – experimental group (X1 = 6.692 cm, X2 = 6.829 cm), control group (X1 = 6.150 cm, X2 = 6.225 cm), GIRLS – experimental group (X1 = 4.700 cm, X2 = 4.838 cm), control group (X1 = 4.578 cm, X2 = 4.635 cm).

The experimental groups demonstrated superior improvements across all performance tests compared with the control groups. The largest gains were observed in the vertical jump test, indicating a substantial enhancement of explosive lower-limb power following the plyometric intervention.

For the male participants, the experimental group improved from 1.934 m to 2.126 m in the standing long jump, representing a progress rate of 9.93%, compared with 6.55% in the control group. Similar trends were observed in the vertical jump test, where the experimental group increased from 0.315 m to 0.395 m, corresponding to a 25.39% improvement, while the control group

recorded only a 9.89% increase. In the medicine ball throw, the experimental group improved by 2.04%, compared with 1.21% in the control group.

The largest difference between groups was observed in the vertical jump test (15.5%), suggesting that the implemented plyometric program had a particularly strong effect on the development of explosive lower-limb power in the vertical direction.

Among female participants, the experimental group increased performance in the standing long jump from 1.718 m to 1.815 m, corresponding to a 5.64% improvement, whereas the control group achieved a 3.81% increase. In the vertical jump test, the experimental group improved by 20.67%, almost double the gain observed in the control group (10.90%). Similarly, the medicine ball throw performance increased by 2.93% in the experimental group compared with 1.24% in the control group.

The greatest superiority of the experimental group was again observed in the vertical jump test, with a between-group difference of 9.77%, confirming the effectiveness of the intervention in enhancing explosive strength capacities in female participants.

The results indicate that the plyometric training program produced superior adaptations compared with the traditional training approach. The most substantial improvements were observed in tests requiring rapid force production and neuromuscular coordination, particularly the vertical jump assessment. These findings are consistent with previous research demonstrating that plyometric exercises enhance the efficiency of the stretch-shortening cycle, improve motor unit recruitment, and increase the rate of force development.

Although improvements in medicine ball throw performance were more modest, the experimental groups still achieved greater gains than the control groups, suggesting that the training stimulus positively influenced explosive power transfer to the upper body as well. Overall, the experimental groups maintained their performance advantage across all tests at the final assessment, highlighting the effectiveness of the intervention program in developing explosive strength among cadet athletes.

From a practical perspective, the differences in progress rates between the experimental and control groups suggest a meaningful training effect. The markedly higher improvements observed in the experimental groups, particularly in vertical jump performance, indicate that the intervention generated adaptations beyond those attributable to regular training and natural growth processes. If confirmed by inferential statistical analysis ($p < 0.05$), these findings would support the hypothesis that the plyometric training program significantly enhances explosive strength development in cadet athletes.

DISCUSSION

The present study aimed to examine the practical effects of a plyometric training program on selected indicators of explosive strength in young school students. Although all groups recorded improvements between the initial and final assessments, the experimental groups consistently demonstrated greater progress than the control groups across all three performance tests. The most substantial improvements were observed in the vertical jump test, followed by the standing long jump, while more moderate gains were found in the medicine ball throw assessment.

These findings are consistent with recent evidence highlighting the effectiveness of plyometric training for enhancing explosive power and jumping performance in youth athletes. Several systematic reviews and meta-analyses have demonstrated that plyometric interventions significantly improve vertical jump height, sprint performance, change-of-direction ability, and lower-limb power in children and adolescents (Ramírez-Campillo et al., 2020; Moran et al., 2018; Behm et al., 2017; Chaabene et al., 2019).

The superiority of the experimental groups in the vertical jump test is particularly noteworthy. The rate of improvement observed in the experimental groups exceeded that of the control groups by a considerable margin, suggesting that the intervention provided an additional neuromuscular stimulus beyond that achieved through regular physical education alone. Similar conclusions have been reported by Ramírez-Campillo et al. (2020), who identified vertical jump performance as one of the physical capacities most responsive to plyometric training. Likewise, Markovic and Mikulic (2010) concluded that stretch-shortening cycle adaptations substantially contribute to improvements in explosive jumping performance.

The positive changes observed in the standing long jump test further support the effectiveness of the program in developing horizontal force production. Previous investigations have shown that multidirectional plyometric drills, bounding exercises, and horizontal jump training improve horizontal power production and sport-specific explosive performance (Moran et al., 2018; Asadi et al., 2016; Slimani et al., 2016).

Although the improvements in medicine ball throw performance were smaller than those observed in the jumping tests, the experimental groups still demonstrated greater progress than the control groups. This finding may indicate that the intervention contributed not only to lower-limb explosiveness but also to improved force transmission through the kinetic chain (Behm et al., 2017).

The present findings are also consistent with the recommendations of the National Strength and Conditioning Association (Lloyd et al., 2014), which emphasize that appropriately supervised plyometric training is both safe and effective for youth populations.

However, caution is warranted when interpreting these results because inferential statistical analyses were not performed. Consequently, the findings provide practical evidence suggesting a potentially beneficial effect of the intervention that should be verified through future studies employing appropriate statistical procedures and effect-size calculations (Lakens, 2013).

Overall, the present findings suggest that the implementation of a structured plyometric training program may contribute to the development of explosive strength in high school students. Future studies including inferential statistical analyses and larger samples are recommended to further validate these findings.

CONCLUSIONS

The present study examined the practical effects of an eight-month plyometric training program implemented during physical education lessons on selected indicators of explosive strength in high school students.

The results showed consistent improvements in all assessed performance variables in both the experimental and control groups. However, participants who followed the structured plyometric program demonstrated greater percentage improvements in vertical jump, standing long jump, and medicine ball throw performance than those who participated only in the regular physical education curriculum. The greatest relative gains were observed in vertical jump performance, suggesting that lower-limb explosive power may be particularly responsive to long-term plyometric training during adolescence.

From a practical perspective, the findings indicate that a progressively designed plyometric program can be successfully integrated into school-based physical education without disrupting the regular curriculum. Such interventions may represent a feasible strategy for enhancing explosive strength, improving neuromuscular function, and supporting the physical development of adolescents. Nevertheless, the findings should be interpreted with caution. Since inferential statistical analyses were not performed, it cannot be concluded that the observed differences between groups were statistically significant. Consequently, the present results should be regarded as practical observations indicating a favourable tendency rather than definitive proof of the superiority of the intervention.

Future research should include larger and more heterogeneous samples, randomized controlled designs, comprehensive statistical analyses, and additional performance indicators such as sprint speed, agility, reactive strength, and change-of-direction ability. Furthermore, controlling biological maturation, training history, and extracurricular physical activity would improve the internal validity of future investigations.

Overall, the present study provides practical evidence supporting the inclusion of structured plyometric exercises in secondary school physical education. While additional statistically validated research is required, the observed improvements suggest that plyometric training has the potential to contribute meaningfully to the developmen of explosive strength during adolescence.

AUTHOR CONTRIBUTIONS

Horea Ştefănescu (Babeş-Bolyai University, Faculty of Physical Education and Sport) contributed to the study conception and design, research methodology, data analysis and interpretation, statistical processing, manuscript writing, discussion and conclusions, and critical revision of the final manuscript.

Marcel Bondor (Agricultural High School, Beclean, Romania) coordinated and implemented the experimental intervention, organized the data collection process, supervised the participants throughout the intervention period, and contributed to the acquisition and validation of the research data.

Cosmin Prodea (Babeş-Bolyai University, Faculty of Physical Education and Sport) contributed to the research design, statistical analysis, interpretation of the findings, preparation of the discussion and conclusions, manuscript editing, and critical review of the final version.

All authors contributed to the interpretation of the results, reviewed the manuscript critically for important intellectual content, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work. This research received no external funding.

INSTITUTIONAL REVIEW BOARD STATEMENT

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. The research was carried out within the regular physical education curriculum at the Agricultural High School in Beclean, Romania, using standard educational activities and non-invasive physical performance tests. Participation was voluntary, and the study complied with the ethical and educational regulations applicable at the institution.

INFORMED CONSENT STATEMENT

Written informed consent was obtained from all participants and, where required, from their parents or legal guardians prior to participation in the study. Participants were informed about the objectives and procedures of the research and were free to withdraw from the study at any time without consequences.

DATA AVAILABILITY STATEMENT

The data sets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

ACKNOWLEDGMENTS

The authors would like to thank the students of the Agricultural High School in Beclean for their participation in the study, as well as the school administration for supporting the implementation of the research during the physical education lessons.
Conflicts of Interest

The authors declare no conflict of interest. The research was conducted independently and received no external funding. The authors declare that they have no financial, commercial, institutional, or personal relationships that could have influenced the design, implementation, analysis, interpretation, or reporting of the study.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 101-112
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).17

Leadership Styles of Rugby Coaches in Romania: A Cross-Sectional Descriptive Study

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Article history: Received 2026 February 27; Revised 2026 April 16; Accepted 2026 April 20; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction:* Leadership style is a central component of coaching practice and may shape the interpersonal climate within team sports. This study investigates leadership styles among rugby coaches across developmental categories in Romanian clubs. *Objectives:* The primary objective was to identify the prevalence of democratic, authoritarian (autocratic), and laissez-faire (neglectful/passive) leadership styles among rugby coaches across age categories (Mini Rugby, U14, U16, U18, U20, Seniors). *Materials and Methods*: The study employed a quantitative, cross-sectional design using a researcher-developed Leadership Style Scale, conceptually informed by the Coaches' Interpersonal Style Questionnaire. The questionnaire included 10 items measuring three leadership styles and was administered online via Google Forms to a sample of 40 male rugby coaches aged 24–50 years. Responses were recorded on a five-point Likert scale (1 = never; 5 = frequently/always). Data were collected anonymously over a one-month period (May–June 2025) and analyzed using descriptive statistics, with results visualized through comparative graphs by age category. *Results:* Democratic leadership recorded the highest mean scores across all age categories, while laissez-faire leadership showed consistently low values. Authoritarian leadership displayed greater variability between categories, with higher mean scores at the senior level. *Conclusions:* The findings indicate a predominant use of democratic leadership practices across developmental levels in Romanian rugby coaching, accompanied by situational use of directive behaviors and limited reliance on

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passive leadership. These descriptive results provide a basis for further research examining how coaching leadership styles relate to athlete experiences and team processes.

Keywords: *coaching leadership styles, rugby, democratic leadership, authoritarian leadership, laissez-faire leadership*

INTRODUCTION

Leadership remains a fundamental aspect of sport coaching, shaping athletes' experiences, motivation, and long-term engagement in physical activity. Coaches are not only instructors of technical skills but also architects of the social and motivational climates in which athletes operate (Côté & Gilbert, 2009). How coaches make decisions, communicate expectations, and involve athletes in problem solving can influence not only performance outcomes but also psychological well-being and team cohesion (Jin, Lee, & Chung 2022; Kim & Cruz, 2016). In many contemporary sport environments, leadership is viewed not solely as a set of behaviors but as a dynamic interaction between coaches' styles and athletes' developmental needs.

Early leadership research in sport adopted a simple triadic framework—autocratic, democratic, and laissez-faire (Lewin, Lippitt, & White, 1939; Fletcher & Arnold, 2011; Raidbard, 2019). Despite the emergence of more complex leadership models, this triad remains useful for understanding fundamental differences in how authority and participation are managed during training and competition. Autocratic coaching is typically characterized by unilateral decision-making and directive control, whereas democratic leadership involves shared decision processes and reciprocal dialogue. Laissez-faire leadership, by contrast, reflects minimal intervention and delegation of decisions to athletes (Sevil-Serrano et al., 2021). Democratic decision making and autonomy support, in particular, have been associated with higher athlete satisfaction and positive team climate, whereas highly directive or controlling leadership can undermine athletes' intrinsic motivation and cohesion (Delrue et al., 2019; Sevil-Serrano et al., 2021).

The developmental context of sport introduces additional complexity to leadership dynamics. Youth athletes experience different physical, cognitive, and social demands compared to older or senior athletes, and these developmental distinctions can shape both athlete needs and coach strategies (Reynders et al., 2020; Zhu et al, 2024). Coaches working with younger age groups often prioritize learning, enjoyment, and supportive communication, which align with participative leadership behaviors. In more competitive or senior contexts, increasing performance

pressure and organizational expectations may encourage more directive strategies (Lefebvre, Turnnidge, & Côté, 2021). This developmental perspective underscores a need for deeper understanding of how coach leadership varies across age categories, rather than assuming uniform coaching approaches across the athlete development pathway.

Despite the steady growth of research on coach leadership, designs that systematically compare leadership behaviors across multiple age categories within the same sport remain relatively uncommon. Bibliometric mapping of the field shows that most studies examine associations between coach leadership and athletes' psychological outcomes, often using mixed-sport samples or focusing on a single competitive level (Cruz & Kim, 2023).

Rugby presents an ideal context for such research due to its structured progression from introductory youth levels through to senior competition, entailing evolving performance demands and psychosocial challenges (Witherspoon, 2024). Identifying patterns of leadership behavior across age categories can offer insight into how coaches adjust their approaches to developmental and competitive contexts, and how these adjustments relate to broader goals of athlete engagement and satisfaction (Brown & Arnold, 2019). Recent rugby-focused work highlights the influence of coaching leadership on team functioning and psychosocial outcomes in youth contexts (Hirose et al., 2025), while age-grade comparisons within non-elite rugby have begun to explore how coach behaviors and coach–athlete relationships differ across child, adolescent, and adult teams (Brown & Arnold (2019), Smith et al., 2023). In addition, rugby leadership appears strongly shaped by the socio-cultural and organizational environment in which coaching takes place, suggesting that "effective leadership" may vary across contexts and developmental stages (Groves & Clements, 2024). Together, these findings suggest that within-sport, age-category comparisons are both feasible and theoretically valuable, yet still underrepresented in the broader coach leadership literature.

PURPOSE OF THE STUDY

The purpose of this study was to examine leadership style tendencies among rugby coaches in Romania and to explore whether these tendencies differ across competitive age categories. The study also focused on comparison between leadership style scores across age categories in order to detect potential differences associated with competitive level, perceived by coaches working with athletes at six developmental levels: Mini Rugby, Under-14 (U14), Under-16 (U16), Under-18 (U18), Under-20 (U20), and Senior teams.

MATERIAL AND METHODS

The study involved 40 rugby coaches affiliated with rugby clubs in Romania. All participants were male, aged between 24 and 50 years, and were actively engaged in coaching athletes at different stages of development. The sample included coaches working in six competitive categories: Mini Rugby (n = 14), Under 14 (n = 7), Under 16 (n = 5), Under 18 (n = 6), Under 20 (n = 4), and Senior (n = 4). Prior to participation, all coaches were informed about the purpose of the study and the confidential handling of their responses. Participation was voluntary and anonymous.

Data collection was conducted over a one-month period, between May and June 2025. The questionnaire was administered online using Google Forms and distributed through electronic communication channels. Participants completed the questionnaire individually and anonymously.

The online format facilitated standardized data collection while minimizing logistical constraints associated with face-to-face administration and encouraging honest self-reporting of coaching practices.

Leadership style tendencies were assessed using a structured 10-item questionnaire designed to measure three leadership styles: autocratic, democratic, and laissez-faire. The instrument used was a researcher-developed Leadership Style Scale, conceptually informed by the Coaches' Interpersonal Style Questionnaire (Pulido et al., 2018). The scale was designed to assess coaches' typical leadership behaviours in training and competitive settings.

Responses were recorded on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The autocratic leadership dimension was assessed through three items, the democratic leadership dimension through four items, and the laissez-faire leadership dimension through three items. The structure of the instrument is presented in Table 1. For each participant, mean scores were calculated separately for the three leadership dimensions, with higher scores indicating a stronger tendency toward the respective leadership style.

Table 1. Structure of the researcher-developed Leadership Style Scale used

Leadership style	Item numbers	Conceptual description of item content
Democratic leadership	1, 4, 7, 10	Participative decision-making, soliciting athlete feedback, joint goal setting, open discussion of training plans and roles, integration of staff input
Authoritarian (autocratic) leadership	2, 5, 8	Unilateral decision-making, directive communication, public correction of errors, firm instructions under pressure

Leadership style	Item numbers	Conceptual description of item content
Laissez-faire (neglectful/passive) leadership	3, 6, 9	Low involvement in conflict resolution, limited monitoring of attendance and engagement, delegation of responsibilities without systematic follow-up

The collected data were processed using Microsoft Excel. Descriptive statistical procedures were employed to summarize leadership style tendencies across the six developmental categories. Specifically, mean values were calculated for each leadership dimension (autocratic, democratic, and laissez-faire) within each age category. The results were subsequently presented through graphical representations to facilitate the interpretation of leadership style profiles across developmental levels.

RESULTS

To obtain a structured overview of leadership styles across coaching categories, the present study grouped the 10 items of the Leadership Style Scale into three conceptual dimensions: democratic leadership, authoritarian (autocratic) leadership, and laissez-faire (neglectful/passive) leadership.

This classification reflects the theoretical organization of the instrument and allows a differentiated examination of coaching behaviors across age categories. The graphical representations facilitate a comparative interpretation of leadership style distributions across developmental stages.

Figure 1 presents the mean scores for democratic leadership across coaching categories. High and relatively homogeneous values were observed across all groups, ranging from 3.88 (Mini Rugby) to 4.25 (U16 and U18). The remaining categories displayed similarly elevated values: U14 (M = 4.07), U20 (M = 4.12), and Seniors (M = 4.00).

Figure 2 illustrates the comparative distribution of mean scores for authoritarian leadership across the six age categories. The highest value was recorded at the senior level (M = 3.83), followed by U14 (M = 3.38) and Mini Rugby (M = 3.26). Lower mean values were observed in the intermediate and upper youth categories, with U16 (M = 2.80), U18 (M = 2.67), and the lowest score at U20 (M = 2.42).

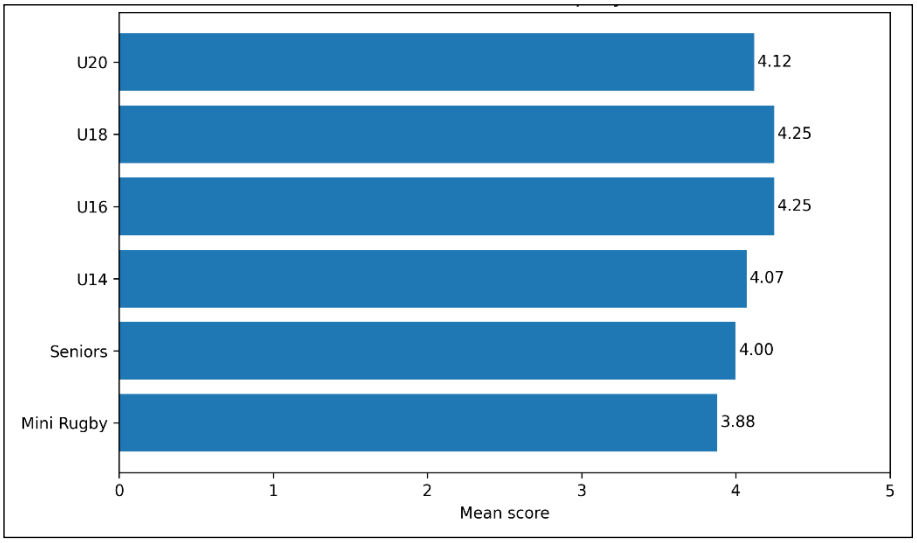

Figure 1. Democratic leadership style among participants

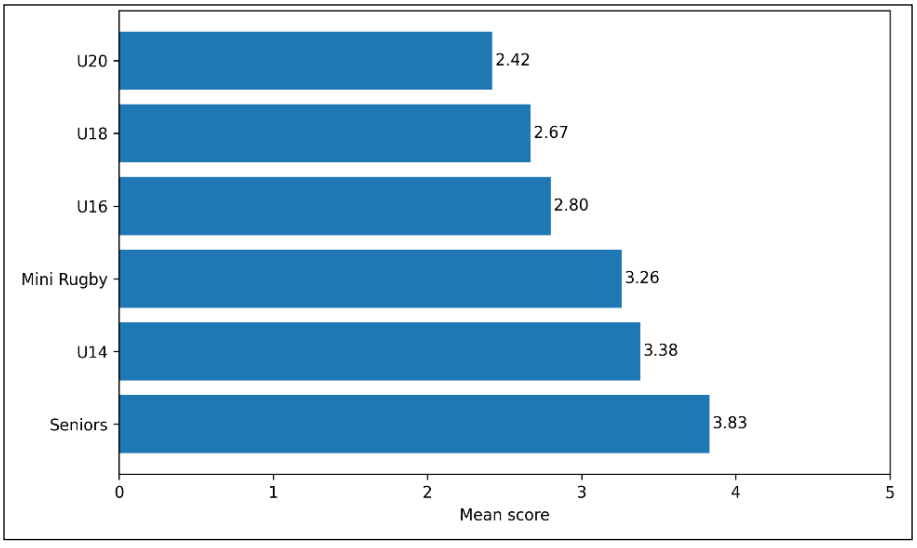

Figure 2. Authoritarian leadership style among coaches

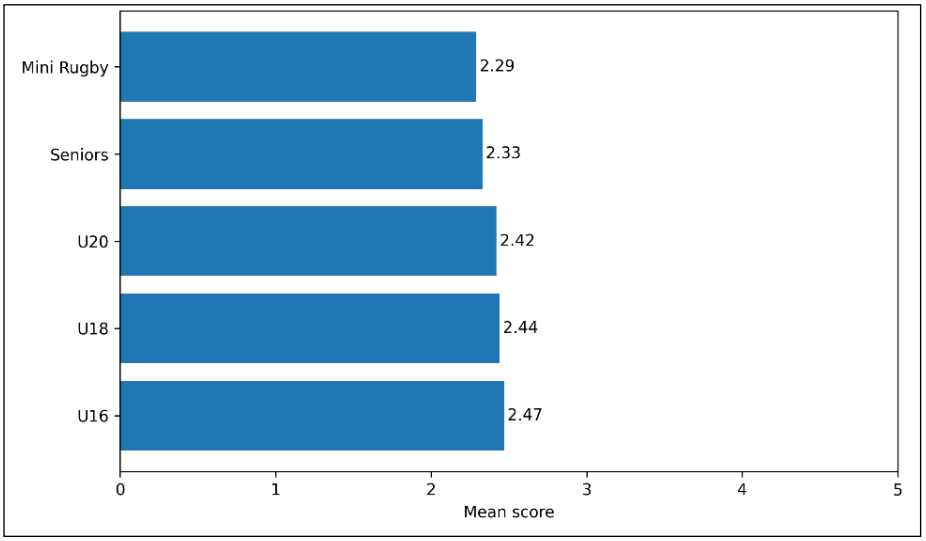

Figure 3. Laissez-faire leadership style by age categories

Figure 3 shows the distribution of laissez-faire leadership scores across age categories. Mean values were uniformly low, ranging between 2.19 (U14) and 2.47 (U16). Comparable values were observed in Mini Rugby (M = 2.29), Seniors (M = 2.33), U18 (M = 2.44), and U20 (M = 2.42).

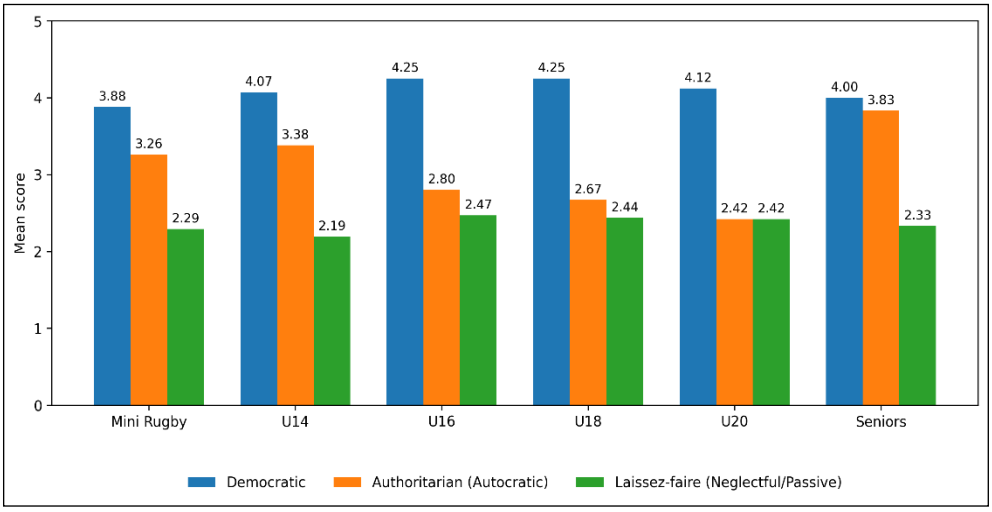

Fig. 4. Comparative leadership style by age category

Figure 4 summarizes the relative distribution of democratic, authoritarian, and laissez-faire leadership styles across age categories, highlighting the predominance of democratic leadership at all levels.

DISCUSSIONS

The present study examined leadership styles among rugby coaches across six age categories using a researcher-developed Leadership Style Scale adapted conceptually from the Coaches' Interpersonal Style Questionnaire (Pulido et al., 2018). The findings indicate a consistent predominance of democratic leadership behaviors across all developmental levels, accompanied by moderate use of authoritarian practices and minimal reliance on laissez-faire approaches.

The dominance of democratic leadership observed in the present sample aligns with contemporary coaching frameworks that emphasize athlete involvement, open communication, and shared goal-setting as central components of effective coaching practice (Côté & Gilbert, 2009). Across all age categories, democratic leadership showed relatively high and homogeneous mean values (Fig. 1), suggesting that participative behaviors are embedded in coaching routines within Romanian rugby clubs. This pattern is consistent with the interpersonal style model proposed by Pulido et al. (2018), which highlights the importance of autonomy-supportive and involvement-oriented coach behaviors for fostering adaptive motivational climates. Although the present study did not assess motivational outcomes directly, the prevalence of democratic leadership provides a contextual basis for future research examining associations between coaching style and athlete motivation or engagement.

Authoritarian (autocratic) leadership displayed greater variability across age categories (Fig. 2), with higher mean values at the senior level and comparatively lower values at U18 and U20. This pattern may reflect contextual demands associated with performance pressure and competitive expectations at senior levels, where directive behaviors and rapid decision-making can be more frequently enacted. Chelladurai's multidimensional model of leadership suggests that coaching effectiveness depends on the congruence between required, preferred, and actual leader behaviors within a given situational context (Chelladurai, 2007). From this perspective, the observed variation in authoritarian leadership across age groups may indicate situational adaptation rather than a fixed leadership orientation.

However, as the present study relied on self-reported coaching behaviors and did not measure athletes' preferences or situational constraints, such interpretations remain descriptive and should be examined empirically in future work.

Laissez-faire leadership exhibited uniformly low mean values across all categories (Fig. 3), indicating that passive or neglectful coaching behaviors were reported infrequently. This finding suggests that coaches generally maintain active involvement in training organization, conflict management, and monitoring of athlete participation. Low prevalence of laissez-faire leadership is consistent with sport leadership research emphasizing the importance of coach engagement and structured guidance for both athlete development and team functioning (Côté & Gilbert, 2009).

The comparative visualization (Fig. 4) highlights a stable configuration of leadership styles across developmental levels, characterized by democratic leadership as the dominant approach, moderate authoritarian practices, and marginal laissez-faire behaviors. This pattern may reflect broader professional norms within organized rugby coaching in Romania, where collaborative communication and structured guidance coexist. At the same time, the variability observed in authoritarian leadership underscores that coaching styles are not uniform across age categories and may shift in response to competitive context, perceived athlete maturity, and performance demands.

Previous research on the coach–athlete relationship emphasizes that leadership behaviors are embedded within relational dynamics and are shaped by contextual constraints and mutual expectations (Jowett & Cockerill, 2003). Several methodological considerations should be acknowledged. First, the study relied on a researcher-developed instrument adapted conceptually from Pulido et al. (2018), which limits direct comparability with studies using fully validated scales. Second, the sample consisted exclusively of male coaches, which restricts generalization to mixed-gender coaching populations. Third, the descriptive design and modest sample size preclude inferential conclusions regarding differences between age categories. Despite these limitations, the study provides an empirical snapshot of leadership style distributions across developmental levels in Romanian rugby coaching and offers a foundation for future research incorporating athlete perspectives, longitudinal designs, and validated interpersonal style measures.

CONCLUSIONS

The results show a clear predominance of democratic leadership across all age categories, with moderate use of authoritarian practices and consistently low levels of laissez-faire leadership. This pattern suggests that rugby coaches in the present sample predominantly employ participative coaching behaviors, while directive leadership is used situationally and passive leadership is rare.

These findings provide a descriptive snapshot of leadership style distribution across developmental levels and offer a basis for future studies examining links with athlete outcomes and coach–athlete interactions.

AUTHOR CONTRIBUTIONS

Sergiu Pop and Dan Mihai Gherţoiu contributed to the conceptualization, design of the study and initial drafting of the manuscript. David Popa contributed to the data collection, literature review and writing of the manuscript. Dumitru Rareş Ciocoi-Pop and Maria-Daniela Macra-Oşorhean contributed to the methodological design, data analysis, interpretation of results and also scientific supervision. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGMENTS

This article is the result of teamwork between the authors and started from the findings in Popa David's dissertation thesis.

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STUDIA UBB EDUCATIO ARTIS GYMN., LXXI, 2, 2026, pp. 113-126
(RECOMMENDED CITATION)
DOI:10.24193/subbeag.71(2).18

The Relationship Between Back Pain and Sedentary Lifestyles and Sports Among University Students

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Article history: Received 2026 March 18; Revised 2026 May14; Accepted 2026 May 16; Available online 2026 June 30; Available print 2026 July 30

ABSTRACT. *Introduction:* Back pain is increasingly prevalent among university students and is commonly associated with sedentary behavior, prolonged sitting, and lifestyle-related risk factors. *Objective:* This study aimed to determine the prevalence of back pain among university students and to examine its association with sedentary lifestyle characteristics, specifically sitting posture and physical activity level. *Material and Methods:* A cross-sectional questionnaire-based study was conducted among 87 university students (M = 23.10 years). Data was collected on back pain occurrence over the past three months, sitting posture habits, sitting time, and physical activity. Physical activity was categorized using MET-minutes based on frequency, duration, and intensity. Associations were analyzed using chi-square tests, Fisher's exact test, and effect size measures. *Results:* Back pain prevalence was 78.2%, significantly exceeding the hypothesized 50% threshold ($p < 0.001$). A significant, moderate association was found between incorrect sitting posture and back pain ($\varphi = -0.358$, $p = 0.009$), with pain occurring predominantly among participants reporting poor posture. No statistically significant relationship was observed between physical activity level and either the presence or frequency of back pain *Conclusions:* The findings suggest that sitting posture may play a critical role in back pain development among university students next to physical activity volume. Preventive strategies should therefore integrate ergonomic education and posture awareness alongside physical activity promotion.

Keywords: *back pain, students, sitting posture, physical activity*

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INTRODUCTION

According to data from the World Health Organization (2023), approximately 619 million people lived with lower back pain in 2020, and the problem is expected to continue to grow as the population increases and ages, which significantly affects the daily functioning and quality of life of university students (Alshehri et al., 2023).

The prevalence of back pain among students in higher education is not negligible; according to research, the prevalence of lower back pain in the higher education population is estimated to be around 66% (Alshehri et al., 2023), while approximately 60-70% of students reported musculoskeletal pain in at least one area (neck, back, shoulders, lower back) in the past 12 months. (Parto et al., 2023)

This information highlights the importance of researching this topic, as young adults may lead a more sedentary lifestyle due to academic demands, which can potentially increase the risk of developing chronic pain, and also by recognizing the circumstances we can help in the long term to take preventive measures, which is well emphasized by research showing the importance of raising awareness among students, using ergonomic seating, engaging in an appropriate amount of exercise, and improving other socio-emotional conditions (Alshehri et al., 2023).

Alshehri et al. (2023) and Mahdavi et al. (2021) report that university students spend substantial time sitting each day for lectures, studying, and leisure screen use, illustrating the prevalence of sedentary lifestyles in this population.

Several studies have shown that regular physical activity may have a protective effect against the development of back pain, especially in the case of moderate-intensity exercise, while physical inactivity and prolonged sitting may be associated with an increased incidence of pain (Scarabottolo et al., 2017). In addition, sitting posture, i.e., correct or incorrect posture while sitting, may also play a role (Bagherian et al., 2023)-prolonged poor posture can lead to muscle tension and increased muscle strain, which can contribute to the development of back pain.

Based on previous research, the prevalence of back pain among students is high, and several factors- including sedentary lifestyle, level of physical activity, and sitting posture -potentially influence this phenomenon. This research therefore aims to determine the prevalence of back pain among students and to explore the relationships between sedentary lifestyle, physical activity, and sitting posture based on data obtained through a questionnaire.

HYPOTHESES

H1: We assume that the prevalence of back pain among students in the last three months is greater than 50%.

H2: There is a significant correlation between incorrect posture while sitting and back pain.

H3: There is a significant correlation between physical activity and the incidence of back pain.

MATERIALS AND METHODS

Participants

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation was voluntary and by completing the questionnaire, each individual agreed to participate in the research. Data collection was conducted using convenience sampling through online student forums and social media groups targeting higher education networks. Due to the decentralized nature of the distribution channels, a specific institutional breakdown cannot be provided; however, the sample includes students from various universities across both Romania and Hungary. We collected a total of 106 responses, but in accordance with the selection criteria, individuals who had suffered acute spinal injuries in the past six months or who had been diagnosed with chronic spinal disorders were excluded from the sample, totaling 19 individuals who, with the exception of this criterion, had very similar characteristics as the final sample (N=19, M=23.73, SD=5.02, Mdn=22.00)

The average age of respondents who met the criteria (N=87) was M=23.10 (SD=4.78, Mdn=22.00), and the majority of respondents were female (n=74, 85.1%), while a significantly smaller proportion of males (n=13, 14.9%) completed the questionnaire.

Variables examined in the questionnaire

The variables used in the research are systematically structured to enable the analysis of correlations between students' lifestyles and musculoskeletal complaints. The first section of the questionnaire records sociodemographic data (gender, age) and health history (previous injuries, spinal disorders), which serve as control variables. The central part of the study consists of independent lifestyle variables: correct posture while sitting, frequency, duration, and intensity of physical activity. Finally, the dependent variable was the prevalence of back pain experienced in the last three months. A combined analysis of these data

makes it possible to verify whether more than half of the students are affected by back pain and whether there is a significant correlation between a sedentary lifestyle, lack of exercise, and the development of pain.

Determining the categories of individuals who sit correctly and incorrectly

Participants were classified into two nominal categories based on the self-reported frequency of their correct sitting posture. Following the "majority rule" for identifying habitual behavior, respondents who maintained correct posture for more than 50% of their sitting time (51-100%) were categorized as "correct sitters," while those maintaining it for 50% or less were classified as "incorrect sitters".

The use of self-reporting to assess postural habits and sitting time is a standard and validated approach in large-scale epidemiological and ergonomic studies. Recent research underscores that participants' subjective perception of their habitual posture is a significant indicator of musculoskeletal health, as habitual patterns -even when self-assessed- correlate strongly with the prevalence of non-specific back pain (Kallings et al., 2021).

Dichotomizing frequency data into binary categories (e.g., predominant vs. non-predominant postural behavior) is a commonly used approach in ergonomic and epidemiological studies, as it facilitates the identification of risk factors and allows the application of robust association tests such as Chi-square and Fisher's exact tests; for example, Bagherian et al. (2023) demonstrated that categorizing habitual posture in this way revealed significant associations with musculoskeletal pain, consistent with standard epidemiological methodology (Altman, 1991).

Determining and categorizing physical activity levels

When measuring physical activity, it is essential to consider frequency, duration, and intensity together, as these factors collectively constitute the "total dose" (volume) of exercise, which directly determines the body's physiological response. There is an inverse relationship between intensity and duration: research shows that higher-intensity exercise (VPA) can produce the same cardiovascular and metabolic benefits in a significantly shorter time than moderate-intensity activity (Garber et al., 2011; Ahmadi et al., 2022).

To objectively compare the physical activity levels of the study participants, we used the internationally recognized MET (Metabolic Equivalent of Task) calculation method. This approach allows the three key dimensions of sports activity -frequency (times/week), duration (minutes/session), and intensity- to be integrated into a single numerical indicator. Since the data were obtained

from a self-reported questionnaire, we used the modified Borg RPE (Rating of Perceived Exertion) scale (1–10 scale) to determine intensity. We converted the subjective perception of exertion to MET values based on the validation studies by Garber et al. (2011). The MET values assigned to the RPE values (e.g., moderate intensity: 4 MET; vigorous intensity: 6–8.5 MET) reflect the relative energy expenditure during the activity. To classify participants into categories, we calculated their total weekly MET-minutes using the following formula:

Weekly MET-minutes = MET value (based on RPE) * (Weekly hours*60) (1)

This methodology is consistent with the IPAQ (International Physical Activity Questionnaire, 2005) analysis protocol, which considers 600 MET-minutes per week to be the minimum threshold for health. Participants were classified into five categories based on the WHO (2020) physical activity guidelines. The frequency of physical activity (at least 4 times a week) was highly emphasized. This is based on the latest epidemiological research (Zhao et al., 2024), which confirmed that the frequency of physical activity is an independent protective factor in addition to volume (MET-minutes). Research indicates that acute physiological responses to exercise can persist for up to approximately 48–72 hours after a bout, but tend to diminish thereafter if exercise is not repeated, suggesting that multiple weekly sessions are necessary to maintain continuous adaptive stimulus to the musculoskeletal and metabolic systems (e.g., improvements in insulin sensitivity measurable 48–72 h post-exercise; regular exercise recommendations emphasizing ≤2-day gaps between sessions) (Way et al., 2016; Gerber et al. 2011). This approach has made it possible to precisely distinguish between 'regular training' and occasional, albeit high-volume, exercise (e.g., "weekend warrior" pattern):

- Inactive (< 600 MET-minutes/week): Individuals who do not meet the minimum amount of physical activity required for health maintenance.
- Low-level exercisers (600-1199 MET-minutes/week): Those who engage in low-volume or low-intensity exercise, and participants who achieve a high total volume but concentrate it into 1-2 sessions per week. Although recent research (Dos Santos et al., 2022) shows that this pattern is also effective in reducing the risk of mortality, however, this does not mean that it would be enough physical activity to counteract the negative effects of sitting.
- Moderate-level exercisers (1200-2500 MET-minutes/week and at least 3 times per week): This category includes those who meet the WHO recommendation. The inclusion of the frequency criterion is justified by metabolic adaptation and injury prevention.

- Active exercisers (> 2500 MET-minutes/week and at least 4 times per week): Those who engage in high-intensity and regular physical activity.

When setting the thresholds, we considered the results of Ahmadi et al. (2022), which emphasize the important role of intense exercise periods (VPA) and the meta-analysis by Ekelund et al. (2016), which points out that university students with a sedentary lifestyle need to reach a higher range (1500+ MET-minutes) to counteract the negative effects of sitting. To perform more accurate analyses, we combined the groups in pairs, thus creating groups of people who exercised sufficiently (Moderate exercisers and Active exercisers) and those who did not exercise sufficiently (Inactive and Low-level exercisers).

Determining the occurrence and frequency of pain

The occurrence and frequency of pain were determined using a self-reported questionnaire. Participants were asked to indicate whether they had experienced back pain in the past three months (group with pain/group with no pain) and, if so, to specify its frequency. The use of the self-report method is supported by the latest international recommendations for pain research, as pain is a subjective and individual experience, and the patient's own report is the primary and most valid source for measuring it (Raja et al., 2020, International Association for the Study of Pain [IASP], 2020). Based on the frequency of pain, respondents were classified into four categories: very rarely (never, once a month or less), sometimes (several times a month or once a week), very often (several times a week), and constantly (daily or constant pain). Structuring the responses into four categories is methodologically justified as it allows for the separation of episodic complaints of low clinical relevance from persistent pain conditions that significantly affect quality of life. This type of differentiation is essential for accurately mapping the heterogeneous nature of back pain and ensuring standardized measurement results.

Statistical processing of data

The data was processed using IBM® SPSS® Statistics Standard GradPack 29 and various statistical tests, all of which are explained in detail for each result.

Following the determination of descriptive statistics (frequencies and percentages), 95% confidence intervals (CI) were calculated using the Agresti–Coull method to estimate population parameters. To evaluate the sample prevalence of back pain, a one-sample proportion test (Score test) was performed against a hypothesized test value of 50% (0.50).

Relationships between categorical variables were analyzed using cross-tabulation and Pearson's chi-square (χ^2) test. In cases where the assumptions of the chi-square test were violated—specifically, when the expected cell counts fell below 5—significance was determined using Fisher's Exact Test. When expected frequencies were below 5 in more than 20% of the cells, the analysis was deemed unreliable due to severe violation of statistical assumptions, and the corresponding results were excluded from interpretation.

To quantify the strength of the associations, the Phi (ϕ) coefficient was calculated for 2 × 2 contingency tables, while Cramer's V (V) was utilized for larger tables. The magnitude of the effect sizes was interpreted based on Cohen's (1988) criteria. For all statistical decisions, the significance level was set a priori at $\alpha = 0.05$ ($p < 0.05$), and the resulting p-values were reported either as exact values or according to their critical thresholds (e.g., $p < 0.001$).

RESULTS

Prevalence of back pain among respondents

We examined the frequency of back pain among respondents over the past three months.

To test the hypothesis, we performed a one-sample proportion test using a test value of 50% (0.5). Based on the descriptive statistical data, 78.2% (68 people) of the participants in the sample ($N = 87$) reported back pain in the past three months. Based on the results of the statistical test (Score test), it can be stated that the observed prevalence statistically significantly exceeds the 50% rate assumed in the hypothesis ($Z = 5.253$; $p < 0.001$).

The accuracy of the measurement is further reinforced by the 95% confidence interval (Agresti-Coull method), according to which the true prevalence of back pain is between 68.3% and 85.6%. Since the confidence interval is entirely above the expected 50% threshold, the hypothesis that more than half of the students are affected by back pain has been statistically confirmed.

Table 1. Prevalence of back pain

Category	Frequency (*N*)	Proportion (%)	95% CI	Test Value	Z-Score	Significance (*p*)
Back pain	68	78.2%	68.3%-85.5%	0.50	5.253	< 0.001*
No back pain	19	21.8%	14.4%-31.7%	0.50	-5.253	< 0.001*
Total	87	100.0%	-	-	-	-

CI= Confidence interval

The correlation between incorrect sitting posture and back pain

We examined the correlation between correct sitting posture and the occurrence of back pain using cross-tabulation analysis and the Chi-square test. Since the expected count was less than 5 in certain cells of the cross-tabulation, Fisher's Exact Test was used to determine significance. The statistical test yielded a significant result (χ^2 (1)=11.12, p = 0.009). The Phi coefficient indicating the strength of the relationship was -0.358, which indicates a moderate correlation (Cohen,1988) between the two variables.

In addition to the significant Chi-square test result, the analysis of frequency data highlights the nature of the correlation: the occurrence of pain is concentrated in the group of people who sit incorrectly (81%), as opposed to those who sit correctly (0%). This may be related to the assumption that poor posture is a risk factor for the development of back pain.

At the same time, it is important to note that the data may be distorted, as only 3 of the 87 respondents stated that they sat correctly in at least 51% of cases, and none of them experienced back pain.

Table 2. Prevalence of back pain

Sitting Posture	BP: Yes (*n*)	BP: No (*n*)	Total (*N*)	IBP (%)
Incorrect sitting (≤ 50%)	68	16	84	81.0%
Correct sitting (> 50%)	0	3	3	0.0%
Total	68	19	87	78.2%

Note: $\chi^2(1)=11.12$, p = 0.009;
BP= Back pain, **IBP**= Incidence of back pain

The correlation between regular physical activity and the incidence of back pain

We used cross-tabulation analyses and chi-square tests to examine the relationships between pain and physical activity in the sample studied (N = 87).

First, we analyzed the relationship between the presence of pain (painful/not painful) and the combined assessment of physical activity (enough exercise/not enough exercise). The conditions for applying the chi-square test were met, as the expected frequency exceeded 5 in each cell. The analysis did not show a statistically significant correlation between the two variables (χ^2 (2) = 0.004; p = 0.949). The Phi coefficient, which indicates the strength of the association, shows a negligible, clinically non-meaningful correlation (φ = -0.007). According to the descriptive statistical data, 67.6% of subjects experiencing pain and 68.4% of those without pain considered themselves to be sufficiently active, which further reinforces the lack of correlation.

Table 3. Sufficient physical activity and the incidence of back pain

IBP	SPA n (%)	ISPA n (%)	Total n
Pain	46 (67,6%)	22 (32,4%)	68
No pain	13 (68,4%)	6 (31,6%)	19
Total	59 (67,8%)	28 (32,2%)	87

Note: χ^2 (2) = 0,004; p = 0,949; φ = -0,007
IBP= Incidence of back pain, **SPA**= sufficient physical activity, **ISPA**= insufficient physical activity

We then examined the relationship between the frequency of back pain (ranging from "very rarely hurts" to "constantly hurts" and subjectively assessed physical activity (sufficient physical activity/ insufficient physical activity). The prerequisites for the chi-square test were largely met in this case as well, as only 12.5% of the cells had an expected frequency of less than 5. The analysis did not reveal a statistically significant correlation between the variables ($\chi^2(3) = 3.230$; $p = 0.358$). Cramer's V index, which measures the strength of the correlation, indicates a weak association ($V = 0.193$). Based on the results, there is no significant correlation between the frequency of pain and sufficient physical activity in the sample studied.

Table 4. The frequency of back pain and sufficient physical activity

IPB	SPA n (%)	ISPA n (%)	Total n
Very rarely	24 (68,6%)	11 (31,4%)	35
Sometimes	20 (74,1%)	7 (25,9%)	27
Very often	8 (50,0%)	8 (50,0%)	16
Constantly	7 (77,8%)	2 (22,2%)	9
Total	59 (67,8%)	28 (32,2%)	87

Note: χ^2 (3) = 3,230; p = 0,358; Cramer 's V = 0,193
In 12.5% of cells, the expected frequency was below 5.
IBP= Incidence of back pain, **SPA**= sufficient physical activity, **ISPA**= insufficient physical activity

We also planned a chi-square test to examine the correlation between the presence of pain (with pain/without pain) and a more objective level of physical activity (inactive, low level of exercise, moderately active and active), but during the analysis, the expected frequency remained below 5 in 25% of the cells. This violated the conditions for applying the statistical test, so we did not consider the results reliable and did not draw any conclusions from them.

Table 5. Frequency of pain and level of physical activity

Level of physical activity	Pain n (%)	No pain n (%)	Total n
Inactive	26 (38,2%)	8 (42,1%)	34
Low-level exercisers	20 (29,4%)	5 (26,3%)	25
Moderate exercisers	14 (20,6%)	3 (15,8%)	17
Active exercisers	8 (11,8%)	3 (15,8%)	11
Total	68 (100,0%)	19 (100,0%)	87

Note: χ^2 (4) = 0,472; p = 0,925; Cramer 's V = 0,074.
In 25.0% of cells, the expected frequency was less than 5

Similarly, when examining the relationship between the level of physical activity and the frequency of back pain, 56.3% of cells had a low expected frequency, which also made it impossible to reliably apply the chi-square test. Accordingly, the results of this analysis were not presented either.

Table 6. Level of physical activity and the frequency of back pain

IPB	I n (%)	LLE n (%)	ME n (%)	AE n (%)	Total n
Very rarely	13 (37,1%)	11 (31,4%)	7 (20,0%)	4 (11,4%)	35
Sometimes	12 (44,4%)	8 (29,6%)	4 (14,8%)	3 (11,1%)	27
Very often	4 (25,0%)	4 (25,0%)	4 (25,0%)	4 (25,0%)	16
Constantly	5 (55,6%)	2 (22,2%)	2 (22,2%)	0 (0,0%)	9
Total	34	25	17	11	87

Note: χ^2 (5) = 5,726; p = 0,767; Cramer's V = 0,148
In 56.3% of cells, the expected frequency was less than 5
I= Inactive, **LLE**= Low-level exercisers, **ME**= Moderate exercisers, **AE**= Active exercisers

Overall, no statistically significant relationship was found between the presence or frequency of pain and the subjective assessment of physical activity in the sample studied, because methodological limitations prevented valid conclusions from being drawn in the case of analyses using more detailed categories of physical activity.

DISCUSSION

The present study aimed to examine the prevalence of back pain among university students and to explore its relationship with sedentary lifestyle factors, particularly sitting posture and physical activity. The results indicate that back pain is highly prevalent in the examined population, with more than three-quarters of respondents (78.2%) reporting back pain in the previous

three months. This finding strongly supports **H1**, confirming that back pain affects more than half of university students and represents a significant public health concern in this age group.

The observed prevalence is consistent with, and in some cases exceeds, values reported in recent international studies. For example, Parto et al. (2023) found a prevalence of 60-70% for pain in different areas (neck, back, shoulders, lower back). The higher prevalence found in the present study may be explained by differences in measurement periods (three-month prevalence), increased academic workload, prolonged screen exposure, and post-pandemic lifestyle changes that have further intensified sedentary behavior among students. These findings reinforce the growing body of evidence suggesting that musculoskeletal complaints are not only common but increasingly normalized among young adults.

A significant association was found between incorrect sitting posture and the occurrence of back pain, supporting H2. The moderate strength of the relationship ($\varphi = -0.358$) suggests that posture is a meaningful risk factor in the development of back pain. This result aligns with ergonomic and biomechanical research showing that prolonged poor sitting posture increases spinal load, muscular imbalance, and static strain, all of which contribute to pain development (Bagherian et al., 2023; Kallings et al., 2021; Mahdavi et al., 2021; Ekelund et al., 2016)

Importantly, the concentration of back pain almost exclusively among participants who reported predominantly incorrect posture highlights the potential cumulative effect of habitual postural behavior. Similar findings have been reported by Bontrup et al. (2019), who emphasized that self-reported habitual posture is a strong predictor of non-specific back pain, even when objective measurements are not available. However, the very small number of participants classified as “correct sitters” ($n = 3$) represents a limitation and suggests that future studies should aim for larger and more balanced posture-based subgroups, potentially using objective posture-monitoring tools.

Contrary to H3, no statistically significant relationship was found between physical activity and the incidence of back pain. This result contrasts with several studies reporting a protective effect of regular physical activity, particularly moderate-to-vigorous exercise, against back pain (Alanazi & Kashoo, 2025; Scarabottolo et al., 2017). However, recent literature increasingly highlights that physical activity alone may not be sufficient to counteract the negative effects of prolonged sedentary behavior, especially when sitting time remains high (Ekelund et al., 2016; Dzakpasu et al., 2021).

One plausible explanation is that many physically active participants in the present sample still spent a large portion of their day sitting, which may have attenuated the protective effects of exercise. This interpretation is supported

by Ekelund et al. (2016), who demonstrated that high volumes of sedentary time require substantially higher levels of physical activity to offset associated health risks.

CONCLUSIONS

This study examined the prevalence of back pain among university students and its association with sedentary lifestyle factors, particularly sitting posture and physical activity. The findings indicate that back pain is highly prevalent, affecting more than three-quarters of students, and represents a significant public health concern in this population. A statistically significant association was found between incorrect sitting posture and the occurrence of back pain, suggesting that habitual poor posture is an important contributing factor. In contrast, physical activity alone did not show a significant protective effect, indicating that regular exercise may be insufficient to offset prolonged sedentary behavior. Overall, the results highlight that sedentary behavior—particularly poor sitting posture—may play a more critical role in back pain development than overall activity levels. Therefore, preventive strategies should combine ergonomic education and postural awareness with the promotion of physical activity.

Limitations of the study and directions for future research

Several limitations should be considered when interpreting the findings: the cross-sectional design prevents causal conclusions, while reliance on self-reported data may introduce bias, particularly in assessing sitting habits and physical activity. The uneven distribution of subgroups-especially the small number of participants with correct posture-reduces statistical reliability, and the MET-based classification of physical activity fails to capture qualitative aspects of movement, which may explain the lack of association with back pain. Future research should adopt longitudinal and intervention-based designs that examine the combined effects of sitting posture, sitting duration, and multiple dimensions of physical activity, integrating objective measurements with subjective assessments and extending analyses across diverse cultural contexts to better reflect the complex lifestyles of university students.

AUTHOR CONTRIBUTIONS

KSZ conceptualized the study, developed the methodology, performed the statistical analyses, and wrote the original draft of the manuscript. ÁZSZ, NM and HSZ were responsible for the data collection and managed the literature review, they supervised the

research process and contributed to the critical revision of the manuscript. All authors have read and agreed to the published version of the manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors would like to thank the supervising teacher (Dumitru Rareş Ciocoi-Pop) for their guidance and assistance,as well as the students who participated in the survey.

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